CERN COURIER

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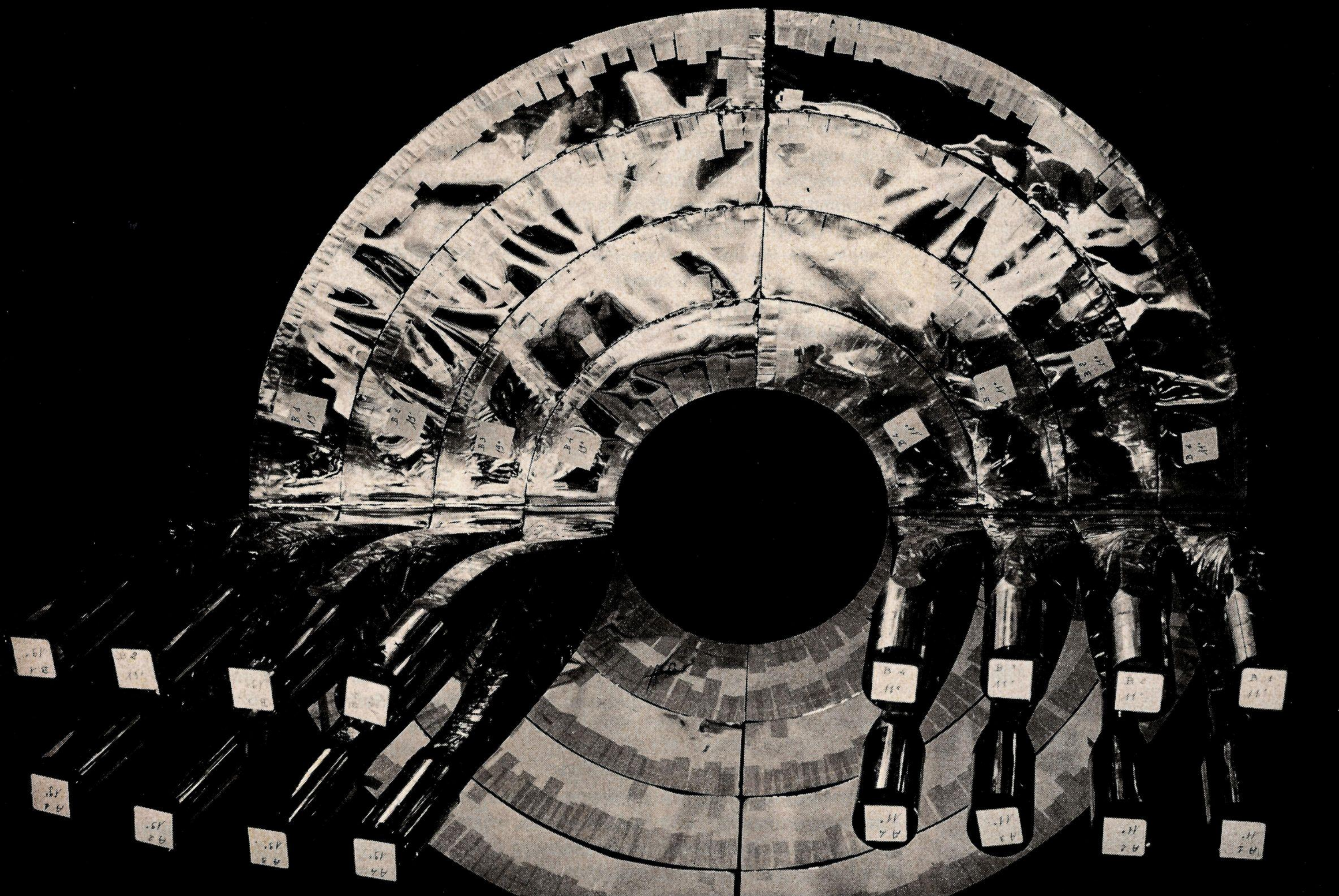
European Organization for Nuclear Research



CERN, the European Organization for Nuclear Research, was established in 1954 to '... provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto'. It acts as a European centre and co-ordinator of research, theoretical and experimental, in the field of sub-nuclear physics. This branch of science is concerned with the fundamental questions of the basic laws governing the structure of matter. 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: Unusual problems demand unusual solutions. The photograph shows a scintillation counter, with its light guides, which has been made at CERN in preparation for an experiment to measure total cross-section which will be carried out by a Pisa group in intersection region 16 at the ISR. Two symmetrical counter hodoscope systems, each with six elements, will detect charged particles emitted at small angles emerging around the beam pipe. The counter has the configuration shown no that it can be mounted around the ISR vacuum chamber at the intersection region. (CERN/PI 157.10.70)

44th Session of CERN Council

The Council met at CERN on 8 October under the Presidency of Professor E. Amaldi

This special session of the CERN Council was called to prepare the way for decisions by the governments of the twelve Member States on the proposed 300 GeV accelerator. It is hoped that the decisions can be taken in December of this year.

The governments are now being asked to pronounce on the new proposal (described in some detail in the April, May and June issues of CERN COURIER) which involves construction of the accelerator alongside the existing Laboratory near Geneva. Before this is possible, the project as now conceived has to be laid on the table in a formal way in a 'programme definition'. This legal document was before Council for approval after which the delegates could carry it away to their respective governments. In addition, the Council received further information on aspects of the new proposal which it is important for the governments to take into consideration in their decisions, namely the conditions under which the new Laboratory site is likely to be made available and the impact of the construction of the 300 GeV accelerator on the programme of exploitation which was foreseen for the facilities of the existing Laboratory.

Programme definition

The CERN Convention requires that the Council approves certain programmes of activities and in so doing defines the programmes concerned. 'The Programme for the Construction and Bringing into Operation of the CERN 300 GeV Laboratory' in its previous form (when the Laboratory was to be at another site) was approved in June 1969 and was then reproduced in full in CERN COURIER. We therefore pick out here just the main features of the new programme definition.

The Laboratory is to include a proton accelerator for energies of about 300 GeV. The accelerator intensity is to be at least 10^{12} protons per second.

The Laboratory is to be built on an extension of the present CERN site and in this circumstance the present 28 GeV accelerator will be used as the injector of the 300 GeV machine and the existing West Hall will be used as the initial experimental area. Research will start at 300 GeV or an intermediate energy level in the West Hall during the sixth year of the programme. A North experimental area will be constructed to come into operation at the 300 GeV energy level eight years after the start of the programme.

Superconducting magnets could be used for part of the bending magnets of the accelerator, if they become practical and economic in the course of the programme, thus raising the energy to 400 GeV. A decision on this option will be required about three years after the programme starts. The energy could eventually be raised towards 1000 GeV by replacing all the iron-cored magnets by superconducting magnets but this is outside the timescale and budget figures of the programme now being put forward.

Member States joining the programme will do so for a minimum initial period which will extend to the bringing into operation of the 300 GeV machine or eight years after the start whichever is the sooner. During the period the total cost will not exceed 1150 million Swiss francs at 1970 prices divided as follows:

Year	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Cost (MSF)	*30*	*105*	*165*	*180*	*175*	*165*	*165*	*165*

Annual budgets will not exceed these estimated figures (adjusted for cost variation) by more than 15 %. If the option of superconducting magnets to be used for part of the accelerator would cost more than can be accommodated in these budget figures a new vote of approval by Council would be needed.

The programme will begin on the date the Council appoints a Director General and votes a budget. Within the following year the Council will receive for approval:

(a) a master plan showing the proposed layout of the installations on the site;

(b) detailed specifications and estimated costs of the proton synchrotron, its buildings and supplies;

(c) approximate specifications of the experimental equipment, its buildings and supplies which will be constructed during the programme, together with the financial provisions to be allocated for these installations;

(d) an estimate of the running costs of the new accelerator when the present West Hall is being used as its initial experimental area;

(e) an estimate of the annual budgets of the programme including the 300 GeV accelerator when the North area comes into operation.

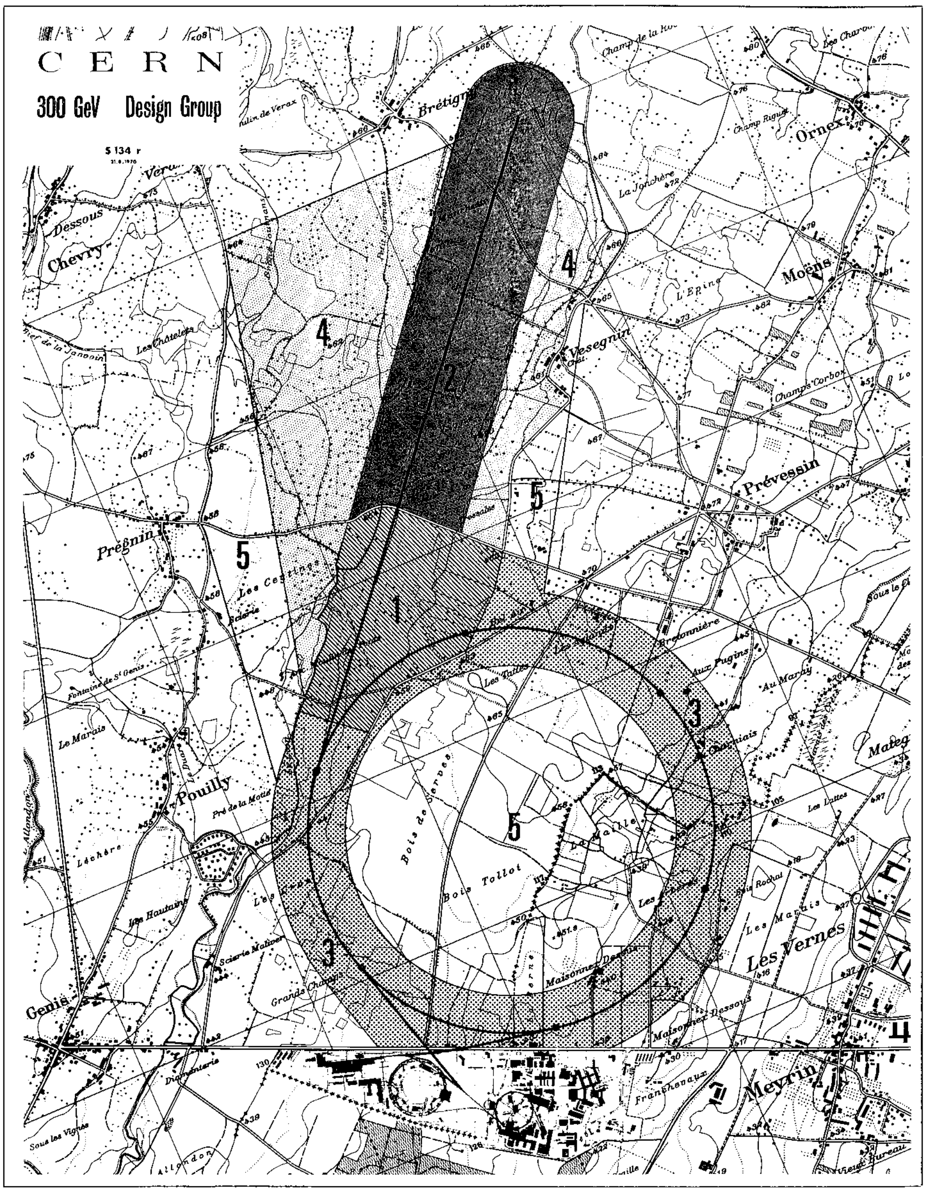
Close collaboration in the implementation of the different programmes of CERN shall be ensured and the Council will examine proposed arrangements for this collaboration as soon as possible. The arrangements will include the creation of consultative scientific committees and will provide for the optimum use by the new programme of existing technical and administrative services. The Director General is required to report periodically to Council on the value and distribution of contracts arising from the programme. In view of the fact that those contracts concerning advanced technological equipment and services have an important effect on industries in Member States, such contracts shall be awarded in conformity with the Financial Rules of CERN whilst being reasonably well distributed amongst the Member States participating in the programme.

The programme definition, as outlined above, was approved unanimously by the Council. Such approval does not, of course, commit any Member States to participate. Decisions on participation will be made known at the December Council meeting.

Interim report on the site

At the June Council meeting CERN was authorized to pursue the study of the proposed site for the 300 GeV Laboratory. This included both a study of the site itself from the point of view of its geotechnical appropriateness to receive the accelerator and further consultation with the French and Swiss authorities (the site lies about 7/8 in France and 1/8 in Switzerland) concerning the conditions under which the site could be made available.

The preliminary results of the site survey were reported in the last issue of CERN COURIER (page 277). It has been found that the quality of the molasse is entirely adequate for the construction of the accelerator being as good as, if not better



A map of the proposed site for the 300 GeV accelerator Laboratory divided into zones where the requirements are different.

1. The area (79 hectares) required for the laboratories, assembly halls, site services, etc. Parts of this area will be required early in the programme and the whole of it within the first five years;

2. The area (150 hectares) required for the new experimental area (North experimental area) which will be required during the last three or four years of the programme;

3. The area (251 hectares) required for the machine itself which will be built about 30 m below ground. In this area there will need to be restriction on building other than that in connection with the accelerator in order to ensure the stability of the machine. Six small buildings on the surface are foreseen but otherwise farming and forestry can continue as at present. The area will be required progressively during the first five years of the programme;

4. The area which may be required after the eight years of the programme for further experimental areas associated with the machine. 60 hectares are categorized as 'required' for the programme and 169 hectares as 'reserved' for the programme;

5. This area (343 hectares) is in three parts which may be needed for long-term developments in association with the machine, in particular the possible addition of intersecting storage rings either inside or outside the 300 accelerator ring. Parts of this area would therefore only be needed in ten or fifteen years' time if storage rings were to be built.

than, that of the molasse on which the present machines are built. In addition the site could accommodate a machine of diameter 2.2 km. Since the greater the diameter the higher the possible ultimate energy of the accelerator, the 2.2 km diameter is the preferred size.

Dr. J.B. Adams, Director of the 300 GeV project, reported that design is now concentrated on a machine of this diameter. Since it is larger than the 1.8 km diameter first proposed, the possible energies at different stages are increased. Thus the possible interim stage where research might begin in the West Hall while only half the ring magnets were in place, would achieve 200 GeV as opposed to 150 GeV. Within the budget for the programme the installation of further magnets would take the energy to 300 GeV. (Increasing the ring diameter will add comparatively little in terms of the increased cost because of boring out a larger circumference but there would be sizeable increased cost in buying the additional magnets to fill the larger circumference.) Filling the ring with conventional iron-cored magnets would give an energy of 400 GeV. Filling the ring with superconducting magnets would probably give an energy of 1000 GeV.

The site for the Laboratory is shown in the map, divided into zones which would be required at different times and with different constraints on their use both for the programme now proposed and for possible much longer-term developments. Discussions are under way with the French and Swiss authorities with the aim of establishing an offer in principle concerning zones 1 to 4, the terms of such an offer and an agreement on the order and timescales in which the zones would be made available.

It is proposed that the contracts which are in force for the existing Laboratory between CERN and Switzerland, CERN and France, and France and Switzerland should form the basis of similar contracts regarding the new Laboratory. Any modifications could be brought to Council after the start of the programme.

Investigations have also been under way with regard to the two major 'services' the Laboratory will require — electricity and cooling water. Together with Electricité de France, solutions to the problem of electricity supply have been studied in detail and costed. It is necessary to tap directly from the Eurogrid probably at the nearest point, Génissiat. The cost of laying on the necessary power will depend on the technical solution selected. The cost of the power itself is proposed as that charged to the most favoured national consumer of comparable amounts.

Similar investigations with regard to cooling water have been under way with the relevant Swiss authorities. A satisfactory scheme has been worked out by which cooling water would be pumped from Lac Léman to the site but a solution to the problem of disposal of the water after use has not yet been selected. Again it is proposed that the tariff charged for the cooling water should be that accorded to the most favoured national consumer of comparable amounts.

The new Laboratory would bring almost 1000 additional staff into the Geneva —

Pays de Gex region by the time construction of the accelerator is completed. The necessary housing for this number of people and the availability of schools for their children are two important questions which have been studied.

On the housing side there are already schemes under way in the region of the Laboratory, both in France and Switzerland and the additional CERN staff will represent only a small fraction of the anticipated influx of population.

The schooling problem however is one which already exists and which will only be aggravated further by increasing the number of staff. Schemes are being discussed to set up a European-type school in the neighbourhood of the proposed site which would offer instruction at all levels up to university entrance.

Discussions about such schools have been going on for many years between the Member States and the European academic bodies and the problems are very complex. For example, it is necessary to reach agreement between the European academic bodies on final school diplomas which will be generally acceptable as a qualification for entry to all European universities. It is the intention of CERN to do all in its power to negotiate an agreement on this complex problem as soon as possible through discussions with the two Member States concerned and with the local authorities, in order that a European-type school will be set up for the children of all the staff of CERN.

(Previous comment on this question and on the opportunity which exists to do something in the field of education in Europe whose significance could extend far beyond the solution of the immediate problem can be found in CERN COURIER vol. 8, pages 187 and 234, and vol. 9, page 177.)

The delegates from Italy and the Federal Republic of Germany urged that, in order to take decisions, information on the site and related questions such as those discussed above, should be developed to the same point as that assembled on the previous site offers from Member States. In the previous offers, acquisition of the site and assuring the necessary 'infrastructure' was not expected to introduce any extra cost to CERN.

The questions of housing and schooling were also raised as important matters by Italy and Germany. They insisted that since housing is recognized to be a problem at present, some positive action by CERN, France and Switzerland will be needed. They also urged action on the schooling problem recalling that other countries had offered to set up a European school to cater for the children of CERN staff.

The delegates from France and Switzerland said that formal commitments on the site questions cannot be given until a formal request for the site has been received from CERN. This would follow a favourable vote on the project. Nevertheless, both countries stated that they would welcome such a request and would have a very favourable attitude in tackling the many problems involved. They would continue to act towards CERN in the same spirit of cooperation which has always existed.

Implications for the existing Laboratory

In bringing the 300 GeV accelerator alongside the present Laboratory it has been judged right that some contribution to the cost of the new programme should be made from the budgets which were foreseen for the exploitation of the facilities already existing or nearing completion. This would mean that the additional money, beyond the foreseen budgets, which Member States would have to find for the 300 GeV Laboratory would be less than the 1150 MSF written into the programme definition.

There has been much debate as to where the additional money figure should be set, mainly revolving round the figures of 900 MSF and 750 MSF. The concensus of opinion at the Council session was that to set the figure at 750 MSF involved cuts in the foreseen budgets for the exploitation of the existing facilities which would make too damaging inroads into the research programme and would be unacceptable in view of the considerable investment from the Member States in building up the research facilities. Thus the figure of 900 MSF is the one which is now being taken in judging the impact on the existing Laboratory.

A total of about 250 MSF during the eight years of construction, would under these conditions, need to be saved out of the foreseen budgets of the Laboratory during the eight years of 300 GeV construction. In addition, it is agreed that the equipping of the West experimental hall for physics in the hundreds of GeV range would fall on the budget of the existing Laboratory. This would mean that something like 40 MSF per year during most of the years of construction would need to be pruned from the budgets which were being planned for the Laboratory. Obviously exploitation could not, in these circumstances, grow to the level originally intended.

The future programme has therefore been carefully examined and a list of possible ways of saving has been drawn up. Some saving can be achieved by cutting minor development work and by delaying the implementation of new techniques. Beyond that, more serious cuts (involving choice among topics such as the development of PS operation, the programme of bubble chamber experiments and electronic experiments, the synchro-cyclotron programme, ISR exploitation, the development of computing and data-handling facilities, restrictions in services and administration) would be needed. It is believed however that it will be possible to sustain a high proportion of the anticipated exploitation by accepting some limitations on performance, variety of programme and flexibility.

It is difficult to be more precise at this stage since the choices cannot reasonably be made in advance of operational experience with the different components of the improvement programme — such as the Booster and the new large bubble chambers. The choices would also be influenced by changes of emphasis in the physics itself. The detail would be worked out when drawing up the annual budgets and would be progressively under the supervision of the Council at the stage of approving these budgets.

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A schematic circuit diagram of the scheme proposed for very rapid pulsing of a septum magnet such as might be used to eject from the PS to the 300 GeV. Enough charge is stored initially for twenty magnet pulses and selective switching of the thyratrons picks out sufficient charge for a single pulse so that the magnet can be pulsed every 50 μs.

Kicking faster for the 300 GeV

The possibility of using the 28 GeV proton synchrotron as injector for the 300 GeV machine is an important part of the proposal to build the machine alongside the existing CERN Laboratory. There would then be no need to construct a separate linac and booster for the 300 GeV which could both reduce construction time and save money. However to use the PS in this way is not without its problems. An ingenious solution to one of these problems — that of 'kicking' the beam from the PS to the 300 GeV efficiently and quickly — has been proposed by A. Bruckner.

There are several possible variants as to how the ejection-injection process might go. We will describe just one of them since in terms of the topic we want to discuss they are all essentially the same.

The characteristics of the accelerated beam in the PS are obviously a fixed starting point. The beam is in the form of 20 bunches evenly spaced around the circumference of the ring 200 m in diameter. The probable diameter of the 300 GeV is 2.2 km (as mentioned in the last issue, page 277) and what we would like to do is to transfer the twenty bunches so that they are evenly spaced around the circumference of the 300 GeV which is eleven times larger than the PS. (The transfer will probably take place at an energy of 10 GeV.) There they will be given time to smear out into a ribbon beam (debunch) probably taking about 0.5 s. The r.f. system of the 300 GeV will then be switched on for further acceleration, imposing its own bunch pattern on the beam.

Obviously if we powered a kicker magnet in the PS for a long enough time that all twenty bunches were ejected immediately one after another during one PS revolution, they would take up only one eleventh of the 300 GeV circumference. What we want to do is to power a kicker magnet for just sufficient time to eject one bunch, wait until that bunch has time to move around the 300 GeV and then power the kicker again to eject another single bunch. Repeating this procedure twenty times would then distribute the bunches evenly around the 300 GeV ring.

However, the conventional powering systems for kicker magnets take some hundreds of milliseconds to recover from one pulse before they can switch the magnet on again. With such powering systems it could take several seconds, if only one kicker magnet were used, to eject all the PS bunches in the way we want. It had therefore been proposed to use the massed kicker magnets of the PS, probably including some new specially installed kickers, to serve one after another to eject bunch after bunch.

The new idea concerns a way of powering a single magnet with pulses separated by only about 50 μs. The operating principle is illustrated in a simplified way in the diagram.

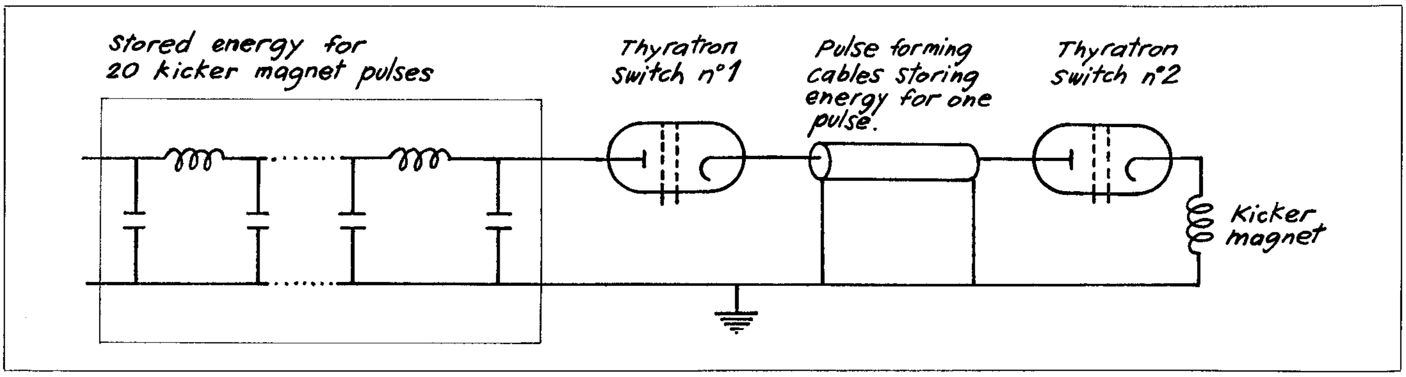
In the interval between accelerator cycles enough power for twenty kicker magnet pulses is stored in the slow storage line on the left. When we are ready for ejection we close thyratron switch No. 1 (thyratron switch No. 2 is still open) and pass charge for a magnet pulse, long enough to eject one bunch, into the pulse forming cables. Switch No. 1 is then opened and switch No. 2 closes to discharge the cables through the kicker magnet. The magnet is thus powered for long enough to pick out one of the orbiting PS bunches and bend it out of the ring towards the 300 GeV. Switch No. 2 opens again and switch No. 1 closes to pass charge for another magnet pulse and so on.

The time necessary for this process will be about 50 μs per pulse. During this time the remaining bunches will orbit the PS about 25 times. By arranging the timing of switch No. 2 we can select the bunch to be ejected in the following sequence — bunch number one, bunch number twelve, bunch number three, bunch number fourteen... and so on (an eleven bunch interval, though other intervals would also work).

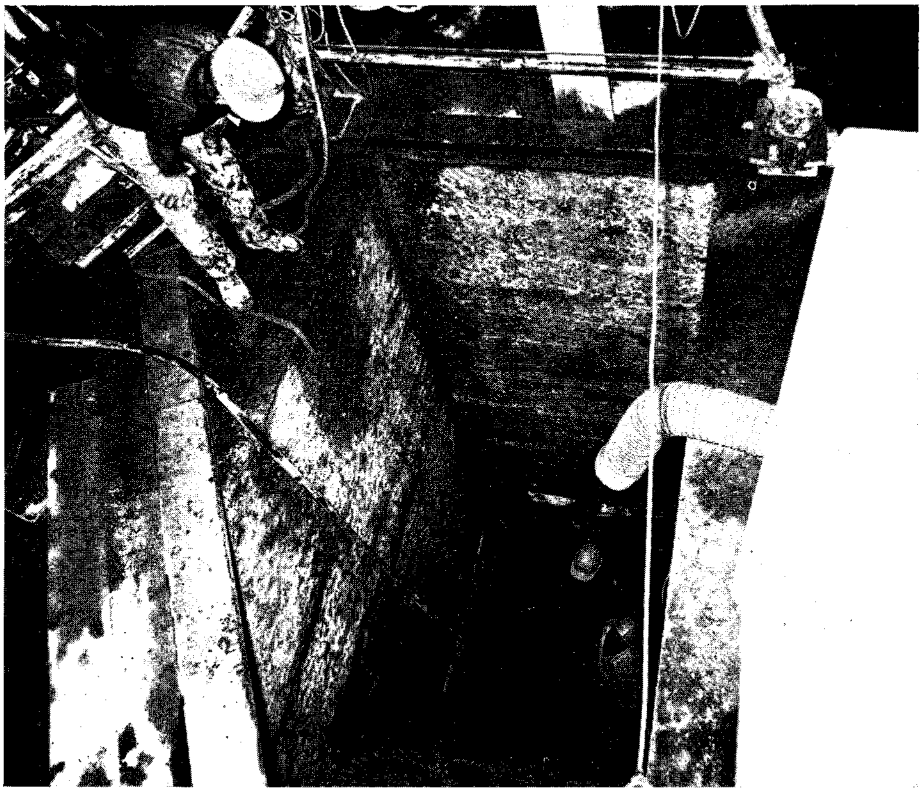
The main difficulty is likely to be keeping the thyratron switches operating independently of one another; the ionization in one thyratron has to die down before the other is fired. A method of 'despiking' the anode of thyratron No. 1 while No. 2 fires should overcome this. It is probable that a model of the powering system will be built in the near future to test the technique.

A heavy lepton

A paper by C. A. Ramm, published in Nature 26 September page 1323, presents evidence for the possible existence of a neutral heavy lepton with a mass of about 430 MeV. In examining data from three



The new source for the synchro-cyclotron (see CERN COURIER vol. 8, page 6) and its associated components, which is being installed as part of the SC improvement programme, will pass through the yoke and lower pole of the magnet through a distance of 2.75 m into the centre of the machine (an aperture is drilled in the steel). There was insufficient height beneath the SC for installing all the components involved, and a rectangular pit 5 m deep (seen in the photograph) has been dug beneath the centre of the machine for this purpose.



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different experiments phenomena compatible with the existence of a particle which decays into a pion and a muon appear at this mass value in each case.

Very short-lived particles cannot be observed in a high energy physics experiment in the same ways as their more stable brethren by tracing their passage through detectors (for example, via bubble chamber tracks). Their existence is deduced from observing other features of the particle interactions in which they are involved, in particular by observing the particles into which they decay. By looking at the particles flying out from an interaction it can be deduced whether some of those particles had clung together in the interaction, i.e. whether for a short time they formed a distinct particle which then decayed into the particles observed. This deduction comes from totting up the masses (including converting energies back into mass) of emerging particles and plotting the number of observations against mass. A graph is thus produced which can show peaks at particular mass values suggesting the existence of short-lived particles corresponding to the mass values. The interpretation has to be done with care because there may be something built into the detection system which makes it more sensitive to particular mass values so that there are a large number of observations not due to the existence of a particle but to a bias in detection.

The heavy lepton story began in examining the results from the 1963 neutrino experiments at CERN but the data was then too sparse to do more than intrigue. More data, with greater precision, came from the CERN 1967 neutrino experiments carried out in the 1.1 m^3 heavy liquid bubble chamber filled with propane. From interactions which were identified as being of the type — neutrino plus proton gives muon, pion plus proton

$$\nu + p \rightarrow \mu + \pi + p$$

it was possible to plot graphs of the number of observations of the muon-pion combination against mass. When this was done a small peak emerged at about 430 MeV. This could correspond to a short-lived particle which was formed in the interaction and immediately decayed into a muon and pion. Since the muon is a lepton and we believe 'lepton number' is always conserved, the particle would be a lepton. Since the muon and pion are always oppositely charged, the particle would have zero charge.

The study was carried further in examining data from two other experiments in which a muon and a pion emerged from an interaction — these were the X4 experiment, also in the heavy liquid bubble chamber at CERN, which looked at the decays of the neutral kaon, and an experiment in a hydrogen bubble chamber at Brookhaven which also looked at neutral kaon decays. In both sets of data the same type of small fluctuation appeared at the 430 MeV mass position.

People have speculated for some time about the possible existence of a lepton spectrum — the possibility that the familiar leptons (electron, muon and neutrino) have heavier relatives that have not yet been seen. This may be the first indication of their existence and there are less prominent clues to other heavy leptons from the same study. However, to put in the opposite scale pan, a team conducting a CERN kaon experiment, which has high statistics on interactions producing a muon and a pion, claims not to have seen any peak at the 430 MeV mass value. The possible existence of the particle obviously needs further investigation.

A search for charged variants of such a heavy lepton is now being undertaken by Ramm by looking at muon-gamma and muon-neutral pion decay modes in neutrino interactions and at muon bremsstrahlung. Again there is some evidence of their existence near the mass of the proposed neutral heavy lepton.

Gargamelle optical system

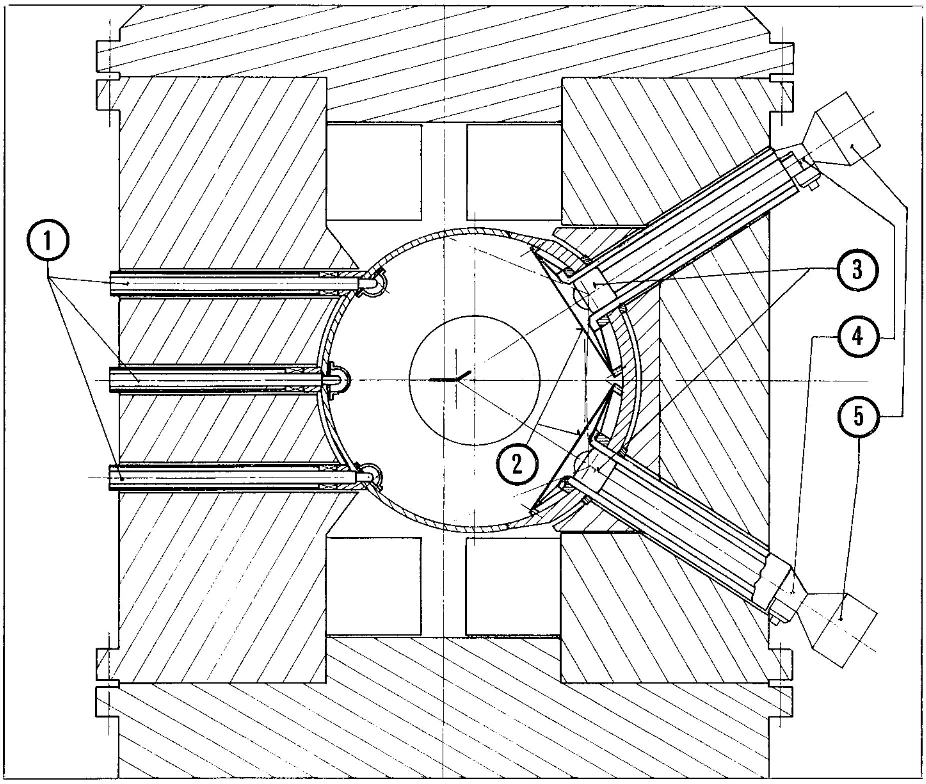
All the sub-assemblies for the Gargamelle heavy liquid bubble chamber built by Saclay for CERN are now complete and are being installed at CERN. This article concerns the optical system which was briefly mentioned in the article on the scanning and measuring tables for the chamber (vol. 9, page 36). Its design was dictated by the configuration of the chamber itself and by experimental requirements.

To provide the maximum possible coverage in terms of photographable volume of the long cylindrical chamber, eight wide-angle (110°) lenses are used in two horizontal rows of four. The cameras had to be placed outside the magnet yoke where the fringe field is weak, and thus the image needs to be transferred over a distance of 1.9 m inside a 20 cm diameter tube. Systems in which the film is taken inside a tube into the immediate vicinity of the liquid were rejected because of their complexity.

The optics are designed to introduce very little distortion (less than 1 %) and to project the rays of light onto the film at an angle as close to the perpendicular as possible (with a deviation of less than 8 %). Although considerable distortion can be allowed for by drawing up distortion charts, it is nonetheless desirable, for example to speed up the scanning of photographs of neutrino events in which there are a large number of gammas (materializing as positron-electron pairs), to use an optical system where straight lines in the chamber are rendered by

A section through the heavy liquid bubble chamber, Gargamelle, showing the position of the various components of the optical system: 1. flashes; 2. diaphragms; 3. lenses; 4. cameras; 5. marking units.

Only three of the twenty-one flashes and two of the eight objectives, which are arranged in two parallel rows, are shown.



straight lines on the film so that the gamma can easily be associated with the vertices where they were produced. Also with the rays of light striking the film at right angles, errors due to the emulsion thickness are reduced.

The main lens is a small diameter wide-angle (90°) lens, of a type already being commercially manufactured for a special purpose by the supplier of the optical system (SOPELEM), with an adaptor lens fitted to it to increase the angle to 110°. The image is transferred by a set of eight lenses which have been designed to reduce chromatic aberration. The final overall resolution on the film is between 15 and 20 microns, corresponding to an accuracy of about 0.2 mm in the beam plane.

A thick, hemispherical fish-eye in contact with the liquid, protects the system against the pressure in the chamber, while an additional safeguard (in case the fish-eye breaks) is provided by a thick lens behind the objective. If the two should break, a diaphragm limits the flow of liquid to a rate equivalent to the evacuation capacity. A warning manometer is also fitted behind the hemispherical fish-eye.

The complete system consists of 24 lenses. A computer program, drawn up at Imperial College London by W. T. Welford (who is now working on the optical system of the Argonne 12 foot chamber), based on a prototype calculated by conventional methods, was used to perfect and optimize the system. The lenses are designed to allow for the installation of a ring of flashes making it possible to use bright field illumination.

There are two identical cameras, one for each row of four lenses. Each uses one film and takes the image from the four lenses in succession. 70 mm film with only one perforation in four as compared with ordinary film is used, making it possible to use a width of 68 mm for the photograph (instead of less than 60 mm). A precision advancing and locating system and a marking unit to identify the photograph is associated with each view.

The film magazine will hold 1200 m of thin film which gives forty minutes' running time. Films can be joined end-to-end by a semi-automatic splicing system. There will eventually be much larger loading magazines associated with on-line continuous film development.

As in practically all heavy liquid bubble chambers, the bubbles are photographed against a dark background. 'Dark field' illumination has been necessary because of the difficulty in obtaining Scotchlite to withstand solvents such as freon and propane. (Scotchlite is a material which reflects light at an angle close to the angle of incidence. It is used in chambers with 'bright field' illumination where the bubbles appear black against a light background).

This determined the position of the flashes which were installed facing the lenses. However, the lenses, as mentioned above, are designed to accommodate a ring of flashes around their optical axis if required and therefore satisfy one of the requirements for bright field illumination, if this is thought desirable in the future.

Each of the 21 flashes is installed in a sleeve which passes through the magnet yoke, the end of which is tightly closed by a hemispherical window which is in direct contact with the liquid. The flash itself is located at the end of a rod which slides inside the sleeve and may be withdrawn without interrupting the operation of the chamber. Behind the window is the actual flash unit which consists of a quartz tube with three turns (its shape is similar to that of the filament of a car bulb). The flash is produced by discharging a 1500 V pulse into the tube for 1 ms, which is preceded by a short steep-fronted ionizing pulse (4000 V for 1 μs). In normal operation each unit can provide about 300 000 flashes (300 joules per flash). It is however impossible to prevent the glass becoming gradually opaque due to tungsten deposit, the crystallization of silica and the photochromic effect (found during tests on Gargamelle and due to the absorption of ultra-violet light by the quartz).

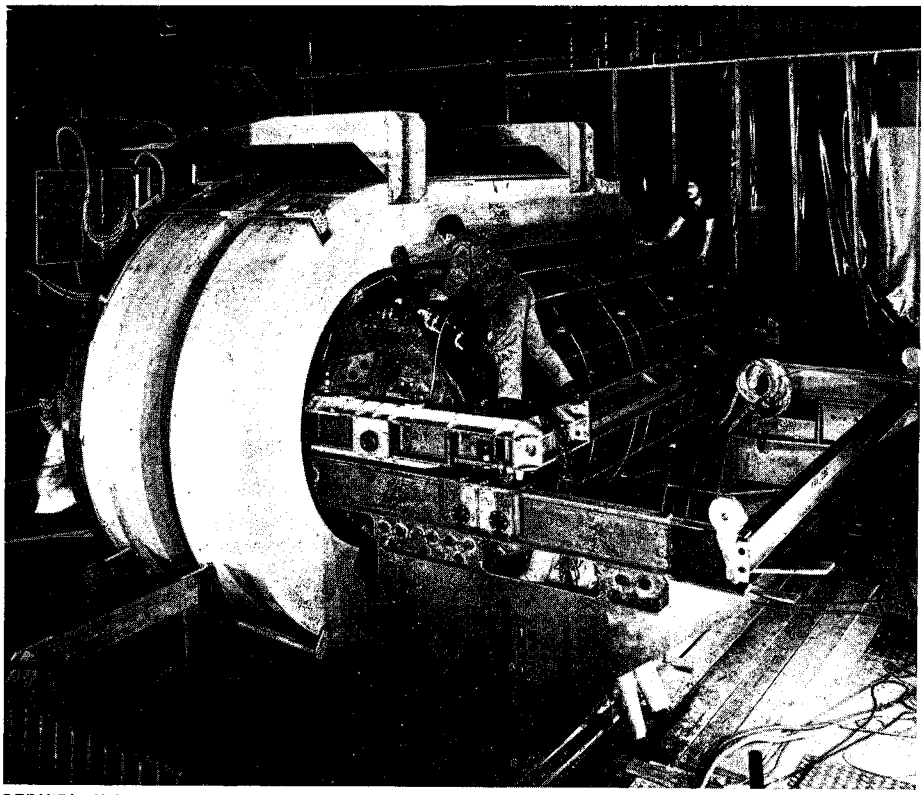
The flash tube is cooled by water which circulates inside the window. The method used is of interest for two reasons: 1) Water absorbs the infra-red light emitted by the xenon, the wavelengths of which correspond to the absorption wavelengths of certain freons. Without this, the infra-red rays might lead not only to parasitic boiling but also to implosion. 2) The temperature inside the window can be matched to that of the propane, thereby avoiding high thermal gradients.

As the flash units face the lenses they must be prevented from fogging the film which would make it impossible to see the particle tracks. Two sets of masks are therefore used preventing the light rays produced by the flash units from entering the lenses.

The poor man's r.f. separator

A radio-frequency particle separation technique involving the use of only one r.f. cavity has been successfully used at CERN in providing a beam of positive pions at 4 GeV/c to take some 400 000 photographs in a bubble chamber experiment.

R.f. separators of the two and three cavity types are by now, well established units in the armoury of beam-line equipment (see vol. 7, page 125, vol. 9, page 7).



CERN/PI 519.9.70

Installation, at the end of September, of the body of the Gargamelle chamber inside its magnet yoke. This operation was carried out following a number of final adjustments to the various components, and the whole bubble chamber is now coming together ready for experiments. The first filling tests are scheduled before the end of November.

The required kind of particle is sifted from others by arranging that the deflections given by the fields in the cavities push the wanted particles around a beam stop while the unwanted particles, which due to time of flight differences have received different deflections, plough into the beam stop. At CERN, for example, the u 5 beam line has a three cavity system and can separate particles over the momentum range of about 6 to 16 GeV/c. Such systems involve the use of two or three cavities, each with its r.f. power system, intermediate focusing units and quite intricate phase controls linking the cavities to ensure that the deflections add together in the desired way. Obviously if separation can be achieved with a single cavity the complication and the cost are greatly reduced.

The idea of single cavity r.f. separators is not new. It was proposed by J.P. Blewett and B. Montague as long ago as 1959. However the necessary quality of cavity and ability for refined control of field has only recently been mastered (see CERN yellow report 70-26, 'New disk loaded waveguides for the CERN r.f. separator' by Ph. Bernard, H. Lengeler and V. Vaghin). The new separators almost double the possible deflection per unit length and the phase velocity of the deflecting fields can be reliably controlled.

It is especially the last feature which is relevant to the single cavity idea. What is done is to select the phase velocity of the field in the cavity to be equal to the velocity of the wanted particles. The particles then ride the field through the length of the cavity as if on the crest of a wave and emerge with maximum deflection (similar, for example, to the way in which electrons are accelerated on the 'travelling wave' in a linear accelerator — except that in the separator we are concerned with deflection, not acceleration).

The unwanted particles will have a different velocity on entering the cavity. (All the particles have previously gone through a magnet system from which they all emerge with the same momentum — mass times velocity. The unwanted particles have a different mass and therefore a different velocity.) They will be out of phase with the travelling wave. If the difference in phase over the separator length is a multiple of 2π, the unwanted particles will emerge with no deflection and can be ploughed into a beam-stop.

Inevitably, this poor man's separator has its limitations. Above 7 GeV it would need an unreasonably long separator. Below 3 GeV/c electrostatic separators are more efficient. Nevertheless, using the single cavity technique the range of momentum which can be covered by the u 5 beam at CERN has been extended appreciably to lower momenta.

There is an interesting possibility of using single cavity r.f. separators in electronics experiments. In contrast with bubble chambers, counters and spark chambers like much higher numbers of particles fed to them for longer times. The deflection that can be given to a particle is proportional to the field in the cavity and to the length of the cavity. The field is in turn proportional to the square root of the power into the cavity. Modern power tubes can provide r.f. pulses of about 20 MW only for between 10 to 50 μs.

To increase the length of time for which particles can be separated the power needs to come down and, to achieve the same deflection, the length would have to go up. An increase in length would reduce the 'acceptance' of the cavity, i.e. reduce the number of particles which can be passed through. At first sight such a system cannot win for electronics experiments; it cannot increase the pulse length without reducing intensity.

However, about ten years ago, P. Lapostolle at CERN proposed superimposing a strong focusing system over a long single cavity separator in order to increase the acceptance. This idea has been taken up again recently at Brookhaven for use in the separation of kaons between 2 and 5 GeV/c. For higher energies this type of separator becomes very complicated and expensive so that for this energy range the development of superconducting r.f. separators (being worked on for example at Karlsruhe and Rutherford) remains of great interest.

Sale of electronic equipment

The CERN Stores Section has a considerable quantity of electronic equipment which has been used in physics experiments and which is now offered for sale on advantageous terms to European universities or physics institutes. A list of equipment, ranging from pulse generators to voltage stabilizers, is given in the advertisement on page 325 of this issue. It is not, however, an exhaustive list and contains only some of the major items.

More detailed information on both the conditions of sale and the equipment itself may be obtained on application to Stores Section, CERN, 1211 Geneva 23, Switzerland.

Fellows and Visitors

It is not always realized that by far the major part of the research programme at CERN is carried out by Fellows and Visitors. In the Summer of this year the average number of scientific and technical Fellows and Visitors on the site was about 700 while, by contrast, the number of staff members who are particle physicists, both theoretical and experimental, is about 90

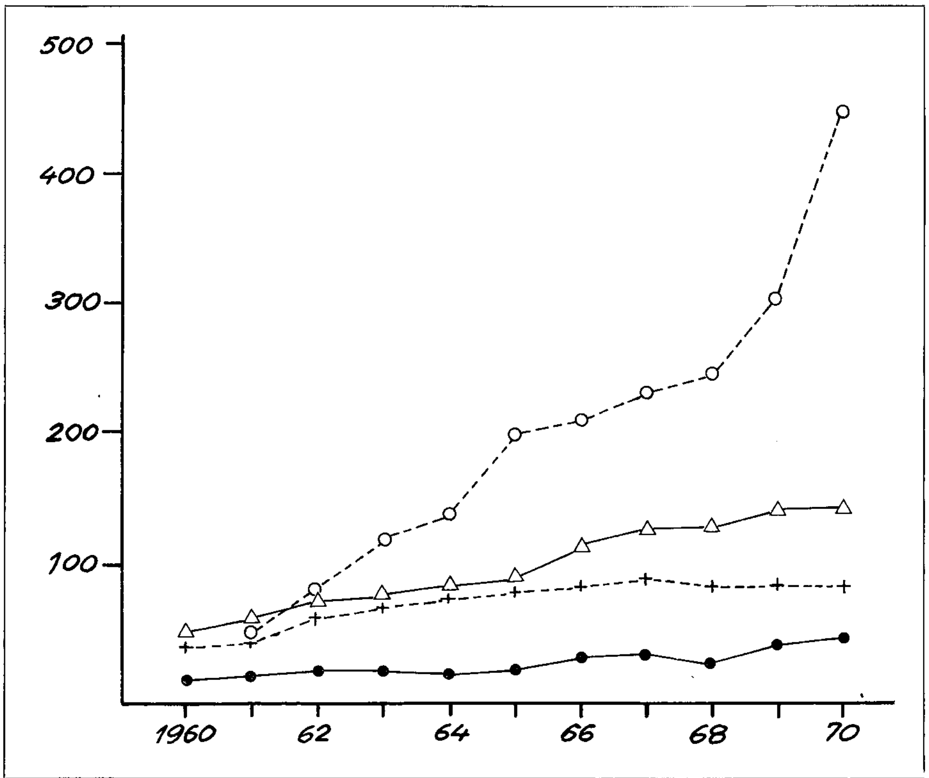
Figure: The evolution of the number of visitors of various categories over the past ten years. The numbers represent man-years per category as follows —

○ *'unpaid' visitors*

△ *fellows and all paid visitors*

+ *CERN staff (particle physicists)*

● *paid visitors from non-Member States.*



Number of Universities and Research Institutes in the Member States participating in experimental physics carried out with the proton synchrotron (PS)		
Country	Electronic experim. (Summer 1970)	Bubble chamber experim.
Austria	1	1
Belgium	1	1
Denmark	—	—
France	5	7
Germany	5	6
Greece	—	—
Italy	6	7
Netherlands	1	—
Norway	—	1
Sweden	2	1
Switzerland	2	2
U.K.	4	9
Total	27	35

Cost of Fellows and Visitors programme in 1969 (not including Guest Prof. and Students) and the estimate for 1975 (in units of 1000 Swiss francs)				
	1969		1975	
	Man-years	Cost	Man-years	Cost
Fellows and Visitors from Member States	130	4940	183 to 212	6980 to 8050
Visitors from non-Member States	43	1900	56 to 65	2470 to 2850
Total	173	6840	239 to 277	9450 to 10900

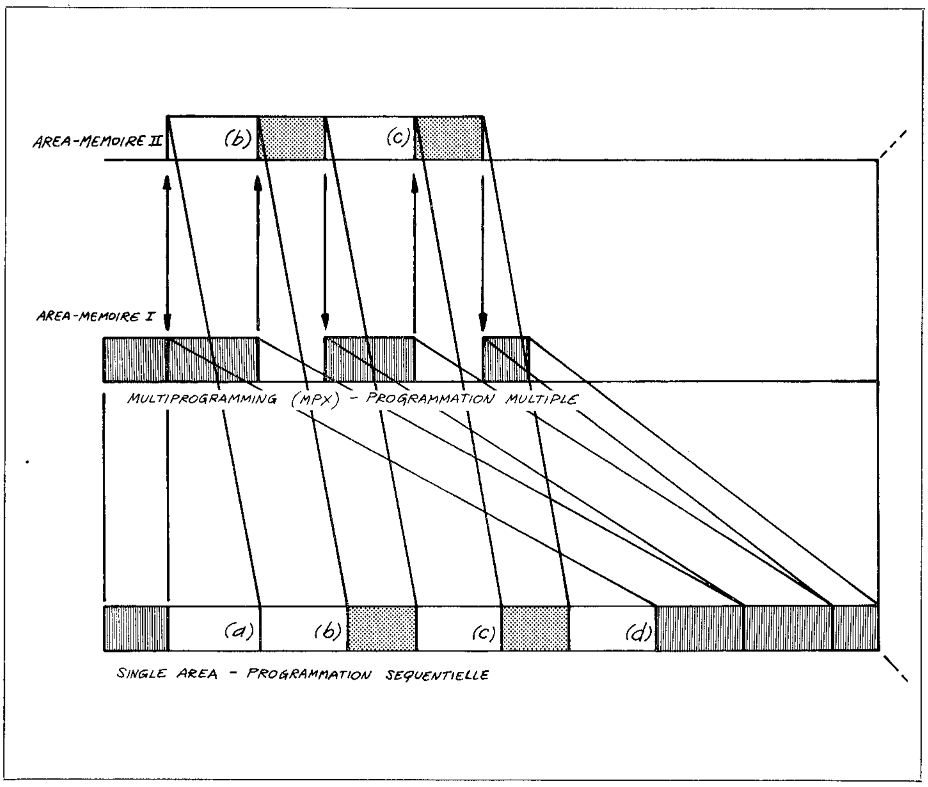
(and most of these are not 'permanent staff').

The evolution of these numbers over the past ten years is shown in the Figure, which is a revised and up-dated version of that published in vol. 9, page 376.

It is striking that Fellows and Visitors come from 108 Universities and Research Institutes in the CERN Member States and from 72 in the non-Member States. As was remarked by the Director General in his progress report to Council last December, the past few years have seen a marked increase in the number of visitors participating in electronic experiments at the proton synchrotron. This is illustrated in the Table which gives the number of Member State groups a) participating in electronic experiments approved for scheduling on the PS as of July 1970, and b) participating in bubble chamber experiments approved for scheduling or analysing film exposed in the first half of this year.

As is clear from the figure, the majority of visitors are 'unpaid' (by CERN); their financial support comes from their parent University. Nevertheless, the number of Fellows and Research Associates and of Visitors either wholly or partially paid by the Organization is now approximately 220. In terms of money the expenditure on Fellows and Visitors in 1969 was about 7.5 million Swiss francs (5.8 MSF came from the budget of the Directorate-General and 1.7 MSF came from the personnel budgets of the Divisions).

In view of the importance of the Fellows and Visitors programme for the research effort of the Laboratory and of that of the Universities and Research Institutes in so many different countries, a paper was prepared which reviewed the evolution of the programme since 1960 and made specific proposals for the years up to 1975. It was submitted to, and approved by, the Council in June of this year. The proposals imply an increase of between 30 to 50 % in the number of man-years of Fellows and Visitors from Member States (both paid from the Directorate-General's budget and from Divisional budgets) over the years up to 1975. Furthermore the expenditure on Visitors from non-Member States will remain at about 1 % of the total personnel budget of each year. The



A diagram illustrating the saving in time achieved by the use of multiprogramming as against time sharing in a computer. The cross-hatched and dotted areas represent the effective operating time of the central processing unit.

The bottom line shows what happens with time sharing when a program (hatched) being processed is interrupted by a higher priority one (dotted). Block (a) represents the time taken transferring to the disc store; block (b) the time taken bringing in the higher priority program. Block (c) represents time calling for more data and (d) time returning the first program. With multiprogramming, illustrated in the top lines, shuffling between the programs saves time.

second Table gives the details of the man-years and money involved for 1969 and 1975 (estimates).

Finally, during the Summer months about a hundred university students come to CERN. They participate in the day-to-day work of some research or technical groups and attend a special course of lectures. The students are not included in the numbers given in the Figure and Tables. The cost of the Student Programme amounted to 270 000 Swiss francs in 1970.

Multiprogramming on PS computer

The work load on the IBM 1800 computer used in PS control has been increasing steadily. Its total present capacity would be greatly exceeded when the Booster is brought into operation and to remedy this, a new job distribution system of the multiprogramming type has just been adopted. It will be possible with this system, together with more storage, to increase the computing capacity roughly fourfold by eliminating 'dead time' in the operation of the central processing unit.

A computer normally uses two kinds of memories or stores. Internal (core or ferrite) memories are fairly expensive and are therefore generally installed in quantities which can store only comparatively small amounts of data. Their advantage is that access time to information stored is very short (of the order of a microsecond). Auxiliary (disc or tape) memories cost much less and can be used to store very large quantities of data, which cannot, however, be transmitted as rapidly to the central processor unit. The programs they contain must be transferred to ferrite memories before use and this takes time (from 50 ms to a few seconds).

Programs which the central computer needs often, such as the operating program and certain subsidiary ones, must be constantly available in ferrite memories. Others can be stored on discs to be transferred at the appropriate moment to a part of the ferrite memory reserved for this purpose. The ferrite memories are thus divided into two regions — the fixed program region ('fixed core'), and the region in which programs are temporarily stored ('variable core').

The IBM 1800 used as the PS control computer has to deal with a whole range of programs linked to the operation of the machine. An order of priority is allocated to each of them and they are taken to the variable memory and processed in order. Up to now the computer has used a time-sharing system whereby each program is processed in sequence according to its priority. There are however two possible exceptions — programs with higher priority can at any time interrupt one of lower priority which returns to the disc memory until the higher priority program is finished. Also if a program being processed requires further data (which is a frequent occurrence at the PS where the data for the programs comes from a number of machine cycles) it is possible, if there is a long waiting time during which the computer is not processing, to pass on to another program. However this process of transfer from the program being processed to another can become complex and time-consuming (because of the transfer time) and it has not been used at the PS.

The loss of central computer time has been accepted. The effective time of use of the control computer, in view of program transfers, waiting times for the retrieval of data and data transfer time, finally boils down to a small fraction of the total time.

Multiprogramming involves the use of several distinct variable cores in addition to the fixed one. At the PS, there will be one for each of the three sections of the machine — linac, booster and synchrotron ring — plus one general-purpose memory which may, for instance, be employed for immediate priority or unusual control operations. There are, thus, four programs permanently present in the ferrite memories. Transition from one to another is very fast, with no long transfer times, and it becomes possible to deal with a part of one program, then with a different one, then a third or a fourth to use up the dead time which would have occurred waiting to obtain new sets of data.

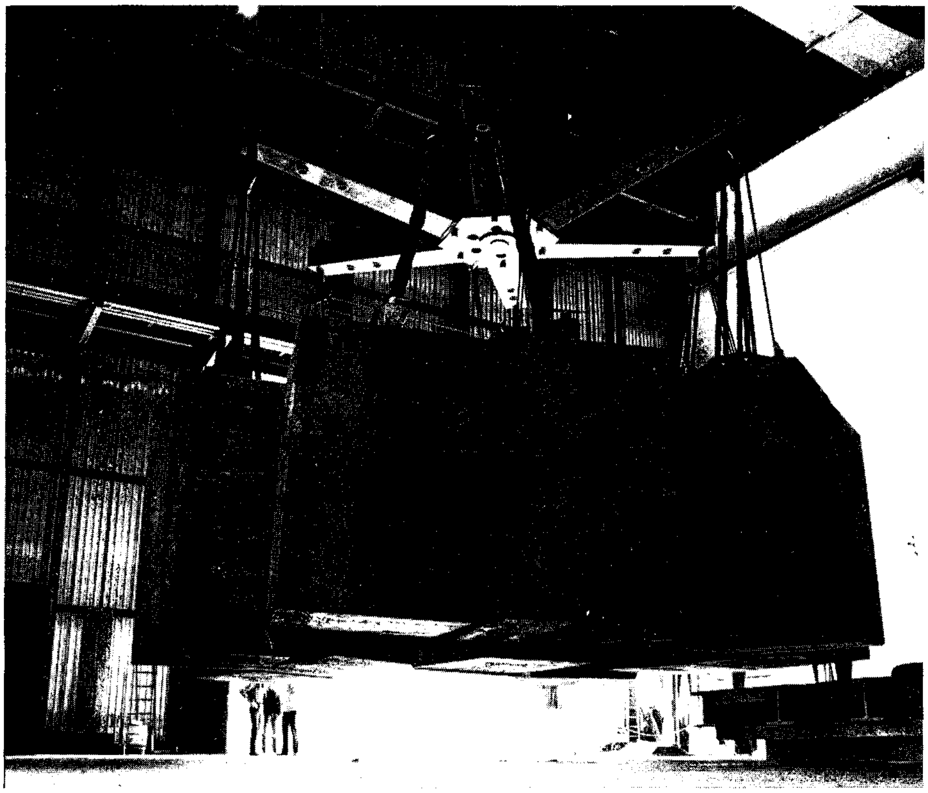
An efficiency for the central computer of close to 50 % should be possible with multiprogramming, as compared with the former rate of about 10 %.

Multiprogramming at the PS control computer thus requires an increase in the number of ferrite memories (the 'fixed cores' being increased from 16 to 20 K words, the variable cores from 8 to 20 K words). In addition, a third disc store has been added to give greater flexibility. The capacity is quadrupled for an expenditure which is only 25 % of the cost of the computer.

The conversion from one system to the other requires a change in the programs and the relevant studies are already on hand. The new memories will be delivered in February 1971, and the new system should come into service a month later.

ESONE General Assembly

The 1970 ESONE (European Standards of Nuclear Electronics) General Assembly was held at CERN from 13 to 16 October bringing together representatives of the 26 institutes, laboratories and organizations who have been participating in



CERN/PI 213.8.70

The acceptance tests on the most powerful crane to be installed at CERN took place in September. It serves the hall where the large European bubble chamber (BEBC) is being built. The crane has a travel of 25.6 m and is designed to carry up to 170 tons. All its movements can be controlled at variable speeds. It was successfully tested with a static load of 240 tons and a dynamic load of 220 tons. The photograph shows the transport of thirteen concrete blocks, each weighing 15 tons.

establishing European standards and also many representatives from electronics industries. It was the first meeting where both ESONE and industry held formal common discussions. In association with the Assembly a very successful CAMAC exhibition was arranged where about thirty firms exhibited their products. This combination of an exhibition with the annual Assembly worked so well that it is likely to become a regular arrangement.

A major decision of the Assembly was the unanimous acceptance of the document on the 'CAMAC organization of multicrate systems' (CAMAC being the name given to the standard electronics system evolved by ESONE — see vol. 8, page 314 and vol. 9 page 303). This was prepared by the Dataway Working Group and is available as document EUR 4600e from the ESONE Secretary (Dr. W. Becker, CCR Euratom, I-21020 ISPRA, Varese, Italy). It gives all the necessary information on the requirements for a compatible crate-interconnection highway (branch highway) which is an important step towards the interchangeability of CAMAC units.

The Analogue Signals Working Group is also well advanced towards finalizing the standards on signals. The selection of positive or negative polarity is still open, since there is no weighty technical argument on either side and may come down on the positive side since this will make opening the door to CAMAC in the USA easier.

Interest in the USA is growing fast. The Chairman of the AEC-NIM Committee was present at the Assembly and phrased it that 'CAMAC is near the threshold of explosion in the USA'. Delegates from the NIM Committee have been present at many of the Working Group meetings during the year and parallel Working Groups have been set up in the USA.

Within Europe itself acceptance of the CAMAC system has been growing steadily. A symptom of this was the number of applications from more research centres to join ESONE. The Assembly welcomed as new members Aktiebolaget Atomenergi from Studsvik Sweden, Instytut Badan Jadrowych from Swierk Poland and Institut voor Kernphysisch Onderzoek from Amsterdam Netherlands. A formal application from the Nuclear Research Centre 'Democritus' from Athens Greece was received just after the Assembly. There were also observers from the Joint Institute for Nuclear Research from Dubna USSR, Nuclear Research Institute of the Czechoslovak Academy of Sciences from Prague Czechoslovakia, Central Research Institute for Physics from Budapest Hungary, and Institutul de Fizica Atomica from Bucarest Rumania.

For the future development of ESONE the possibility of setting up a central bureau of two or three people, to cope with administrative matters and the flow of information, has been under discussion for some time. The growing volume of activities is becoming a heavy load for a part-time Chairman and Secretary to bear. An international organization is thought to be the most appropriate centre for such a bureau and both CERN and Euratom (European Communities) have been approached. CERN is unable to accept the responsibility at present, the European Communities have offered support at a regional level (secretariat in ISPRA, printing in Luxembourg). Some thought is being given to the production of an 'ESONE Bulletin' and a Working Group to outline its policy is being set up.

In accordance with the ESONE rules a new Chairman, M. Sarquiz of Saclay, was elected to succeed F. Iselin of CERN to serve until the next General Assembly in a year's time. That Assembly may be held at DESY in Hamburg, Saclay in Paris or the University of Bari in Italy (since next year is the 10th Anniversary of the proposal to set up ESONE by Professor G. Gianelli of Bari). The Assembly organizers have extended their thanks to all those at CERN who helped make the Assembly and exhibition a success, and to the Geneva authorities who, in the person of A. Chavanne (Conseiller d'Etat), received them at the Geneva Town Hall.

ISR injection septum

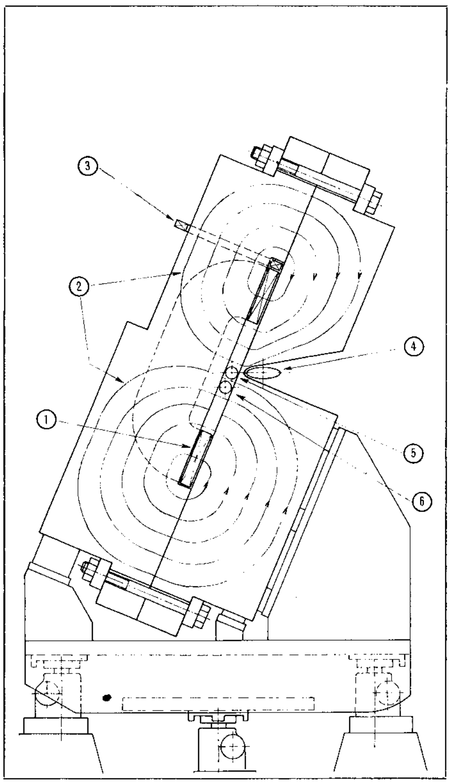
At the end of September, protons were transported along transfer tunnel TT1 connecting the proton synchrotron to one of the intersecting storage rings. They reached the end of the tunnel positioned with the same impeccable accuracy as was achieved in tunnel TT2 a few weeks before (see CERN COURIER vol. 10, page 280). The tunnel construction and the magnet alignment problems are similar to those which would be met with in construction of the 300 GeV machine and the remarkable success in the transfer tunnels, where beam was accurately transported over some 450 m on the very first pulse, is therefore very encouraging for the proposed future project.

The second of two large steel septum magnets to be used for injecting the protons into the ISR was installed at the beginning of October. (Moving these magnets was a tricky operation, since their height is within a few centimetres of the available height beneath the hook of the overhead crane.) The magnets are very large (50 and 40 tons, 3.3 m long) and nothing like the delicate septum magnets used to extract protons from the PS. The ISR magnets have a steel septum, 14 mm thick, machined in the solid material of the yoke (see CERN COURIER, vol. 8, page 223), which shields the high field region (the magnet gap where the beam to be injected is deflected) from the region

A diagram of the steel septum magnet used in the injection system of the Intersecting Storage Rings. The septum, a thin part of the yoke machined from solid, shields the region of high field (13 kG) in the magnet gap from the region of the ISR vacuum chamber, where the stored beams are circulating. The asymmetry between the upper and the lower parts of the yoke causes the lines of flux to be unevenly distributed, resulting in a small stray field, which could affect the beam circulating in the vacuum chamber. To counteract this a correcting coil is used which is fed with current governed by the variations in the stray field itself.

The diagram picks out: 1. main coil, 2. flux lines, 3. correction coil, 4. ISR vacuum chamber, 5. injection beam chamber (downstream), 6. injection beam chamber (upstream).

The photograph shows the second of two steel septum magnets of the ISR injection system being installed in October. The system is now being made ready for the first injection tests.



where the beam is circulating inside the ISR vacuum chamber.

An advantage of the steel septum is that it is a passive component, not subject to the mechanical and electrical stresses experienced by the usual pulsed copper septum. The steel septum is therefore likely to be very reliable, which will be important in the injection region where radioactivity is likely to reach high levels and which therefore will be very restricted in access for maintenance.

To avoid problems connected with ultra-high vacuum, the vacuum chambers have been built so that no part of the steel septum magnets is in vacuo. The principle of the steel septum has also allowed the magnet coils to be built on conventional lines and they are powered with direct current, so that the magnetic field is very stable. However the geometry of the magnets is complicated and these advantages have been obtained only after long development work involving building three models.

A few design features are:

1. Because of the asymmetric shape of the magnet, the reluctances of the return yokes on either side of the septum are unequal. Thus, without some special precaution, a stray field would be produced in the aperture where the ISR vacuum chamber is located. This is eliminated by artificially increasing the reluctance on one side of the yoke by means of a compensating coil fed by a current whose magnitude is governed by the strength of the stray field.

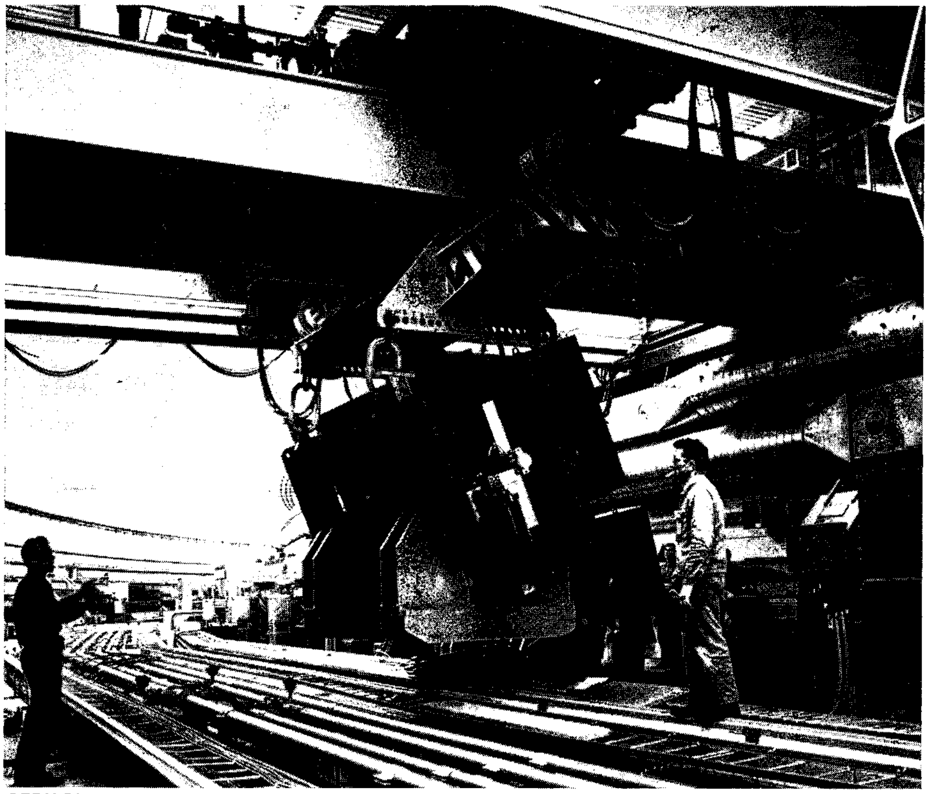
2. Although the septum magnets are not pulsed, it was decided, in order to obtain better reproducibility of the field to make the yoke of laminations 50 mm thick.

3. The epoxy resin used for the winding insulation is of the latest type and has excellent radiation resistance (5×10^9 rad).

4. The oval ISR vacuum chamber which fits into the aperture in the yoke of the septum magnet was made in an unusual way. It involved passing through a flattened tube a mandrel with edges of the desired shape and progressively increasing its width. The shaping carried out at CERN with improvised equipment was quite satisfactory giving an accuracy of better than one millimetre over a length of four metres.

5. Because of lack of room, it was difficult to insert a heating strip around the vacuum chamber where it passes through the magnet for the purposes of baking out. It will therefore be heated by passing a current of about 1000 A between the two ends of the chamber section.

With the septum magnets in place the ISR injection system is now ready for action and the first injection tests will take place just before the shutdown of the PS in November. Detailed studies are scheduled in January when the PS is back in service. Then the long haul towards the design parameters of the ISR will begin in earnest.



CERN/PI 130.10.70

Radiation Conference

An International Congress on 'Protection against Accelerator and Space Radiation' will be held at CERN from 26 to 30 April 1971. The Conference is organized by the Société Française de Radioprotection and the Fachverband für Strahlenschutz in collaboration with CERN.

The Conference will concentrate on problems relevant to the design, installation and operation of accelerators from the point of view of basic dosimetry, radiobiology and radiation protection applied to accelerator produced radiation. Since some of the problems are also met in evaluating the hazards of space radiation, this will also be covered. The emphasis will be on recent progress and results.

The closing date for registration is 1 February 1971. Further information may be obtained from:

Scientific Conference Secretariat
(Miss E.W.D. Steel)
CERN, 1211 Geneva 23, Switzerland.

Batavia Linac Conference

This short report of some of the topics at the Conference was put together with the help of C.S. Taylor who attended the Conference from CERN.

Accelerator builders who 'think straight' met for the 1970 Proton Linear Accelerator Conference at the National Accelerator Laboratory, Batavia, from 28 September to 2 October.

Two years ago the Linac Conference held at Brookhaven was dominated by the problems which concern people in the design stage, for at that time major projects were starting at Los Alamos (800 MeV LAMPF), Brookhaven (200 MeV new injector for the AGS) and Batavia (200 MeV injector). The Batavia machine at that time was not even a hole in the ground. The emphasis was then on accelerating structures, particle dynamics and component design.

It is almost incredible that two years later the discussions could cover 10 MeV beam currents of 160 mA from the Batavia injector, even higher beam currents of 215 mA from the Brookhaven injector as well as the first results on operation of Tank I at Los Alamos. With the announcement of these excellent performances there came many reports on the development of beam diagnostic instrumentation and techniques. J. P. Blewett remarked in his concluding talk that it is a backward Laboratory these days that cannot press a button and produce a three-dimensional plot of particle density in the phase plane.

The stage of design problems is now the prerogative of another batch of machines. These include linacs for the acceleration of heavy ions (both heavy ion and electron linacs crept under the banner of the Conference title, although both types are likely to accelerate protons only by accident). Papers were presented on several machines with potential stretching to the acceleration of uranium ions — the SuperHILAC at Berkeley, an extension of the successful HILAC scheduled to be ready in August 1971; the UNILAC which is at an advanced stage at the University of Heidelberg, and the HELAC being studied at Frankfurt incorporating a helix structure which has been tested in electron and proton models.

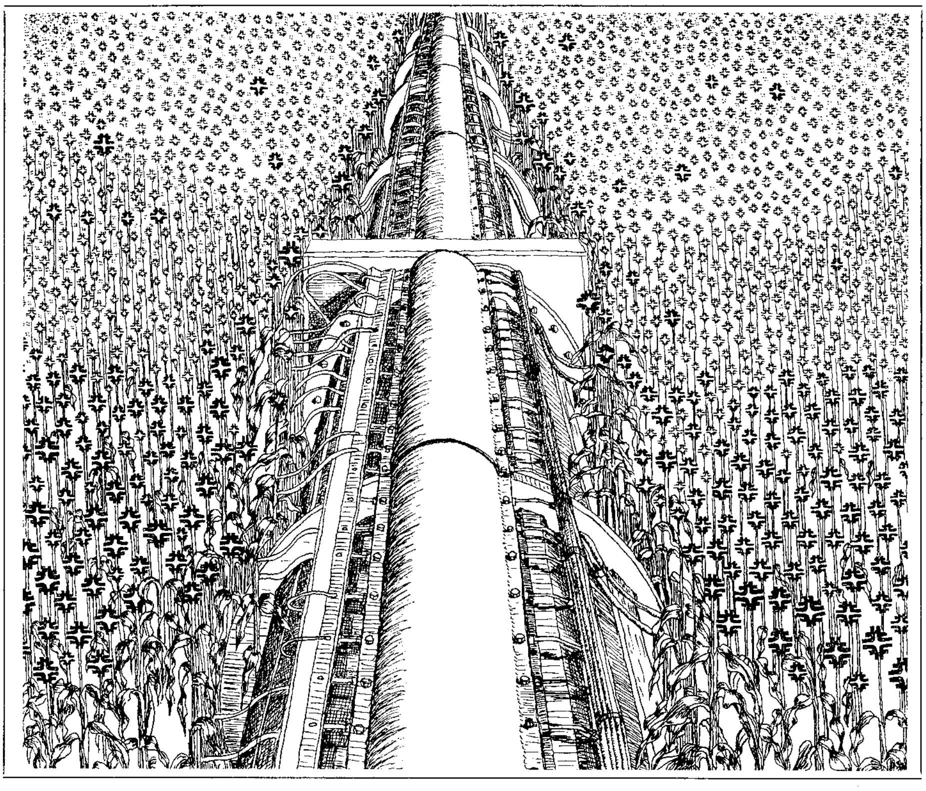
Another design-stage linac of importance is the 20 MeV injector for the Japanese proton synchrotron project which has been authorized this fiscal year for construction at Tsukubah near Tokyo. (We hope to carry more information on this project in CERN COURIER in the near future.) A scale model has been tested with electron beams and has accelerated 100 μA. From these tests a 200 mA beam at 20 MeV should be feasible.

There was much interesting progress reported from all the Laboratories but the Conference programme also allowed time for the discussion of more general questions in a 'Round Table' session on the performance of new linacs. One topic concerned the extent to which measured performances were in agreement with theoretical predictions. The success of these machines indicate a fair degree of agreement and, in comparison with the situation three or four years ago, the understanding of beam behaviour under intense space charge conditions has obviously made great strides. Another implication in many of the results was that the worries about transverse perturbations in the new linac structures, which were expressed in 1968, in fact seem largely unfounded.

One happy convergence of thought appeared from independent calculations from several Laboratories of dispersion diagrams and field patterns in the passbands of accelerating structures. R.H. Helm from Stanford (SLAC) and M. Bell and G. Dome from CERN approached this basic problem from different angles and R.L. Gluckstern from the University of Massachusetts tried yet another approach.

The intensive recent efforts on construction were emphasized by a tour of the Batavia site where the progress on the 200-500 GeV machine is quite staggering. On the last day of the Conference it was announced that protons at 139 MeV from the first six tanks of the linac had been injected into the Booster where half the ring is complete. They were steered round this half-ring and ejected towards the main ring. It was impressive to see the reproducibility and reliability of the low intensity 139 MeV beam after so short a period of running.

This period of major construction of proton linacs in the USA will be coming to an end in a year or so. We can then look forward to the challenge of the next generation where, hopefully, superconductivity will be playing a major role.



The cover design from the book of abstracts for the 1970 Proton Linear Accelerator Conference.

Frascati Colliding Beam Meeting

An informal meeting on electron-positron colliding beam rings was held at the Frascati Laboratory from 15 to 18 September. This report of some of the topics discussed was put together with the help of F. Amman.

The meeting followed close on the heels of the Kiev Conference and provided an opportunity for discussing the results which had emerged from the electron-positron storage rings in operation. Recent improvements in the performance of these rings and news on the progress of rings under construction were also reported. We will cover these reports taking the Laboratories in alphabetical order with some emphasis on the host Laboratory Frascati, where experimental physics with the highest energy electron-positron storage ring currently in operation began at the end of last year.

Cambridge

At the Cambridge Electron Accelerator Laboratory the 'Bypass Project' is now number one priority; heavy budget cuts have meant that the research programme on the 6 GeV electron synchrotron has had to be curtailed in order to concentrate on the Bypass where the Laboratory believes its most interesting contributions to physics now lie. The Bypass was described in vol. 8, page 289. It uses a loop added to the existing accelerator ring where beams can be specially treated before entering the collision region.

In October of last year stable storage of electron beams was achieved for the first time. Since then single beam operation has been improved to the point where beam lifetimes through the Bypass reach 30 to 60 minutes with a beta of about 15 cm. Control of beam instabilities has improved following the addition of an r.f. quadrupole which gives different betatron wave number to different bunches of particles and by separating the synchrotron frequency of the bunches (an r.f. cavity is used on the 362nd harmonic while the main r.f. system is on the 360th harmonic). The maximum current obtained is between 50 and 70 mA per bunch.

Injecting both positron and electron beams it has been possible to store 25 to 30 mA of electrons without loosing a low intensity positron beam already circulating. The expected luminosity with 15 mA per beam is $10^{29}/cm^2$ s.

DESY

The electron-positron double storage ring, DORIS (see vol. 8, page 289) is now in its second year of construction at the DESY electron synchrotron Laboratory. The two rings are mounted vertically one on top of the other and will initially operate at up to 3.5 GeV with an installed r.f. power of 1.5 MW (which can hold 2×300 mA beams at 3.5 GeV). The magnet system is however designed for up to 4.5 GeV but it is expected that this energy will only be reached when superconducting r.f. cavities can be installed. The design luminosity is $10^{32}/cm^2$ s at 3 GeV. Completion is scheduled for the end of 1973.

A large superconducting magnet (see vol. 10, page 231) will be installed in one of the collision regions. A prototype, 1.4 m internal diameter, 1.15 m long, which will give a 20 kG field parallel to the beams is now being built and is scheduled for delivery in the spring of 1971.

Frascati

Operation of ADONE for experiments began in December 1969 with head-on collisions at a maximum energy of 1.2 GeV. A second pair of r.f. cavities which will make it possible to reach the design energy of 1.5 GeV are scheduled for installation in a few months time. Design values for the luminosity are being achieved at energies above 950 MeV and the total integrated luminosity, over 1360 hours of effective two-beam time up to August of this year, was about $10^{36}/cm^2$ (about $2.5\times10^{35}/cm^2$ in each experimental region).

Three methods are used in measuring the luminosity (small angle scattering, single and double beam-beam bremsstrahlung) and the measurements are now in agreement within the expected accuracy of about 20 %. The energy dependence of the luminosity is steeper than expected on the basis of the beam-beam incoherent effect (varying to the power of 6 rather than the power of 4). The maximum luminosity achieved has been about $3\times10^{29}/cm^2$ s at 1 GeV.

Several groups reported their first results. A Naples, Pavia, Frascati collaboration have 1700 events of large angle electron-positron scattering in the energy range 750 to 1000 MeV. The comparison with small angle results is consistent with the prediction of quantum electrodynamics (QED). About 200 non-coplanar events in the same energy range have been observed and this corresponds to a cross-section of $(3\pm0.3)10^{-32}/cm^2$ on the hypothesis that four charged particles are produced.

A Bologna, CERN, Frascati collaboration has also observed large angle scattering compared to small angle scattering consistent with QED. Muon pair production (200 events total, 150 events corrected for background) is also consistent with QED. About 20 events showing collinear hadrons have been observed corresponding to a cross-section of 0.49 ± 0.19 for the production of a point-like boson. Non-collinear, non-electromagnetic events represent about 3 % of the large angle scattering data.

A Genoa, Padua, Rome, Frascati collaboration have similar confirmations of QED and their observations of collinear hadrons give a cross-section of 0.48 ± 0.24 for the production of a point-like boson. They have recorded 66 'many-body' events (three or more charged particles observed) corresponding to a cross-section of about $3\times10^{-32}/cm^2$ on the hypothesis that four charged particles are produced.

A Rome, Frascati collaboration has studied the angular distribution of gamma rays emerging from 200 events of the type

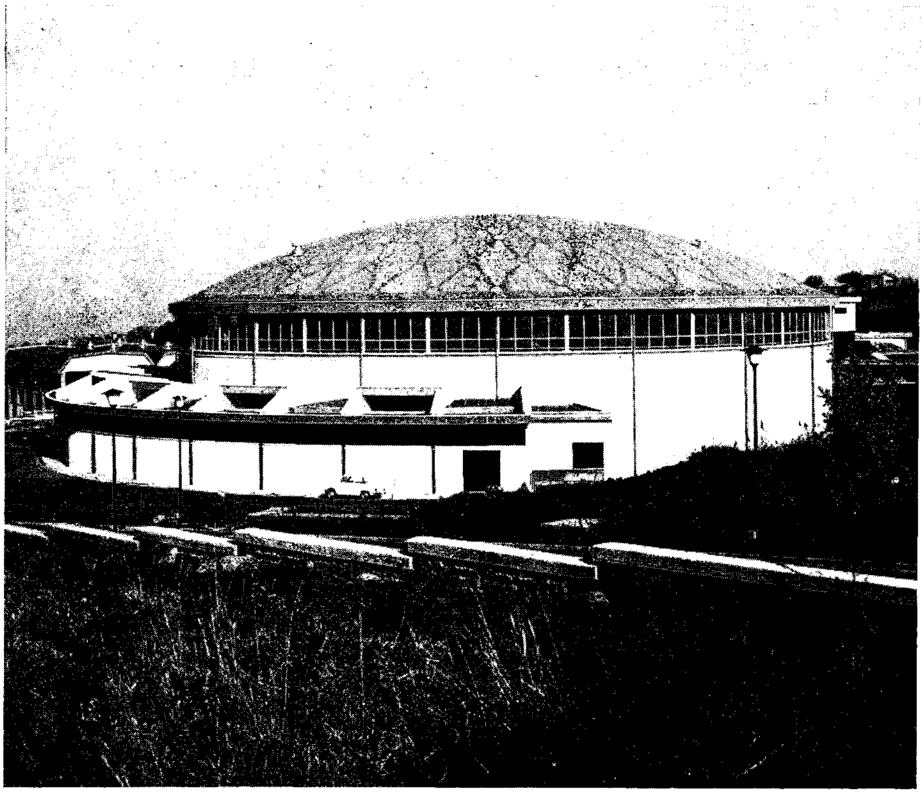
$$e^+ + e^- \rightarrow \gamma + \gamma$$

The results are in agreement with the prediction of QED. They have also recorded 14 events where many charged or neutral particles are produced — 9 show one or two charged particle tracks together with showers from gammas, 4 show three or four charged particle tracks, 1 shows two showers from electrons together with a shower from an electron or gamma. An upper limit for the cross-section of the interaction

$$e^+ + e^- \rightarrow \pi^+ + \pi^- + \pi^\circ$$

is estimated as $1.5\times10^{-32}/cm^2$.

These results from ADONE can be summarized as follows: Large angle electron-positron scattering and pair-production is in accord with QED up to momentum transfers of 2 GeV/c in the time-



The elegant building at Frascati which houses ADONE the highest energy electron-positron storage ring currently in operation. The Frascati Laboratory was host in September to an informal meeting on electron-positron colliding beams.

(Photo CNEN)

line region and 1.5 GeV/c in the space-like region. The production of hadron pairs is unexpectedly high, the cross-section being about half that for the production of a point-like boson. The result is significant even though the statistics are still poor. Many-particle production is still under discussion in terms of identifying the products but there is a common opinion that a sizable fraction of them are hadrons. The interpretation of this high production rate is still unclear.

Novosibirsk

For those who get mixed up in their VEPPs the list at present is as follows:

VEPP2 is a 700 MeV electron-positron storage ring which is in operation for physics with beams of 40 mA positrons and 70 mA electrons.

VEPP2' is being designed to achieve high luminosities, in the region of $10^{31}/cm^2\,s$, with 100 mA per beam and a low beta section. VEPP2 is intended to be used to store the positron beam before injection into VEPP2'. It will cover the low energy range when its partners of higher VEPP number come into operation.

VEPP3 is being tested with low intensity electron beams and two beam operation is scheduled for the summer of 1971. The expected luminosity at 2 GeV is $3\times10^{30}/cm^2\,s$. The peak energy with the r.f. power presently installed is 2.5 GeV.

VEPP4 may be used for electron-positron colliding beams up to 10 GeV peak energy. The magnet is almost all installed and the ring is scheduled for completion in 1971. In 1972 it is intended to inject protons and anti-protons — then the ring becomes a VAPP.

New experimental results were reported from VEPP2. Measurements on the phi meson have given a production cross-section of $(3.96\pm0.35)\ 10^{-30}\,cm^2$ with a width of 4.67 ± 0.42 MeV. The observed decay rates were $54\pm3.4\,\%$ into positive and negative kaons, $25.7\pm3.0\,\%$ into neutral kaons, $20.3\pm4.2\,\%$ into three pions. Checks of QED from measurements on muon pairs and wide-angle gamma pairs gave lower limits for the boson mass of 2.3 GeV (from muons) and 1.3 GeV (from gammas).

Non-collinear and non-coplanar events were observed at three energies 590, 630 and 670 MeV. The total number of events of this type with two charged particles was 94 (compared to 35 muon pairs).

Orsay

The storage ring ACO at Orsay has been for several years probably the most fruitful source of electron-positron colliding beam physics. Recent improvements in the ring performance have included achieving a higher positron flux so that the injection rate is now 1.2 A per hour in two bunches under the usual operating conditions. A higher pumping speed on the ring has given an increased beam lifetime (45 hours at 510 MeV).

A new periodic structure is being tried on the ring in an attempt to reduce beta in the collision regions and thus increase the luminosity by as much as a factor of twenty. The first experiments on the new structure are promising. There has also been a first experiment on beam polarization with improved apparatus which has yielded results close to those expected both as regards polarization time and percentage. It has been confirmed that on passing through a resonance at 440 MeV the polarization is lost.

A project for a new storage ring at Orsay was described in vol. 9, page 382. It has now been trimmed down a little and the possibility of building a pair of 1.5 GeV rings in the end station of the electron linac building is being studied. Luminosities in the range of $10^{32}/cm^2\,s$ with beam currents of the order of 1 A are expected.

Recent physics experiments with ACO have studied the phi decay into eta and gamma, and into neutral pion and gamma. The rates (compared to all decays) were measured as 0.02 ± 0.0075 and less than 0.0024 respectively.

Stanford

The Stanford Linear Accelerator Centre had been studying a two asymmetric ring scheme known as SPEAR (see vol. 9, page 271). They are now beginning construction of one such ring with maximum energy initially limited to around 2.5 GeV but capable of extension to 4.5 GeV. The design luminosity is $10^{32}/cm^2\,s$ at 2 GeV. Operation is planned for mid-1972. A fuller description will appear in the next issue of CERN COURIER.

On the theoretical side there were two main topics discussed during the Meeting — the two-photon interaction, and models to explain the observed hadron production. The two photon interaction, in for example $e^+ + e^- \rightarrow e^+ + e^- + (\pi^+\pi^-$ or $e^+e^-...)$ has a cross-section which increases slowly with energy and therefore is of particular interest for study at the higher energy colliding beam rings. This type of event should be mostly coplanar and not collinear with two electrons travelling in the line of the primary beams. The multiple events observed at Frascati cannot be explained by this sort of analysis both for kinematical reasons (since they should be mainly coplanar) and because the absolute rate is lower than predicted.

To explain the hadron production, the most promising approaches seen to be variants of the parton model. More accurate experimental data will be needed to select between the different theories.

The Role of Nuclear Particle Physics in European Science and Education

In conjunction with the formal papers presented at the session of the CERN Council reported earlier in this issue, a booklet entitled 'The European 300 GeV Accelerator Programme' (more colloquially known as 'the white book') has been prepared. It aims to present the 300 GeV project and its background in a more general way.

We reproduce here the opening chapter which puts the research at CERN and related Laboratories in Europe in the context of European science and education.

Nuclear particle physics — a basic science

Nuclear particle physics is one of the basic sciences which has enjoyed a continuously evolving history in Europe ever since the discovery by Rutherford in 1917 that one of the components of the atomic nucleus was the proton and the discovery by Chadwick in 1932 that another component was the neutron. It is, however, only the most recent phase of the search for the fundamental constituents of matter and the laws governing their interactions. The original enquiry can be said to have started in ancient Greece, with Democritus, who postulated that atoms formed the building blocks of all material objects. Thus Europe not only was the cradle of this fundamental enquiry, but has supported its development over many centuries, and today continues to support those of its scientists who work on this basic research in its latest form.

As the frontiers of this research have advanced decade by decade, there has been left in their wake a vast knowledge of the material world which has illuminated other sciences, notably chemistry, metallurgy and other solid-state sciences. The application of this knowledge has moulded the form of modern civilization and has helped man to live at ease with his environment. It has also given man great power over the physical world, which has transferred his fears away from a seemingly capricious and hostile environment back to himself, his social problems and the deleterious effect he is now having on the environment he once feared.

Bigger tools cost more money

As the research has pushed forward in the last three or four decades, the research tools have grown larger and more costly and this has changed the character of the work though not its method. As in other basic sciences, progress in understanding depends on the interplay of theory and experiment. Without experiments, theories remain unchecked; without theories, experiments lack generalized explanation. The essential experimental tools are nuclear particle accelerators which generate beams of high-energy particles, and these beams of particles, impinging on the target nuclei, are used to create new entities whose properties and interactions are the object of the research.

As the research has progressed, more and more new particles and resonant states have been discovered and their place in the scheme of nature partially unravelled. But instead of getting simpler as the research has progressed, the nucleon world has proved to be more and more complicated and, as the complications have been uncovered, the need for more and more energetic beams of particles has steadily increased. To create beams of particles with more energy requires larger particle accelerators, and larger accelerators cost more money.

However, as the size and cost of a particle accelerator increases, the number of scientists which can use it also increases and the machine is designed to operate for more and more years. Thus the cost per scientist per year has not increased dramatically as the accelerators have grown. For example, it is estimated that the 300 GeV Programme will provide experimental facilities for over 1000 nuclear particle physicists in the European universities for a period of thirty years or more.

International action

In the early 1950s the size and cost of accelerators had grown so large that 12 European States decided to join together to build an international laboratory which would house a very large particle accelerator. Only in this way could the essential research facilities for nuclear particle physics be provided for the European universities at a cost which was acceptable to the European States. Thus CERN was founded near Geneva in 1953, and its accelerator, a 25 GeV proton synchrotron, first came into operation at the end of 1959.

A method was thus found to continue the research in Europe and at the same time an experiment was carried out in European co-operation which was to prove useful as a basis for more extensive collaboration in other fields later on. The foundation of CERN and the concept of joint European research illustrate the relationship of nuclear particle physics to European science and education which is the subject of this chapter.

The growth of the basic sciences

The 1950s and early 1960s were a period of extraordinary growth of national projects sponsored by Governments, military projects, technological projects, and projects aimed at improved material well-being. In all these projects science was seen as the key to success and, since they required a great number of scientists, the university system, particularly the science departments, was rapidly expanded to meet the needs. The teaching staff at the universities expanded with the increasing output and, since it was considered essential to carry out research in order to be able to teach effectively at the university level, the support for research increased accordingly. Also, basic research was seen to be essential as the source of new ideas and new knowledge for the national projects, which consequently invested a substantial part of their budgets in basic research.

The growth of nuclear physics

During the whole of this period, therefore, basic science in the universities and elsewhere increased rapidly in volume, and those basic sciences which most closely related to the national projects increased the fastest. Nuclear physics related strongly to many of the projects, to military nuclear projects and civil nuclear energy projects in particular. Also, as sometimes happens in scientific research, the subject was ready to respond to this social pressure since the techniques were available and the scientific concepts sufficiently well developed. This coincidence of a popular demand and an ability to respond to it led to a rapid growth of the nuclear sciences in Western Europe, America, and Russia.

Limitations to the growth

All growth, however, is limited; in a finite system the parts can only grow to a certain size; inevitably in time a plateau is reached. The first signs of growth limitation in nuclear particle physics were evident in the mid-1960s, first in Britain and then, soon afterwards, in America. It can be traced primarily to a certain disenchantment of the public with the national projects which had been selected earlier and to a growing preoccupation of Governments with economic affairs. The application of cost/benefit analysis to Government investments became widespread and as benefit was often equated with relatively short-term economic benefit some of the national projects were found unsatisfactory.

As the budgets for these projects levelled off, so did their support for the basic sciences. Also, the basic sciences were examined in their own right and since it is difficult to prove economic benefit from investment in basic research, at least on the time scales of Government activities, the purpose of the basic sciences in the universities and elsewhere was questioned closely.

These two effects combined in the late 1960s to cause a general levelling off of the investment by Governments in basic science and the growth rate at present, at the beginning of the 1970s, is very much smaller than that of the early 1960s. It is against this background that the future support for nuclear particle physics in Europe must be examined and the new 300 GeV Programme justified.

The growth potential

As far as the research itself is concerned, there is little doubt of its growth potential or what the next step should be. This question has been discussed and debated for many years and the answer has always emerged that a larger particle accelerator, of an energy of 300 GeV or more, is required if the research is to continue to progress in Europe during the 1980s and 1990s. Such a machine could only be built nowadays in Europe by collaboration between the Member States of CERN using the Organization which they have built up over the past 17 years and, when it comes into operation, it will serve as the principal research tool for all the universities in Europe engaged in nuclear particle physics for many decades ahead, probably to the end of this century.

Future support for nuclear particle physics

The questions which arise, therefore, concern not so much the kind of new facilities required, or the growth potential of the subject, or the methods by which it should be achieved, but rather the support which should be given to this particular basic science in Europe in the future and its relationship to European affairs and interests. It now seems clear that the special relationship between nuclear physics and the national projects of the 1950s no longer exists or exists only indirectly through the higher education system and therefore it is the relationship between nuclear physics and higher education, particularly the university system, which should be examined and where the main justification must lie. This is not to say that no further technological advances will arise from this research in the future. On the contrary, unless there is a sharp break with the past, new technologies and even new industries, as yet unknown, may be predicted with some confidence.

Nuclear particle physics and the university system

The relationship between nuclear particle physics and the university system falls broadly into two parts. On the one hand, this research adds to knowledge about the natural world which it is the purpose of all basic sciences to increase. On the other hand, scientists taking part in this research teach in the universities at both the undergraduate and graduate levels, and hence the investment in nuclear physics also helps to produce new graduates and postgraduates from the university system.

It should be remembered that the trained manpower output of a university is principally at the first degree level and that these graduates are subsequently employed in industry, commerce and other social activities. Only a fraction of the first degree graduates continue in the university system and carry out basic research.

Nuclear particle physicists in the universities, in company with other academic scientists, teach not just their own specialization but mainly general courses in physics to physics undergraduates and to undergraduates in the other disciplines of science. In other words, nuclear particle physicists take a full part in university teaching at all levels, and since they are often numerous their contribution to the graduate output of the university system is correspondingly large. It is therefore important to consider how the manpower output of the European universities is likely to develop in the future and how this development will affect nuclear particle physicists in their capacity as teachers and researchers.

Further expansion of higher education

It seems very likely that the demand for more university-type education, particularly in the sciences, will continue to grow in the next decade, and it might therefore be expected that basic scientific research will grow with the output of the universities. Several factors could, however, intervene to moderate the growth of basic scientific research in the universities in the future.

In the first place, the money allocated to the basic sciences by Governments may not increase proportionally with a further increase in university education. In the second place, within whatever allocation is made to the basic sciences, nuclear particle physics may not grow at the same rate as other basic sciences. Thirdly, within whatever growth rate is allocated to nuclear particle physics in the future, it may not be possible to accommodate the capital expenditure necessary to build the very large nuclear particle accelerators essential for carrying the research forward. These factors therefore need to be examined.

Will the basic sciences grow with the university system ?

If university education in science expands in the future without an increase in financial support for the basic sciences, it will be necessary to review the premise that research activity is essential to teaching at the university level. This premise is a very old one and is based on the notion that the function of a university is to create knowledge, to preserve knowledge and to teach knowledge. All these activities were, and still are, considered essential in a university in order to produce, by association with the best brains of the day, young people with informed and critical minds able to replace their elders in all aspects of the European societies. However, other forms of higher education which do not involve a research activity exist in Europe and could be expanded, although it may be questioned whether the quality of the output of these alternative systems is sufficient for a modern society which is steadily becoming more complex and more science-based.

Will nuclear particle physics grow with the other basic sciences ?

Within whatever growth rate is decided on in the next decade for the totality of the basic sciences as a component of higher education in the university system, nuclear particle physics could be allocated a lesser growth rate if it was concluded that other basic sciences were more important for the future of a society and gave a sufficient scientific background for future generations of scientific manpower emerging from the university system. For example, it might be concluded that a higher proportion of biologists was required in the future than at present, and that the basic science budgets should be modified to assist this change in the output of the university system.

In the physical sciences, however, nuclear particle physicists in the universities teach physics to undergraduates, not just nuclear particle physics, and their teaching, because of their association with a wide range of scientific and technological skills, is particularly suited to producing graduates broadly based in science. Also it can be argued that some knowledge of such a fundamental science as nuclear particle physics is indispensable to any new generations of university science graduates.

A possible growth rate for nuclear particle physics

Although some growth rate in expenditure on nuclear particle physics as a component of university scientific education seems likely in the next decade, in the absence of clearly defined plans for university science expansion in the different disciplines, it is difficult to predict what that growth rate will be in the various countries of Europe. A guess might be that it will lie in the range of 3-6 % per annum bracketing a predicted growth rate of the overall European economy of about 4 1/2 % per annum during the decade 1970-1980.

It should be noted that, owing to the increasing cost of experimentation in nuclear particle physics (the next experiment usually costs more than the last one because the apparatus required is more complex), a growth rate in the range 3-6 % per annum will not allow any growth in the number of nuclear particle physicists in the next decade and the lower figure will require a reduction in their numbers.

Can a 300 GeV machine be afforded ?

It remains then to consider whether, with an annual growth rate of this size, the 300 GeV Programme could be accommodated on a European basis. The Project A version of the 300 GeV Programme would require a growth rate in the international part of nuclear particle physics expenditure of about 9 1/2 % per annum over a period of eight years. The Project B version would require about 6 1/2 % per annum.

The ratio of national to international expenditures on nuclear particle physics varies widely amongst the Member States of CERN. In some of the larger countries the ratio is three to one, in others expenditure is equally divided between the national and international components, and in some of the smaller countries the international component predominates. In the second case, for example, the Project B version of the 300 GeV Programme could be accommodated within a total growth rate for nuclear particle physics expenditure of about 3 % per annum over the next decade if the national expenditure was held at about a constant level during this period. Some countries may also allow a bump to occur in an otherwise smoothly and slowly increasing expenditure profile in order to accommodate a single capital investment of this magnitude and plan to level off the annual expenditures later on.

Thus in each Member State of CERN the financial impact of the 300 GeV Programme in the next decade is different and dependent on national science and education policies. Overall, however, it seems that the Project B version of the 300 GeV Programme, at least, would not distort the development of the various basic sciences in the European university system in the next decade and could be accommodated within likely growth rates for nuclear particle physics. No special relationship between nuclear particle physics and any national projects need be invoked in the agreement nor any growth rates of the national university systems in Europe in the future, which cannot now be predicted with any confidence.

CERN — a successful example of international collaboration

The relationship between nuclear physics and the European science and education system has been explored in some detail in this chapter since this seems the principal way in which this basic science relates to European affairs. There is, however, another relationship which should not be ignored, which is the wholly beneficial effect CERN has had on European collaboration in science.

Amongst the many European scientific organizations set up since 1950, it may be claimed that CERN still maintains its leading place as the example of effective and successful collaboration in Europe. This has not been at all an inward-looking collaboration, content only to satisfy European needs, but has successfully pioneered collaborative programmes with America, with Eastern European countries, with the Soviet Union, and with the Middle-Eastern and Eastern countries.

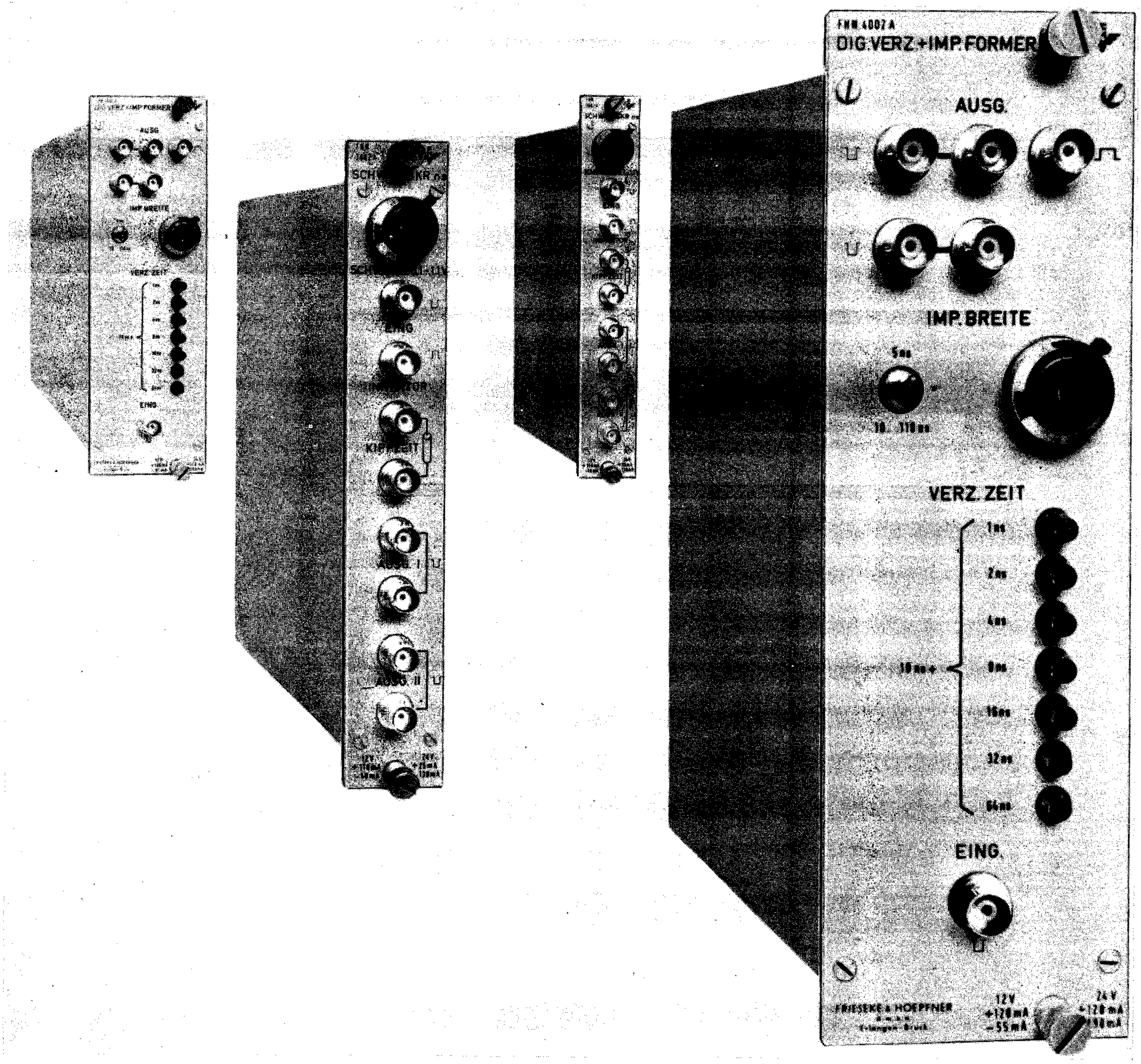
It is impossible to put an economic value on all these collaborative efforts, which sprang from the ideas and ideals of those statesmen and scientists who first founded the Organization, but in the years to come it may well be concluded that important though the contribution of CERN has been to nuclear particle physics in Europe, its contribution to international collaboration has been of no less value.

The choice

The future progress of nuclear particle physics in Europe and the role of CERN in research in the future depend critically on the 300 GeV Programme, for without it this basic science seems likely to decline steadily in Europe in the next decade. In the Soviet Union, at Serpukhov near Moscow, a particle accelerator nearly three times the energy of the present CERN 25 GeV machine has been operating for several years. Next year, or early in 1972, a 400 GeV accelerator will come into operation in America, at Batavia near Chicago. The major experimental facilities for this research in Europe are rapidly being surpassed by those in Russia and America. If this basic science is allowed to die out in Europe it will leave a great gap in the university education system of the whole continent. If the subject gradually declines, CERN will also wither away and Europe will lose its principal example of successful international collaboration.

Alternatively, if the 300 GeV Programme is approved towards the end of this year, European nuclear particle physics will be equipped with the necessary research tools until the end of this century, and CERN will be able to continue to play its international role as the European centre for this research.

Every one of them . . .



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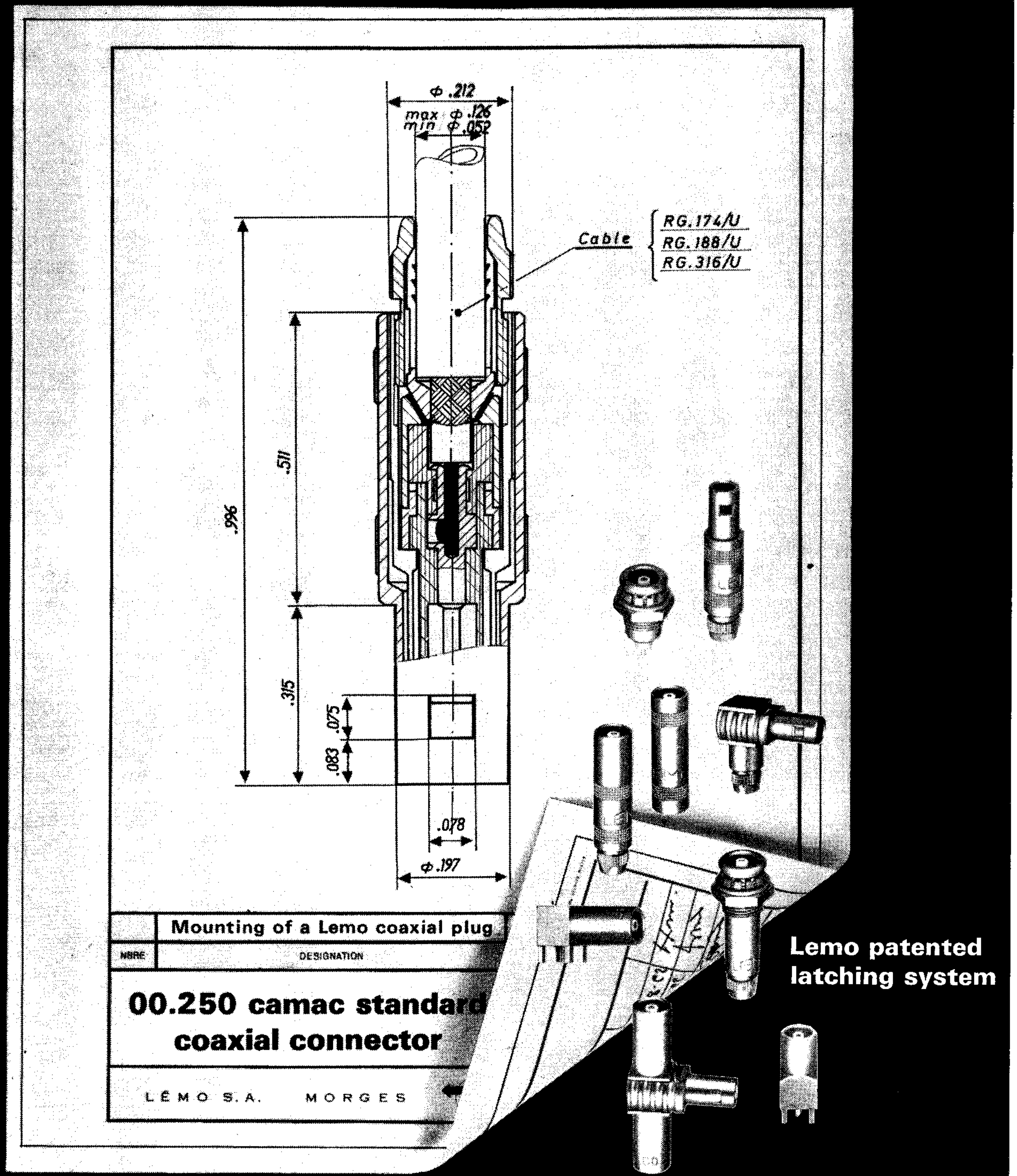

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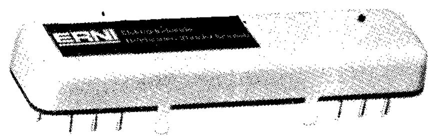

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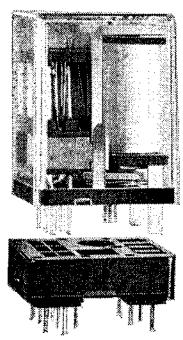

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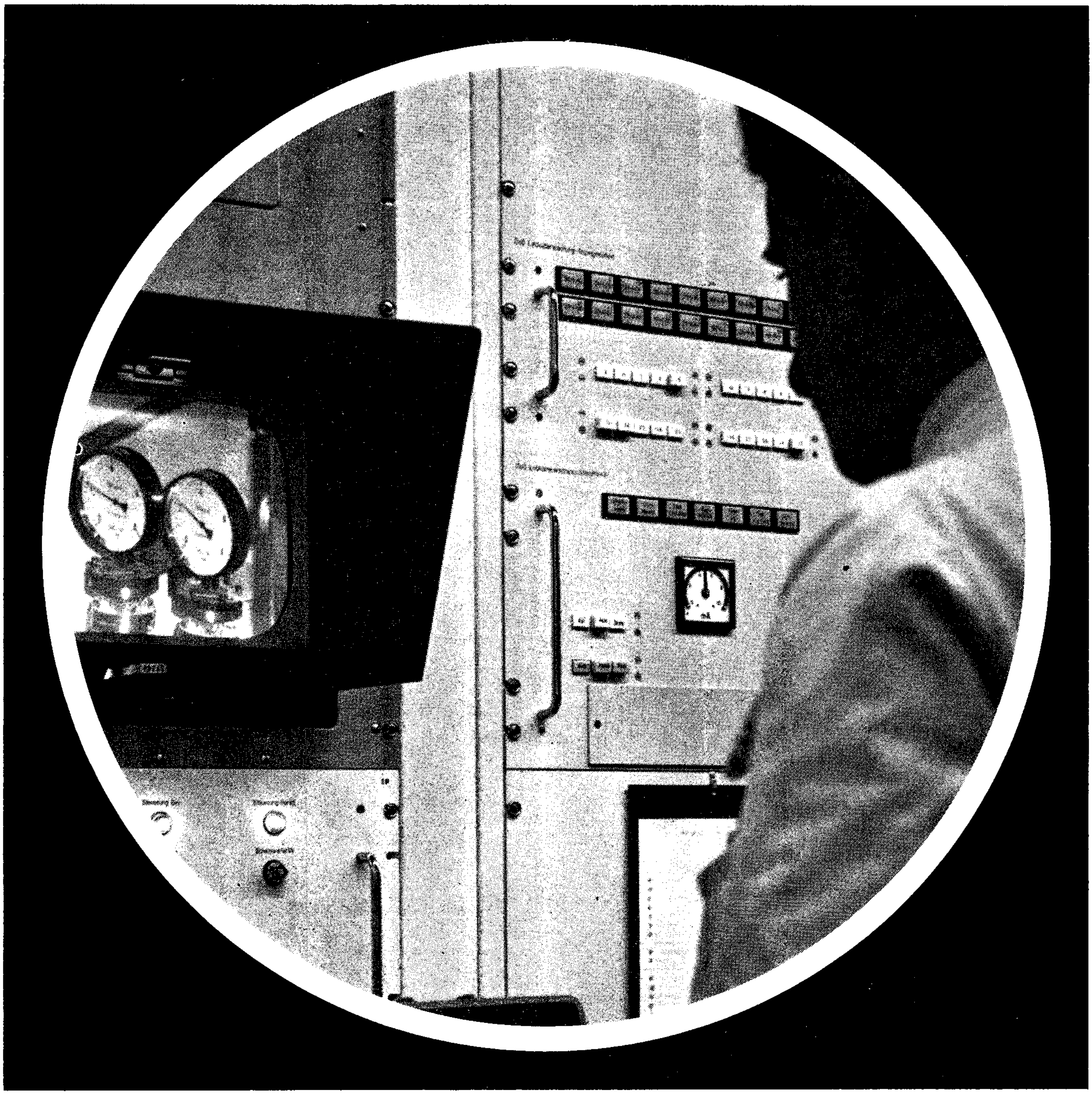

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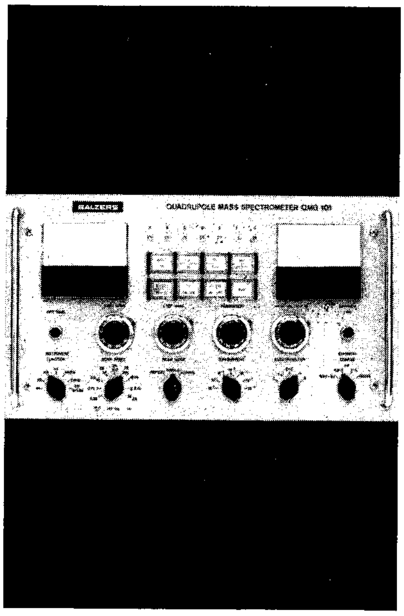

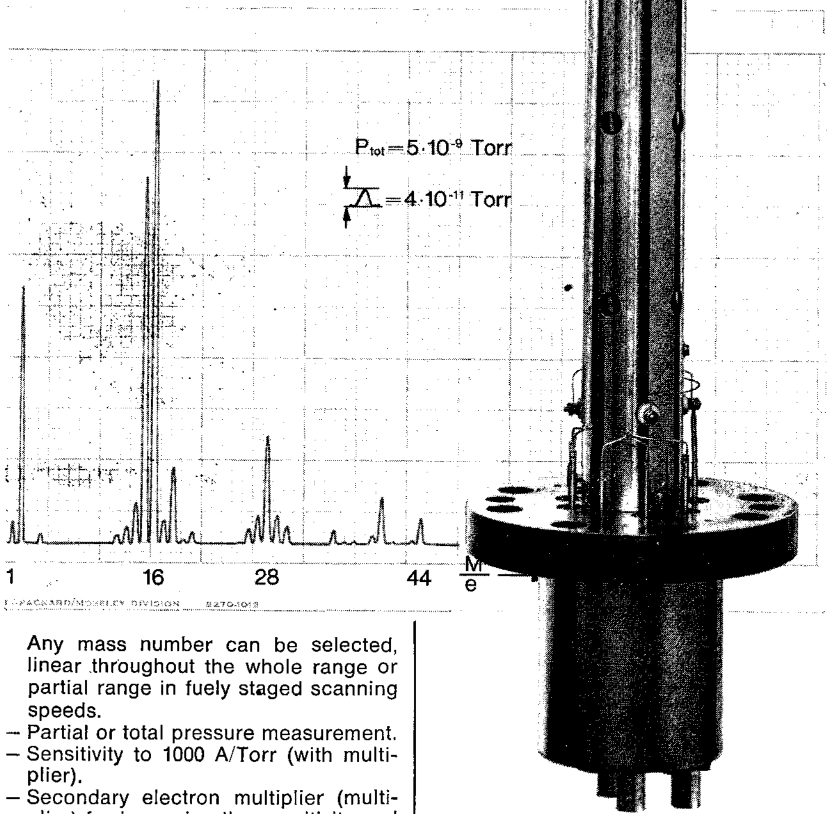

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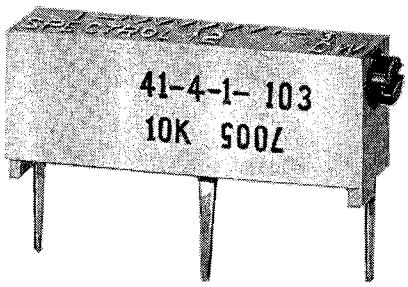

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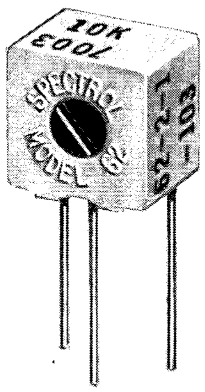
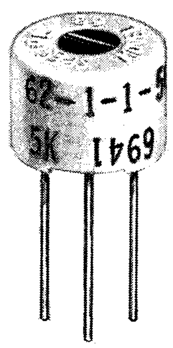
—65° C at 125° C

The narrow housing of this popular trimmer allows tighter side-by-side installation and closer board socking - you save space and money.





Model 62

10 Ohm - 1 MOhm
0,75 W at 25° C
—65° C at 125° C

Top and side adjust versions.
The model 62 is a high performance single turn cermet trimming potentiometer, ideally suited for applications requiring subminiature size coupled with low cost and dependable service.

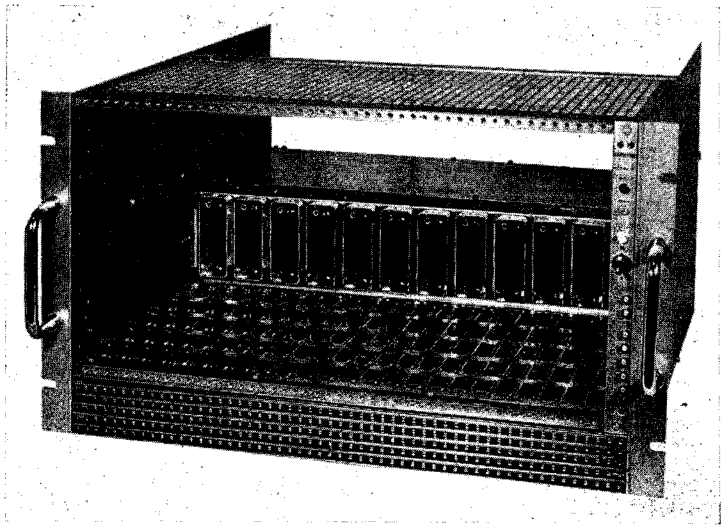
Almost infinite resolution, a resistance from 10 Ohm up to 1 MOhm, stability under severe conditions, and 'last but not least' the price. These are good reasons to have a close look to these Cermet trimmers. For further details ask for data sheets and the price list 14TR870. Call or write us and we will tell you more about the advantages of SPECTROL trimmers.

elettronica Pero, Milano

P.O. Box, 8021 Zurich, Tel. (051) 42 99 00

baerlocher

C7 ALN 13



CHÂSSIS ALIMENTATION NIM

- **Ce châssis pour tiroirs modulaires est destiné à l'alimentation des éléments fonctionnels normalisés NIM-TID 20 893.**
- **Permet le montage de 12 tiroirs**
- **Utilise l'alimentation P 7 ALN 10 délivrant:**
  + & — 24 V 3 A
  + & — 12 V 3 A
  + & — 6 V 6 A
  + 200 V 0,1 A
  117 V 50 Hz 0,5 A
  Puissance utile 200 watts
- **Trois ventilateurs pour le refroidissement des tiroirs**
- **Brochage du connecteur: 42 contacts.**

+ 200 V	+ 24 V	— 24 V	+ 12 V	— 12 V	+ 6 V	— 6 V	117 V alt.	0 V	Masse spéc.
8	28	29	16	17	10	11	33 et 41	34	42

CARACTÉRISTIQUES PROVISOIRES

Tension de sortie	± 24 V	± 12 V	± 6 V	+ 200 V
Plage de sortie	± 5 %	± 5 %	+5 % à —18 %	± 10 %
Régulation pour 100 % de variation de charge et les variations du réseau (+ 10 % à — 12 %)	$\pm 5.10^{-4}$	$\pm 5.10^{-4}$	$\pm 10^{-3}$	$\pm 5.10^{-2}$
Coefficient de température de 0 °C à +60 °C	2.10^{-4}/°C			
Dérive à long terme à charge constante après 24 h et sur 6 mois	$\pm 3.10^{-3}$			
Ondulation résiduelle et bruit crête à crête	⩽ 2 mV	⩽ 2 mV	⩽ 3 mV	5 mV
Réponse transitoire (overshoot et undershoot inférieurs à 10 %)	⩽ 20 µs			
Impédance de sortie dynamique jusqu'à 100 kHz	0,3 Ω	0,3 Ω	0,15 Ω	
Sécurité individuelle par limitation du courant réglé à	3,3 A	3,3 A	6,6 A	fusible
Plage de température	0 °C à +50 °C sans derating			
	de +50 °C à +60 °C avec derating de 3 %/°C			
Protection thermique	2 vigithermes: > 50 °C Lampe orange > 60 °C Lampe rouge et coupure de l'Alimentation			
Visualisation d'une surcharge	un voyant par tension			
Réseau	220 V 50 Hz (possibilité 117 V)			
Dimensions	483 × 525 × 6u			

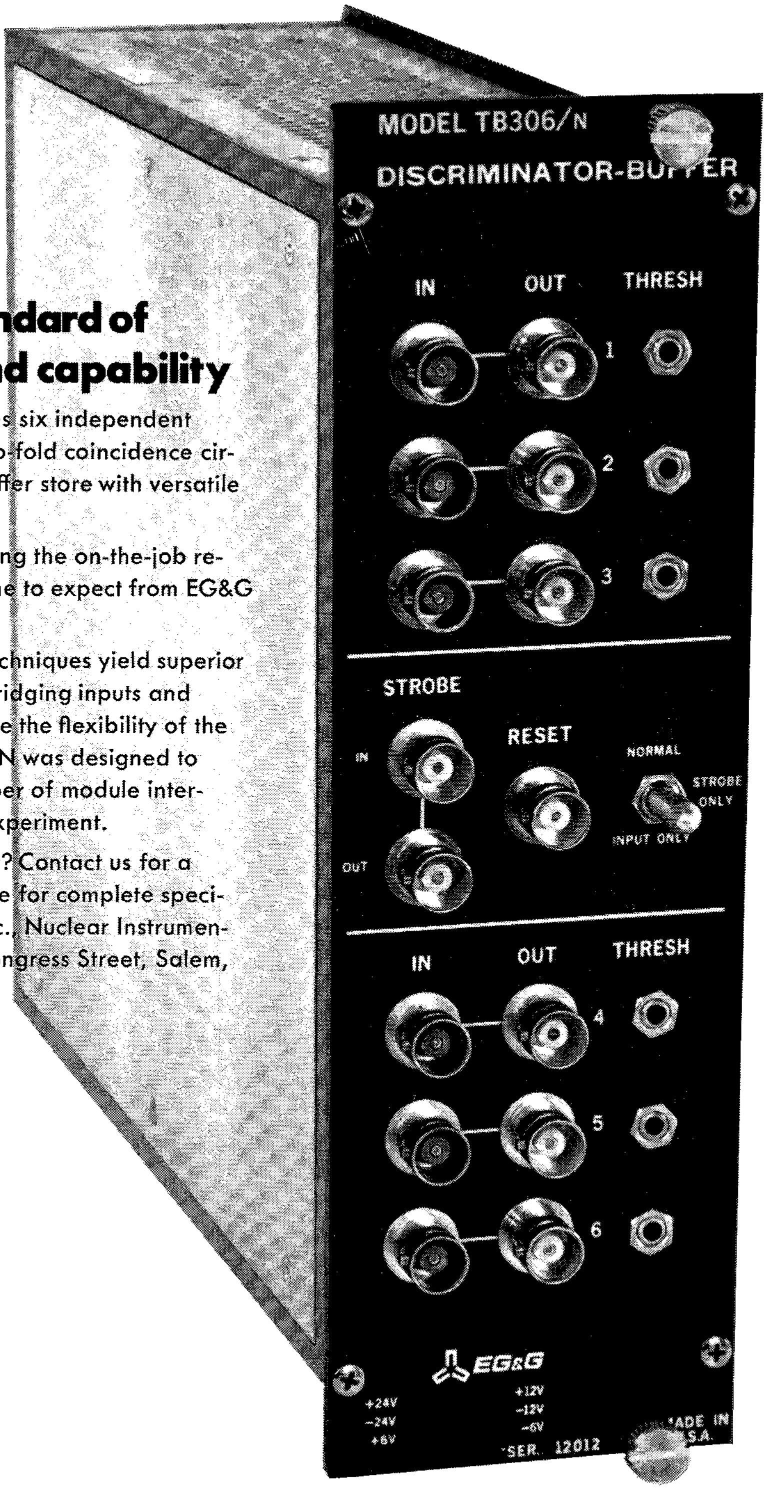
SAPHYMO-SRAT

DÉPARTEMENT ALIMENTATIONS

SERVICES COMMERCIAUX

51, RUE DE L'AMIRAL-MOUCHEZ
75-PARIS XIIIe
Tél. 588 45 39 - 588 16 39

Our New Discriminator/Buffer Module



A higher standard of reliability and capability

The TB306/N contains six independent discriminators, six two-fold coincidence circuits, a fast six-bit buffer store with versatile outputs and controls.

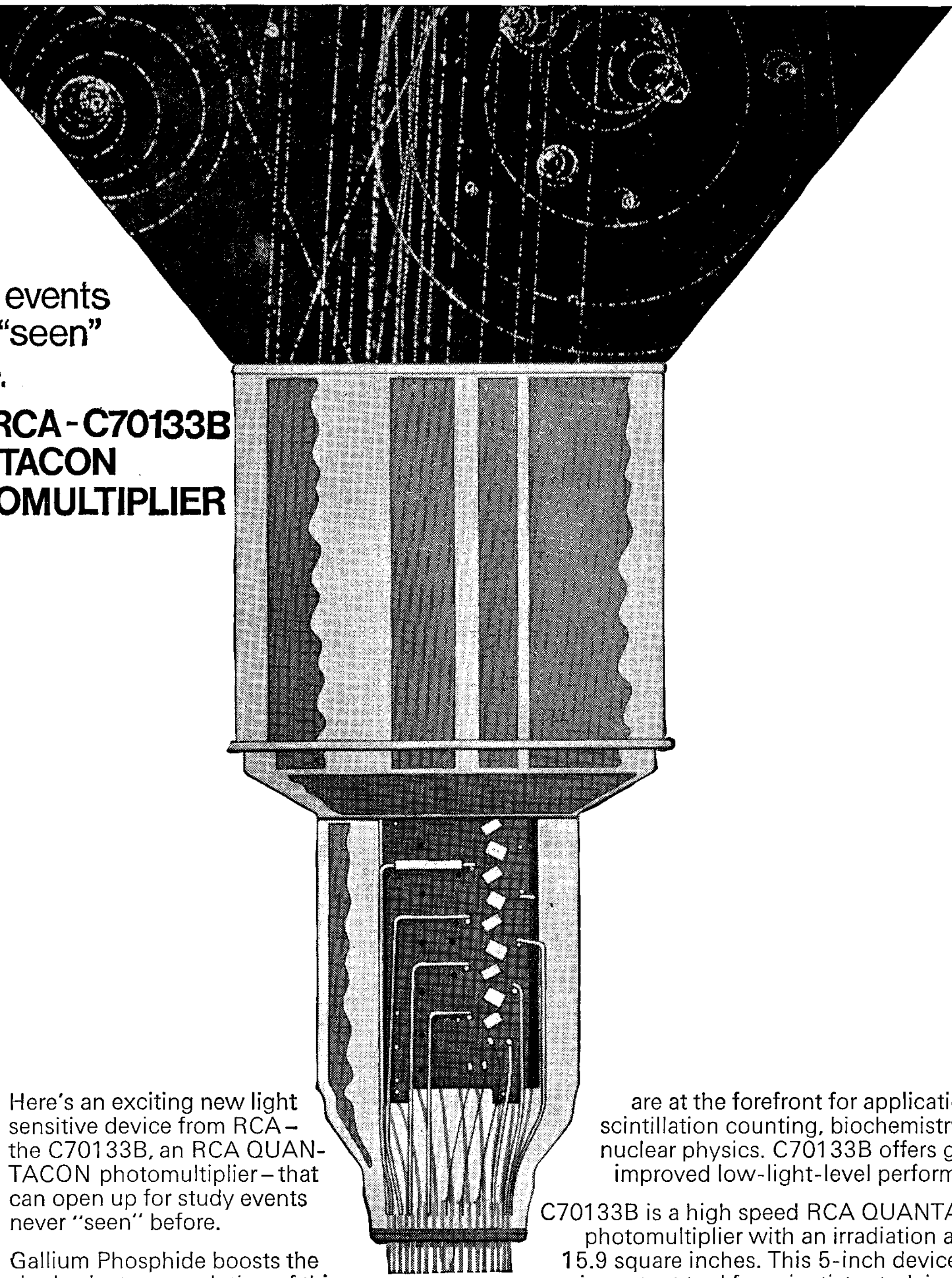
All without sacrificing the on-the-job reliability you have come to expect from EG&G modules.

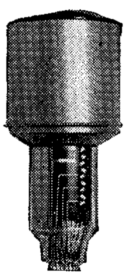
Improved circuit techniques yield superior noise margins, and bridging inputs and strobe further increase the flexibility of the module. The TB306/N was designed to reduce the total number of module interconnections in your experiment.

Want us to prove it? Contact us for a demonstration or write for complete specifications to EG&G, Inc., Nuclear Instrumentation Division, 35 Congress Street, Salem, Mass. 01970.

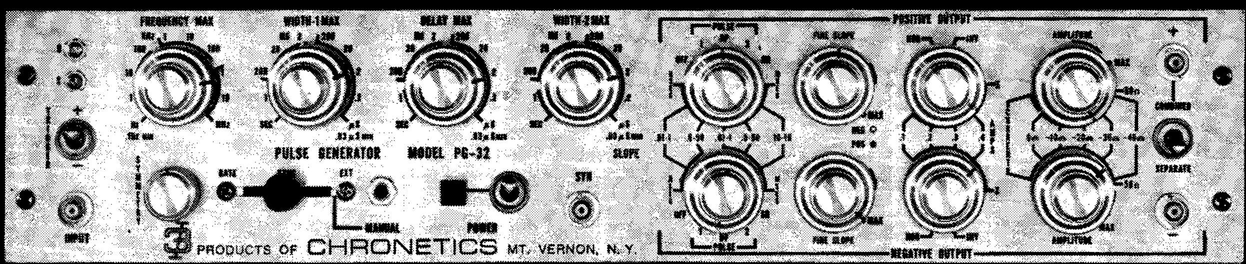
- Flexibility and lower system cost result from the fanout capabilities of the TB306/N's bridging inputs and strobe.
- Simple and accurate in-process testing is assured by the convenient test mode.
- Both space and cost are reduced, as the TB306/N's six independent circuits provide 36 channels/NIM bin.

EG&G
NUCLEAR INSTRUMENTATION DIVISION





Pulsemanship



The name of the game is versatility.

Formal designation Model PG-32 — probably the most versatile pulse generator ever designed. A single PG-32 can do just about everything two conventional pulsers can do and do it better, much more economically, reliably and simply.

The PG-32 is really two independent pulse generators in a single package, operating at the same repetition rate. Two *channels,* not just two BNC's. From either channel one can get single or double pulses, positive and negative, the complement of either, all at rep rates from 0.1 Hz to 20 MHz (double pulse) in 8 ranges plus vernier. Current pulses, ±25 mA to 400 mA, or voltage pulses, ±20 mV to ±20V, or square waves. A 3V sync.

Please note: you can control independently for each channel, rise and fall time (10 ns to 1 sec), width (independently for each pulse — 30 ns to 1 sec) and delay (50 ns to 1 sec), all over the widest dynamic ranges available. The two outputs are simultaneous and can be used separately or in combination; the combined mode makes possible DC-offsets or bipolar pulses of up to 10V. All of this comes in a 3½" high solid-state package.

With the output parameter control provided, the PG-32 is capable of producing a variety of waveforms otherwise requiring a plethora of pulse and waveform generators. *Does this tell your capital budget anything?*

We'd like to tell you more: about frequency, width, delay, stability, distortion, source impedance, gating and triggering, etc., etc.; but it can't all be done here. So . . . Invite us to your next pulsemanship match. We'll bring one of our Grand Masters, the PG-32.

CHRONETICS. *500 Nuber Avenue, Mt. Vernon, New York (914) 699-4400. Europe: 39 Rue Rothschild, Geneva, Switzerland (022) 31 81 80.*

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