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 scientifice 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 700 physicists outside CERN are provided with their research material in this way.

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 2350 people and, in addition, there are over 400 Fellows and Visiting Scientists.

Thirteen European countries participate in the work of CERN, contributing to the cost of the basic programme, 197.5 million Swiss francs in 1968, 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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Comment

These last two months, CERN COURIER has relayed information about the excellent progress of the collaboration between CERN and the Institute of High Energy Physics at Serpukhov, USSR. The June issue told the story of the first experiment involving scientists from CERN (the dispatch of equipment to Serpukhov for the experiment is photographed on the front cover) and this issue describes the near-final state of the design of the fast-ejection system being provided by CERN for the Soviet machine.

It is exactly a year ago that the Agreement between the State Committee for the Utilization of Atomic Energy and CERN was signed, and perhaps none of the signatories then expected the collaboration to progress so far within a year. There have inevitably been difficulties (CERN, for example, is now in the situation of learning at first hand the problems — long experienced by European Universities working at CERN — of being an 'outside user' in the experimental programme of a Laboratory) but the will on both sides has been such they are being overcome. All those who worked to bring this collaboration about are having their highest hopes fulfilled.

The CERN Council had the courage and faith to support the collaboration at a time when many aspects of how it might go were by no means clear. CERN itself has not been deviated by the realization that sacrifices might be necessary within its own Laboratory, for — though the cost of the collaboration is comparatively modest — in these years of belt-tightening there is not much flexibility in assigning money to projects.

Professor Weisskopf who initiated the move towards collaboration in 1965 (his last year as Director General of CERN) regards it as one of the most important developments in European physics since CERN itself was set up. He was at Serpukhov at the historic moment when the equipment from CERN arrived and felt deeply moved by the significance of this unique association of Soviet and Western European scientists. He sees it as a symbol above and beyond what it immediately involves.

Contents

Cover photograph : Crates labelled 'CERN Serpukhov' are loaded on a plane bound for Moscow on 3 July. They carried counters and electronics to be used in the first collaborative experiment between European and Soviet scientists at the 70 GeV proton synchrotron of the Institute of High Energy Physics, Serpukhov. (CERN/PI 54.7.68)

CERN News

Fast ejected proton beam for Serpukhov

As reported in the previous issue, a delegation from the Institute of High Energy Physics, Serpukhov, came to CERN in June. One of the items on their agenda was to finalize some details concerning the fast ejection and external proton beam transport systems which CERN is supplying for the Serpukhov 70 GeV proton synchrotron as part of the CERN-Serpukhov collaboration. (See CERN COURIER vol. 7, page 123 for details of the Agreement between the two Laboratories and for a general explanation of fast ejection.)

For the moment, two fast ejection systems are planned for the 70 GeV machine — the so-called 'channel A' being provided by CERN, and 'channel B' being built at the Institute for Electrophysical Apparatus, Leningrad (sometimes less reverently known as Komar's Shop — it is directed by Professor E. G. Komar).

System A has evolved as follows : In the original publications it appeared as a two magnet system, using a fast kicker magnet and a septum magnet, both hydraulically plunged into the vacuum vessel of the machine, as were the first fast ejection magnets used on the CERN proton synchrotron. Preliminary studies on this basis were undertaken by CERN early in 1967. At a joint meeting of experts held in Serpukhov in June of that year, the Soviet scientists proposed a new layout with a stationary septum magnet at the inside of the orbit which would use local closed-orbit deformation to bring the beam in front of the septum shortly before ejection. This involves introducing additional magnetic fields in the ring so that the regular, quasi-circular, closed-orbit of the protons is locally distorted at the position of the septum magnet. Owing to their shape, these deformations are popularly called 'bumps'.

CERN presented a design study based on this layout in September 1967. Different possibilities were considered in this study and, in addition to the bump for the septum magnet another bump was proposed to bring the proton beam into the gap of a stationary kicker magnet. This scheme would make it possible to benefit from the relatively high kick strength of a small aperture kicker, and to use an adapted version of the kicker at present used on the CERN machine (but without moving mechanism), thus saving the development time which is needed for these advanced types of pulsed magnets. On the basis of this proposal more detailed studies were made in the autumn of 1967.

It was found, however, that the creation of closed-orbit deformations requires substantial equipment and a prolonged study of their possible influence on the accelerator behaviour. Though results of the latter study were encouraging, the hope of eventually achieving higher energies than 70 GeV in the accelerator (an energy as high as 85 GeV has been quoted) resulted in the decision to work without bumps. An additional, intermediate, septum magnet with a hydraulic mechanism then became necessary.

This septum and the kicker will do the job of bending the proton trajectories into the other, stationary, septum magnet which completes the bending out of the ring. Using the additional septum also relaxes somewhat the parameters of the kicker magnet and provides some more flexibility in conjunction with the second ejection channel B.

The intermediate septum magnet and its hydraulic plunging mechanism will be provided by CERN. It is a common and essential element for both the systems A and B (they are physically very close together in the machine) and there has therefore been close liaison also with Komar's Shop in fixing the details of this magnet. The final layout was agreed jointly between Serpukhov, CERN and Leningrad at a meeting at Serpukhov in March.

The three magnets have the following preliminary parameters:

Kicker: located in straight section 16, hydraulically-plunged pole-pieces or full-aperture type, length about 3 m, angular deflection about 1 mrad, pulse length variable in steps of 0.15 μs from 0.15 μs to 5 μs, up to 3 pulses possible within one acceleration cycle at intervals of 0.25 s.

Intermediate septum : located in straight section 24, hydraulically plunged, length 2 to 3 m, angular deflection about 5 mrad, pulse duration about 200 μs, same multi-pulse facilities as the kicker.

Septum : located in straight section 26, stationary, length about 3 m, angular deflection about 15 mrad, pulse duration about 200 μs, same multi-pulse facilities as the kicker.

At a joint meeting of experts in November 1967, it was decided by CERN to supply also the external proton beam transport system, thus extending CERN's responsibility as far as (but not including) the target in the experimental hall. This beam transport system consists of several pulsed horizontal and vertical deflector magnets to bring the ejected proton beam to the target position, and a series of pulsed magnetic quadrupole lenses to squeeze the beam to a small spot (of cross-section 1.5 X 2 mm) on the target. This small spot size is dictated by the requirements of the radio-frequency separated beam, following the target.

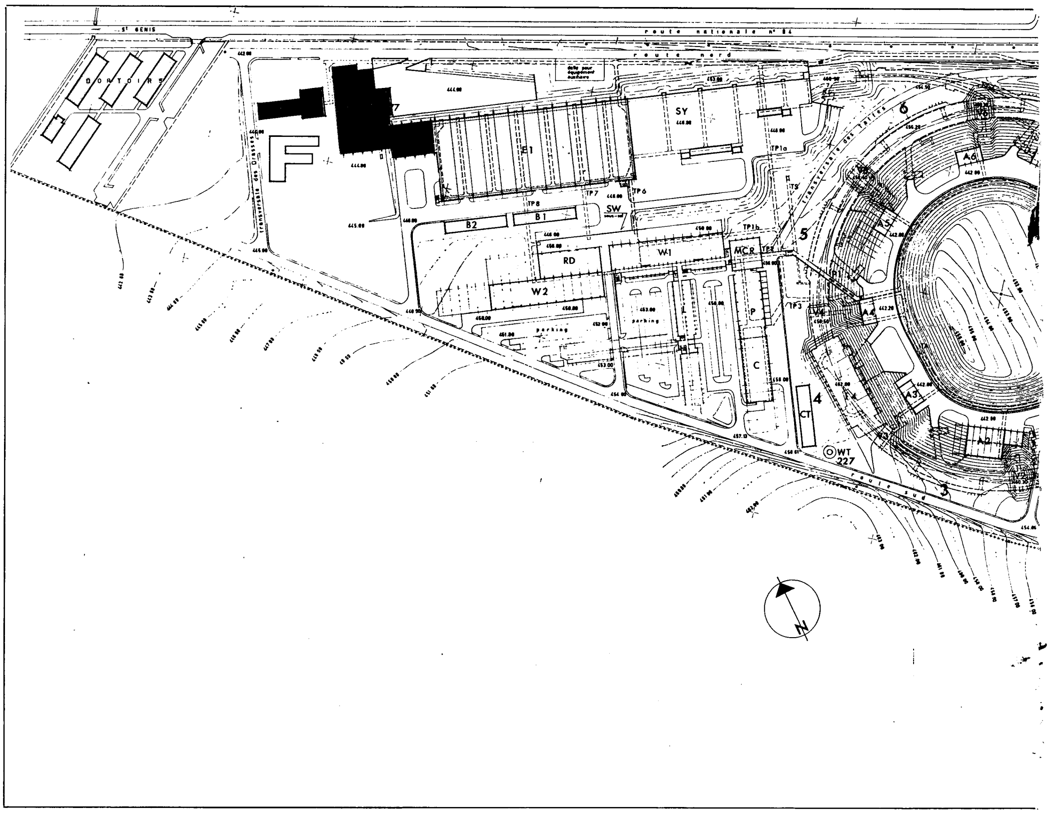
A design study of this system was presented in March 1968 and agreement on the main specifications has been reached. The system will give the required spot size, the apertures of the lenses will be 70 mm in diameter, and four pulses during one accelerator cycle will be possible at intervals of 0.5 s.

A special building is to be built close to the straight sections (no. 14 to no. 28) which will contain the magnets of the two ejection systems. It will house all the pulse generators and power supplies for the ejection and external proton beam transport systems A and B and other planned equipment, including the pulse generators and power supplies for a slow ejected beam channel. The building will also have a local control room but the details of its relationship with the main control room have not yet been decided.

The work at CERN on the fast ejection and external proton beam transport for Serpukhov has been assigned to the PS Department. The work on the ejection system is being carried out in the fast ejection group led by B. Kuiper. The beam transport system is being constructed by the pulsed beam transport group of the Nuclear Physics Apparatus Division led by B. Langeseth.

New buildings

A brief survey of the construction work the Technical Services and Buildings Division (SB) has on hand which is due to be finished in 1968 or 1969.



Booster

The work involves the construction of the ring tunnel for the booster, which is completely underground, and of the two tunnels linking it to the proton synchrotron. The excavations, which go down to a depth of 14 m have already been done. The concrete shielding forming the outer wall of the PS ring had to be pierced and a process very similar to thermit welding (see photograph) was used to cut five openings, ranging from a size of 3 m² to 40 m², in the concrete, which is between 40 and 65 cm thick at these points. (These openings give space for the passage of the beams, the sight-lines for aligning the magnets and access for the service staff.) This process was adopted because it allows fast, dust-free and, above all, vibration-free working. The SB Division will also construct the central buildings for the booster, to contain the control-rooms, the electricity and cooling-water supplies and the air conditioning units. The units of the booster magnet, the heaviest of which weigh between 15 and 20 tons, will be lowered into the tunnel via a shaft sunk close to the centre of the ring with a horizontal transfer tunnel.

Building at the centre of the PS ring

This is a hall with a floor area of some 600 m² in which it is intended to place the amplifiers feeding the PS accelerator cavities, the number of which will at the same time be reduced from fifteen to thirteen. These amplifiers are at present located in the PS tunnel. About half the floor area will be used for power supplies for the ejection system magnets. This new building will adjoin that already constructed at the centre of the ring which contains the r.f. control room, the beam observation controls and a maintenance laboratory for accelerator equipment.

New store (Hall 119)

The new store (see vol. 7 page 221) has a useful floor area of 2 400 m², sub-divided in the following way :

— a semi-mechanised store measuring about 28 × 42 m, with a total volume of 13 000 m³, 43 % of which can be used for storage. Two fork-lift trucks travel between the banks of metal shelves where goods are arranged on some 2 500 pallets measuring 1.2 × 1.2 m. About 25 % of the total volume is at the disposal of the Divisions for the storage of equipment temporarily not in use. The store is served by the operators of the two fork-lift trucks and two storemen, who have two small electric trucks available for their own transport.

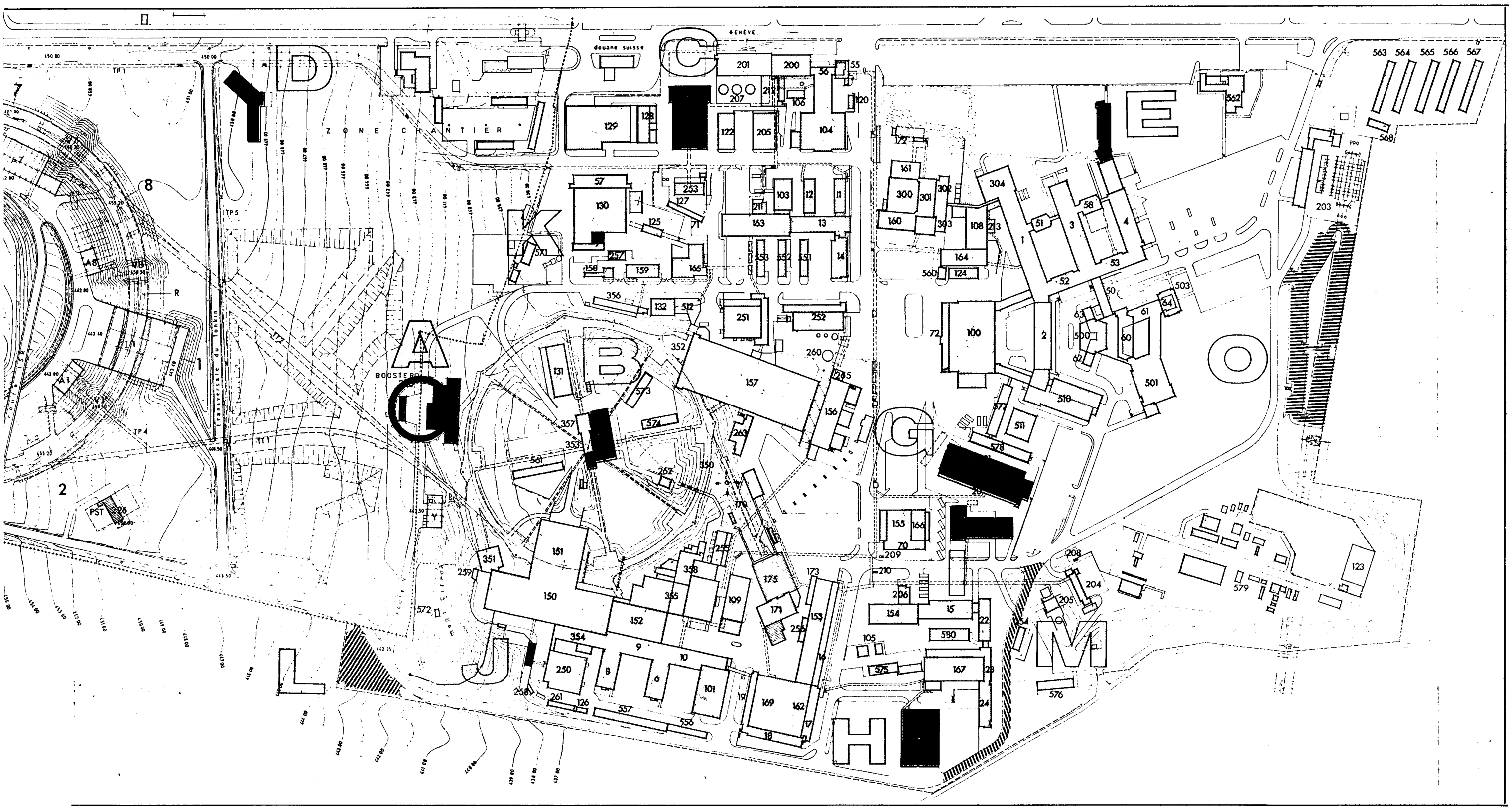
— a three-story building housing the stores administration and goods reception hall.

'Services' building on the ISR site

This is a new home for offices and sections of the SB Division including the Division administration, the Design and Projects Group, the Maintenance and Works Group (except for the maintenance workshops and the boiler-house) and the administration of the central workshops. It has three floors plus a basement and is constructed of prefabricated units so that further sections could easily be added later if other services are moved to this building.

Laboratory 5

This is an extension of Laboratory 4, having six floors and a basement. The sixth floor will contain twenty-nine individual bedrooms for those who have to spend a night at CERN on duty, or for certain visitors. It will thus be a kind of hostel. It will also be possible, if necessary, to convert the fifth floor, which will normally be divided into offices, into bedrooms. The floor of the ground floor will be removable to provide halls about 6 m high for the installation of computers if necessary. This building unfortunately takes away the area at present used as a football field but the footballers can console themselves with the thought that his field, which was in fairly bad condition and not of standard size, will be replaced by a better one on the ISR site.



Buildings under construction by SB Division

NAME	REF. ON PLAN	BUILDING NUMBER	CONSTRUCTION DATES	CLIENT DIVISION	AREA COVERED	STAFF HOUSED	MAIN CONTRACTORS
New stores Hall and offices	C	73-119	1967 - 1968	FIN	2400 m²	50	S.A.C. DEXION Ltd MUNCK (crane)
Hall 168 Hall + 2 office wings	G	20-21-168	1967 - 1968	NP	2800 m²	100 à 125	S.A.C. MULLER HAUSMANN
GODET workshop	I	102	1967 - 1968	SB	350 m²	18	S.A.C.
Hall 174	H	174	1968	PS-SI	1450 m²	70	S.A.C. MULLER DURISOL
Booster tunnel Auxiliary buildings	A	360 361	1968 - 1969 1969 - 1970	SI	~4 000 m²	— —	S.A.C. MULLER VIAT (excavation)
Labo 5	E	5	1968 - 1969	PE-FIN-DI	3000 m²	150 à 200	S.A.C.
Services building	D	54	1968 - 1969	SB	3400 m²	180	S.A.C.
Central building (r.f. hall)	B	359	1969	PS	700 m²	35	S.A.C. MULLER
South Hall convertors	J	264	1968	PS	100 m²	—	S.A.C. - MULLER
Safety Group	K	7	1968 - 1969	DI-SY	100 m²	10	S.A.C. - MULLER
BEBC: Hall E 2 Services building Assembly workshop Bubble chamber hall Compressor hall	F	190 AM 110 L 36 191 276-277	1968 - 1969 1968 - 1969 1968 - 1969 1969 1969	TC TC TC TC TC	1000 m² 1800 m² 450 m² 1200 m² 1500 m²	20 100 25 — —	S.A.C. - MULLER S.A.C. S.A.C. - MULLER DURISOL

Cutting through the concrete wall of the proton synchrotron tunnel to make the aperture for connecting the booster.

Assembly at Saclay of the superconducting coils for the polarized proton target used in an experiment at CERN. This superconducting magnet is one of the biggest in operation in the world. The central large aperture, which can be seen, is that through which the target is inserted. The struts between the coils have to withstand an attractive force of about 20 tons when the coils are powered. When in operation the coils stand vertical (turned through 90° with respect to their position in the photograph). (Photo Saclay)

Large European Bubble Chamber complex

This consists of an area of 6 000 m² which will house the 3.7 m European bubble chamber and its auxiliary equipment. The foundations, on piles, are complete, and work on the main building has begun. Anchoring the slab which will take the forces caused by the movement of the expansion system, whose mass (1000 kg) will be subjected to accelerations of up to 200 g, has presented special problems.

Hall 168

The total floor area of this building, 2 800 m², is divided into 1 200 m² for the hall proper and 1 600 m² for offices. It will be used mainly by the Nuclear Physics Division. A point of interest is that the hall, which is an extension to the East experimental hall, could, if required, be used for experiments supplied by an extension of the beams from the PS.

Hall 174

This hall will be used by groups of the MPS Division for work on the booster equipment, Gargamelle, equipment for Serpukhov, etc. Its construction has involved the disappearance of a 600 m² car park.

Extension to the Surface Treatment Workshop

Here, areas to house the serial-changer radiography installations and those for the manufacture of printed circuits and also a chemical laboratory are being built. They need to be fitted with a special ventilation system. It is known as the 'Godet workshop'.

Other work

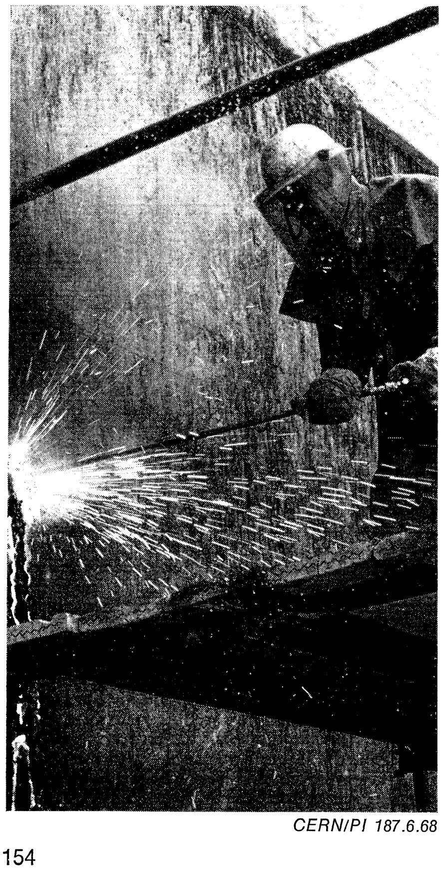
This includes smaller-scale operations, like the construction of a hall to house the rectifiers supplying the South hall of the PS (at J on the plan) and of a building serving as an experimental hall for the General Safety Group (at K on the plan). Moreover, three car parks are projected : one at 'Mont Citron' (O on the plan), providing space for about seventy vehicles, which is due to be finished in the autumn of 1968 ; one under the high-voltage line (L on the plan), due to be finished at the end of 1968, which will provide space for about 208 vehicles ; and the SC car park with some 95 spaces, which is due for completion in the spring of 1969.

Finally, the construction of a road (M on the plan) will provide more direct access to the ISR site from the CERN entrance, and work is scheduled to start on it at the end of 1968.

Saclay polarization experiment

In the experimental programme of the proton synchrotron prior to the shut down, three experiments, (briefly described in vol. 7, page 65 and vol. 8, page 73) were studying pion-proton scattering using polarized proton targets (see vol. 7, page 28).

Two of these experiments, numbered S48 (now completed) and S59, involved the measurement of the probability of interaction (the differential cross-section) with the protons polarized perpendicular to the plane of scattering. The third, S54, consisted of measuring the polarization parameters with the protons polarized within the plane of scattering. It was carried out



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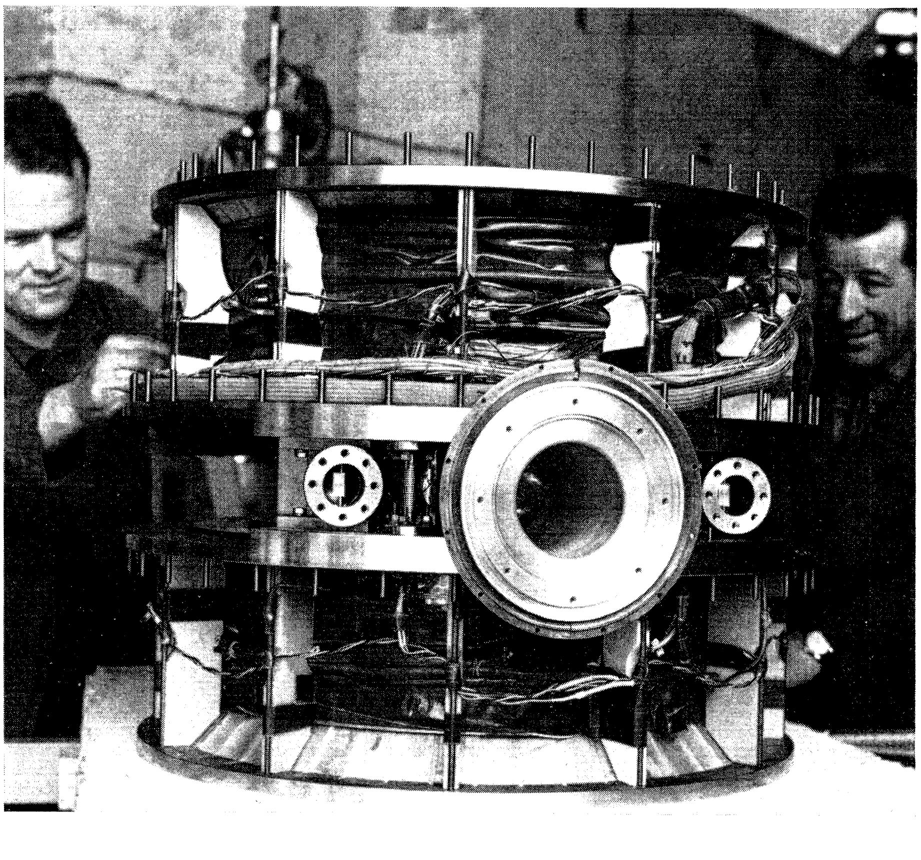


by a Saclay team and required more complex equipment because

— it involved two successive scatterings: primary pions on the polarized target and recoil protons on a carbon target ;
— superconducting coils had to be used to create the magnetic field for the polarized target ;
— it required fast electronic circuits of modern design, developed two years ago, with a response time less than 130 ns.

The last two features are worth describing. In order to detect the scattering in the plane containing the polarization vector, the magnet surrounding the target had to allow particles to pass freely not only in the usual air-gap perpendicular to the magnetic field but also in directions close to the axis of the field. Ironless coils satisfy this condition, but, to reduce their bulk, they have to be wound with superconducting wire carrying a very high current density. These coils, operating at liquid helium temperature (4°K), were designed and constructed by the Magnet and Cryogenics Groups at Saclay and are the biggest in operation in Europe with the exception of the BRARACOURCIX test assembly (see vol. 8, page 23). They generate a field of 25 kG within a volume large enough to contain a 6.5 cm long target.

The electronic system had to distinguish the events to be studied, the scattering of primary pions on the polarized protons in the target, from the background arising from the scattering of primary pions on unpolarized protons. In fact, the LMN crystal forming the target contains only about 6 % polarizable free protons, and the probability of the incoming pion striking an unpolarized proton is about seven times greater. Some background can be eliminated by rejecting events in which the incoming pion, the recoil proton and the emergent pion are not co-planar ; this involves finding the exact geometrical configuration of each event. Banks of scintillation counters were used to detect the paths of the three particles and signals from the counters were fed into a logic circuit consisting of fast coincidence matrices in the form of integrated circuits. Only those events which satisfied the required geometrical conditions could trigger the high voltage pulse to the wire chambers positioned in the path of the recoil protons. The time limit of 130 ns for the electronics is dictated by the very brief period, (less than 400 ns) which is available between the moment when the scintillation counters detect the particles and that when the wire chambers no longer give sparks in the wake of the charged particles. (The ionisation produced by the charged particles in the chambers persists for only 400 ns.) The remaining 270 ns are needed to pass signals along wires, for the response time of the pulsed power supplies and so on.

The whole of the equipment has been operational since March, 1968. It has recorded several hundred thousand events using negative pions of momentum 6 GeV/c to measure the polarization parameter 'A'. Work is currently in hand on the reconstruction of the tracks and on finding the asymmetry in the proton-carbon scattering. The analysis of this first measurement will probably be completed before the end of the year.

The experiment will continue during 1969, first measuring the polarization parameter R with the same momentum pion beam, before moving to higher energy to repeat the measurements.

'Measurements of the parameters A and R in pion-proton scattering between 5 - 18 GeV/c'
B. Amblard, P. Autones, R. Beurtey, G. Cozzika, J. Deregel, Y. Ducros, J.M. Fontaine, M. Hansroul, A. Lesquen, J.P. Merlo, G. Movchet, J. Rieubland, T.C. Raoul, L. Van Rossum.

USAEC Citation

On 10 June, the United States Atomic Energy Commission presented a 'Special Recognition Citation' for 'the outstanding scientific contribution to the development of nuclear energy' made by the team of Frederic Joliot, Hans Halban, Lew Kowarski and Francis Perrin.

The citation reads 'The experimental research performed by this team in 1939 and 1940, as well as theoretical considerations put forward by Francis Perrin, played a major role in early research on nuclear fission. Their discoveries concerning neutron emission in the fission process and their determination of critical cross-sections of nuclear fuels and moderators served to help establish the possibility of a self-sustaining chain reaction. Their dedication to their task in the face of war-time adversity resulted in the successful conduct of an important experiment at Cambridge, England in 1940 which provided experimental evidence that a homogeneous heavy-water uranium oxide mixture would support a chain reaction.

The contribution made by this group of devoted French scientists towards the early development of nuclear reactors, capable of producing fissionable materials and useful energy deserves the highest praise'.

Two of the group have been intimately involved in CERN since its creation. Professor Kowarski was one of the first members of the team which did the preliminary planning from 1952 before the Organization came formally into being and has worked for CERN ever since. (A fuller story of his life can be found in CERN COURIER vol. 7, page 11.) Professor Perrin has been one of the French delegates to the CERN Council from its very beginning.

Professors Perrin and Kowarski photographed together at the last CERN Council meeting.

CERN/PI 190.6.68

Particles, Accelerators and Society

Taken from the 1968 Richtmyer Lecture given by Professor R. R. Wilson, Director of the USA National Accelerator Laboratory, to the American Physical Society and the American Association of Physics Teachers.

R. R. Wilson

My participation in physics has been with particles and accelerators, and since the cost of all this is no longer trivial, I would like to trace the relation of particles and accelerators with people and society. I think that it is only if we can understand this involvement that we will be able to explain the value of physics to society. Then we can justify the cost — in manpower, in effort and in thought — that is going into physics. While my remarks pertain to particle physics, in general they apply to all physics. I have chosen particle physics not only because it is my field, but also because it has come under attack for being too far removed from society to be supported.

There is certainly nothing very novel in my assertion that particle physics and people are inextricably interrelated. They have been interrelated for the thousands of years that the idea of atoms has existed. Whatever the origins of atomic theory in the dim and distant past, by the time it came to be formalized by Democritus, it became the basis of what could be called a religious cult — Epicureanism. During those times, people were victimized by their natural religion. No wind blew, no stone turned without the intervention of a minor deity. Incantations, oracular consultation and even sacrifice were necessary preparations for any endeavour, to ensure a friendly rather than unfriendly nature.

The atomic theory of Democritus, especially as it is poetically described in « De Rerum Natura» by Lucretius, provided a completely mechanistic rather than a completely teleological explanation for all of the actions of nature. After this atomic theory, the gods were no longer necessary to explain motion, or to explain other natural phenomena. Thus, the first serious study of particle physics served to free the Greeks from the tyranny of their gods. With a firm belief in atoms, it was no longer necessary to sacrifice an Iphegenia in order to ensure a fair wind to Troy.

Of course, I may be prejudiced, but the trouble with the Greeks was that they did not build accelerators ! Had a Rutherford or a Lawrence been born before his time in Athens, the technological explosion might have taken off right then. A serious search to discover the physical existence of the atom and then to measure its properties would have led inexorably to the development of vacuum pumps, even to electricity, and probably to electronics. Man might have reached his present stage of technology by the time of Christ — and it staggers the mind to think of the potential of modern technology controlled by the superior civilization of the Greeks, and tempered by the love of Christ. Instead, Greece put her money and effort into a series of tragic wars. The moment, the country itself, and for thousand years, the civilization was lost... all for the lack, not of Diogenes' honest man, but of what is just as good, an experimental physicist ! There are lessons to be drawn from all this, but the only one that I dare point to is — let us by no means miss any opportunities to build accelerators.

If Greek particle theory destroyed one religion, Aristoelian-Christianity in turn superseded atomic-Epicureanism. Now it is hard to show the relationship between particles and the most important movement of the next thousand years, namely Christianity, but several years ago I amused myself by comparing one of the principal artifacts of particle theory, the accelerator, with those great material expressions of Christianity, Gothic cathedrals.

This came about because I had been subjected, as a tourist in Europe, to the inevitable exposure to numerous cathedrals. I had expected to be overwhelmed by a combination of spiritual uplift and transcendental beauty, but frankly, it wasn't getting through to me. However, on one occasion while face to face with one of them, and while awaiting a revelation, I found myself instead involved strictly as one technical person taking a hard look at what another technical person had done. Then, thinking in those terms, and especially in the context of the 13th Century, I became tremendously impressed by the innovation, the invention, the understanding that had gone into the construction. As a builder of accelerators myself, I could relate to, and thrill to what appeared to me to be a medieval physicist responding to a very challenging physical problem.

I found a striking similarity between the tight community of cathedral builders and the community of accelerator builders, both of them were daring innovators, both were fiercely competitive on national lines, but yet both were basically internationalists. I like to compare the great Maître d'Oeuvre, Suger of St. Denis with Cockcroft of Cambridge ; or Sully of Notre Dame with Lawrence of Berkeley, and Villard d'Honnecourt with Budker of Novosibirsk.

My point is that the cathedrals were technological constructions of great beauty and significance that expressed the aspirations and spirituality of their age. Who of that period, if he lived now, would not be proud of what had been done ? I like to think, that six centuries hence, we will be as proud of our accelerators. I like to think that even though they will only endure then as the Stonehenges of the future, the discoveries we make today will be part and parcel of the culture of that future.

Now the justification of particle physics does not have to rely upon these far-fetched examples. Particle physics is, after all, the direct descendent not only of atomic physics but also of nuclear physics. The cost of atomic and nuclear physics has been negligible compared to almost any scale of values. Certainly the cost is trivial when compared to the value of the industries which have been spawned by them.

The cost of particle physics, on the other hand, is beginning to be measured in terms of billions of dollars. It is not unreasonable that the people who pay the bills want the best explanation that we can give them. Let us not forget that taxpayers are traditionally unmoved by aesthetic or cultural arguments. It is therefore important to remind them, and ourselves too, that in the past this kind of research has always brought to light new knowledge which has then become the foundation for new important industries. We need look no further than the nuclear power industry, for our most recent example.

We should not forget to mention, as we make our case, the kind of unexpected but immediately applicable practical developments that accompany any intensive technological activity. 'Spin-off' is the current jargon that describes these. The high power transmitting tube, first developed for cyclotron oscillators, is one exam-

Professor Wilson photographed at CERN in February, following a lecture he gave on the American 200 GeV project.

CERN/PI 174.2.68

ple of this. So are the fast pumps and the high vacuum techniques developed for the large metal chambers of the accelerators. The particle counters that gave rise to the flip-flop circuits that contributed so basically to the modern electronic computer is another example. Now in turn there is the symbiosis that we see between particle detectors, computers and accelerators.

I have not the slightest doubt as we embark on the construction of higher energy accelerators, that further such practical developments will occur again and again. Just off-stage and ready to take a bow is the application of superconductivity to the instrumentation of particle physics. The development of superconductivity will become practical for other reasons, but its use will be hastened by the immediate needs of accelerators.

But as physicists we are not really inclined to emphasize this kind of practical benefit. Perhaps this is so because we worry, if ever so slightly, that man will really not be benefited by all this technology. What gives us greater satisfaction is to emphasize the relatedness or the relevance of particle physics to other sciences and to other human activities. I do not mean by this such things as the medical use of particles as indicators or tracers. What I do have in mind, for example, is its relatedness to a field such as astronomy, cosmology, or cosmogony.

Nuclear and particle physics are relevant to astronomy because matter is found in the same environment of stress and strain in the centre of a star as in the beam of an accelerator. Now even more violent regions of space are being observed by astronomers in quasars. At the same time particle physicists are investigating new regions of energy by the use of accelerators. I find it almost poetic to consider this unlikely relatedness between two such different fields — the one, studying the universe at its largest scale, the other at its smallest scale — that the exotic sub-particles produced in the fevered imagination of a theoretical physicist could be of immediate importance to an astronomer who conjurs up in his fertile imagination an exploding galaxy or a cataclysmic convergence of the universe.

Now these are lovely thoughts and we physicists can go into ecstacies of enthusiasm in telling each other about them. But I have been speaking of the more prosaic task of selling our subject to the taxpayer. Whereas we can probably convince him that he or his children will reap tangible benefits from his investment in particle physics, can we bring him to share with us or to appreciate another part of our activities of great value — namely, the cultural, aesthetic and philosophical value of our work ?

I think we can do this better than we have done in the past ; that we owe it to those who pay the bills not to assume too readily that these matters will be of little or no interest, or that they are too remote for general understanding. We should try to make our explanations about the nature of the world as simple and as fascinating as possible. One of our best hopes is that we can genuinely persuade the humanists that there is real humanistic content and appeal in these aspects of physics. Perhaps then, they could do a better job of explaining our work than we have done, and will weave the world that the physicist sees into the world that they write about.

The physical world is enlarged in every dimension by the discoveries of physicists and astronomers. We may well have done more for society by enlarging this vision of the world, and thus enriching the general culture, than we will have done by increasing its material well-being.

Of course I am speaking of these relationships between particles and people because I am committed to help build the 200 GeV proton synchrotron. When I accepted a part to play in this construction, it was the technical fascination of the project that attracted me. I knew that there would be the usual administrative headaches, but I expected that the fun and interest of building a large instrument would more than compensate for the pain. I am happy to say that the technical part has been every bit as satisfying as I expected it to be. What I did not realize was that my social and political involvement would be as great as my technical involvement. The surprise has been that the satisfaction in addressing social problems is just as great as is the satisfaction of confronting the technical problems, that the two aspects are not as separate as one might think, that both work on and intensify each other, that both are dependent on a deeper understanding.

By the time the first design of the 200 GeV synchrotron had been completed in 1965, it had become evident that the cost of the machine would be of the order of a quarter of a billion dollars and that the accelerator would be a principal instrument of many of the nuclear physicists in the country. It became a matter of global interest where the synchrotron was to be placed and how it was to be administrated. Somehow, for better or worse, this led to the famous site-ing sweepstakes. I have been told by members of the site selection committee that most of the people who put sites forward did so with a surprising degree of sophistication, they realized that more than the immediate spending in their community was involved. In some cases, they realized that it might bring a new cultural level.

At the same time that this difficult choice was being made, another innovation was in preparation. This was the spontaneous formation — if I may so call something so carefully planned — of the Universities Research Association. This strange organization was founded by a large number of universities in this country solely to construct and operate the 200 GeV synchrotron.

Another remarkable concatenation of particles and society was the coupling of the 'open housing' issue with the choice of the site. A tremendous conflict arose in Congress at the time the project was up for authorization because the State of Illinois had not passed an open housing bill. We immediately found ourselves involved in an effort to improve the situation in this regard. Some physicists may feel that the project should not have been put here because of the lack of this state legislation, but I have come to feel — and come to feel strongly — that much good has already been done in bringing open housing to our part of the state at the community level, and that a lot more good is yet to come. Oddly enough, in this case particles may provide society with an element of social change.

We, at the Laboratory, decided at once to meet these problems head-on and as agressively as possible. It was clear to us that the project could not survive an attempt to shift the site. However, as a national and international Laboratory, we had an absolute requirement to create conditions in which any physicist or any engineer or any technician could visit, work and live at or near our site. The decision on our part to be aggressive about this has taken us into situations which, for physicists, are rather unusual, to put it mildly. Building an accelerator, no matter how large, will not produce by itself any solution to our social ills. However, it will be gratifying if this accelerator will play even a small part in contributing to better social conditions in Illinois. Paradoxically, it would play no part at all had it been located in a community of social tranquillity.

There is another feature of the project that we have decided to be aggressive about — the site. It has been described by its detractors as just a plain old corn field. This accusation is not wholely unjustified ; it is a bit on the flat side. However, the accelerator involves a ring one and a quarter miles in diameter as well as a number of support buildings, cooling towers, and so forth. Our architects have already been most imaginative in suggesting ways to put this all together in a manner such as to capitalize on some of the really lovely forests that exist on the western part of the site. By gathering most of our support buildings together to make a truly high tower and by the dramatic use of cooling water, they can make of Weston an architecturally significant centre, a place to which physicists will be attracted by the physical beauty as well as by the beautiful facilities for research in particle physics.

At this point of the project I am thoroughly confused about the distinction between particles, accelerators, and society. If I have not been able to resolve society into its elemental particles, I have at least found out that it is easier to accelerate particles than it is to accelerate societies. But in the course of giving a very large acceleration to our particles, let us hope that we can contribute at least a small acceleration to society.

It may be of some interest to look a little into the future. It is not likely that we will find all the answers that we are seeking by building the 200 GeV machine. Even if we do, new answers open up new questions. It is the nature of science that, whatever point we reach and however good our understanding is at that point, we will always want to go beyond it for a deeper understanding. If we were to stop, I suspect that the nature and spirit of science would change, and change for the worse. It would become more sterile. The spirit of science, of free inquiry, of the search for truth is deeply a part of our society.

There are many frontiers of science, but an important one is particle physics. I do not see man abandoning his investigation of these fundamentals of nature in our time. Consequently, I see the necessity of constructing larger and ever larger accelerators.

But as the cost of this activity mounts, we physicists will have to respond in several directions. In the first place, we will have to give society a much better understanding of what we want to do and why we want to do it. In the second place, we will have to use our ingenuity to the utmost to keep the cost and effort within reasonable bounds. We will also have to respond with new social innovations.

I see the whole effort escalating to a more international level. Already the Soviet scientists with the 70 GeV machine at Serpukhov, have the highest energy proton accelerator. They have developed plans for a 1000 GeV proton synchrotron, and an idea of Veksler for a new principle of acceleration has been brought to the experimental stage at Dubna. At CERN intersecting storage rings are being constructed to be used in connection with their present proton synchrotron giving head-on collisions between two beams of protons, each having 28 GeV. The resulting total energy of 56 GeV will be equivalent to an accelerator producing protons of 1700 GeV used in the conventional way of allowing them to strike protons at rest. They have also designed a 300 GeV synchrotron. Our problem of picking a site among the states seems trivial compared to their problem now of picking a site among the many put forward by the countries of Europe. They have been even more ingenious than we in inventing social structures which have had a significant social impact in breaking traditional barriers of nationalism.

Once before, in 1961, it was officially suggested by our government, and by Russia, that a 1000 GeV machine should be constructed as a truly international cooperation and the idea was carried quite far before it was abandoned. When the time is ripe again, I have no doubt but that an international equivalent of the Universities Research Association will arise to serve the idea of such an international machine. It will be a practical organization, because physicists have demonstrated time after time that they can work across national lines. We can hope for additional experience in the Serpukhov collaboration now under consideration. The greatest force of such an international Laboratory will be in developing our common culture in physical science. However, as on the national scale, particles, accelerators, and society may interact again — this time to provide a force for better cooperation and understanding on an international scale.

News from abroad

1. *The face of Professor Abdus Salam, Director of ICTP, lit up in discussion during the International Symposium on Contemporary Physics.*

2. *Professor Paulo Budini speaking at the dedication ceremony of the new building of ICTP.*

(Photos Rice, Trieste)

International Centre for Theoretical Physics

Motorists driving into Trieste in the month of June were greeted by a road-sign 'Contemporary Physics 400 metres ahead'. The International Centre for Theoretical Physics (ICTP) was holding a major symposium to inaugurate the fine new building which has just become its permanent home. While carpenters screwed together the last pieces of wood and electricians connected the last wires, about 350 leading physicists from countries throughout the world gathered, during the three weeks 7 - 29 June, for an 'International Symposium on Contemporary Physics'.

The Symposium

Professeur Abdus Salam, Director of ICTP, described the aim of the meeting as 'to review the whole spectrum of modern theoretical physics, to share the insights of different disciplines and to acquire, if possible, a deep sense of the scope and unifying nature of the subject'. Certainly, the range of the symposium was broad and the standing of its speakers high. The topics covered included biophysics, condensed matter including the solid state, nuclear and elementary particle physics, astrophysics, plasma physics, foundations of quantum theory, general relativity and cosmology. And among the participants were Nobel Prize winners M. A. Bethe, F. C. Crick, P. A. M. Dirac, W. Heisenberg, C. H. Townes, T. D. Lee, J. Schwinger and E. P. Wigner. It is about twelve years since the whole of physics was covered in such concentrated way in one place, and it was appropriate that ICTP should be that place.

ICTP

The idea of the International Centre for Theoretical Physics originated with Professor Abdus Salam, who proposed its creation to the International Atomic Energy Agency (IAEA), a subsidiary body of the United Nations, and it has been largely thanks to his continuing drive and enthusiasm that ICTP has established itself, within four years of being set up, as an excellent centre of theoretical research. Abdus Salam sees it as effectively the first department of a United Nations University having the particular aim to help theoretical physicists from the developing countries. As yet, these physicists usually cannot find in their home environments the intellectual stimulation which they need to make their research flourish. Work in theoretical physics is an obvious way to build up pure science in these countries since it does not require extensive investment in experimental equipment. Salam conceived the Centre as a place where the scientists could come for brief periods to sharpen their minds by working alongside the most distinguished men in physics. He is acutely aware of these problems and some of his other activities are obviously motivated by similar thinking. He serves on the United Nations Advisory Committee on Science and Technology and is chief scientific adviser to the government of his own country, Pakistan.

In achieving his aim, he has had the invaluable help of Professor Paulo Budini who has been instrumental particularly in securing the extensive support of the Italian government and the city and university of Trieste, which has been the mainstay of the Centre up to now.

After a planning stage, in which extensive use was made of the experience gained in the Theory Division at CERN and in the CERN Fellowship Programme, the Centre came into being in 1964, initially guaranteed for a period of four years. This period was extended by the IAEA for a further six years in 1967. Temporary premises were found in Trieste and Salam was appointed Director, with Budini as Deputy Director. Finance has been provided by the Italian government, Trieste, the IAEA, UNESCO and the Ford Foundation - the annual budget is around $500 000 of which Italy provides about $250 000.

Activities

The functions of the Centre are listed as —

a) to train fellows fom developing countries for research
b) to help in fostering the growth of theoretical physics at an advanced level in the developing countries
c) to conduct through its professors, visiting and guest scientists and fellows, research in the various fields of theoretical physics

1

2

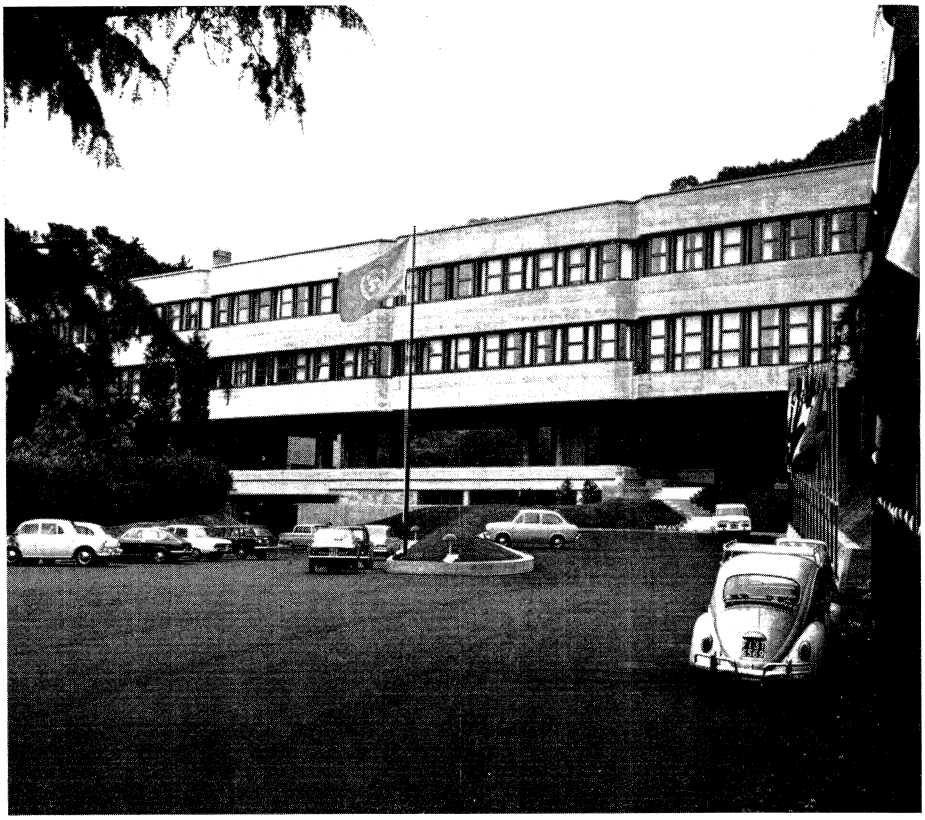
3. The building, designed by architects from Trieste University, which becomes the first permanent home of ICTP.

4. A photograph, taken during the dedication ceremony for the new building, showing the fine main lecture hall.

(Photos Rice, Trieste)

1. A general view of the 2.5 GeV electron synchrotron at the University of Bonn. This photograph was taken before the shielding tunnel was completed.

(Photo Bonn)



3

4

d) to provide an international forum for personal contacts vital to research in theoretical physics.

The policy is to avoid specialization in any given area of theoretical physics and to be strictly inter-disciplinary.

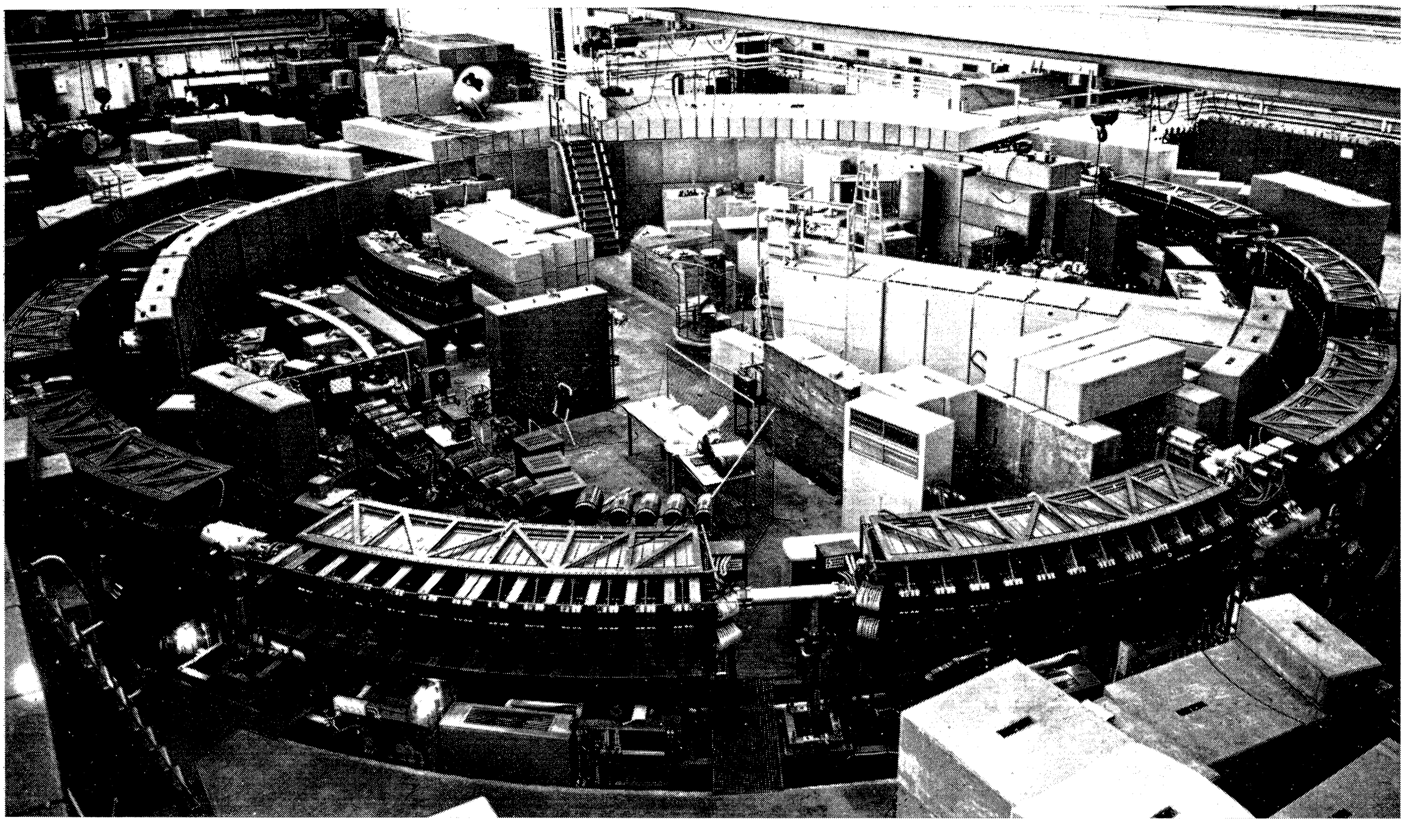
Several examples of the ways in which the Centre carries out these functions are worth picking out. The scientific personnel consists of a small nucleus of staff surrounded by a cloud of visitors who may be there for periods ranging from one month to two years. A very successful scheme has been the appointment of 'Associate Members'. These are distinguished scientists, selected from the developing countries, who are entitled to spend periods of up to four months per year working at the Centre. In this way, these physicists are not lost to their countries while still benefiting from contact with their peers from other lands. It is believed that the scheme has helped considerably towards staunching the flow of scientists from the developing countries. The selection of the Associate Members is done by the Scientific Committee which plays an important part in the life of the Centre. Its members are Chairman — S. Vallarta (Mexico), Secretary — A. Sanielevici (Rumania), A. Bohr (Denmark), R. E. Marshak (USA), A. Matveyev (UNESCO) A. Salam (ICTP), V. G. Soloviev (USSR), L. Van Hove (CERN) and H. Yukawa (Japan).

A major feature of each academic year is a blitz on particular topics in physics during extended seminars (lasting four to ten weeks). Many scientific big guns are brought together at the Centre to bombard a specific problem. The topics have included plasma physics, high-energy physics, nuclear physics and the theory of condensed matter.

Over the four years of its existence, 600 scientists from 53 countries (including 200 from 23 developing countries) have worked at the Centre. About 400 publications have resulted from their research.

New building

On 9 June the new premises of ICTP were dedicated. Mr. R. Ducci, Italian Ambassador to Austria and Representative to the IAEA, presented a golden key for the building to Dr. S. Eklund, the Director General of IAEA.



1

The building, beautifully situated near Miramare castle, has been designed by architects from the University of Trieste and it is the university, city and region of Trieste who have financed its construction at a cost of 900 million lire.

It remains formally the property of the University of Trieste and is rented by the Centre at a nominal cost of $1 per year. The relationship of the Centre with the University of Trieste, particularly with its theoretical physics department, has always been very close.

The building is 90 m long covering an area of 1553 m^2. It has a splendid lecture hall with accommodation for 320 people, three other lecture rooms, a large library, and 65 offices for physicists.

Despite all this, the Centre is still not out of the financial wood. There remain difficulties due to lack of funds and the activities in the second half of this year may have to be severely curtailed. It is possible that UNESCO may enter fully into partnership with the IAEA in operating the Centre which could resolve many problems from 1970 onwards.

Bonn synchrotron

In 1967, a 2.5 GeV electron synchrotron was brought into operation at the University of Bonn, Federal Republic of Germany. This article describes the machine, its present performance and its experimental programme.

The history of high energy physics at Bonn began in 1953 when it was decided to construct a 500 MeV electron synchrotron. This came into operation in 1958 and was the first alternating gradient synchrotron in Europe. It has given over 30 000 hours of service and has an average beam intensity of 5×10^{11} electrons/s. Research with this machine has concentrated on photoproduction of pions, deuteron disintegration, and the structure of electron-photon showers.

By 1963 however, it had become obvious that, to keep pace with the development of high energy physics, a higher energy machine was needed and work began on a 2.5 GeV synchrotron. This slotted nicely between the electron machines at Cambridge (USA), DESY and Daresbury which have energies between 4 and 7 GeV and existing machines of energies around 1 GeV. The first electrons were accelerated in March 1967. It now operates 24 hours a day with one day a week for maintenance.

The machine

The synchrotron had to be squeezed into an area 30 X 60 m^2 and this dictated the use of rather higher magnetic fields (up to 10 kG) than usual in electron synchrotrons, to keep the machine radius down to 11 m. (The radius of an electron synchrotron is made as high as possible to reduce the energy lost by radiation from the orbiting particles and hence the fields in the ring magnets are usually low.) There are twelve magnet units around the ring each weighing 18.5 tons. They are powered with a peak current of 1380 A corresponding to a total stored energy of 370 kJ. The magnet aperture is 6 cm X 9 cm containing an all ceramic vacuum chamber where a pressure of 10^{-7} torr is maintained.

A 25 MeV linear injector feeds the ring with pulses 1 μs long. The peak injected current is 250 mA. To take advantage of a ring acceptance higher than the injector emittance, multi-turn injection is used.

The radio-frequency system operates at 499.67 MHz providing a peak energy gain per turn of 700 keV compared with an energy loss per turn at 2.5 GeV of 350 keV. There are two accelerating stations in the ring.

The maximum intensity achieved from the synchrotron is 5×10^{12} electrons/s. The average intensity is around 3×10^{12} electrons/s, corresponding to a circulating current of 0.2 μA. The pulse repetition rate is 50 Hz.

A slow ejection system, using the 3.5 half-integer resonance, was brought into operation in July 1967. It is now producing external electron beams in the energy range 0.5 to 2.0 GeV with spill-times up to 1 ms. An ejection efficiency of about 60 % is achieved. In addition, there are five tungsten targets installed in the ring to produce photon beams.

Experimental programme

Moving around the ring in the direction downstream from the injection point, the first experiment is the photoproduction of positive kaons and lambdas.

$$\gamma + p \rightarrow K^+ + \Lambda^0$$

It has been set up since the beginning of this year and work up to now has concentrated on improving a strong focusing spectrometer to distinguish between the positive kaons and positive pions. A spark chamber array is now being tested which will be used to measure the polarization of the lambda by observing the up-down asymmetry of the proton produced as the lambda decays.

2. *Part of the experimental area at Bonn seen from the top of the synchrotron ring. The beam pipe of the ejected electron beam is visible in the top right hand corner of the picture emerging from its shielding tunnel. The electron arm of the electron scattering experiment, consisting of three quadrupoles and a bending magnet, is in the background at an angle of 90° to the ejected beam. In the middle, is the platform with the three magnets of the strong-focusing positive kaon spectrometer.*

(Photo Bonn)

The second experiment uses the ejected electron beam to study elastic and inelastic scattering of electrons on protons. Two spectrometer arms are set up to measure the electron and the proton. The electron arm is a 'sloped-window' spectrometer, which is in operation; the proton arm is a momentum analysing magnet with a wire spark chamber system, which is being installed. Proton form-factors are now being determined to high accuracy by measuring the elastic scattering cross-sections of the electron at different angles (30° to 110°).

The third experiment is to study the photoproduction of the phi meson.

$$\gamma + p \rightarrow \emptyset + p$$

The detection equipment is under construction. It involves a special homogeneous magnet and a wire spark chamber system which will detect the positive and negative kaon pairs from the decay of the phi, in coincidence with the outgoing proton.

Several different experiments are set up to measure the polarization of the recoil proton from the interaction

$$\gamma + p \rightarrow \pi^0 + p$$

and the polarization of the recoil neutron from the interaction

$$\gamma + p \rightarrow \pi^+ + n$$

in different energy regions. Acoustic spark chamber systems built partly inside the spectrometer magnet are used in these experiments, which are now doing their first tests.

Measurements of the « bremstrahlung » spectrum by means of a pair spectrometer are now complete. The spectrum of the photon beam for different final energies has been measured.

Another experimental group is preparing a measurement of the positive pion photoproduction cross-section in the backward direction. A magnetic spectrometer with high momentum resolution, consisting of two quadrupoles in connection with a normal synchrotron magnet with an alternating field gradient, has been built to analyze the outgoing pions. At present, this group is doing floating-wire measurements to determine the pion trajectories in the spectrometer.

2

Brookhaven slow-ejection

Tests are now well advanced on the slow-ejection system being provided for the Brookhaven 33 GeV alternating gradient synchrotron. By the time this article appears, it is scheduled (mid-July) to have started its first high energy physics experiment.

Quite a number of eyes from other Laboratories also are watching the progress at Brookhaven because slow-ejection is one of the un-tamed, or at least not fully tamed, problems of accelerator technology. CERN brought a system into operation at the 28 GeV proton synchrotron in 1963, but ejection efficiencies have remained stubbornly around 50 %, below what is theoretically expected. Last year, following the addition of a thin septum lens, the efficiency was increased to 80 % in a test set up (see CERN COURIER vol. 7, page 151), a considerable improvement but still not as high as expected.

It is now becoming very important to push these efficiencies higher. Both at Brookhaven and CERN, an increase of a factor of ten in the beam intensity should be reached in the next few years. Unless high-ejection efficiencies can be achieved, the operation of the slow-ejection systems would have to be severely limited to avoid the serious problems of radio-activity and radiation damage to accelerator components that the loss of a high percentage of an intense beam in the ring would produce. In addition to the concern of Brookhaven and CERN, the Weston team for the American 200 GeV machine have based many of their design decisions on the need for high slow-ejection efficiency and on the belief that efficiencies close to 100 % will soon be realizable.

The new Brookhaven system uses the 8 2/3 non-linear resonance — the normal orbits of the accelerated protons are deliberately modified so that they spiral into the ejection magnets. This is achieved by using four correction sextapoles of the AGS, positioned 90° apart with alternating polarities. It is possible to control the rate of ejection by adjusting the rate at which the beam spirals into its resonance radius. This is done by controlling the voltage applied to the main magnet ring, during 'flat-top', and experiments are in progress using a small computer to generate a control programme for the magnet power supply. The computer checks the amount of beam ejected in several time intervals and corrects the power supply programme to give a more uniform rate of ejection on the next pulse.

Using 'back-leg windings' on eight of the AGS magnets it is arranged that the particles enter the septum magnet, which gives them their first kick out of the ring, before striking any other aperture limit. The septum is only 0.7 mm thick and since the beam is spiralling out at the rate of 7 to 10 mm every three turns, the ejection efficiency is theoretically calculated to be about 90 %. Once particles pass into the septum magnet, they experience a field of 1.2 kG which deflects them behind the 6 mm thick coil of the ejector magnet, five magnets down-stream, which completes their deflection into the external beam pipe.

The septum and ejector magnets contain no organic materials so as to reduce the problem of radiation damage. Electrical insulation is achieved by spraying the conductors with aluminium oxide and the 0-rings, used for the water-cooling connections, are of metal. The power supply for the ejector magnet uses a 'brute-force' series transistor regulator. 500 power transistors in parallel, cooled to -20°C supply the pulses of 6.5 kA required by the magnet.

The external beam pipe is under high vacuum and there are no windows between the AGS and the target. A large dipole magnet can be used to switch the beam along two separate channels to two different areas. One of these channels has analysis equipment where extensive measurements can be performed on the beam without radioactive contamination of the area used for high energy physics.

Commissioning of the system began at the end of January and it has been developed to a very encouraging state. Ejection efficiencies of about 80 % with pulse lengths of 400 ms have been achieved. Some difficulties are still under investigation. The efficiency is below the theoretical figure and the emittance is a little larger than expected. This means that the 'spot size' of the beam is not as small as predicted but it is already adequate for the first experiments scheduled to use the beam. The first experiment is a search for intermediate bosons being carried out by a group from Brookhaven and Yale University.

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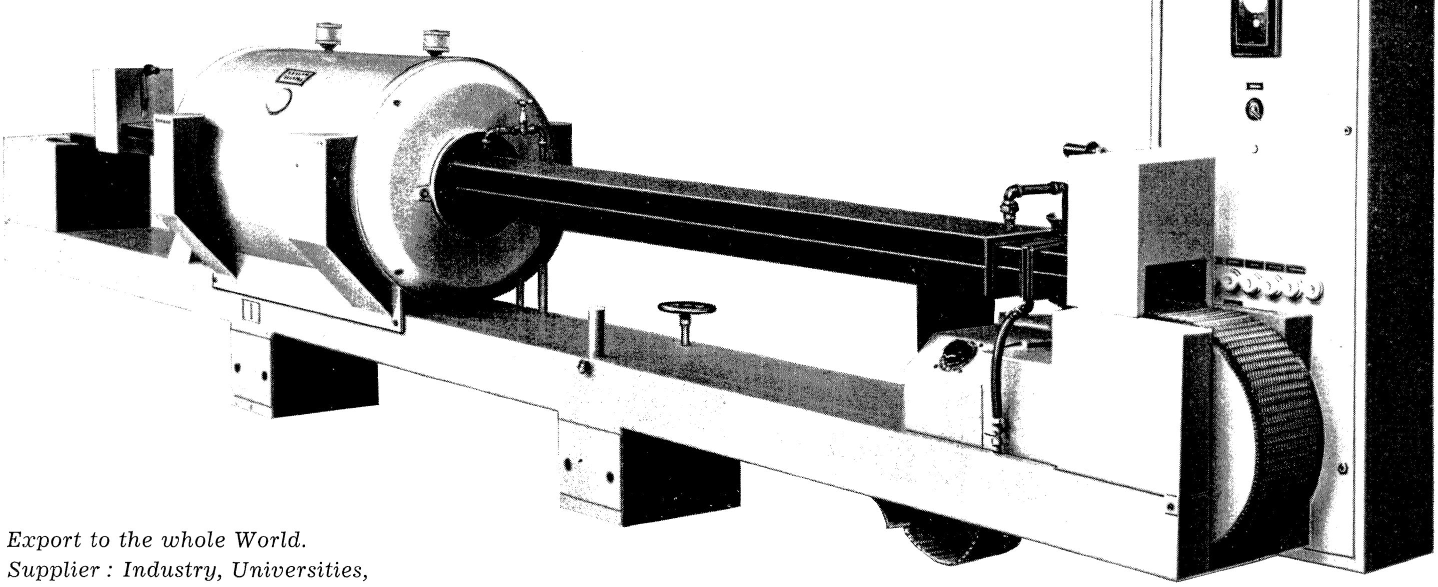

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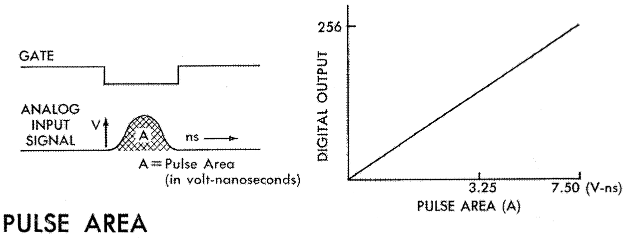
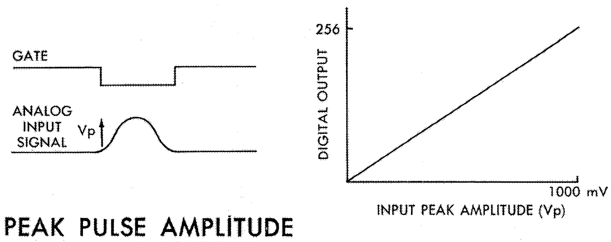


PULSE AREA



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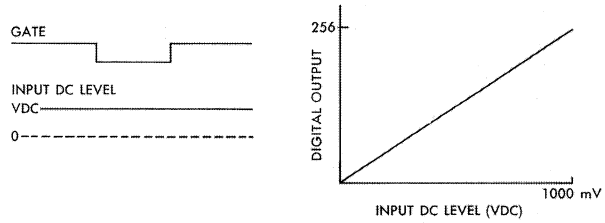

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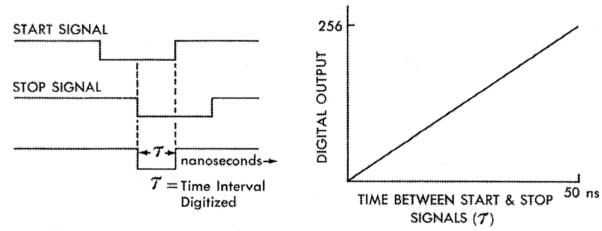

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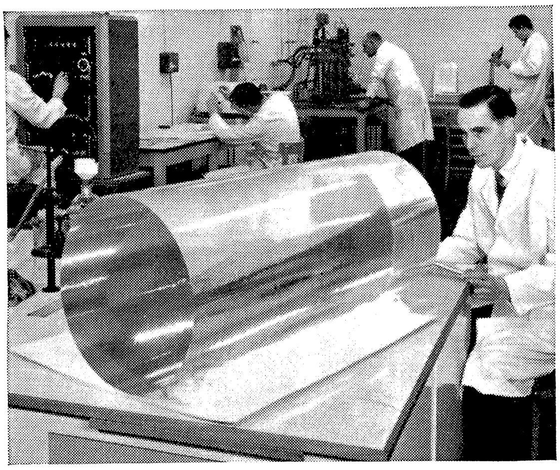

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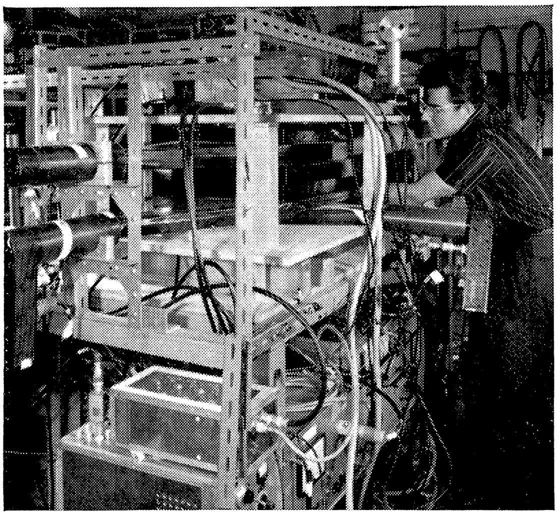
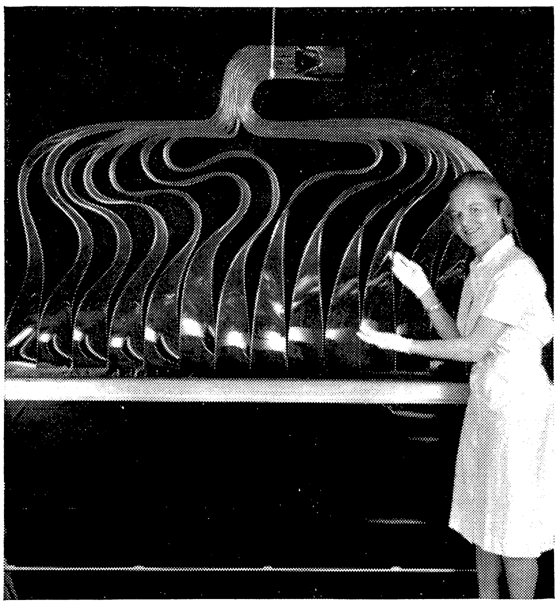


Radiation detectors from Nuclear Enterprises being adjusted in the 'Quark'-hunting telescope at the laboratories of the European Organisation for Nuclear Research (CERN) Switzerland. (Photo CERN)



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These plastic scintillators are available in all geometries, including VERY LARGE AREA SHEETS WITH LINEAR DIMENSIONS UP TO 2.25 METRES.

SCINTILLATOR	Light Output % anthracene	Pulse Width* ns	Decay Time** ns	Light Attenuation Length cm	Max. emission A
NE 102A: Unequalled allround performance; the world-leader in sales. Hundreds of references in journals attest to this.	65%	3·3	2·5	170	4250
NE 110: The plastic scintillator with the best LIGHT TRANSMISSION especially recommended for large area sheets, large or long scintillators.	58%	3·9	3·3	250	4370
NE 111: Easily the FASTEST of all scintillators; for ultra-fast timing experiments, in sizes up to 5 in. dia. x 4 in. length.	55%	1·54	1·7	8	3700
NE 104: with very short decay time, high light output and moderately good light transmission; for fast timing experiments, no size limitation.	68%	3·0	1·8	100	4050

* Scintillation pulse widths (full widths at half maximum) measured at Manchester University. This is a more meaningful parameter than decay time; reference, paper by J. B. Birks "Energy transfer in organic scintillators", given at Symposium on Nuclear Electronics and Radioprotection, Toulouse, March, 1968.

** These are true measured scintillation decay times, and not fluorescence decay times (which are shorter).

Nuclear Enterprises Limited

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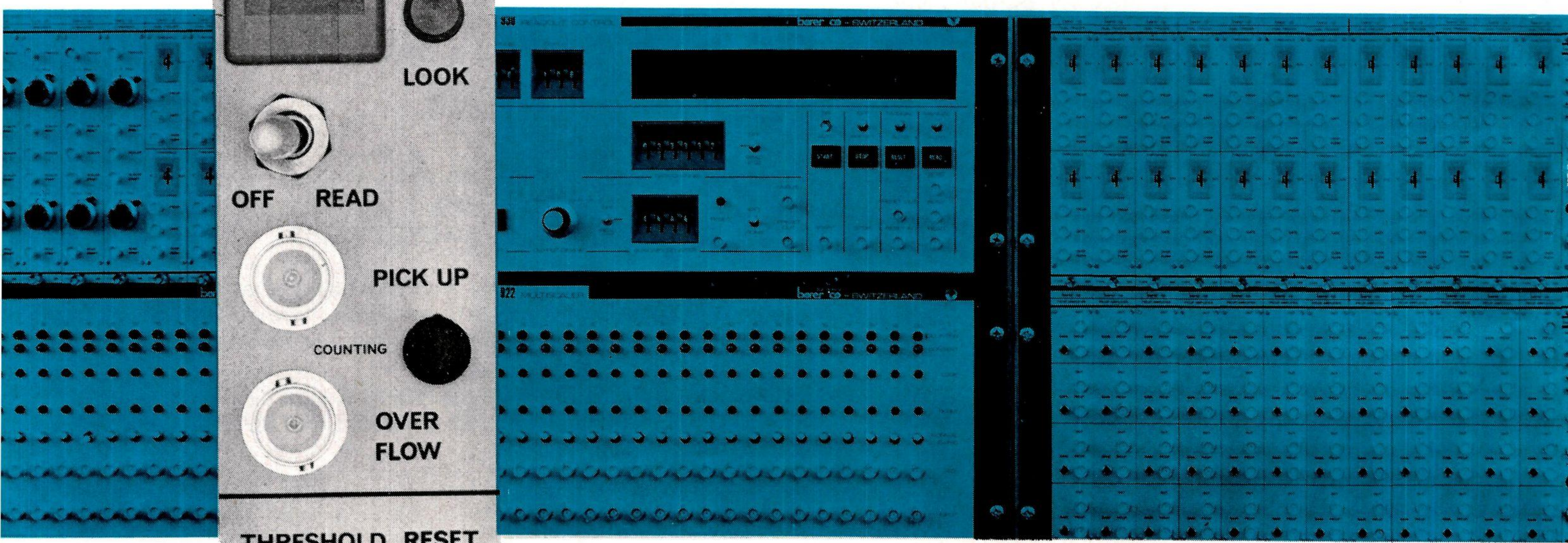
HIDAC means flexibility and reliability!

The HIDAC system is kept up-to-date even in some years by the permanent introduction of new modules, which helps to automise and expand your experiment.



Time to Digital Converter 909

The TDC 909 consists of two independent channels for digitizing the sonic transit time of spark chambers. It consists of a special discriminator input-circuit giving low jitter triggering of the subsequent 16 bit binary scaler, which counts the pulses from a clock-generator with a maximum speed of 20 MHz. The threshold of the input-discriminator is variable from 0,5 to 4,5 Volt in steps of a 0,5 Volt. For multiple-spark-detection with wire-spark-chambers, a special overflow-output is provided, by passing the second and all the following pick-up signals, which can be used to trigger second or further channels. In this way there is no limit to the multiple-spark-detection by switching TDC's in cascade. The double-spark-resolution is 0,5 μs or 2,5 millimeters for wire-spark-chambers. Using the LOOK-button the contents of this 16 bit binary scaler are displayed on the central control unit in decimal form.

The HIDAC Data Acquisition System is designed for collection of all data in experimental high and low energy nuclear physics. Many special units are available for particular applications, such as recording of data from spark chambers, Hodoscope-arrays, time-of-flight measurements, pulse-height information and counting-rates up to 100 MHz. This equipment was conceived from the many special units over the last few years, together with the latest requirements for ON-LINE control. Our programme does not only consist of a single component for the system, but we have a fully integrated range from spark chambers to interface of computers. We do not claim to have developed this system entirely ourselves, but with the help of our many customers it therefore covers most the requirements in the field.
On the left one the modules is introduced.

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Telephone 4305
Germany: Verkaufsbüro München, Kaiserstr. 10, D-8000 München 23
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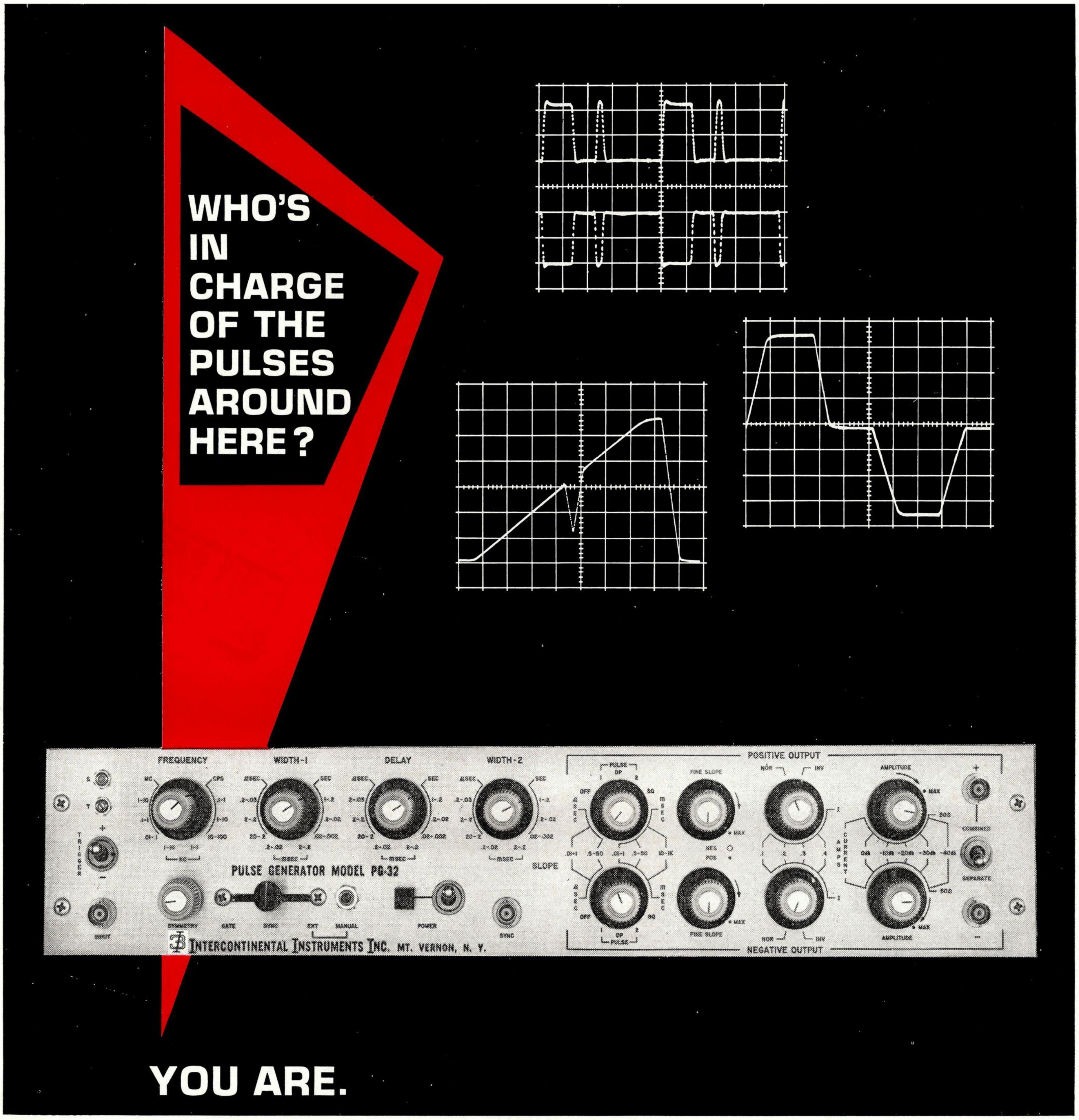
ELECTRONICS



One of the nice things about the 3-I Model PG-32 Dual Channel Pulse Generator is that it keeps things in perspective. If you don't care for what its output waveshape is, you can change it — it doesn't limit your usage.

You can control continuously the repetition rate, amplitude, rise time, fall time, pulse width, delay and so on of either or both of its dual output channels. If you want a current source, it's a current source at 500 ohms minimum impedance (current up to 400mA). When voltage is the thing, it's a voltage source (±20mV to ±20V from 50 ohms). Want bipolar outputs? Combine the channels and, voila!, bipolar outputs. The complement of the normal output of either channel? Easy. Throw a switch. Since both output channels are completely DC-coupled, any combination of waveforms is possible . . . including 100% duty cycle.

From each channel you can get single or double pulses; either first or second pulse. Or square waves. Plus sync pulse. You can externally trigger or gate the PG-32 to 10MHz. One-shot? Pushbutton. DC offsets to 10V via front panel controls.

All (silicon) solid-state; 3½″ high; modest price. If you would like technical literature or a demonstration, please write or 'phone.

Model PG-32. From Intercontinental Instruments, Inc. . . . an affiliate of CHRONETICS.

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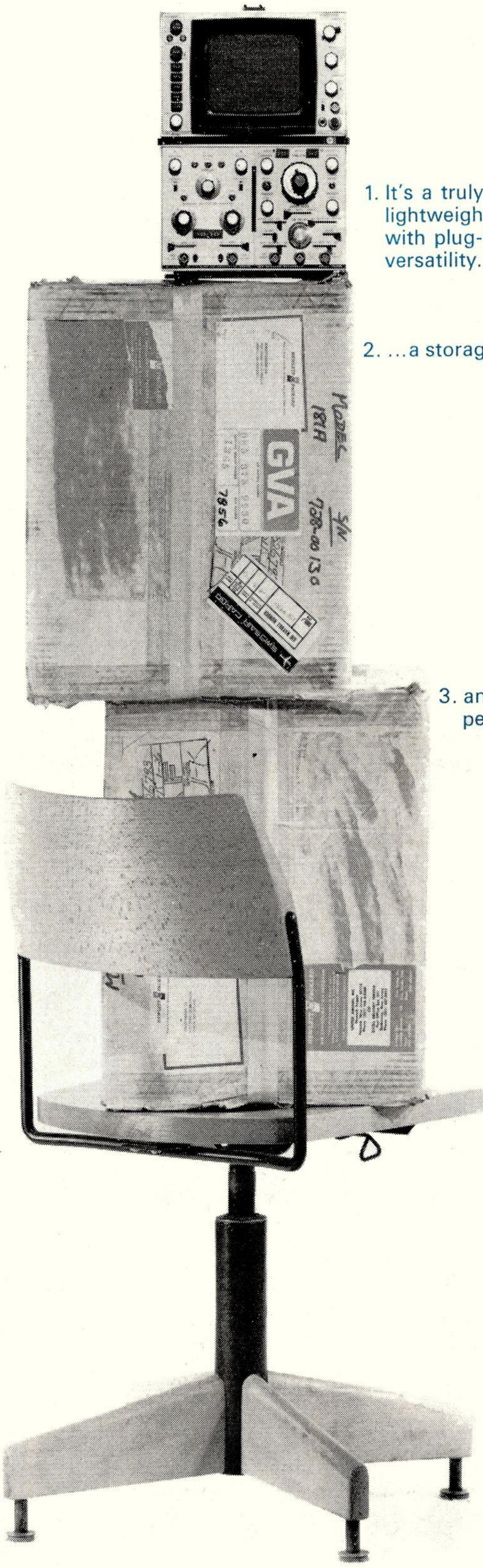
Now meet the oscilloscope which is three scopes in one: the 181A from HP



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2. ...a storage scope...

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