

# CERN

# COURIER

No. 12 Vol. 10 December 1970

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. CERN is one of the world's leading Laboratories in this field.

The experimental programme is based on the use of two proton accelerators—a 600 MeV synchro-cyclotron (SC) and a 28 GeV synchrotron (PS). At the latter machine, large intersecting storage rings (ISR), for experiments with colliding proton beams, are under construction. 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 their research material from CERN.

The Laboratory is situated at Meyrin near Geneva in Switzerland. The site covers approximately 80 hectares equally divided on either side of the frontier between France and Switzerland. The staff totals about 2950 people and, in addition, there are over 650 Fellows and Visiting Scientists.

Twelve European countries participate in the work of CERN, contributing to the cost of the basic programme, 244.1 million Swiss francs in 1970, in proportion to their net national income. Supplementary programmes cover the construction of the ISR and studies for a proposed 300 GeV proton synchrotron.

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Cover photograph: Part of the crowd of CERN staff who assembled on 18 December to bid farewell to Bernard Gregory (speaking on the rostrum flanked by the flags of the twelve Member States). Professor Gregory left CERN at the end of December after five years as Director General.

# 45th Session of CERN Council

The Council met on 22 December under the Presidency of Professor E. Amaldi

## 300 GeV project

Yet again the subject of most interest was the possibility of a go-ahead for the construction of the 300 GeV proton synchrotron which it had been hoped would be possible at this Session.

First an important preliminary measure was passed. At the end of 1967, the Council recommended to the governments of the twelve Member States some amendments to the CERN Convention the essence of which was to permit a second Laboratory, to house the 300 GeV machine, to come into being (see vol. 8, page 56). On 18 December the last acceptance of these amendments was received, so that all the Member States (as was necessary) have given their accord. The new Convention will thus come formally into force on 17 January 1971 and from that date CERN can, within the provisions of its Convention, establish a new Laboratory.

All delegations agreed that discussions will now concentrate exclusively on the 'Project B' version of the 300 GeV Laboratory (see vol. 10, page 146). J.B. Adams reported on recent work in preparation for the start of the project saying that when it is remembered that Project B was put before Council for the first time in June, only six months ago, a remarkable amount of progress has been made.

1) In consultation with the European High Energy Physics community, particularly through the European Committee for Future Accelerators (ECFA), various possibilities which were opened by Project B have been improved and the project has now taken a better form.

2) A detailed machine design study, carried out by the 'Machine Committee' representing over a hundred physicists and engineers from accelerator Laboratories throughout Europe, has been completed and published in two volumes. The first volume is a condensation of the second which consists of chapters assembled by the specialist working groups on different aspects of the machine. (We shall be returning to the machine design in a coming issue of CERN COURIER.)

3) The investigations on the proposed site alongside the existing Laboratory have proved very satisfactory with regard to the quality and extent of the underlying mo-

lasse ridge where the tunnel, 2.2 km in diameter, will be bored to receive the machine.

A further report on the site was presented to this Council Session. Discussions between CERN and the French and Swiss authorities have already gone a long way towards resolving the problems of site availability and servicing. Most important it was announced that the areas which will be needed for the laboratories and service buildings, for the North Experimental Area and that overlying the ring tunnel will be made available to CERN by the governments of France and Switzerland.

Discussions have also taken place concerning the important services of electrical power and cooling water to the site. A unit tariff for power no higher than that charged to the most favoured French consumers of comparable amounts has been agreed. Payment of the capital cost of the power lines to the site (involving about 10 MSF) is still under discussion with Electricité de France. Switzerland has agreed to provide the capital cost of bringing cooling water to the site and discharging it after use while charging CERN a unit tariff for the water no higher than that paid by the most favoured Swiss consumer of comparable amounts.

Accommodation of the additional staff is not seen as a problem requiring particular attention since the influx of 100 extra CERN staff per year for the next eight years will be a very small fraction of the general influx into the area for which extensive housing schemes are already in existence. The French government is willing to establish a European type school in the neighbourhood of the site which will offer courses in several languages to children of CERN staff and the Geneva authorities are also studying the schooling problems arising from the increase in the international population.

Dr. Adams concluded by recording his thanks to all those who had participated so enthusiastically in assembling so much basic material on Project B in so short a time.

The different delegations then stated the present position of their governments

with regard to the 300 GeV project. They are recorded here in the sequence in which they were given at the Council Session.

*Federal Republic of Germany:* The government confirms its decision to participate in the project. The letter of intent can be presented when a majority of (though not necessarily all) countries, including the major partners, declare their willingness to participate.

*France:* The government confirms its decision to participate adopting the same position as that of the Federal Republic of Germany and has already accepted various responsibilities with regard to the required site.

*UK:* The intention of the UK government to participate in the project was announced a few weeks ago. Before the letter of intent can be presented however, the government wished to be assured that the site will be made available at nominal cost and that the envisaged reductions will take place at the existing Laboratory (both conditions which can be easily met) but also that all Member States will agree to participate in the project. This last condition was imposed in an effort to press for a renewal of complete unity among the Member States which has always been such a distinctive mark of CERN's activities. The condition did however cause a certain amount of embarrassment to other Member States willing to go ahead under less stringent conditions. The UK delegation is therefore carrying back the views of the other countries and will seek a relaxation of the government's position.

*Netherlands:* It has not been possible up to now to take a decision on participation. The matter remains under discussion in the appropriate bodies and a decision may be forthcoming inside two months. To stress European unity in the project is likely to be of great influence in the Netherlands.

*Norway:* No definite position with regard to the project has yet been adopted by the government. A decision is, however, likely early in the New Year. Here again European unity is regarded as an important influence.

*Italy:* The government confirms its decision to participate given a majority of



countries participating and had hoped very much that the project would have the go-ahead at this Council Session.

*Austria:* The government confirms its decision to participate and is ready to submit its letter of intent when the seven highest contributors (which includes Sweden) plus Denmark and Norway have agreed to participate also. The importance of the unity of CERN was again a theme of the Austrian declaration.

*Belgium:* The government confirms its decision to participate and the Belgian representative urged that the present 'yes buts' should be rapidly converted into clear agreements to participate without difficult conditions.

*Switzerland:* The government confirms its decision to participate. It is ready to make available the land required and to finance the provision of some of the site services (as explained above).

*Denmark:* The government is not yet in a position to announce its decision. The project remains under study by advisory bodies and it is hoped that a decision may be possible in the near future.

*Greece:* The Greek government had authorized its delegation to vote positively on all decisions concerning the 300 GeV project but this is only on the understanding that the special financial provisions which are at present accorded to Greece will continue to prevail. Thus the position of the government is not a formal declaration of intent.

*Sweden:* All the preliminary work is completed but the government has not yet taken its decision. This is expected within the next six weeks.

The position is therefore that seven countries (representing 87% of the financial contribution to CERN) have declared their willingness to participate. Five countries have not yet taken their decision. Professor Amaldi presented the needs now as — to preserve the goodwill of those countries who have already said 'yes'; to 'soften' the reservations which some of those countries have imposed; to receive further positive decisions from countries. To give a little time for positions to be modified the Council Ses-

sion was adjourned and will be reconvened on 19 February 1971.

## Five years at CERN

The Council Session had opened with a report from B.P. Gregory, which covered the five years for which he has been Director General. It covered two subjects — on overall view of the development of CERN with a status report on the improvement programme, and a review of developments in particle physics in which CERN and its Member States have participated at the highest level. Some of the highlights from this report are picked out here.

The growth of CERN can be illustrated in three ways. First there is the development of the site itself and its installations which will be illustrated below. Second, there is the growth in the use of CERN facilities by physicists from the European Universities. While the CERN staff participation in the experimental programme has stayed virtually constant, outside participation has doubled both in terms of the number of visiting groups which has grown from 20 to 43 (or to 68 if the experimental programme which is preparing to use the Intersecting Storage Rings is included) and in terms of the number of visiting scientists at CERN for a period of time. Thirdly there is the growth in CERN budgets which have also about doubled in the past five years with something like 50% being capital investment in the ISR and improvement programmes at the accelerators. These budgets are now to be held steady while an increasing proportion is given to the exploitation of the facilities which have been built up.

The projects which this capital investment has supported are going extremely well. Commissioning tests on the ISR in November were a spectacular success and, barring any unforeseen difficulties, this huge, complex project should be completed next year within its cost and time-scale estimates. At the beginning of December the large heavy liquid bubble chamber, Gargamelle, took its first pictures and an exciting new phase of neutrino physics with this chamber is opened up. Construction of the 3.7 m European hydrogen bubble chamber is proceeding well with the superconducting magnet



coils also completed this month. Contracts have been placed for a major extension of the central computing system. The large electronic detector project, Omega, the 800 MeV four-ring Booster, the modifications to the proton synchrotron itself and the improvements at the synchro-cyclotron are all proceeding well and are all due for completion in the next few years.

Meanwhile exploitation of the existing facilities has improved remarkably within a fairly constant budget. Operation of the PS has yielded beam intensities double those obtained in 1965 and touched their peak a few weeks ago just before the machine shutdown. Injection into and ejection from the PS have been made much more efficient. In the experimental halls separated beams, polarized targets and various types of wire chamber have improved beyond recognition. The sophistication of the electronic experiments is greatly increased and bubble chamber experiments, with chambers now double-pulsing, have garnered 7.5 million pictures in the past year which is double the average five years ago. At the synchro-cyclotron the number of physics hours, thanks to more sophisticated beam-sharing has grown from 9000 to 14 000 hours per year.

Turning to the progress of particle physics in the past five years it is possible to speak generally because CERN and the European community of physicists which uses CERN have participated very significantly on all topics. The Director General selected just the phenomena controlled by the strong interaction to illustrate the growth of knowledge in recent years.

High energy collisions between protons have revealed that a whole host of other particles under the collective name of hadrons can be produced. They are of two types — the mesons which are radiated off and baryons which are effectively transformed protons. Five years ago two impressive symmetry patterns had begun to impose themselves in an understanding of these phenomena. The first, Unitary Symmetry or SU3, is now well established. The behaviour of the hadrons, to a first approximation, does not depend on their charge or strangeness quantum numbers,

and SU3 considers groups of, for example, eight particles being manifestations of the same particle. Experiment has by now confirmed these groupings remarkably for the mesons and the baryons. All the particles allowed by Unitary Symmetry can be explained under the hypothesis of quarks — a baryon being built up of three quarks and a meson of a quark and an antiquark — but presently available energies have not revealed a quark as a separate entity perhaps because they have high mass of because the beautifully simple mathematical picture does not translate into physical facts.

The second way of looking at the hadrons is to group the particles with the same charge and strangeness. They can then be plotted according to their mass and spin in linear patterns or Regge trajectories. Again a wealth of experimental detail assembled in the past five years has been remarkably consistent with this picture.

Our understanding of the way in which hadrons interact has developed considerably. When one particle is scattered from another the outcome is the result of the exchange of particles and a seemingly infinite range of possibilities is involved. It is no longer possible to distinguish between the elements of the interaction, all the particles are effectively playing equivalent roles.

One hope for penetrating deeper in our understanding has come from the first experiments in which CERN participated at Serpukhov. The observations at the 28 GeV CERN PS do not extend as expected to the 76 GeV Serpukhov machine. Further information at higher energies might be the way to master the intricacies of the strong interaction.

CERN has also been prominent in the branches such as the electromagnetic interaction (the g-2 experiment confirming the validity of quantum electrodynamics at very small distances, the eta decay experiment restoring faith in charge symmetry), the weak interaction (the neutrino results, Cabibbo theory, many experiments on neutral kaon decay) and nuclear structure (the investigations of newly identified isotopes with ISOLDE, the production and study of exotic atoms — muonic, pionic, kaonic, sigmic and antiprotonic). From all

this work a large amount of new experimental data and new theoretical ideas have emerged.

The Director General concluded '... I believe that Europe can be proud of the technical and scientific achievements that have been made during these past five years through the harmonious association of the physicists of our Universities and the CERN staff. We have been able to show that Europeans, when they want to work together can succeed in creating an intellectual centre second to none in the world.

I believe our secret is a very simple one. On the one hand, the Council has insisted yearly on being precisely informed on the development of our programme when deciding the annual budgets of the Laboratory but has also been extremely consistent in following the main lines of development which they had accepted in December 1965. On the other hand, the staff at CERN, that have been carrying out the work, are of the highest technical and scientific level and have been fully aware of the responsibility entrusted to them.

We are at the eve of a decision which is of paramount importance for the continuation of this successful European venture. I am convinced that the people working in this field, both at CERN and in the Universities, have the necessary qualities to achieve successfully the programme that is proposed. It is now for the Council to show that the European spirit is still strong enough for this new venture to start.'

# Tribute to Professor Gregory

*Based on the speech of Professor Amaldi at the end of the Council Session on 22 December in honour of Professor Bernard Gregory who is leaving CERN after five years as Director General.*

The period from January 1966 to December 1970 during which Bernard Gregory has been Director General of CERN represents about a third of the life of CERN as a 'grown-up' Organization. It has been characterized by a number of developments and scientific and technical achievements many of which carry the stamp of the personality of Gregory.

The first development concerns the increase in CERN's potential. On the one hand this covers the projects which are being realized in the context of the improvements to the existing Laboratory — the construction of the Intersecting Storage Rings (where commissioning got off to such a resounding start at the beginning of November), the modifications to the existing accelerators and construction of major new detectors. The broad outline of this programme had been established at the end of the period of office of the previous Director General but it has been under the direction of Gregory that the execution of the programme has been so magnificently carried out and that many big decisions were taken such as those on the large European hydrogen bubble chamber, the Omega project and the PS Booster. It has also been under Gregory that the agreement with Serpukhov has taken shape and this has already proved very fruitful in physics in addition to its role as a very successful experiment in wider collaboration.

On the other hand, the increase in CERN's potential covers the work towards the 300 GeV project. Here Bernard Gregory has made continuous and untiring efforts to get the project off the ground and was the principal motor of the programme prior to the arrival of John Adams. Even since then he has continued to give a considerable part of his time and thinking to pushing the project forward.

A second feature of the years when Bernard Gregory has been Director General of CERN has been his very close contact with the experimental programme. He regularly attended the preparatory meetings where the programmes are worked out and was in a position to really understand the proposed experiments. His encouragement and close involvement has had a big influence on the thriving experi-

mental programmes. It is an interesting comparison that in 1965 there were twelve groups from European Universities working at the proton synchrotron where they were fed by fifteen particle beams; in 1970 there were twenty-five groups (plus more preparing experiments for the ISR) using eighteen beams of altogether another order of sophistication. The number of bubble chamber pictures taken per year has almost doubled. The number of visiting scientists has doubled to 600.

These figures reflect a development to which Gregory has done more to contribute than any previous Director General, namely the participation in the use of the facilities of CERN by as large a number as possible of the physicists from Universities and Laboratories throughout Europe.

The most important criteria for judging a period of years in CERN's history is the quality of the scientific results which are achieved. Here CERN under Bernard Gregory has every reason to be proud. For many years now, the quality and quantity of experimental and theoretical work from CERN, as reported at the International

*Bernard Gregory (left) receives from Professor Amaldi an album of photographs, recording some of the major events of his five years as Director General of CERN, during a dinner with Council delegates on the night of 22 December. On the right is his successor Professor Jentschke.*

Conferences, have been on a par with, if not in advance of, those from any other Laboratory in the world. Results such as the contributions to the meson spectrum from the missing mass spectrometer together with its discovery of the mysterious A2 splitting, the charge symmetry measurement in eta decay, the second series of neutrino experiments, the study of the proton-proton diffraction peak, the polarized target experiments, the series of experiments connected with charge-parity violation in the neutral kaon decay, the refined measurement of the g-2 of the muon, the total cross-section measurements at Serpukhov, the studies of exotic atoms, and a wealth of theoretical contributions have been highlights in our increasing understanding of the nature of matter in the past five years.

Bernard Gregory now returns to the Ecole Polytechnique in Paris but will be a regular visitor to CERN particularly in the role of Chairman of the ISR Experiments Committee. His collaboration here and in other capacities will be a great asset for the future life at CERN. He carries away with him our admiration and gratitude.





*The cryostat of the 3.7 m European hydrogen bubble chamber swinging into position in the bubble chamber hall at the end of November. Further news from BEBC — the last pancake for the superconducting magnet coils was completed on 14 December.*

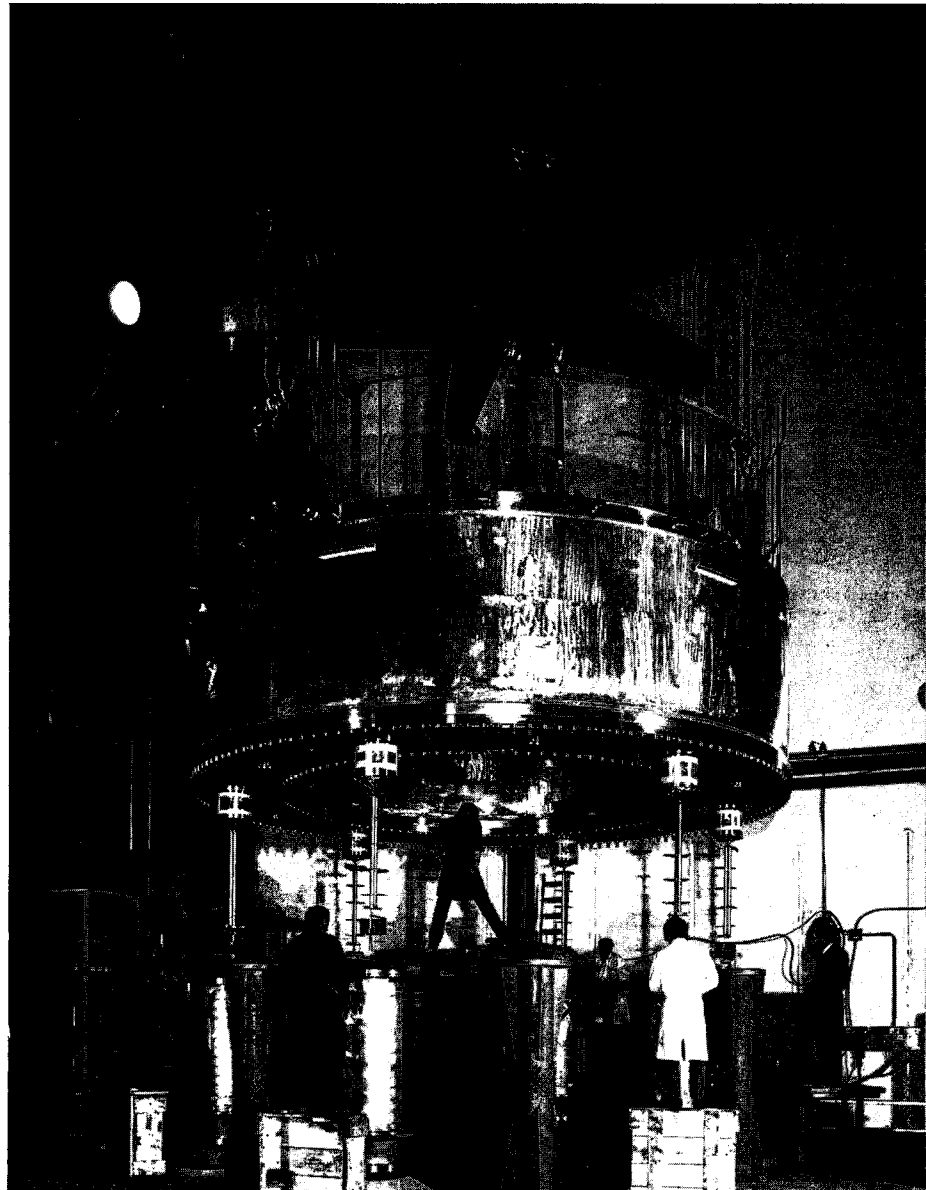
## European Molecular Biology Conference

The European Molecular Biology Conference resumed its 1970 session on 26, 27 November under the Presidency of H. Voisier. (The earlier meeting in April, which was also held at CERN, was reported in vol. 10, page 117.) Major items on the agenda were a discussion on a plan of activities covering five years and decisions on aspects of administrative structure.

Working parties were set up by the Conference to study the proposal for a European Laboratory of molecular biology and other plans of collaboration, the intention being to submit specific plans to the governments of the Member States in the near future. Most delegations to the Conference gave strong support to the proposal to set up a European Laboratory for molecular biology, in line with the scientific opinion within their countries. The Federal Republic of Germany has already offered to be host to such a Laboratory and has suggested Munich as its site. The possibility of locating the Laboratory close to CERN site in Geneva has also been mentioned. The Scandinavian delegations, however, and Sweden in particular, believe that, rather than an international centre, more collaboration between national centres could prove the better way to further the research.

Four working parties together with the European Molecular Biology Organization (EMBO), are to prepare detailed plans for the development of a European Laboratory and at the same time investigate possible ways of extending collaboration between national centres. They will report back to the Conference at a special session in October 1971.

In discussing a five year plan of activities, covering the years 1970-74, a total budget of 6 million units of account (a unit of account being equivalent to a US dollar) was agreed. It is predicted that the current budget for 1970 (714 000 units) will rise to about double in 1974. For 1971 the agreed budget is about one million units and will be used mainly for funding various types of fellowship in molecular biology research. A Finance Committee was formally constituted under the Chairmanship of A. Alline.



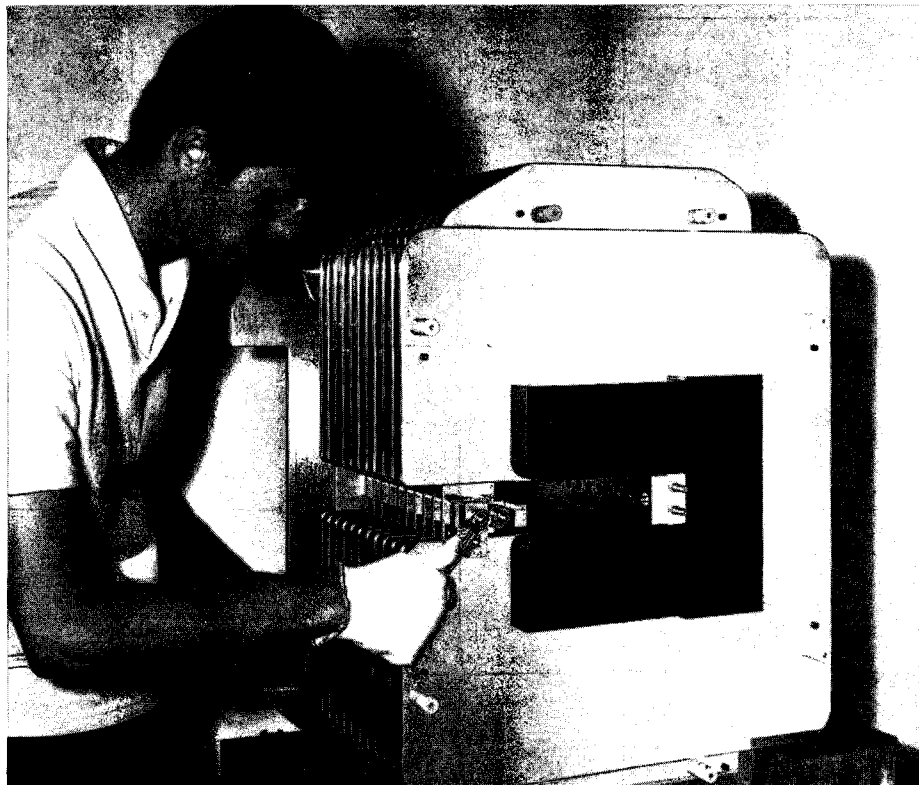
CERN/PI 248.11.70

## Fast ejection

Fast ejection facilities at the 28 GeV proton synchrotron are being developed in several ways. On the one hand, a fast kicker magnet identical to the existing one in straight section 97 (see CERN COURIER vol. 8, page 175) has been installed in straight section 13, adding some redundancy in case of failures and to help realize exploitation schedules of increasing complexity (several shots per cycle at short intervals, fast change to ejection

towards the ISR, etc.). This kicker system has been assembled to a large extent from spare parts and will be brought into operation during the first half of 1971. Much painstaking laboratory work has gone into improving the pulse performance of these fast kickers; the necessary modifications will be implemented in the forthcoming months.

On the other hand, a new fast kicker system is being developed (in connection with the PS Improvement Programme) which differs from the type mentioned



CERN/PI 21.1.70

above in that it will use static magnets of full machine aperture. Furthermore, it will have faster rise and fall times (typically 70 ns instead of 90 ns) in order to eject cleanly the longer bunches which are expected at the higher intensities when the Booster is operational. It should be remembered that an ejection efficiency of 90% which is now considered reasonable, could then result in proton losses of more than  $10^{12}$  particles per pulse.

Adequate deflecting power cannot be obtained from a single magnet because this would entail an excessively high operating voltage. A pulse voltage limit of 40 kV (normally 30 kV now) has been set for the new system, which in turn will necessitate the use of 12 identical magnet modules for ejections at 28 GeV/c (two identical units are used in each of the present systems). Tests have shown however that the number of modules can be reduced by a local modification of the focusing properties of the PS magnet lattice; it is estimated that in many cases powering eight modules will be sufficient for ejection at top energy.

Initially it is intended to install nine magnet modules in one long straight section (71 for example). Each module will be excited from its own 100 MW pulse generator installed in an extension to the Central Building. The type of pulse generator selected will allow a minimum interval between ejections of 25 ms (now 100 ms).

Much effort has gone into life testing of components for the new scheme. Six EEV Co. CX 1171A thyatron tubes have been in continuous operation for over six months and one tube has switched over 140 million pulses (40 kV and 2600 A) and several others over 80 million pulses without noticeable fall-off in performance. The important feature of switch time jitter with the CX 1171A thyatron is as low as 5 ns overall from the low voltage synchronizing pulse through the trigger stages to the high voltage output pulse.

A prototype magnet (shown in the photograph) has been built and pulsed nearly 40 million times at 40 kV and pulse lengths between 100 and 2100 ns. This prototype has yielded valuable information concern-

Partly assembled prototype of the full aperture kicker magnet showing the C-shaped ferrite core and diamond machined capacitor plates.

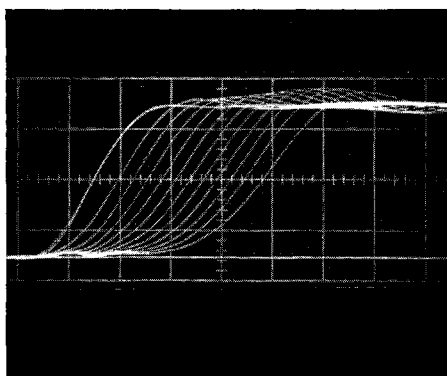
1. Pulse propagation through the prototype full aperture kicker measured on successive capacitor plates. The horizontal scale is 20 ns per division.
2. Pulse shape when 40 kV is applied to the prototype. The scale is 500 ns per division.
3. Pulse shape (opposite polarity) in the existing small aperture kicker, when used for the ejection of eleven of the PS bunches. The scale is again 500 ns per division.

ing kick rise and fall times, flat-top oscillations, field uniformity in the aperture and high voltage breakdown in vacuum. Sufficient detailed information has now been acquired to optimize the magnets and pulse generators.

Finally, a new scheme for the ejection of short bursts of particles for use with bubble chambers, which has been receiving increasing attention at Batavia, Brookhaven and in the 300 GeV study during the past months, is also being studied at the PS. It involves two fast kickers with a rise time of the order of one microsecond (rather than  $0.1 \mu\text{s}$  in the present technique) and an electrostatic septum to replace the fast kickers used at present. This proposal has the attraction that the fast burst can be produced while the beam is debunched (during the slow ejection process). This has great interest when a bubble chamber can be expanded 3 or 4 times while most of the beam is being slowly ejected for counter experiments, and it would at the same time reduce the 'multishooting' requirement for the present fast kickers.

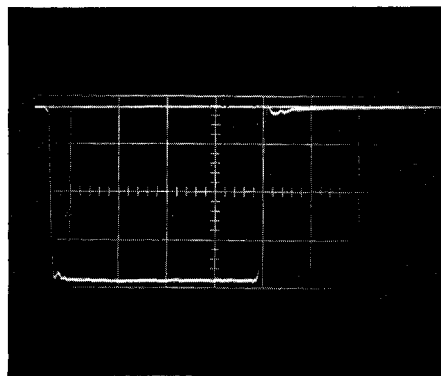
## Current transformer for the ISR

Beam current transformers are used to monitor beam intensities on nearly all particle accelerators. They use the beam itself as effectively the primary of a transformer, the secondary side of which consists of several turns wound around a high permeability toroid (made of ferrite or nickel-iron alloy) encircling the beam. A signal proportional to the beam intensity is collected from the secondary (see

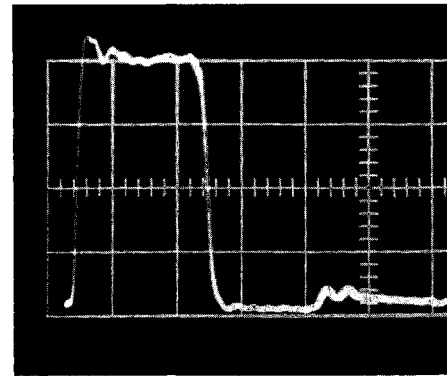


1.

380



2.



3.



Simplified block diagram of ISR beam current transformer.

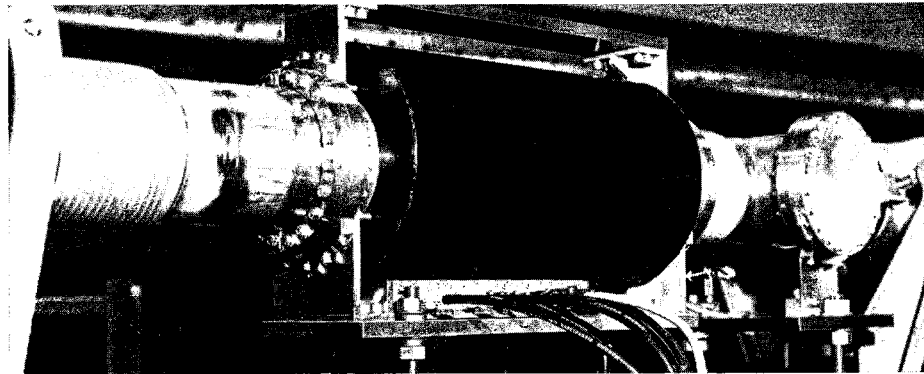
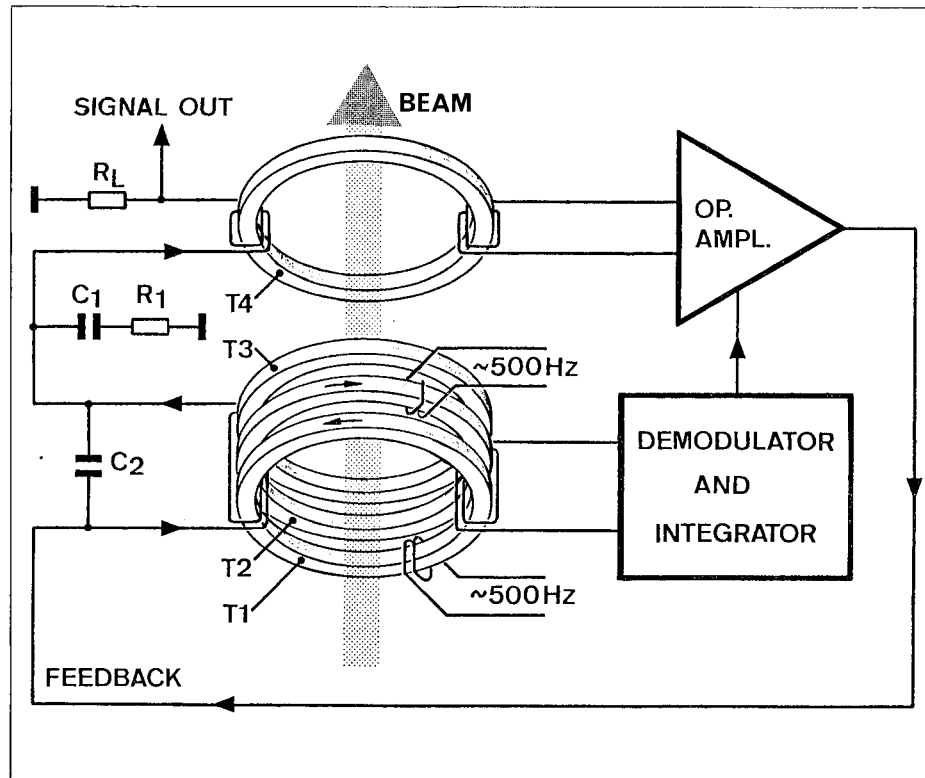
Beam current transformer assembly in position in one of the ISR rings.

vol. 9, page 17). Such a system has the advantages of excellent longterm stability and simple calibration.

However, existing equipment could not be used as it stood for the ISR, mainly because of the enormous variations in intensity (from a few mA for a single bunch of protons to 20 A for a stacked beam) and because there is no structure or modulation in the stored current (which resembles a direct current). The entire problem had therefore to be reconsidered, the result being the development of a completely new system combining a d.c. transformer and a medium and high frequency transformer. This combined transformer, two of which will be installed on each ring of the ISR, has already provided invaluable information during tests on the first ring at the beginning of November (see vol. 10, page 344). Its principle was described in IEEE Transactions on Nuclear Science, June 1969, in a paper by K. Unser (CERN).

In 1961, H.G. Hereward had the idea of putting a bifilar wound transformer in the feedback loop of an amplifier and opposing the feedback current to the primary current (beam) with the result that the time constant ( $L/R$ ) of the circuit was multiplied by a high factor. The low frequency cut-off is then lowered to the  $10^{-4}$  Hz region. The 'Hereward transformer' was the first practical instrument to measure circulating beam current in a slow cycling synchrotron, like the PS, with good precision and independent of beam structure. However, one of the problems connected with the use of the amplifier was the zero reference drift; the output signal for a zero beam current did not remain steady and an automatic switch had to reset the zero after each acceleration cycle (every few seconds).

Resetting is made unnecessary in the ISR transformer by the use of a magnetic modulator to detect any error there might be between the average beam current and the feedback current generated by the equipment (see diagram). The modulator comprises two toroids (T1 and T2) excited to saturation by an auxiliary oscillator (about 500 Hz) in opposite directions. Since the effect of the inductance of the two toroids is neutralized, a winding common to both of them receives hardly any of the



CERN/PI 79.12.70

excitation signal. Any difference between the feedback and beam currents causes a shift, in opposite directions, of the hysteresis curves of both toroids. This distortion in the original symmetry generates a signal proportional to the difference and its phase indicates the sign of the difference.

This type of modulator is not in itself an ideal current detector. It has several drawbacks such as slow response, sensitivity to overloading, poor linearity, etc. These problems are eliminated by associating it with a Hereward-type transformer (toroid T4 and amplifier), since the modulator is then subject only to the error in balance between the average primary current (beam) and the equivalent feedback current. This error builds up slowly and the modulator has time to react and to generate a compensating signal. Nevertheless, the modulator does produce a great deal of unwanted noise, which is attenuated by the use of an additional toroid and a.c. short circuit (T3 in the diagram).

Another novel feature of the ISR transformer is the fact that the signals pro-

duced by very fast variations in the beam intensity no longer pass through the amplifier, but are taken directly to the measuring resistors ( $R_L$ ) as soon as frequency ranges with which the amplifier cannot cope are reached (since the circuit is completed via  $C_1$  and  $R_1$ ).

One more important point: the equipment is so arranged that there is no source of error in the case of slow phenomena, and thus the accuracy of measurement is governed solely by the stability of the zero point of the magnetic modulator ( $\pm 10 \mu A$ ) and that of the measuring resistor ( $R_L$ ), the one used being extremely stable and giving excellent performance at high frequency.

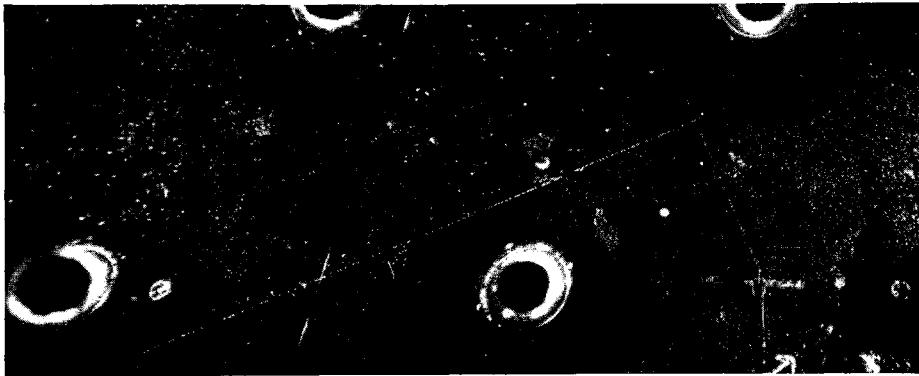
Considerable research on magnetic materials, control loops and circuit technology was necessary, but in less than two years, the device matured from a rather complex feasibility model into a relatively simple and reliable instrument of very high precision.

The mechanical design of the transformer assembly was not without problems. The toroids are located in a co-



*In the Gargamelle control room on the night of 8 December when some of the first film from the large heavy liquid bubble chamber was held up for examination.*

*One of the first photographs showing the nice clean track left in the chamber by a cosmic ray.*



thing. The optimists had a job to make out the tracks; the pessimists could see nothing at all. After half an hour the first film was completely exposed and developed and then at last the film gave its objective verdict. Cosmic rays tracks were there and the bubble chamber team joyfully celebrated their achievement.

Apart from the fact that all the equipment worked straightaway, two points deserve mention: the success in making such a large volume sensitive using the two expansion diaphragms 4 m long and 1 m across which were being tried out for the first time and the success in taking photographs in such a large volume of freon. The optical system was shown to be working efficiently and the thermal equilibrium of the chamber was more or less satisfactory. The tests were carried out at a rate of one cycle per 4 s with a decompression time of 60 ms.

Since the first tracks were obtained magnetic field tests have been carried out and a month will be spent making various adjustments to reduce parasitic boiling. In January, when the PS beam is available, it will be possible to make final adjustments which cannot easily be carried out with cosmic ray tracks. The physics experiments should start, as scheduled, in May 1971 after 100 000 photographs have been taken as part of the acceptance tests.

axial cavity into which the magnetic field of the beam can penetrate through an insulating gap (AlO<sub>2</sub> — ceramics) in the vacuum pipe. All elements of the vacuum system are provided with heaters and have to stand a bake-out temperature of at least 300° C. At the same time the transformers themselves have to be protected from any excessive temperature rise.

A coaxial cavity as described may interact with the stored beam causing instabilities and possibly beam loss. It was therefore necessary to damp out all possible modes of resonance with special resistive structures and with ferrite loading on all outgoing cables. The virtual impedance seen by the beam across the gap of the vacuum chamber has to be kept small well into the Gigahertz region.

Analog and digital signals of the ISR circulating beam current monitor are used in various ways. High speed phenomena are displayed on wide-band oscilloscopes. The slow evolution of beam current during stacking and beam-life tests are recorded by servo-pen recorders (see last issue of

CERN COURIER for examples). High precision readings are obtained on a six digit display (2 ranges) and are also available for the control computer for further processing.

Another important use of the system is for machine protection, i.e. to trigger the beam dump automatically in case of a sudden beam loss.

## Tracks in Gargamelle

On the night of 8 December the first expansion tests on the heavy liquid bubble chamber Gargamelle, installed at CERN by Saclay, were carried out. Since the cameras and flashes were already set up, it was decided to bring them into action right from the start and very satisfactory photographs of cosmic ray tracks were obtained, as can be seen from the photograph.

There was a tense atmosphere in the control room as the first thuds of the expansion cycle were heard, and everyone in turn peered through the observation window in an effort to see some-

## A thousand wires at the synchro-cyclotron

A Caen-CERN collaboration (C. Bricman, J. Déclais, J. Duchon, M. Ferro-Luzzi, J.-M. Perreau, J. Seguinot, T. Ypailantis) are currently carrying out some measurements, with detection equipment including several multiwire proportional chambers (Charpak chambers), at the 600 MeV synchro-cyclotron. These measurements are a necessary preliminary to their experiment on the proton synchrotron and are scheduled to be finished before the end of December.

The purpose of the PS experiment is to measure the differential cross-section of the elastic scattering of negative kaons on neutrons. The incident kaon momenta will range between 1 and 2 GeV/c and the angular region in which scattering is observed will cover all directions except



The lay-out of an experiment to be mounted at the proton synchrotron to measure the differential cross-section of elastically scattered negative kaons on neutrons. The Caen/CERN experimental team is currently carrying out a necessary preliminary measurement at the synchro-cyclotron.

those corresponding to very forward-scattered kaons.

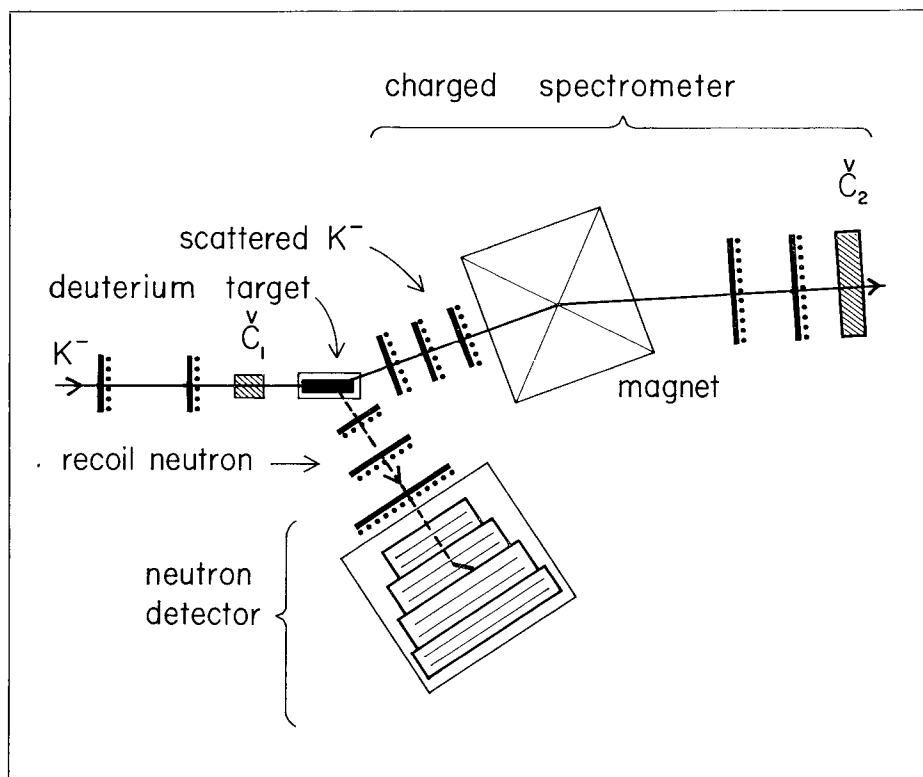
The measurement of the  $K^-n$  differential cross-section gives information on the isospin component of the  $\bar{K}N$  system. The  $\bar{K}N$  system is a general definition covering all possible combinations of the  $\bar{K}$  mesons and the nucleons  $N$  (proton and neutron). Charge independence tells us that only two states are possible for the  $\bar{K}N$  system: a state characterized by isospin 0 and another by isospin 1. The physical combinations observed in nature can be regarded as mixtures with different proportions of these two basic states. Thus, for example,  $K^-p$  is an equal mixture of the isospin 0 and 1 states; the same mixture, but with different signs, explains the combination  $\bar{K}^0n$ . In this respect the  $K^-n$  combination (as the  $\bar{K}^0p$ ) is a special case, being made up by only one of the basic states.

The study of the  $\bar{K}N$  system (sometimes referred to as a phase-shift analysis) is a way to obtain information on the states called 'strange baryon resonances'. One of the quantum numbers necessary for the classification of these states is the isospin. The appearance of any such state when examining the  $K^-n$  system already labels that state with a definite isospin.

#### Experimental procedure

In order to scatter negative kaons on neutrons a target of neutrons is needed. The simplest form in which this is available is with the neutron tied to a proton in the nucleus of deuterium. Thus the reaction to be measured is  $K^-d \rightarrow K^-n(p)$  with the proton in parentheses because it does not participate in the interaction, it is a spectator. The experimental set-up is shown in the Figure.

A separated beam of negative kaons will be focused on a liquid deuterium target. Apart from a window allowing the scattered kaon to emerge, the target is surrounded by a series of anti-coincidence counters which veto reactions other than  $K^-n$  (the spectator proton has such a low energy that it will be stopped in the target most of the time). The reaction is identified as follows: The incident kaon, of known momentum, determined by the beam-line settings, is identified by a Cher-



enkov counter ( $C_1$ ), and has its direction accurately measured by a series of Charpak chambers positioned along its trajectory. The scattered kaon is detected by Charpak chambers in a spectrometer arm, its momentum being measured by the deflection of its trajectory when passing through the magnet and its identity verified by a Cherenkov counter ( $C_2$ ). The neutron counter consists of a series of spark chambers sandwiched between polythene plates, where the neutron is identified from the charged particles emitted in a possible interaction occurring during its traversal of the polythene plates. The position of the interaction is determined by the spark chambers, thus indicating the direction in which the neutron was emitted from the target.

The information coming from the wires of the Charpak chambers is recorded instantaneously on magnetic tape via a small on-line computer (HP 2115A), the same computer also allowing simple checks on the performance of the apparatus during the run. The information from the spark chambers is recorded on film and subsequently analysed. The above data, after a straightforward application of the laws of energy and momentum conservation, are sufficient for a complete identification and reconstruction of the reaction.

#### At the synchro-cyclotron

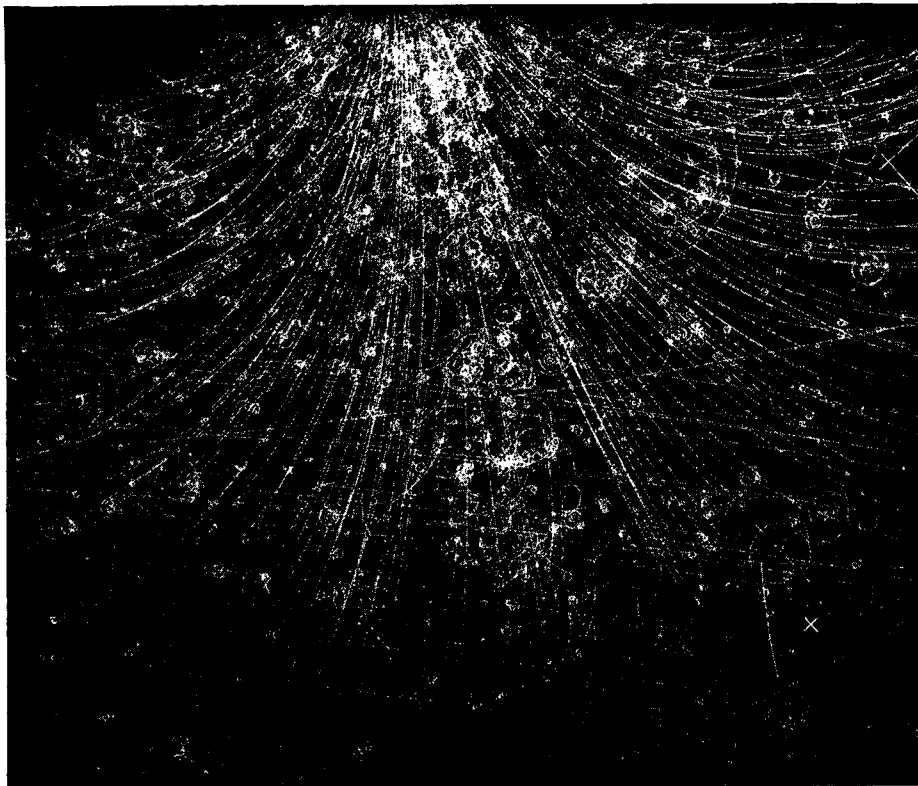
The neutron detector described above is not a uniform detector of all possible neutrons. In fact, the probability that a neutron interacts with the polythene, thus allowing the spark chambers to signal its presence, depends to a large extent on

its energy. In order to know exactly in the final experiment how neutrons of a given energy are emitted in a certain direction, this probability must be known. In other words the detector must be calibrated and this is where the SC comes in.

A beam of neutrons (of which there is a large availability at the SC) is fired into essentially the same experimental set-up as is intended at the PS. The neutrons, coming from an internal target of the SC and collimated so that their direction is accurately known, impinge on a liquid hydrogen target. The recoil proton is detected by the spectrometer arm and the scattered neutron enters the neutron detector. From the measurement of the recoil proton momentum the complete configuration of the neutron-proton collision can be reconstructed to give the energy and direction of the neutron that entered the detector. Thus, looking at the photographs from the spark chambers of this detector it will be possible to calculate precisely how many times neutrons of a given energy are 'seen' by the apparatus. This gives the scaling factor by which the events recorded have to be multiplied in order to obtain the real number.

In the final stage of the set-up 12 Charpak chambers will be employed with a total of about 5000 wires. Their size will range from  $10 \times 20 \text{ cm}^2$  to a maximum of  $120 \times 80 \text{ cm}^2$ . At present there are only 3 chambers (two coordinate planes each) with a total of about 1000 wires in operation, these being quite sufficient for the purpose of the calibration described above.

The chambers are of the type described, for example, in CERN COURIER, vol. 10, page 151. The technical characteristics



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are as follows: the sensitive wires are made out of tungsten and have a diameter of  $20\ \mu$  with 2 mm spacing. On each side, 7.5 mm away, are the high voltage planes made of wires with  $100\ \mu$  diameter and 1 mm spacing. All these wires are stretched over frames of Vitronite (a plastic material) between mylar windows. A gas made of 80% oxygen and 20% isobutane circulates inside this volume. This gas passes through isopropyl alcohol before entering the chambers; it has been found that the introduction of a small amount of this alcohol considerably improves the performance of the chambers, reducing the amount of noise on the wires.

The read-out electronics and the subsequent interface with the computer has been developed by the TC electronic laboratory (by G. Amato and E. Chesi). It has been in operation for several hundred hours, registering more than 10 million particle trajectories on magnetic tape without any serious breakdown.

## Site Security

The CERN Site Security Service is, fortunately, not very often in the news for it comes most conspicuously into action in case of trouble such as fire, flood or accident. Nevertheless, it is there, round the clock, for such emergencies and more mundane things also such as a faulty lift, lost keys, etc... and a variety of supervisory tasks.

It has four main jobs:

- acting in the case of accidents;
- rendering first aid, resuscitation, transporting the injured, and taking decisions on immediate treatment;

- policing the site, guarding the entrances and traffic control;
- checking the staff of contractors.

In addition it has administrative tasks such as responsibility for all site keys, the distribution of vehicle authorization discs and passes.

Because of its vital importance to safety, the Service has been built up of experienced people. With two exceptions only, its 44 members were formerly professional firemen and have spent at least three years on active service (fifteen in the case of team leaders). They are led by P. Vosdey and his assistant G. Verny, and are divided into four teams working continuous shifts, so that there is always at least one team on the site.

As well as the general work listed above, each team has specific tasks allocated to it, including:

- (a) responsibility for the reliable functioning of some 1400 fire extinguishers;
- (b) the care of fire hoses and protective equipment (asbestos suits, fire blankets);
- (c) some monitoring work on vehicles, road traffic equipment, etc.;
- (d) the maintenance of first-aid (stretchers, resuscitation devices) and fire-fighting equipment.

The members of the Service also organize first-aid courses and training for fire-fighting, which have provided the Organization with 118 trained first-aid auxiliaries and 30 auxiliary firemen, whose help can be called upon in case of emergency.

The focal point of the Service's work is the alarm panel in the Safety Control Room, to which audible and visual alarm signals for all the safety systems (alarms

Portent of things to come. While scanning (at Heidelberg) film taken in the 2 m hydrogen bubble chamber during a CERN-Heidelberg experiment, this dramatic shower of particles was discovered. It is interpreted as being caused by a cosmic ray of energy 100 GeV or more which has interacted in the piston of the chamber resulting in this shower of about a hundred tracks in the hydrogen.

Right:

All lined-up and ready to go — the vehicles of the Site Security Service which can be called on at any time of day or night to come into action in the case of emergency.

for fire, smoke, dangerous gases, lift operation, vacuum, etc.) are relayed, and on which direct telephone lines from fifty safety warning stations on the site, the calls made to the internal emergency telephone number (2222) and emergency radio calls from outside, converge. This room is also in direct radio contact with the Geneva firemen and police, the airport fire brigade and the French police, so that concerted action can be taken if a serious accident occurs.

The safety equipment includes four ambulances, two fire engines, a first-aid wagon and several water pumps. All this equipment is kept in heated garages to ensure that engines can move into action immediately, even during the coldest weather.

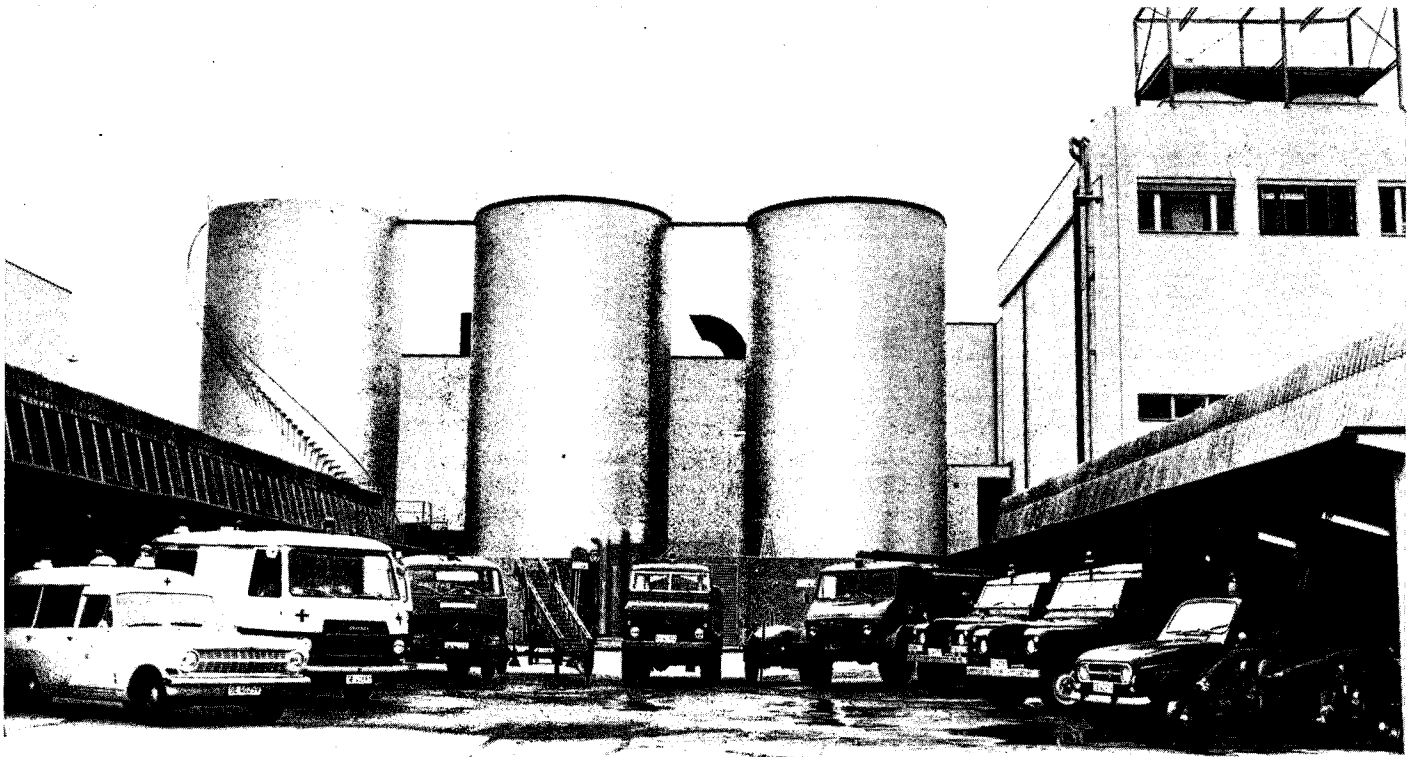
A good idea of the Service's work can be drawn from the following figures for 1969: 40 fire calls, 141 flood calls, 32 cases of the escape of dangerous gases, 26 people rescued from lifts, 397 injured persons transported, 13 850 passes issued, 124 accident reports made out. The number of calls on the Service increases from year to year but the number of injured persons needing to be transported is decreasing due to excellent preventive measures, which are put into effect not only by the Service itself, but also by the Medical Service, the Health Physics Group (radiation protection) and the General Safety Group, with which it collaborates closely.

Finally, two jobs should be mentioned which, while lying slightly outside the specific work of the Service, are nevertheless often undertaken. The first is the surveillance of dangerous equipment operating at night (continuously operating furnaces, etc.) which is done by the patrolmen on their rounds and which takes a burden off the shoulders of experimental and workshop staff. Secondly, the Service is frequently called upon for help from outside the CERN site, both in France and Switzerland. The reputation of the Service for promptness and efficiency is widespread.

## Longitudinal instabilities

The quality of the beam which the ISR receives from the PS is one of the keys to





the success of colliding beam experiments. In particular, the luminosity of the ISR (see vol. 8, page 68) is strongly influenced by the longitudinal phase-space density of the injected beam. For several years, therefore, attention has been focused at the PS on methods of retaining longitudinal density.

Some good results were obtained with the Q-jump technique, which considerably reduces the dilution produced at transition (see vol. 9, page 229). However the very dense bunches as obtained by adiabatic trapping (see vol. 10, page 355) make longitudinal oscillations which ultimately result in dilution of the bunches. Oscillations may be divided into two main types: coherent (all bunches oscillating in phase) and incoherent (each bunch oscillating in a different phase).

The coherence of the first type of oscillation makes it possible to eliminate them, following H.G. Hereward's suggestion in 1961, by means of a servo-loop acting upon all the accelerating cavities and controlled by signals from electrostatic pick-up stations.

This method was first tried out at the Brookhaven AGS, then at the PS where it was put into permanent operation at the beginning of 1970.

Very violent oscillations of the second type were observed at the AGS after new r.f. cavities were installed and spurious resonances in the cavities were suspected. At the PS also, research has shown that the oscillations observed were due to spurious resonances in the cavities (ranging from 46 to 52 MHz). The higher the density of the bunches the more strongly are the resonances produced. The voltages caused by the passage of a bunch

through a cavity decrease rapidly, but they will nevertheless affect subsequent bunches and especially the bunch immediately following. Coupling is thus produced between bunches, and, as the system repeats itself after 20 bunches, the oscillations can increase (the time constant for the development of instability being from 50 to 150 ms).

The theory concerning this instability agrees well with the results obtained from experiments. To reduce the instability, modifying the impedance in the cavities or having different frequencies in the different cavities, were studied. For the moment it is thought preferable to use a neat method which is simple (in practice if not in theory) and which involves the deliberate detuning of the frequencies of the oscillation of the bunches (if one compares each bunch to a pendulum, the effect is equivalent to having different lengths for the different pendulums so that a stimulus received by one is barely transmitted to the next).

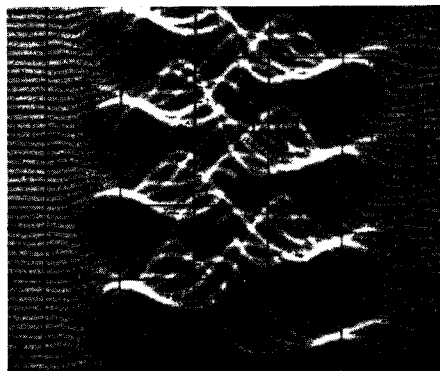
The method has already been used, for example, on the ADONE electron storage

ring. The existence of the beam control system in the PS means, however, that the research conducted upon electron bunches is not directly relevant. Refinements had therefore to be introduced into the theory and produced a surprising result — if the frequency variation from one bunch to the next is the maximum obtainable, in theory effective stabilization is possible. To obtain this distribution, all that is necessary is to superimpose upon the accelerating voltage a sinusoidal voltage at half the frequency and this is done by feeding one of the 14 cavities at half the normal frequency. This was successfully tested in October, as shown in the diagrams, and tests will be resumed when the PS is started up again.

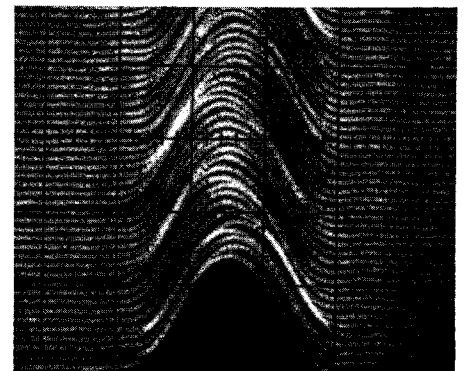
*Signals from a wide-band electrostatic pick-up station (sweep rate 5 ns/cm) at the end of a 10 GeV/c flat-top showing the effect of a new cure for longitudinal instability in the PS.*

1. Usual operation. As a result of the instability which has developed, the bunches are completely distorted.

2. Operation with a cavity fed at half frequency. By eliminating the instability, both the shape of bunches and the longitudinal density are preserved.



1.



2.

# USSR Accelerator Conference

The USSR 2nd National Conference on Particle Accelerators was held in Moscow from 11-18 November. It was attended by about 500 scientists including about 25 invited from Western Europe and USA. Over a hundred papers were read and we pull together here just a few notes on new items of information from accelerator centres in the Soviet Union.

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## Dubna

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The 10 GeV proton synchro-phasotron has recently been used to accelerate deuterons. The peak deuteron energy was around 11 GeV. It is possible that a sizable proportion of the experimental programme with the machine will be given to the use of deuteron beams, and may be later of heavier ion beams. By stripping the protons from the deuterons, high energy neutron beams will also be available. Deuteron acceleration was first achieved in the Birmingham (UK) 1 GeV proton synchrotron in 1961. It has also been done (to an energy of 2.3 GeV) on the Saclay 3 GeV proton synchrotron, Saturne, and heavy ions ( $Xe^{4+}$ ) have been accelerated to modest energies in the Princeton 3 GeV proton synchrotron but Dubna is first with high energy deuteron beams.

The 680 MeV synchro-cyclotron which has been in operation since the end of 1949 is to be improved by spiral ridging the magnet. The internal beam intensity is 2.3  $\mu$ A and external beams of up to  $10^{12}$  protons per second can be achieved. Three polarized proton beams (about 40% polarized) two unpolarized proton beams, neutron, pion and muon beams are available. It has a strong experimental programme under way essentially covering the same research topics as at the CERN synchro-cyclotron (see vol. 9, page 3). Recent experimental results include measurements on rare decays of the pion and muon, nucleon scattering, muon capture and meso-chemistry.

Electron Ring Accelerator research is temporarily halted while hardware rebuilding is in progress. This novel form of particle acceleration emerged at Dubna in 1967 (see vol. 8, page 28 and vol. 9, page 198). The Dubna team under V. P. Sarantsev have succeeded in forming electron

rings, introducing positive ions, extracting the stable rings from the compressor where they are formed and accelerating them to an energy of 60 MeV (nitrogen ions).

A new injector to provide electron beams at an energy of 3 MeV into the compressor is scheduled to come into operation next year. Four versions of the compressor and its associated coil system, which produces the required magnetic field configuration, are under study. The vacuum in all the elements of the accelerator is being improved and r.f. accelerating sections added.

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## Serpukhov

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The experimental programme at the Serpukhov 76 GeV proton synchrotron was described in vol. 10, page 256. On the accelerator itself much thinking is going into an improvement programme designed to increase the beam intensity from a few  $10^{12}$  to  $5 \times 10^{13}$  protons per pulse.

The main element of the programme would be the addition of a booster, presently seen as a 1.5 GeV fast cycling machine fed by a new 30 MeV linac with a 25 Hz repetition frequency. For the linac the idea of r.f. alternating gradient focusing is being studied. (It is also being studied at the Institute for Theoretical and Experimental Physics, ITEP, and the Radiotechnical Institute, RTI, in Moscow.) The idea of using r.f. fields for focusing a linac beam is not new but it has not yet been applied in any large project.

Some very nice instrumentation for beam monitoring has been developed at Serpukhov (and other USSR Laboratories). One new device uses the Hall effect for beam intensity measurements. A 'concentrator' surrounds the beam aperture and a metallic ribbon (Hall probe) carrying a current is positioned in a gap in the concentrator. When the beam passes the probe experiences a magnetic field at right angles to the current it carries. This induces a potential difference between opposite points on the edges of the ribbon which can be measured giving a signal proportional to the beam intensity. It is claimed that intensity measurements with accuracies up to 1% can be achieved, for beam currents down to a few tens of

milliamperes. Obvious complications are operation in the vicinity of other magnetic fields and the possibility of radiation damage to the probe.

An ionization beam scanner is in operation using a method different from that developed at Argonne and CERN (see vol. 9, page 9). The Serpukhov device collects electrons, liberated by the beam by ionization of residual gas in the vacuum chamber, along the magnetic field lines in the electric field direction in the IBS (rather than along an earth equipotential moved across the chamber). It differs from the Argonne type in that it has a magnetic field for focusing; the electrons stay close to the magnetic field lines and small perturbations in the electric field do not affect the performance.

An advantage of this method is that the signals are not perturbed by the electric fields due to the beam itself. So far a beam image has been produced on a fluorescent screen and observed by a closed circuit TV camera.

A Q measuring technique is also in operation on the machine. An a.c. field is applied across the vacuum chamber to stimulate resonances. The resulting beam behaviour is observed at electrostatic pick-up stations as the a.c. field frequency is varied. The system has worked well right through to peak machine energies.

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## Radiotechnical Institute

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The linac studies have already been mentioned. Work with the 1 GeV cybernetic model (described in vol. 9, page 77) is continuing. Completely cybernetic operation, whereby the proton beams via pick-up stations inform a computer of their position and the computer calculates and applies the necessary magnetic field corrections, has been achieved for injection and orbiting at injection energy.

Superconductivity is also receiving attention at the Institute. A large d.c. magnet project is on the drawing board. It is designed to have an aperture of diameter 60 cm in a magnet 5.5 m long, over which a field between 50 and 60 kG will be applied. They are also constructing a superconducting dipole for pulsed fields of 40 kG with 10 cm internal diameter, 30 cm external diameter, 70 cm long. The

The Institute of Nuclear Physics (more commonly known simply as the 'Budker Institute' since the personality of the Director, G.I. Budker, is so prominent in its work). In and around this building is carried out some adventurous accelerator physics principally on storage ring technologies.

method of construction is unusual consisting of a series of corrugated cylinders of thin stainless steel where the superconductor lies in the valleys of the corrugations. Thirty such layers are used in building up the magnet. The superconducting wire itself is of rather large diameter (250 microns) and the rise time of the field will be limited to 10 s.

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#### Novosibirsk

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The idea of ironless synchrotrons for multi-GeV beams appears to have been carried to the stage where a model to accelerate protons is to be built. The term 'ironless' needs interpretation since the design includes quite a lot of iron serving to hold the coils and with a strong steel band surrounding the whole cylindrical structure to contain the high mechanical forces which will be produced when the coils are powered. The magnetic field is however not shaped by the iron but by the conductor itself, hence the term 'ironless'. The model will be 60 cm in radius with a FODO structure where fields up to 80 kG will be achieved.

The main work is, of course, concentrated on the VEPPs and was reported in the October issue, page 320.

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#### Institute for Theoretical and Experimental Physics

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The 7 GeV proton synchrotron at ITEP is currently carrying out an improvement programme to increase the accelerated beam intensity and to have better experimental facilities. We report here only on an unusual target which has recently been brought into operation at the machine.

With the aim of achieving a dense target which would contain a high proportion of hydrogen nuclei and be resistant to radiation damage, an oil jet target (saturated hydrocarbon molecules) has been developed. The oil is forced through a jet 0.13 mm in diameter and streams upwards across the path of the beam. At the top of the chamber, the pressure of the oil as it arrives opens a valve to collect the oil. The target has been operated at a repetition rate of once per four seconds and the jet can stay on for half a second. Operation in a vacuum of  $2.5 \times 10^{-6}$  torr

has brought no discernable deterioration of the vacuum.

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#### Gatchina

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The highest energy synchro-cyclotron in the world is at the A.F. Joffe Physico-Technical Institute at Gatchina near Leningrad which came into operation at the end of 1967. (The machine was described in vol. 9, page 206.) Proton beams are accelerated to a peak energy of 1 GeV. The internal beam intensity is now about  $0.4 \mu\text{A}$  and can be pushed to  $1 \mu\text{A}$  for short periods. The extraction efficiency is about 25% giving proton beams of  $6 \times 10^{11}$  particles per pulse ( $1.5 \times 10^{12}$  for short periods). The machine operates at a repetition rate of 40 pulses per second.

The synchro-cyclotron is situated in a circular hall 32 m in diameter (the machine itself having a magnet pole diameter of 6.85 m). It feeds four proton beam-lines (a polarization experiment and a time-of-flight proton-nucleon experiment are currently underway), a negative pion beam into a hydrogen bubble chamber, and another pion beam (about  $10^6$  positive pions or  $10^5$  negative pions).

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#### Others

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The Lebedev Physical Institute, which has been rather restricted in its experimental activities by virtue of its location in Moscow, is building an extension at Plakha some 40 km outside the city. Initial equipment is to include a 1.5 GeV electron synchrotron to push further the nuclear research currently done with 250 and 680 MeV machines. They are also working on collective ion accelerators and on a cyclotron to give beams of very small energy spread (10 keV in 100 MeV beams) for spectroscopic research. This will be built in collaboration with the Leningrad Institute for Electrophysical Apparatus.

Progress reports were received from the 6 GeV electron synchrotron Laboratory at Yerevan, from Kharkov on the electron linac and storage ring, from Tomsk on a 1.5 GeV electron synchrotron, on microtron work by P. Kapitza's team, on accelerator studies by the Georgian Academy of Sciences at Sukhumi and Tbilisi, and on accelerator design at the Leningrad Institute for Electrophysical Apparatus.





# Around the Laboratories

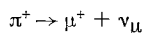
## ARGONNE

### Neutrinos in hydrogen

Contrary to superstition, Friday 13 November was a lucky day at the Argonne National Laboratory. Late in the afternoon an elated scanner picked out the first neutrino event to be observed in pure hydrogen from film taken in the 12 foot bubble chamber.

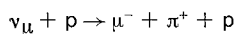
The running period started at the beginning of November when a beam of 12 GeV/c protons was fired into the chamber being used to tune up the operating conditions to give the best quality of picture. Excellent track contrast throughout the chamber volume was achieved after a few days of optimization. It was possible, for example, to measure a four-prong interaction successfully on the Argonne automatic measuring machine POLLY. (Successful processing by automatic measuring machines is often a shrewd test of bubble chamber picture quality.)

Picture taking for the neutrino experiment began a few days before the first event was identified. The neutrino beam is produced from the Zero Gradient Synchrotron ejected beam ( $10^{12}$  protons per pulse) striking a beryllium target 60 cm long to give positive pions which decay into neutrinos. The pions are focused in a focusing horn and guided towards the bubble chamber. The neutrinos produced in their subsequent decay



are thus aimed in the right direction. Before reaching the chamber they pass through a thick iron shield which serves to filter out other types of particle to prevent them reaching the hydrogen.

Film was being scanned as rapidly as it could be obtained. The first observed neutrino event is reproduced in the photograph; it was measured and processed through the computer programs in a matter of hours. It fits beautifully (and uniquely) the interpretation that the incoming neutrino has interacted with a proton in the hydrogen of the chamber to give a muon, a pion and a proton



The momentum of the neutrino was measured as 1100 MeV/c and the measure-

ments on the emerging pion and proton give an effective mass of 1222 MeV squarely in the region of the known resonance  $N^*$  of mass 1236 MeV which is built of a pion and proton clinging together. The spatial reconstruction of the event situates it about 30 cm from the Scotch-lite covering the chamber wall.

The 12 foot bubble chamber is the largest currently in operation. It has a superconducting magnet designed to give a peak field of 18 kG in the chamber volume of 25 m<sup>3</sup>. (A description of the chamber can be found in vol. 9, page 43.) It was built at Argonne especially for the study of low energy neutrino interactions on free nucleons (a study to which the 12 GeV ZGS is particularly well suited).

The chamber will continue its present run filled with hydrogen to accumulate about 500 000 pictures hoping for at least 500 neutrino events. Depending to some extent on the experience gained during this run, it will then be filled with deuterium to take a million pictures of neutrino interactions in deuterium. Of particular interest will be the study of the interaction of the neutrino with a neutron to produce a muon and a proton. The experiment is expected to yield about a thousand examples of this interaction and their analysis should greatly increase our knowledge of the vector and axial vector form factors in the weak interaction.

It is a very nice Christmas present for Argonne to be at last, after the inevitable trials and tribulations of such a novel project as the 12 foot chamber construction, on the brink of the first study of neutrino interactions in hydrogen and deuterium.

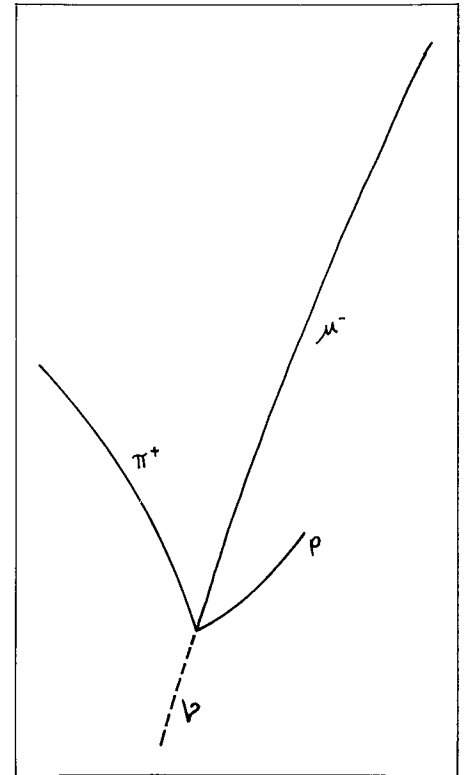
## BROOKHAVEN

### Beams from 200 MeV linac

On 18 November at 1.44 a.m. the new injector for the 33 GeV Alternating Gradient Synchrotron produced a 200 MeV beam for the first time. The injector thus became the highest energy linac in the world and just pipped the Batavia linac (which took over the Brookhaven design) to first operation (see the Batavia section below).

With this higher energy injection (com-

The first photograph of a neutrino interaction in pure hydrogen recorded in the 12 foot hydrogen bubble chamber at Argonne. The sketch shown below illustrates the analysis of the event. A neutrino enters from the bottom of the picture and interacts with a proton at the hydrogen nucleus to yield a positive pion, a proton and a muon.



pared with the original 50 MeV linac) the space charge limit in the AGS will go up by a factor of five and the present accelerator intensity ( $2.5 \times 10^{12}$  protons per pulse at a pulse repetition rate of once every 2.4 s with 0.2 s flat-top) should climb to comfortably above  $10^{13}$  protons per pulse. A new main magnet ring power supply and r.f. accelerating system will make possible a higher repetition rate — once every second without flat-top or once every 2 s with a 1 s flat top. The following paragraphs are put together from information prepared by G.W. Wheeler, Head of the Conversion Project.

The preinjector for the new linac consists of a 750 kV Cockcroft-Walton generator with a duaplasmatron source and high gradient accelerating column with which pulsed currents of 400 mA have been achieved. The transport system from preinjector to linac contains eight triplets, two fundamental frequency bunchers and beam current and emittance monitors. It is followed by a linear accelerator: 145 m long, made up of nine independent resonant cavities operating at 201.25 MHz. The first cavity, about 7.3 m long containing



59 drift tubes, has been in operation since last March and has yielded proton beams in excess of 200 mA accelerated to 10.4 MeV. Emittances were about  $7\pi$  cm mrad. The remaining eight cavities are each about 16 m long and have a multi-stem drift tube system, developed at Brookhaven, to achieve high electric field stabilization. Each of the 295 drift tubes in the linac contains a pulsed quadrupole magnet to give gradients ranging from 10 kG/cm at the low energy end to about 1 kG/cm at 200 MeV. The r.f. power for the cavities is generated by nine power amplifier stations, each capable of generating 5 MW of pulsed power.

During the period 3-18 November, the proton beam was accelerated step by step through each cavity. An aluminium absorber and a Faraday cup were placed at the end of each cavity successively and the phase and amplitude of the cavity field were optimized and the quadrupoles adjusted before proceeding to the next cavity. A peak current of 20 mA was measured at 200 MeV, the current being deliberately kept low to avoid unnecessary activation of components during the

tune up. The group responsible for bringing the linac into operation is headed by K. Batchelor and includes T.J.M. Sluyters, J.F. Sheehan and P. Grand, supported by about 20 physicists and engineers.

The 200 MeV beam will be transported to the AGS through a tunnel about 125 m long. In addition to the quadrupoles and dipoles of the transport system, there will be a debuncher cavity to reduce the energy spread of the beam and extensive diagnostic equipment. The transport system will be used to match the linac beam to the AGS acceptance before injection via a new magnetic inflector. Linac beam pulses which are not needed for injection in the AGS will be diverted by a pulsed magnet into a separate tunnel where beam diagnostics may be carried out and where the beam will be used for other purposes. Provision is being made to insert thin targets in this beam for radio-chemistry studies but the bulk of the beam will be absorbed in targets specially designed for the production of radioisotopes by the spallation process. Under optimum operating conditions, about 180  $\mu$ A average proton current at 200 MeV will be available.

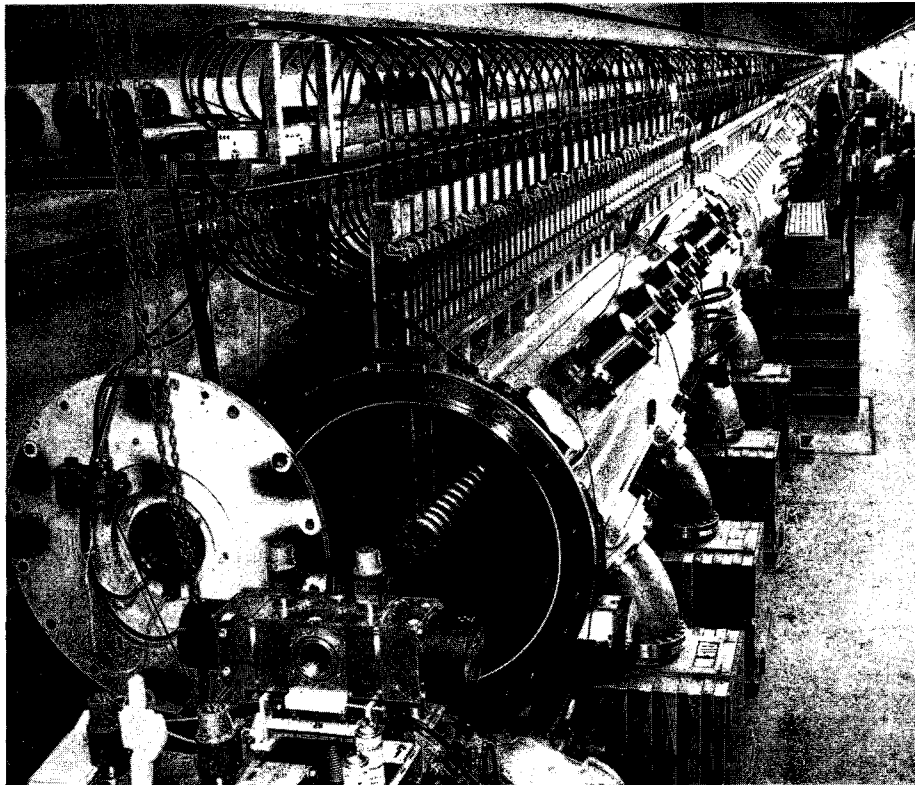
Modifications to the AGS itself which are also part of the \$50 M Conversion Project are moving ahead well. In order to double the acceleration rate (acceleration to 30 GeV in 0.5 s), an entirely new main magnet power supply has been installed and initial operation achieved. The supply consists of a Siemens motor-generator set (12 000 hp and 96 MW peak respectively) and two rectifier banks, each containing 48 mercury arc excitrons. On 18 November, the synchrotron magnet ring was excited at 12 000 volts to 6150 A (30 GeV) in 480 ms, the complete cycle (no flat-top) requiring less than one second. On 24 November, the full operating cycle was achieved. The new power supply is expected to be in regular operation in January 1971.

With the shortened acceleration cycle, much higher r.f. voltage gain around the main ring is needed. To this end an entirely new r.f. power amplifier system has been installed and has been in operation since 1969. The new accelerating cavities which are needed in the ring to accelerate  $10^{13}$  protons per pulse have been delayed somewhat and will be installed later. An entirely new vacuum chamber and pumping system has been built and has been installed in about one third of the ring. Many other modifications are being made in the main ring, primarily to reduce radiation damage and to make servicing easier. The modifications to the AGS are being directed by C. Lasky and J.G. Cottingham, with about 15 physicists and engineers.

Completion of the Conversion Project is scheduled in a three month shutdown of the AGS starting in April 1971. During this shutdown, the 200 MeV linac will be connected to the AGS and will start injection. The new magnet power supply will already be operating. The installation of the new vacuum chamber and pumping system will be completed. The other modifications to the main ring will be installed as far as time permits including a new fast ejection system to feed bubble chambers. When the AGS comes back into operation in July, the intensity is expected to exceed  $3 \times 10^{12}$  protons per pulse and increase rapidly to about  $7 \times 10^{12}$  with increased repetition rate and duty cycle. Because of the delay in delivery of the ferrites for

The cavities of the Brookhaven 200 MeV linac stretching off into the distance. This photograph was taken during September in the final stages of installation. The linac produced its first full energy beam on 18 November.

(Photo BNL)



the new accelerating cavities, a second shutdown of about two months will be required in the early part of 1972. The cavities will then be installed in the ring and the other modifications completed.

### Multiparticle spectrometer

Due to come into operation soon at the AGS is a multiparticle spectrometer being built by a Brookhaven-Virginia Polytechnic Institute collaboration. It will be used to study multiparticle production in 28 GeV/c proton-proton collisions measuring the outgoing protons with high resolution and the secondary particles which are produced (predominantly pions) with less accuracy.

The system consists of three wire chamber spectrometers with an associated PDP9 computer connected via the 'Brooknet data link' to a CDC 6600 computer. One of the spectrometers (referred to as  $\pi$ S) uses a large volume magnet and wire spark chambers surrounding the hydrogen target. The other two spectrometers, a high momentum spectrometer (HMS) and low momentum spectrometer (LMS), are

more conventional, each consisting of one or two magnets together with wire spark chambers, to analyze with higher accuracy some of the particles emitted from the target. Because of the  $\pi$ S, the system is capable of handling many final state particles, much as a bubble chamber does.

The HMS and LMS can each provide  $\pm 0.25\%$  momentum resolution at 20 GeV/c and 2 GeV/c respectively and each contains a threshold Cherenkov counter for particle identification. Both the HMS and LMS can be moved in order to study different particle production angles. In addition, time of flight information can be obtained from the LMS. The  $\pi$ S uses a magnet about 1.5 m long, 1 m wide and 1 m high, together with a total of 15 wire spark chambers arranged around the target to provide  $4\pi$  detection. Momentum resolution for charged particles varies between  $\pm 3\%$  and  $\pm 12\%$  at 1 GeV/c depending on particle direction, and lead or steel plates inserted before the outermost chambers will make it possible to detect gammas.

The overall system has the capability of detecting all charged and most neutral

final state particles, and determines the momentum and angle of most of the charged ones. One of its main advantages is in the versatility of its trigger — particles of a desired mass, momentum range and production angle can be selected in either the HMS or LMS and this selectivity, together with the capability of the  $\pi$ S for measuring multiparticle final states over a large solid angle, should make the system a very versatile and powerful research tool which could serve for a long series of experiments.

## RUTHERFORD

### Wire grids in separators

Some very successful tests have been carried out at the Rutherford Laboratory using wire grids as the electrodes in an electrostatic particle separator replacing the usual solid electrode system. It is now intended to install wire grid electrodes in all the separators in operation at the Laboratory.

In recent years understanding of high voltage phenomena in vacuum has advanced considerably (see vol. 9, page 132 and page 208). One mechanism which limits the voltage holding capability of large gap devices such as electrostatic separators is ion exchange breakdown and this has been shown to be much more influential than had been thought. The source of the ions is almost certainly the film of contamination inevitably present on the surface of the electrodes. Breakdown is affected by the energy of these ions, which is directly related to the voltage applied across the electrodes, but not very much by the field at the surface of the electrodes. Using a plane consisting of an array of wires rather than a solid surface could therefore be expected to improve performance.

Experiments were carried out with an electrode constructed from stainless steel wire, 1 mm in diameter, in a mesh of 6.35 mm pitch. The results were so encouraging that an electrode such as would be suitable for a separator was built using wires 3.2 mm in diameter bent to the desired profile and clamped to the sides of an aluminium alloy frame at intervals of 10 mm.



An imaginative photograph taken inside the main ring tunnel at Batavia. The arches of light appear between the pre-cast concrete sections about 3 m high which have been put in place but not yet sealed together. The tunnel is then covered with earth shielding. On the 30 November the last of the concrete sections was slotted into position to complete construction of the tunnel. Installation of the magnets is going ahead at high speed.

(Photo Chicago Daily News)

A cluster of people around the controls of the Batavia 200 MeV linac when it produced its first full energy beam in the early hours of 1 December. In the foreground are R. Rihel, R. Goodwin, E. Hubbard and M. Shea.

(Photo NAL)

The important results are as follows: The conditioning time is extremely short (less than 24 hours) compared with a conventional system (about a week for solid stainless steel electrodes and at least two weeks for heated plate glass cathodes). The performance of a wire electrode system is very insensitive to contamination. In one test the liquid nitrogen trap was turned off while the separator was running without any effect on voltage holding. Even opening the separator and deliberately contaminating an electrode with vacuum pump oil brought no deterioration in performance. Performance figures are virtually the same as for conventional systems; for example, with a 10 cm gap, wire electrodes held off 720 kV peak and operated at 600 kV after a 24 hour conditioning time compared with heated glass electrodes which held off 650 kV peak and operated at 600 kV after two weeks conditioning time.

The reduction in conditioning time, the lack of sensitivity to contamination and the removal of the need to heat electrodes (glass type) should make operation much more reliable and servicing much simpler. For these reasons all the operating separators are being converted to wire electrodes.

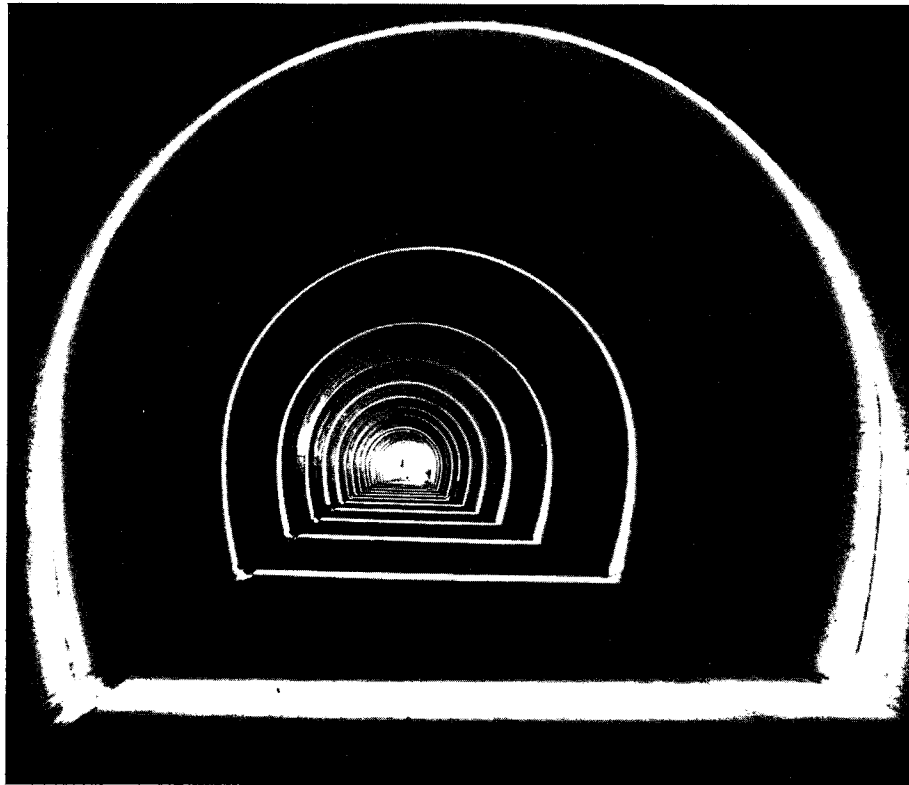
## BATAVIA

### Ring tunnel completion Linac operation

At the turn of the month, Batavia ticked off two more important steps on route to completion of their 200-500 GeV proton synchrotron.

On 30 November the last of the pre-cast concrete sections to complete the main ring tunnel was moved into position. Over 6 km of tunnel around the circumference of the ring is thus ready to receive the accelerator. So far about a third of the 774 bending magnets have been installed. The magnets were being assembled at a rate of about 30 per week with a record production of eight magnets in one day.

Not long after the closing of the ring tunnel, the linac came into action accelerating protons to the peak energy of 200 MeV in the early hours of the morning of 1 December. The accelerated beam



A small, just about portable, radiation detector, known as the Albatros I Neutron Monitor, has been designed by the Radiation Physics section at Batavia to monitor fast neutrons, which are usually the most serious radiation hazard in personnel-occupied areas when a high energy accelerator is operating (in certain areas high-energy muons may also be a problem, but for most areas neutrons are the most troublesome).

It uses a polyethylene moderator designed for uniform Rem response using a Geiger-Muller tube wrapped in silver-foil as the neutron detector. Because of the sensitivity of GM tubes to gammas, a second GM tube is included to

compensate for the gamma response. As the half-life of the induced activity in the silver foil is many seconds, the detector has no duty-cycle problem when used around a pulsed accelerator.

The meter can be read in dose rate or in occupation time per day. Total integrated neutron dose is also recorded. An audible signal sounds when the dose rate exceeds 50 mRem/hr. The unit operates either on a battery pack or on a.c. power. It weighs approximately 10 kg (221 lbs).

Other attractive features in the photograph are exclusive to Batavia.

(Photo NAL)



intensity was around 20 mA and the coming months will be occupied in tuning up the linac to achieve, or surpass, the design intensity of a 75 mA beam to be fed to the Booster. To the day, the construction and bringing into operation had taken two years, for ground was broken to erect the linac building on 1 December 1968.

The linac design was essentially taken over from that prepared for the Brookhaven AGS Conversion Project whose first operation is reported above. Like the Brookhaven machine its total length is

145 m with nine tanks, containing 286 drift tubes, fed with r.f. power at 201.25 MHz. First operation came several months ahead of the revised schedule date, a considerable achievement for the Linac Section led by D. Young.

Now the pressure moves to the Booster Section, led by R. Billinge, who are scheduled to take the linac beam and push the energy up to 8 GeV in the Spring of 1971. After that the buck will go home where it belongs with the Director of the Laboratory, R.R. Wilson, to bring beams

to hundreds of GeV energies in the main ring by 1 July.

Preparations for the experimental programme are now moving into greater prominence. The Program Advisory Committee (O. Chamberlin, T.H. Fields, V.K. Fitch, M. Gell-Mann, T.B.W. Kirk, T.D. Lee, W.K.H. Panofsky, D.D. Reader, R. Sachs, N. Samios and W.J. Willis) met at Aspen, Colorado, in August with the daunting task of picking their way through 88 separate proposals (another seven have since trickled through). Fourteen proposals have been approved and, in addition, groups putting forward similar proposals have been urged to collaborate on experimental topics which have been approved.

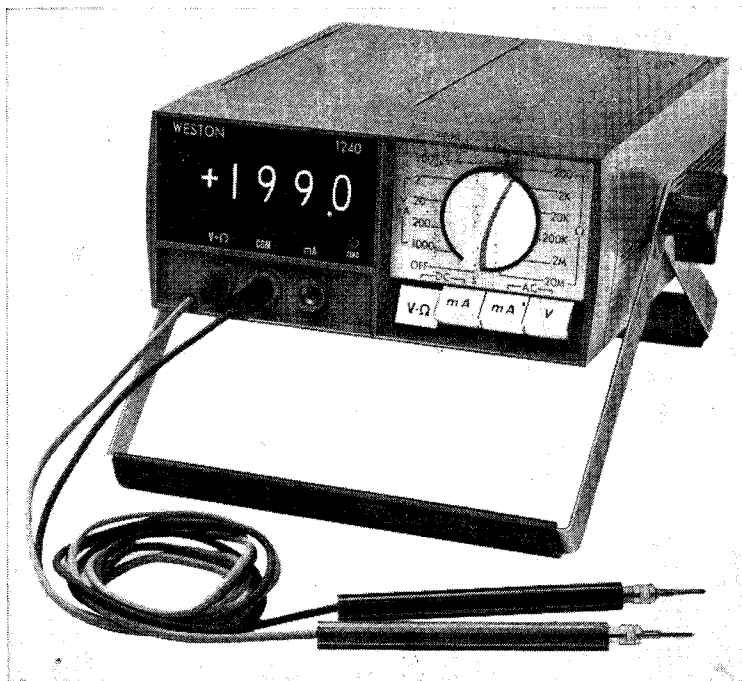
The hardware side of the experiments is particularly urgent in order to have facilities ready soon after the first beam date. Contracts have been placed and are being placed for the construction of target areas, secondary beam tunnels and experimental halls. Design of the 15 foot hydrogen bubble chamber is well advanced and some contracts have already been placed — for example the vacuum chamber (which is scheduled for assembly in February 1971) and the superconductor for the magnet (ordered by Argonne which is responsible for producing the magnet). SLAC is responsible for the expansion system. To have a bubble chamber ready for the time of first accelerated beams, the 30 inch hydrogen chamber will be brought from Argonne and will operate near the downstream end of the neutrino shield. Spectrometers (double arm, single arm and multi-particle) are being studied by collaborations of groups interested in using them.

## EPS Conference

The first specialized Conference to be organized by the High Energy and Particle Physics Division of the European Physical Society will be held at Bologna, Italy, on 14-16 April 1971. The topic of the Conference is 'Meson Resonances and Related Electromagnetic Phenomena'.

The subjects covered will include, for example: meson splitting, hadron production by colliding electron-positron beams, omega-rho interference, electromagnetic interactions of mesons, pro-

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duction of vector mesons using hadronic targets, theoretical predictions on meson classification, the problem of exotics and their relation to duality, etc... Each session will either be introduced by a review talk (followed by short presentations of recent results) or will centre on detailed presentation of new results.

The Conference will be limited to two hundred participants (by invitation only) who are actively engaged or have special interest in this field of research. Further information may be obtained from any member of the Scientific Committee of the Conference: R.H. Dalitz (Oxford University), W. Paul (University of Bonn), J. Lefrançois (University of Paris-Sud), M. Jacob (CERN) and A. Zichichi (University of Bologna).

## USA - USSR Protocol

On 30 November the USA Atomic Energy Commission and the USSR State Committee for the Utilization of Atomic Energy signed, in Washington, a protocol 'on carrying out of joint projects in the field of high energy physics at the accelerators of the National Accelerator Laboratory (Batavia) and the Institute for High Energy Physics (Serpuukhov)'. The protocol will be in force for five years and can be extended by mutual agreement.

The terms of the protocol envisage collaboration on joint research projects,

including joint experiments, initially at the 70 GeV machine in operation at Serpuukhov and later at the 200 GeV machine nearing completion at Batavia. Each Laboratory will mount one or more joint experiments, the final detail of these experiments and the forms of participation of American and Soviet scientists will be worked out as the experiments take shape and will be attached as annexes to the protocol.

Meetings and consultations between American and Soviet specialists will prepare the joint projects. The protocol also covers the administrative details of travel of personnel, transport of equipment, and associated documentation. The experimental equipment will remain the property of the 'sending Laboratory' (unless otherwise agreed) and the host Laboratory will provide all the necessary services such as beams from the accelerators, space in the experimental halls, electricity, cooling water, gases, etc... Equipment of the host Laboratory can also be incorporated in the experiment.

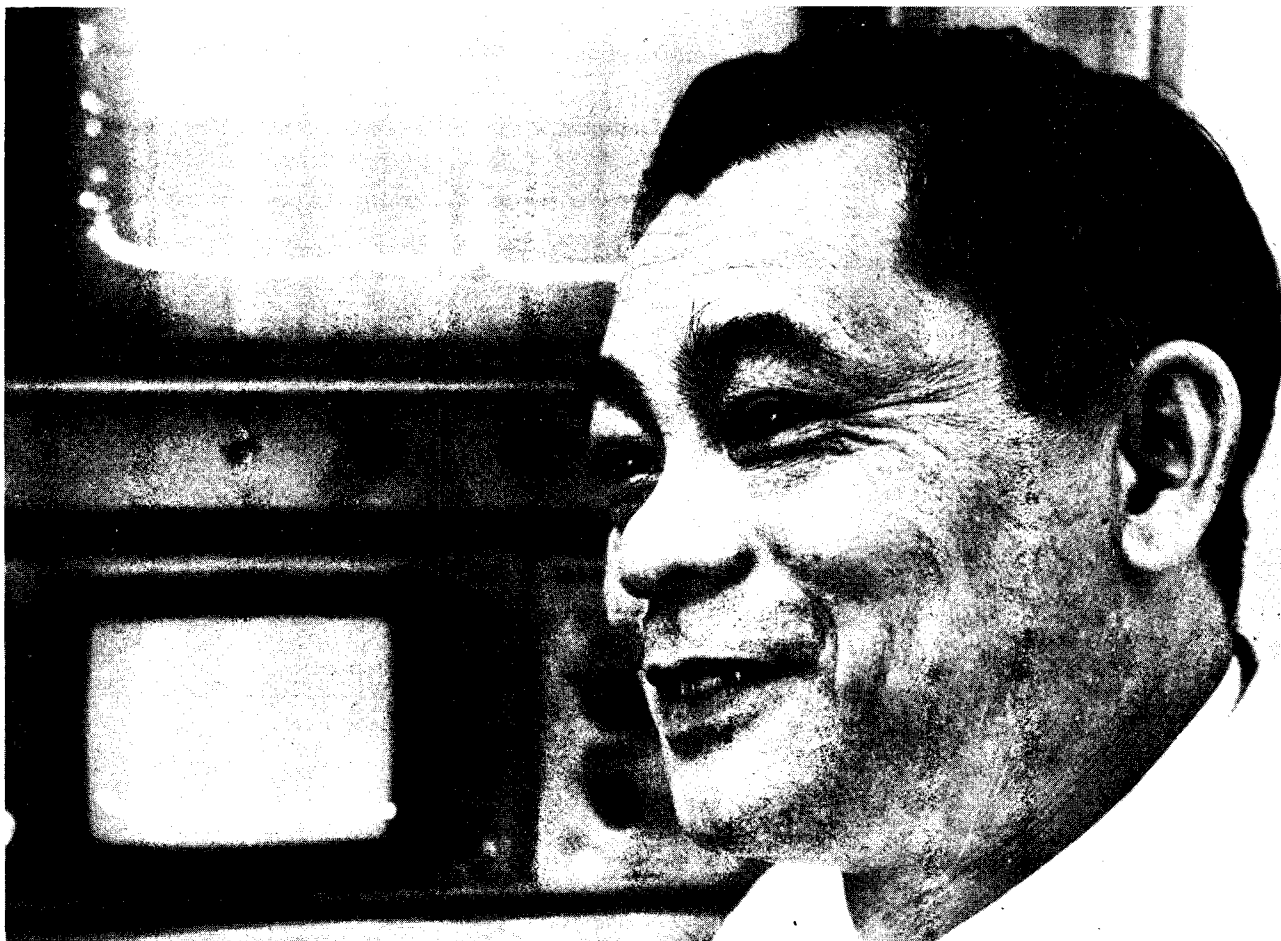
This protocol is the happy outcome of many months of negotiation and is further evidence of the world-wide collaboration among high energy physics Laboratories which is probably more highly developed in this field than in any other. Coming on top of the extensive CERN-Serpuukhov collaboration it forges still further links between physicists in different countries.

## COURIER Correspondents

As we close this last issue of 1970 we should like to thank our correspondents in other Laboratories for their cooperation throughout the year. The quality and topicality of the contributions add a great deal to the liveliness and usefulness of CERN COURIER:

Argonne:	T.H. Groves
Batavia:	C.W. Larsen
Berkeley:	G. Kalmus G. Goldhaber
Bonn:	H.E. Stier
Brookhaven:	J. Spiro
Cambridge:	W.A. Shurcliff
Cornell:	K. Berkelman
Daresbury:	T.W. Aitken
DESY:	G. Söhngen
Dubna:	V.A. Biryukov
Frascati:	M. Ghigo
Karlsruhe:	F. Arendt
Los Alamos:	W.H. Regan
Orsay:	P. Lehmann
Princeton:	J. Riedel
Rutherford:	A.P. Banford
Saclay:	G. Neyret
Stanford:	J. Sanders
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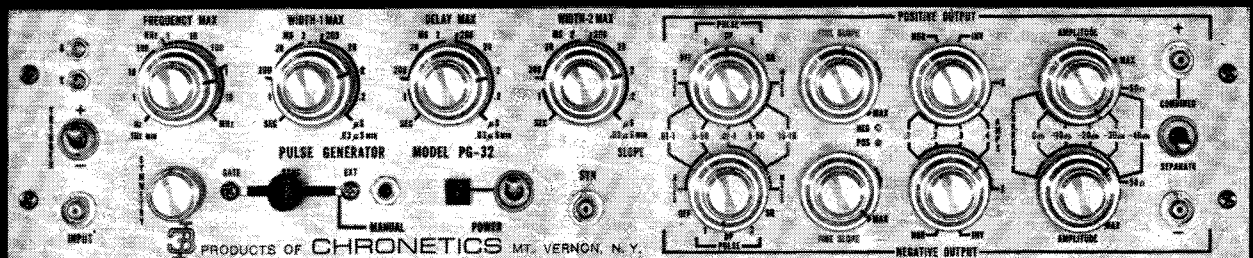


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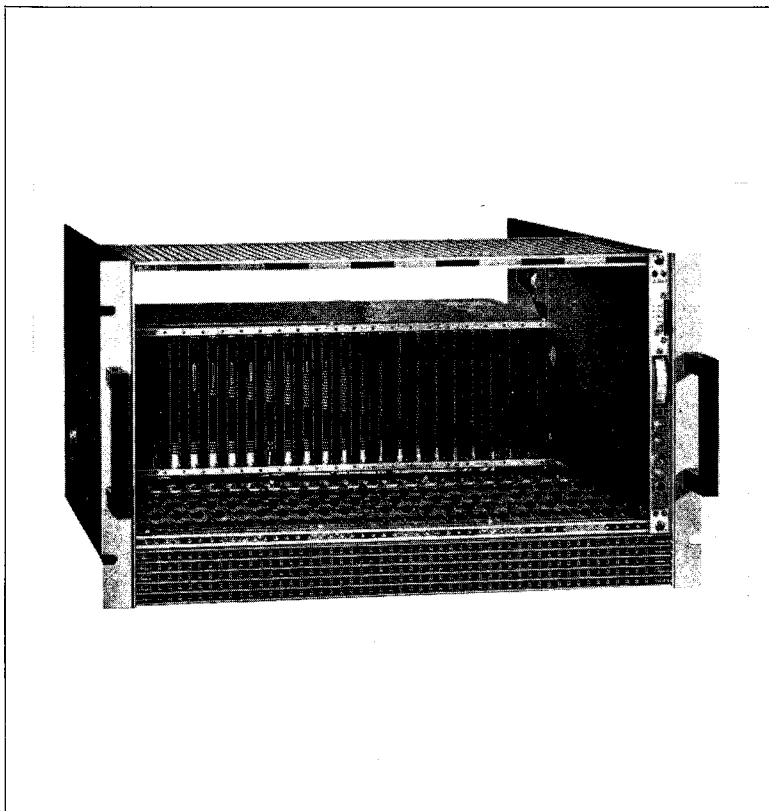
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Taux de régulation en fonction du réseau (+10 % à -12 %)	± 5.10 <sup>-4</sup>				
Régulation pour 100 % de variation de charge et des variations du réseau (+10 % à -12 %)	± 10 <sup>-3</sup>				
Stabilité globale (réseau-charge-température)	± 5.10 <sup>-3</sup>	± 10 <sup>-2</sup>	+2,5.10 <sup>-2</sup>	± 10 <sup>-2</sup>	± 10 <sup>-2</sup>
Coefficient de température de +10 °C à +45 °C	5.10 <sup>-4</sup> /°C		2.10 <sup>-4</sup> /°C		3.10 <sup>-4</sup> /°C
Dérive en fonction du temps 8 h 24 h. 6 mois			10 <sup>-3</sup> ± 3.10 <sup>-3</sup> ± 5.10 <sup>-3</sup>		
Fluctuations en sortie crête à crête	≤ 2 mV	≤ 2 mV	≤ 5 mV	≤ 5 mV	50 mV
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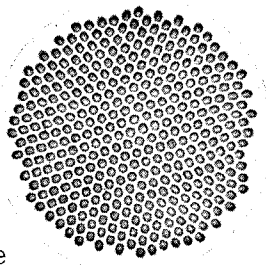
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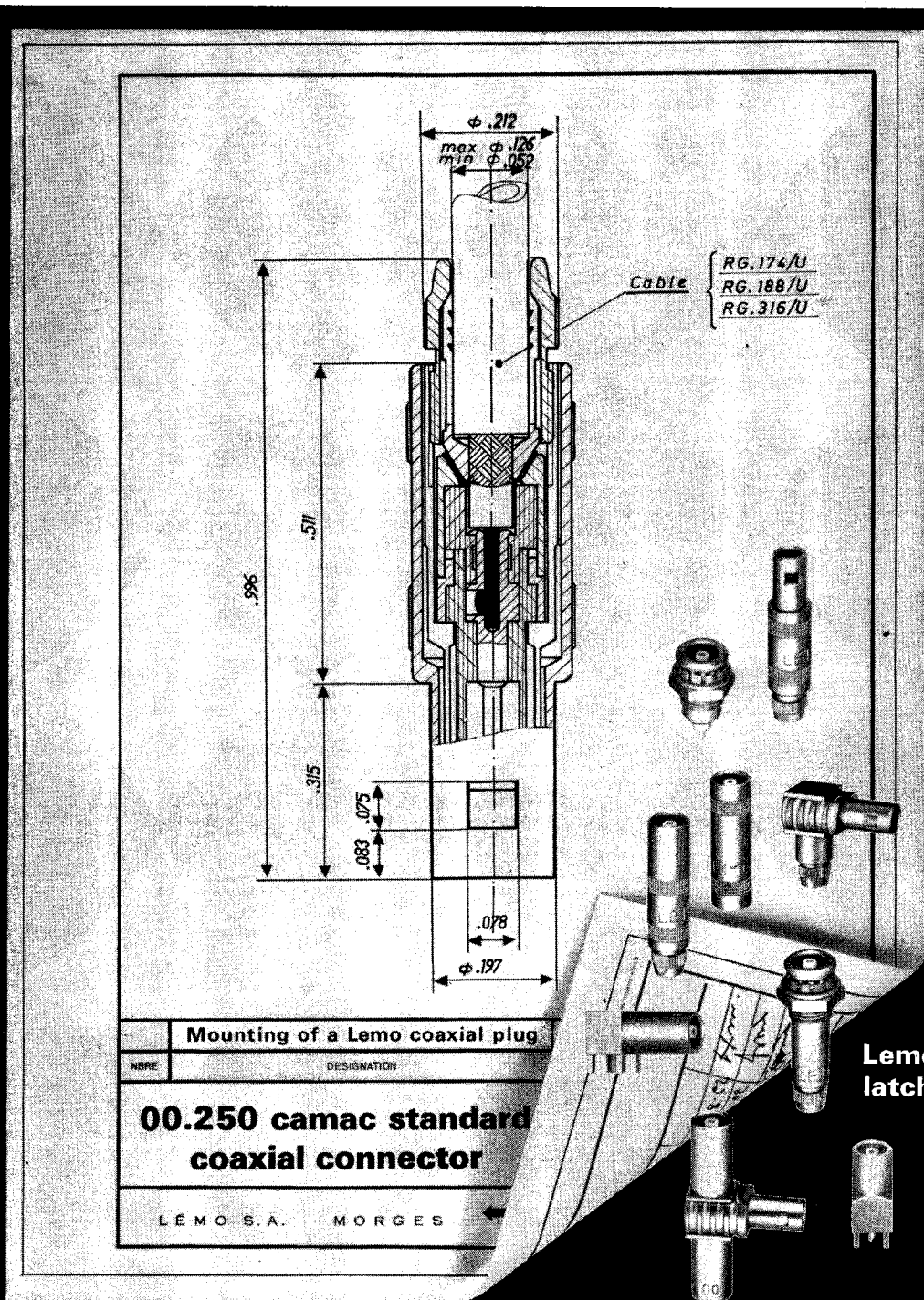
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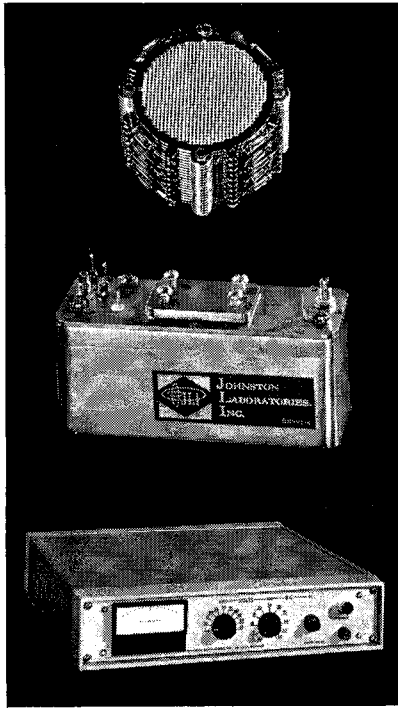
## Spectrometry Components

**Particle Multiplier (MM-1).** For pulse counting or current measurement of electrons, ions, UV or x-ray photons, and energetic neutral atoms or molecules.

Guaranteed reactivateable. Delivered gain:  $10^6$  to  $10^8$ . Noise less than 1 count/minute at  $10^7$  gain. Dark current less than  $10^{-13}$  amps at  $10^7$  gain. Gain stability at count rates in excess of  $10^6$ /second. Bakeable at  $350^\circ$  C. No ion feedback, non-magnetic. 1.5 sq. in. active surface area. (Model MM-2, miniaturized version of MM-1.)

**Pulse Amplifier Discriminator (PAD-1).** Low power consumption. Charge sensitive input. Rise time: 3 nanoseconds. Adj. discriminator: 20:1 range. Rugged. Miniature. (Model PAD-2 for pulse counting rates to  $10^7$ /sec.)

**Regulated High Voltage Power Supply (HV-4R).** No vacuum tubes. Output: 500 v. to 6.1 kv. Reversible polarity. Noise less than 300 microvolts RMS. Drift less than .01%/hour, .02%/day.



## Radioactive Gas Monitors

Our TRITON systems monitor gamma radiation, tritium, argon-41, carbon-14, chlorine-36, fluorine-18, krypton-85, radon-222, sulfur-35, xenon-133, and xenon-135. Features: 0.5 micron absolute filters, electrostatic precipitators, positive displacement pumps, gamma compensation to 5 mR/hour.

**Triton 955.** Exceptional sensitivity:  $10\mu\text{Ci}/\text{M}^3$  full scale.

**Triton 1055.** Portable. Operates on rechargeable batteries.

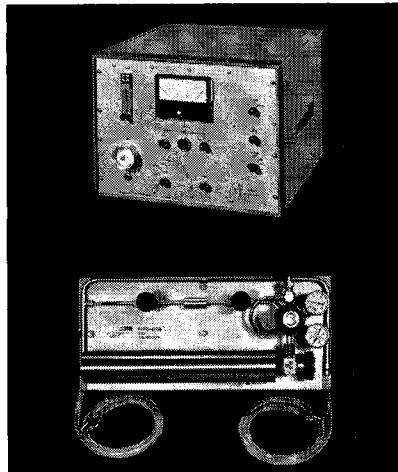
Sensitivity:  $50\mu\text{Ci}/\text{M}^3$  full scale.

**Triton 755C.** Suitable for rack mounting.

Sensitivity:  $100\mu\text{Ci}/\text{M}^3$  full scale.

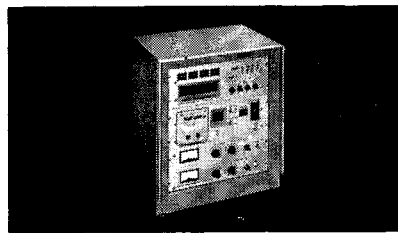
**Tritium Calibrator (CL-1).** For field calibration of Triton monitors. Accurate, rapid calibration in 3 to 5 minutes.

**Remote Alarm (RA-1).** Audible and visual. Powered from main instrument. Operates up to 500 ft. from main instrument.



## Beta Logic Analyzer

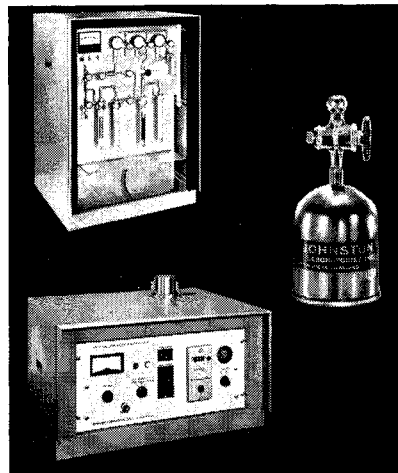
**Electronic Console (GEC-12).** For simultaneous, ultra low level analysis of carbon-14, tritium, radon, and beta radio gases. Absolute efficiency: 85%. Reproducibility: 0.1%. More sensitive than liquid scintillation. Use in tracer studies, radio-carbon dating, biochemistry, hydrology.



## 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)**.



# Dependability you can count on!

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Please:  phone  visit  send information on models \_\_\_\_\_

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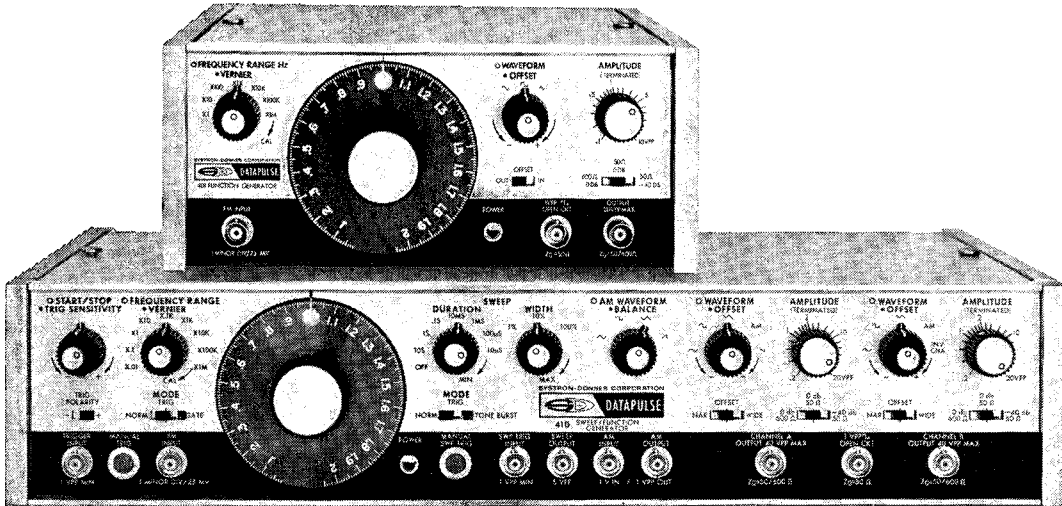
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# Tips + Topics



## A new family of Datapulse function generators



Big or little, one channel or two, FM or AM, square, triangular, sine or swept: Datapulse makes better waves. Here are the few specifications you should know about:

### Little MODEL 401

- Dial accuracy: 1 %
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- Sine distortion only 0,25 %
- Squarewave rise time: 40 ns
- Dynamic Amplitude range: 80 dB
- Price Swiss Francs: 1950.—

### Sophisticated MODEL 410

- Frequency range: 0,0002 Hz to 2 MHz
- FM and AM modulation
- Built-in triggerable sweep generator
- 2 independently controlable 40 V output channels
- Output: sine, square, triangle, sawtooth and swept waves
- Price Swiss Francs: 4900.—

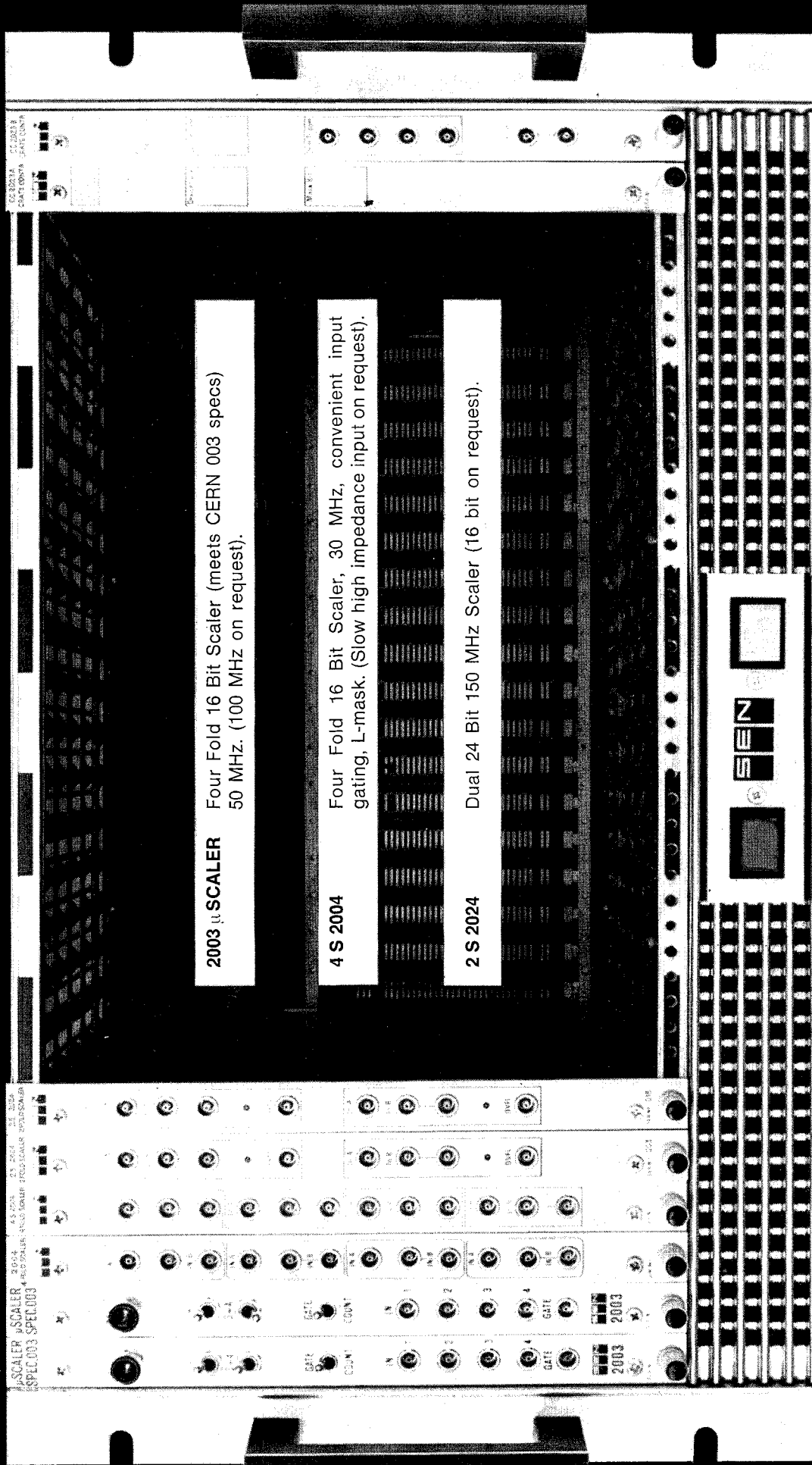
To arrange a demonstration or obtain more data, call us and you will know why you should buy this SYSTRON-DONNER instrument.

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# baerlocher

If you have not seen  
the 24 different modules  
in last month's issue, you will find here  
the SEN SCALERS.

# SEN CAMAC



**2003 u SCALER** Four Fold 16 Bit Scaler (meets CERN 003 specs)  
50 MHz. (100 MHz on request).

**4 S 2004** Four Fold 16 Bit Scaler, 30 MHz, convenient input  
gating, L-mask. (Slow high impedance input on request).

**2 S 2024** Dual 24 Bit 150 MHz Scaler (16 bit on request).

ask for Data Sheets

next month you'll find the I/O REGISTERS.



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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



## EG&G's new Time Encoder talks CAMAC's language

The new ET100/N Time Encoder lets you make many time measurements and conversions—at less than half the cost of other schemes or techniques. You could say that it permits twice the number of measurements for the same investment. The Module incorporates time-to-amplitude and analog-to-digital conversion circuits, working directly into a 40 MHz CAMAC-compatible scaler. This configuration effectively solves computer interface problems, simplifies shielding, noise, cabling and power supply complexities, and conserves premium NIM bin power.

#### Primary specifications:

- Full Scale Range: 120 nsec
- Pulse Repetition Frequency: 40 MHz
- Conversion Factor: 200 psec/pulse
- Integral Non-Linearity: < 1%
- Twelve ET100/N's can be powered from a standard NIM bin.

To see how this new Time Encoder is systematically compatible with CAMAC, ask for the new ET100/N Data Sheet. Write EG&G Inc., Nuclear Instrumentation Division, 35 Congress Street, Salem, Massachusetts 01970, U.S.A. Phone (617) 745-3200. Cables: EGGINC-SALEM. TWX: 710-347-6741. TELEX: 94969.

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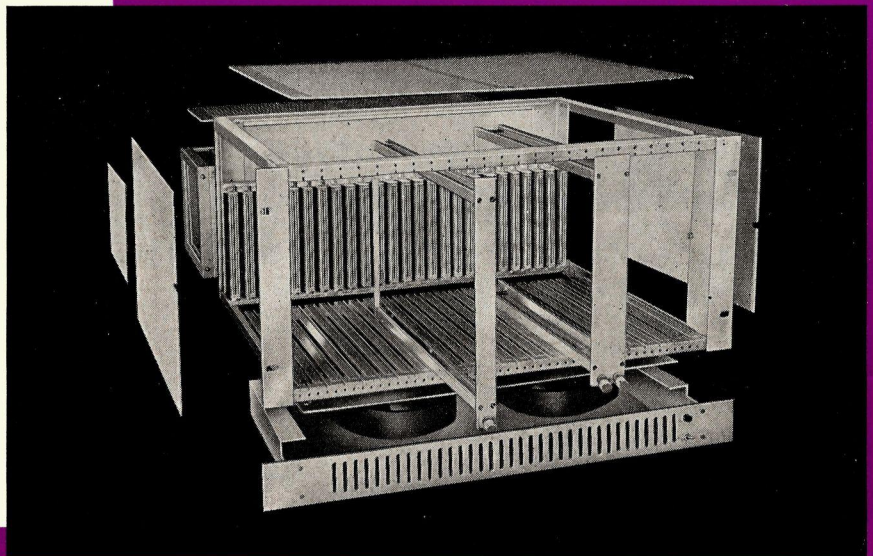
# ING. ROSSELLI DEL TURCO ROSSELLO s.r.l.

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### Mechanical constructions for the electrical and electronics industries

The CAMAC chassis is designed to CAMAC specifications which most European laboratories, under the auspices of the ESONE, have drawn up for standardizing data transmission to computers.

## Châssis mod. CAMAC-RDT





LE GROUPEMENT

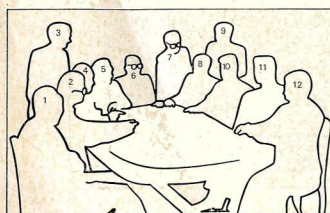
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