CERN COURIER

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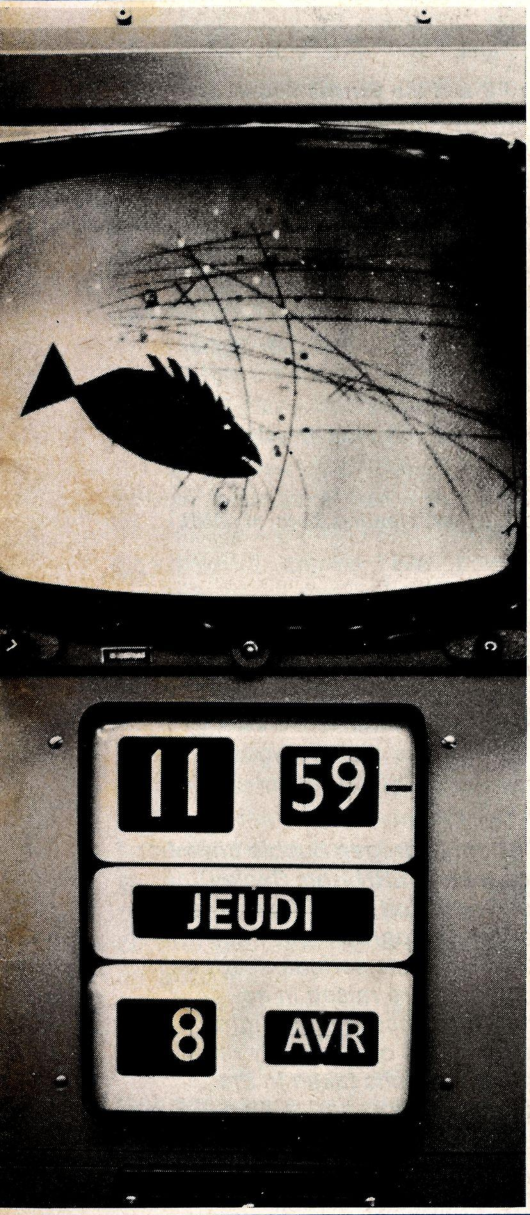
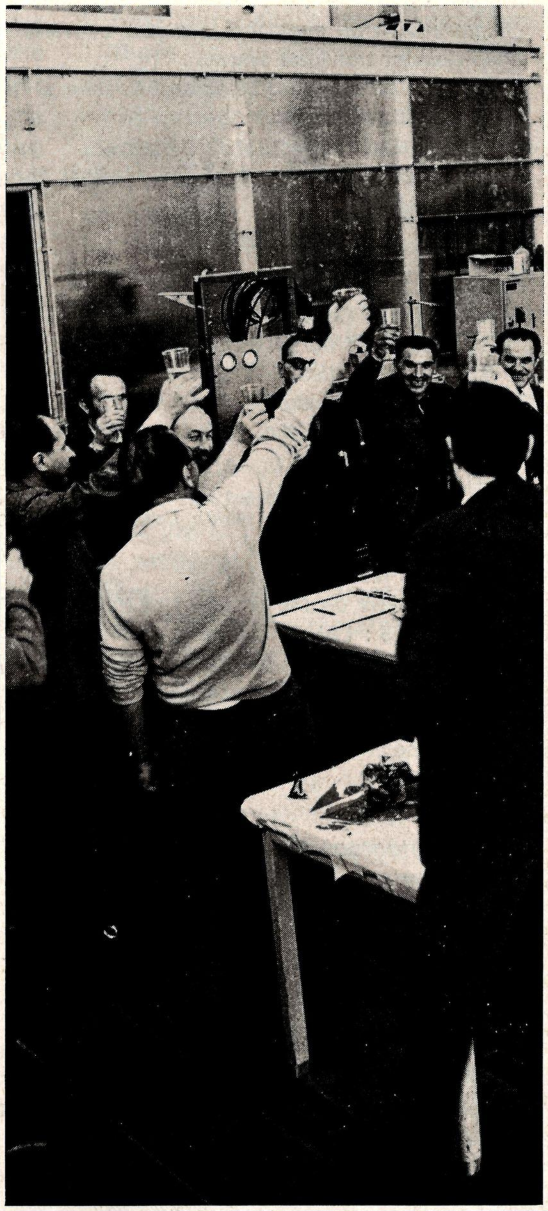
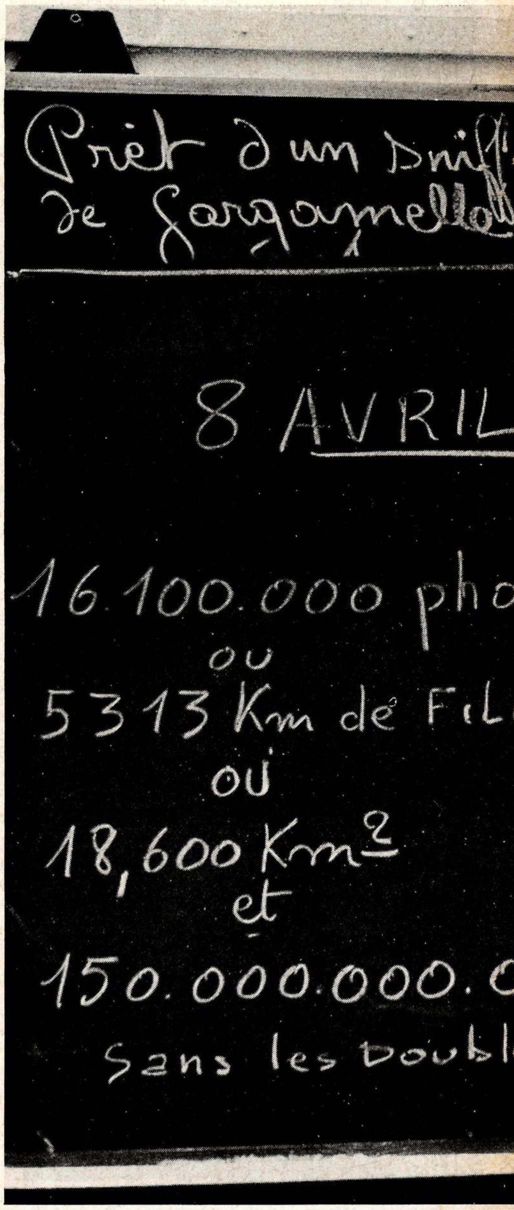
European Organization for Nuclear Research







CERN, the European Organization for Nuclear Research, was established in 1954 to '... provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto'. It acts as a European centre and co-ordinator of research, theoretical and experimental, in the field of sub-nuclear physics. This branch of science is concerned with the fundamental questions of the basic laws governing the structure of matter. The Organization has its seat at Meyrin near Geneva in Switzerland. There are two adjoining Laboratories known as CERN I and CERN II.

CERN I has been in existence since 1954. Its experimental programme is based on the use of two proton accelerators — a 600 MeV synchro-cyclotron (SC) and a 28 GeV synchrotron (PS). Large intersecting storage rings (ISR), are fed with protons from the PS for experiments with colliding beams. Scientists from many European Universities as well as from CERN itself take part in the experiments and it is estimated that some 1200 physicists draw research material from CERN.

The CERN I site covers approximately 80 hectares almost equally divided on either side of the frontier between France and Switzerland. The staff totals about 3000 people and, in addition, there are about 650 Fellows and Visiting Scientists. Twelve European countries contribute, in proportion to their net national income, to the CERN I budget, which totals 353.4 million Swiss francs in 1971.

The CERN II Laboratory was authorized by ten European countries in February 1971 ; it will house a proton synchrotron capable of a peak energy of hundreds of GeV (usually referred to as the 300 GeV machine). CERN II also spans the Franco-Swiss frontier with 412 hectares in France and 68 hectares in Switzerland. Its budget for 1971 is 29.3 million Swiss francs.

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Editor: Brian Southworth
Assistant Editor: Philippe d'Agraives
Advertisements: Micheline Falciola
Photographs: PIO photographic section

Public Information Office
CERN, 1211 Geneva 23, Switzerland
Tel. (022) 41 98 11 Telex 2 36 98

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Cover photograph : At mid-day on 8 April the 81 cm hydrogen bubble chamber (often known as the Saclay chamber since it came to CERN from Saclay) pulsed its last pulse at the proton synchrotron. On the left, the TV camera peering into the chamber transmits one of the last photographs (at 11.59 h.) to the TV screen. (The mysterious presence of a fish casts serious doubt on the origin of all those bubbles.) In the centre, glasses are raised in acknowledgment of the chamber's magnificient performance. On the right, the blackboard records some figures from the ten years of extremely reliable operation in many experiments — 16.1 million photographs taken in the chamber (5313 km of film) recording an estimated 150 thousand million bubbles !
(CERN 27/29/28.4.71)

Ultrasonic bubble chambers

Some information on ultrasonic chambers following a meeting at the Rutherford Laboratory on 18 March. The meeting was organized by the Laboratory together with the Acoustics Group of the Institute of Physics and the Physical Society. It concentrated on ultrasonic chambers in particular but covered fast cycling bubble chambers in general.

The evolution of particle detection techniques has been extremely rapid. It is difficult now to appreciate that, when construction of the CERN proton synchrotron was started, the detectors planned to be used with the machine included nuclear emulsions and Wilson cloud chambers as predominant techniques. At that time Glaser had only just got bubbles in a tiny bottle of liquid hydrogen and the plethora of different types of spark chamber had not even been conceived.

How this evolution will continue can only tentatively be predicted but we can confidently say that when the 300 GeV machine is well into its experimental programme it will be surrounded by detection techniques different in many cases from those in common use today. The fast cycling bubble chamber, where already a little experience has been gathered, is one possible way in which things might go for some specific applications. Within this category ultrasonic bubble chambers have interesting properties if their problems can be mastered.

Up to now the development of bubble chambers has involved predominantly a growth in size. (Attendant on this, of course, has been the mastery of all the cryogenic, optical and mechanical techniques in using larger volumes.) There have been moves towards higher fields from superconducting magnets and towards using hydrogen target volumes within denser sensitive liquid mixtures. In addition, the expansion systems of large chambers have been pepped up so that they can operate several times per second, making it possible to take several photographs in one cycle of an accelerator.

It is likely that the large chambers will be around for a long time yet. Their property of catching virtually all that goes on in and around a particle interaction has no substitute and, for example, is a useful property when pioneering in a new range of energies. Whereas the electronic technique, with counters and spark chambers, is likely to be set to pick out something specific (and thus 'expected'), the bubble chamber will inevitably also catch the unexpected. On the other hand this lack of discrimination is often a drawback. The ability of the electronic technique to record only the events of interest (without the equivalent of ploughing through hundreds of thousands of photographs) and to record them at very high speeds is usually a great advantage.

There is a distinct tendency at present for the two techniques to move towards common middle ground. Electronic detection systems (like Omega being built at CERN and large multiparticle spectrometers elsewhere) are becoming more bubble chamberish in being 'universal' instruments capable of being used in a wide variety of experiments catching a wide variety of particle events. Bubble chambers are moving towards integration in counter systems (Princeton and Argonne) so that photographs can be taken selectively. Such an ability is particularly important in the study of rarely occuring events (there are many currently of high interest in strong-interaction physics) and could open up a new range of experiments.

Since the electronic detectors, up to now, catch only the particles flying off from an interaction and interpret back as to what happened at the point of interaction, it is an obvious move to put a small bubble chamber to record what happens at the point of interaction, its own liquid being the target. To get maximum advantage from this arrangement the bubble chamber ought to be sensitive (i.e. in a state where tracks can be recorded) for as high a proportion as possible of the time for which it can receive beam and be able to take pictures at very high rates so that all the fast data recording ability of the electronic detectors is not wasted. It would probably be possible to feed such an integrated detector system with, effectively, a pulsed slow spill (using the synchrotron r.f. system).

Fast cycling bubble chambers which could fulfil this role can be divided into three types :

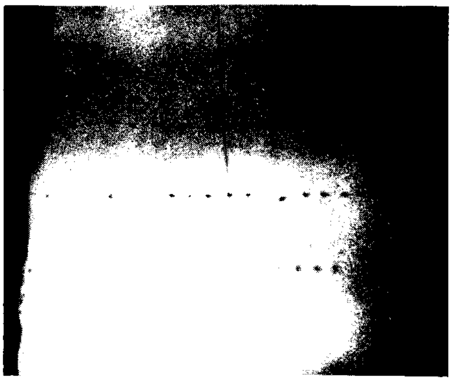
1. Rapid cycling — where a 'normal' bubble chamber has its mechanical expansion system hotted up to give many expansions per second. 90 Hz in small chambers has been achieved at Stanford, who lead the field in this type of chamber (see the January issue page 17 for a fuller story). There is also work on rapid cycling chambers at Saclay and Wisconsin. The Rutherford Laboratory are investigating the possibility of absorbing some of the research they have already done on the high field bubble chamber project into the construction of a 100 Hz chamber, 15 cm in diameter, with a large (3π) solid angle over which particles can emerge virtually uninhibited (a vital asset in the sort of integrated arrangement discussed above).
2. Sonic — where a pressure wave is applied to a chamber volume along a length equal to a multiple of a quarter of its wavelength so that a section of the volume becomes sensitive. This has been achieved at Dubna applying sonic pressure fields on top of that produced by a mechanical expansion system and is being attempted at Argonne, in heavy liquids, and at Stanford.
3. Ultrasonic — where high frequency standing waves are created in the chamber volume producing sensitive regions distributed across the volume. This has been achieved at CERN and is being attempted at Dubna and Tokyo University.

The maximum repetition rate which can be achieved by any of these types

1. Particle tracks recorded in a helium ultrasonic bubble chamber. The striated appearance comes from the fact that the standing ultrasonic wave between piezoelectric crystals results in bands of the liquid being made sensitive rather than the entire volume.

2. A track recorded in hydrogen in the 1 m model bubble chamber at CERN applying an ultrasonic pressure wave on top of a conventional expansion system (in itself insufficient to sensitize the hydrogen).

3. In trying to push the pressure swing in hydrogen higher with the piezoelectric crystals, so as to get nearer to the point (about 2.5 kg/cm² swing) where the crystals alone (without the help of the conventional expansion system) would sensitize the hydrogen, the crystal on the left cracked under the strain.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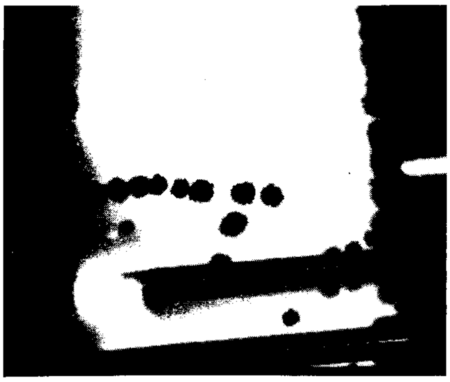
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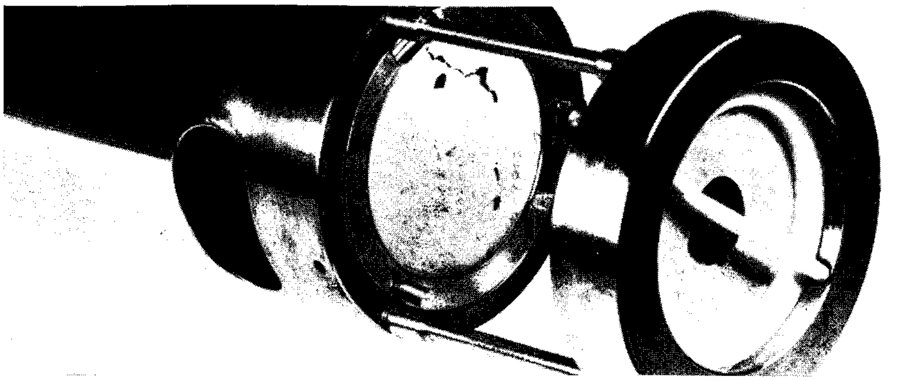
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is dictated by the time which is needed to apply the pressure wave which makes the liquid sensitive (dictated in turn by the velocity of sound in the liquid), to grow the bubbles to photographable size and then to snuff them out ready to record tracks again. Independently of the type of chamber it can be shown that the maximum repetition rate in hydrogen comes out less than 100 Hz m divided by the sensitive length of the chamber expressed in metres. (A 1 m chamber could theoretically reach rates up to 100 Hz.)

From the point of view of maximum repetition rate there is, thus, little to choose between the types. We will now concentrate on the ultrasonic where there are other advantages since they do not require a mechanical expansion system and they control the expansion directly electronically (which would tie in nicely with electronic detector logic systems).

Tracks were first recorded in an ultrasonic bubble chamber at CERN in December 1968 (see vol. 8, p. 316). The chamber was filled with helium, chosen because the necessary pressure swing to make the liquid sensitive is only about 0.2 kg/cm^2. This pressure swing was achieved using two piezoelectric crystals (7 cm diameter, 5 cm apart) setting up standing waves between them with a frequency of 110 kHz. The first photograph shows some of the tracks obtained. Note their striated appearance due to the standing wave making bands of the volume sensitive rather than the entire volume. The crucial fact to emerge from this first operation was that the bubbles formed in the wake of a charged particle are not snuffed out when the pressure of the standing wave swings in the opposite direction but continue to grow to photographable size over subsequent cycles (to at least 25 μm in less than 1 ms). It was also shown that bubbles disappear completely within 10 ms of switching off the crystals (tested by pulsing them again after a 10 ms interval and observing no bubbles from the re-growth of old bubble remnants) which is another important parameter to know in discussing the applications of ultrasonic chambers.

The investigation then moved into hydrogen, the much more favoured bubble chamber liquid. The first problem is that the required pressure swing is more than ten times greater than in helium (about 2.5 kg/cm^2) and it was doubted that the piezoelectric crystals then available (PZT4) were capable of producing such pressure amplitudes in bubble chamber liquids. The help of a conventional expansion system was therefore called in and the crystals were set up within the 1 m hydrogen bubble chamber model at CERN.

The crystals were powered with a voltage of 1 kV to give a pressure swing of about 1 kg/cm^2. The chamber piston was operated to apply progressively higher pressure swings (though not by themselves sufficient to produce tracks) until tracks appeared. The second photograph shows one of the tracks recorded. Information was gathered about the conditions under which the hydrogen became sensitive, on the amplitude of the ultrasonic waves and on the ratio of the crystal voltage to this amplitude.

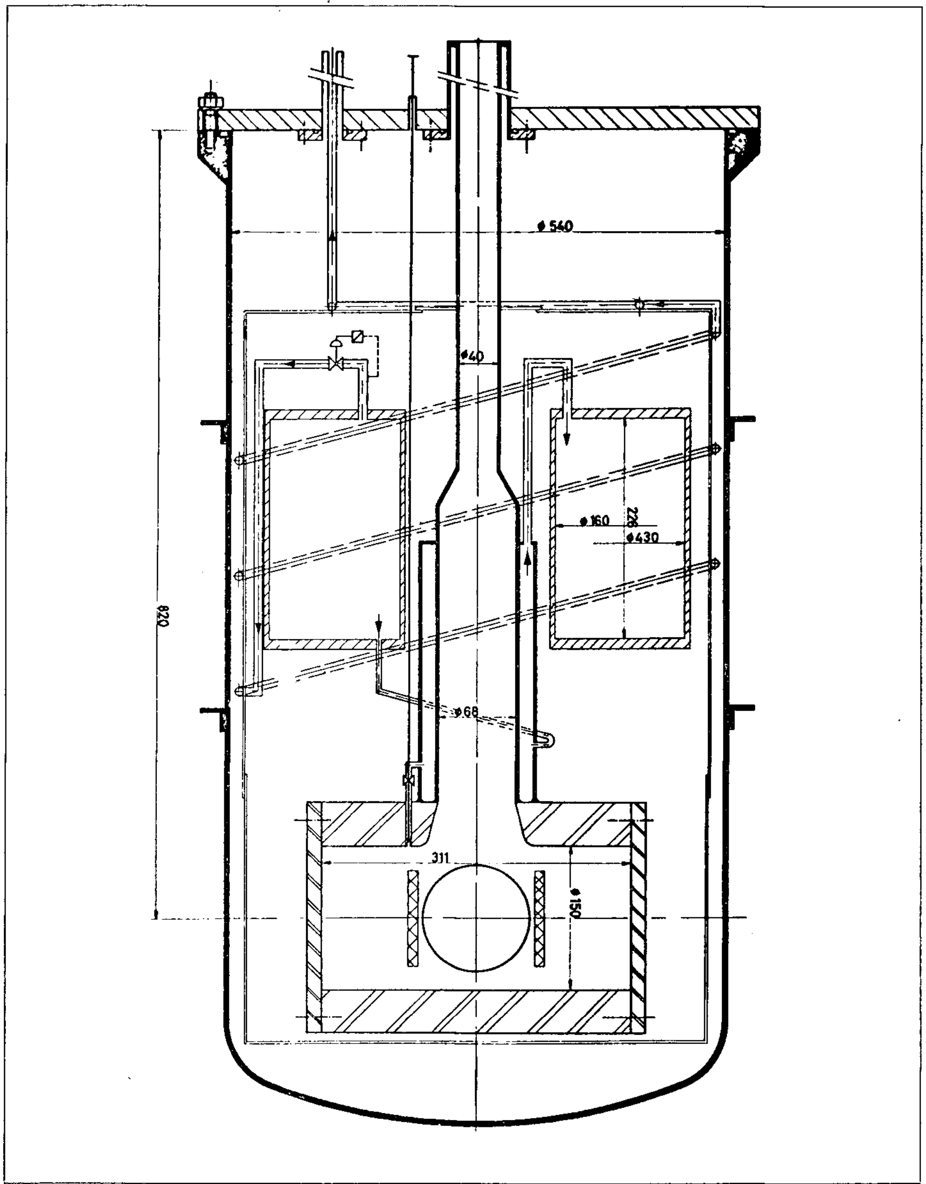
It was then decided to push the piezoelectric crystals as far as they would go in an attempt to achieve the first photographs of tracks in hydrogen sensitized by ultrasonic waves alone. The voltage was increased to 2.6 kV corresponding to a pressure swing of 2.6 kg/cm^2. The third photograph shows the sad result. Before tracks were seen the crystals were stressed too much and shattered.

4. *A diagram of the chamber (30 cm long, 15 cm diameter) which is being built at CERN to attempt ultrasonic operation in hydrogen without the help of a conventional expansion system (though the vertical bore would enable such a system to be installed). This chamber is designed so that modifications can be fairly easily applied as dictated by the progress of the research. Dimensions on the diagram are in millimetres.*

To carry out the detailed studies which are obviously going to be necessary before the ultrasonic hydrogen chamber can be shown to be a detector which will find its way into the experimental halls, it has been decided to build a small test bubble chamber at CERN specifically for such research. The fourth photograph is a diagram of the chamber. Obviously the first thing which needs demonstrating is that crystals which can take higher stress can produce sufficiently high pressure swings in hydrogen to sensitize the liquid without help from a conventional pressure system.

One aid to this will be to achieve a better 'match' of the acoustic impedances presented by the crystal and the liquid. If this were close to a value of one, virtually all the power fed to the crystal would be transmitted to the liquid and the stresses would not be so high. (It is estimated, for example, that in attempting a pressure swing of 2.5 kg/cm^2 in hydrogen the mismatch with PZL4 crystals was such that they needed to be stressed to 1700 kg/cm^2, many times beyond the maximum they could sustain.) Tests are being carried out to find an appropriate intermediate material to insert as a quarter wavelength plate between the crystal and the liquid. Something like araldite or an aluminium honeycomb structure might help a great deal.

Another problem is the effect of the heat in the crystal heating the hydrogen liquid, altering the velocity of sound in the liquid and thus playing havoc with the parameters carefully set to achieve the standing wave pattern. A feedback system has been developed to alter the frequency at which the crystals are powered to counter this effect. Work will also be needed to achieve good uniformity of the sound field. Appropriate design of the transducer system should be able



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to ensure this but it may prove the main difficulty.

If these problems are solved we can imagine an integrated detector system working something like as follows : The ultrasonic field is switched on and particles are fired into the chamber which is, say, a few tens of centimetres long. During less than a millisecond the field remains while bubbles grow to photographable size. At the same time the produce from any interactions is caught by electronic detectors and the extremely fast logic circuits say whether that particular burst of particles has produced a candidate for the interaction of interest. If the answer is 'yes' the flash/camera system records the bubble pattern. The sound field is then switched off. Within 10 ms the bubbles disappear and the process is repeated.

A potential of a hundred photographs per second with such a system is an alluring prospect to help get hold of quite a lot of information on rare interactions of current interest (such as, interactions involving the production and decay of hyperons whose short tracks would be caught in the chamber, peripheral processes where the recoil proton would be recorded, deuteron interactions where the spectator proton would be recorded). Whether the technique can be thoroughly mastered, and whether it proves the best method of acquiring this information, remain to be seen.

CERN News

ISR commissioning progress

We left the Intersecting Storage Rings in the February issue with the drama of first colliding beam operation. Since then commissioning has been going through the slower, harder process of attempting to master the machine in fine detail. Nevertheless quite a lot of progress has been made and also, in an atmosphere of great enthusiasm, some first makeshift particle physics experiments have begun.

Both rings are now virtually complete in terms of equipment and both are capable of stacking high currents. Their performance can be summarized in outline as follows :

1. Up to the 1 A level it is possible to stack and store beams reliably with almost negligible loss rates (equivalent to the expected loss rate from interactions with the residual gas in the vacuum chambers). Thus, typically, a 1 A beam stored at midnight at the end of a machine commissioning period to be used for experiments, had fallen in intensity by 1 mA at the end of the physics run at six o'clock in the morning. This corresponds to beam half-lives of many months. But what is important is that this ability gives virtually ideal 'background' conditions for the experiments. From the machine point of view (for example, concerning the number of times the rings would have to be filled) much higher loss rates seem acceptable, but the experimenters become uncomfortable when particles are lost at a higher rate giving them signals in their detectors which are not coming from true proton-proton collisions in the colliding beams.

2. At intensity levels between about 1 A and 2.5 A stored beams can be achieved with acceptable loss rates for the experiments but such beams cannot yet be set up reliably. Sometimes a good stack comes off, sometimes it doesn't.

3. Beyond 2.5 A, the first thing to note is that the 'brick wall' has been knocked down. At the time of first operation we recorded that in both rings an intensity limit (called the brick wall) was being experienced which caused an abrupt loss of a high proportion of the beam whenever the limit was reached. Further study showed that this was caused by transverse instabilities in the beams (due possibly to phenomena such as the inductive effect of the varying shape of the vacuum chambers in which the beams travel) and it was cured by applying fields in sextupole correction magnets which are installed for precisely that purpose. When this was done, intensities climbing just over 4 A became possible. Here, what looks like a much more solid brick wall has been encountered, for when this limit is reached the beams decay very rapidly and do not show the characteristics associated with known instabilities. The phenomenon does not seem to be influenced by sextupole fields or by changing the working point of the machine (as had been the case with the first brick wall).

The runs have been carried out at about 15 GeV and 22 GeV to give experimenters a taste of proton-proton interactions equivalent to those at a conventional accelerator of 500 GeV and 1000 GeV. Luminosity measurements are in excellent agreement with expectation. About ten periods have been given to experiments — at the end of a commissioning run beams were stacked and stored in the rings and left orbiting for periods of six or twelve hours while proton-proton interactions were studied. These physics runs were carried out on the understanding that if the beams deteriorated badly, or disappeared, there would be no re-filling of the ring. Re-filling was never needed in any case.

A mini-shutdown of the ISR is now under way. For about a month installation of equipment for experiments at the intersection regions is taking priority. The machine will come back on the air on 6 May.

PS Booster bending magnets arriving

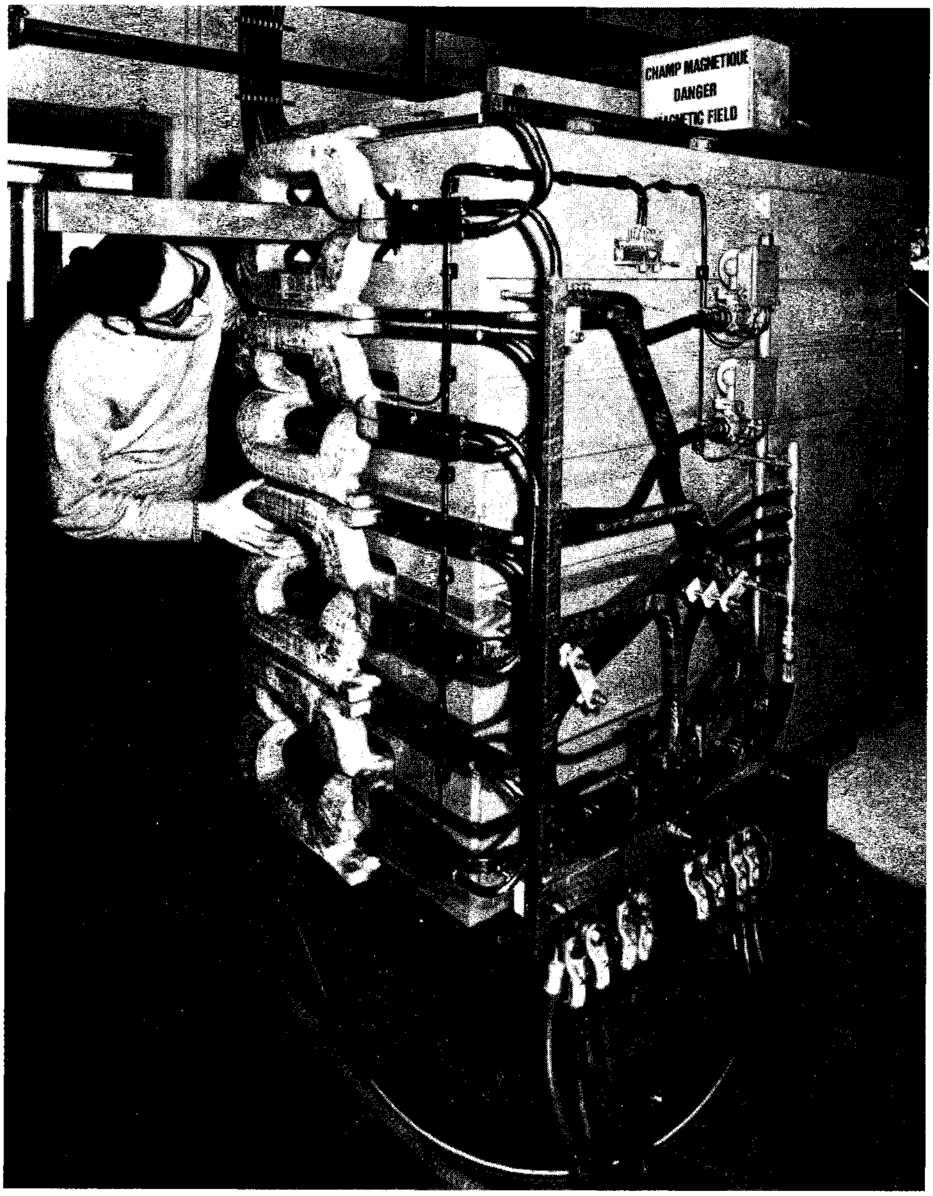
The first of the bending magnets for the 800 MeV Booster has arrived at CERN and has been tested. These magnets are rather special in that they each accommodate four synchrotron rings stacked one on top of the other. (A description of the magnets, indicating their special problems and the way in which they are solved, can be found in vol. 10, page 73). Thirty-two bending magnets are needed to complete the machine. The second one is expected to arrive at CERN from the manufacturers, Alsthom in France, in April and the others will follow in rapid succession. Installation in the ring will probably begin in May/June.

The four-tiered quadrupole focusing magnets, manufactured by BBC in the Federal Republic of Germany, will follow about two months behind the bending magnets. A quadrupole triplet, together with correction magnets, and beam observation stations, will be mounted on a single girder and carried to the machine as one unit, installation probably starting about August/September.

The main power supply, which does not contain any rotating machinery, is being installed in its final location by the manufacturing firm, Siemens (Federal Republic of Germany).

The civil engineering work for the Booster is complete and some services, such as cooling water pipes and cable supports, are now being installed in the machine building.

The first bending magnet for the 800 MeV Booster being tested following its arrival at CERN. Note that the magnet has four apertures since the Booster consists of four identical synchrotron rings mounted one on top of the other. Magnetic field measurements are under way in the top aperture.



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Protons have already been brought 45 m along the injection line from the linac towards the Booster (see below). It is hoped that in the course of next year they can be injected into the four completed rings to begin commissioning of the machine.

ISR beam dump

Whereas the intensity of the beam circulating in the PS is of the order of 80 mA, a current of up to 20 A per ring is planned to be stored in the ISR. As long as the stored beams circulate under control there are no problems, but if in the course of operation there is a fault such as a power failure, or disturbance from other sources, the beam would go out of control and strike the walls of the vacuum chamber... which could overheat and even melt, lead to vacuum implosion, put the machine out of action and cause a considerable amount of damage. To avert such danger, an emergency dumping system is provided to direct the beam into a block of metal which is well able to withstand local heating without damage, and which safely localises the resulting radioactivity.

The need for an extremely fast response to any machine failure excludes the sort of system used for example between the linac and the PS where a stopper falls across the beam to prevent it entering the PS. We have to resort to beam ejection. This is done conventionally with a fast kicker magnet system with the following features :

1. the beam is bent vertically (upwards for one ring, downwards for the other) ;
2. the dump block is not outside the ring but surrounds the beam, and as such is part of the vacuum chamber (thus the beam can be dumped by a fairly small deflection) ;
3. the magnets are not ferrite yoke (giving high outgassing in ultra high vacuum) but parallel stainless steel electrode magnets, four in each ring, placed in series and giving a field of a few hundred gauss. An 8 kV current passing through them for 3.6 μs results in a bending angle of 2 mrad with a 28 GeV/c beam.

The dumping was programmed and operated automatically from the first injection into the ISR. At present stored beams with an intensity of 4.3 A are dumped by pressing the appropriate button when required.

In addition to programmed and 'manual' triggering, the beam is dumped automatically under various circumstances, namely :

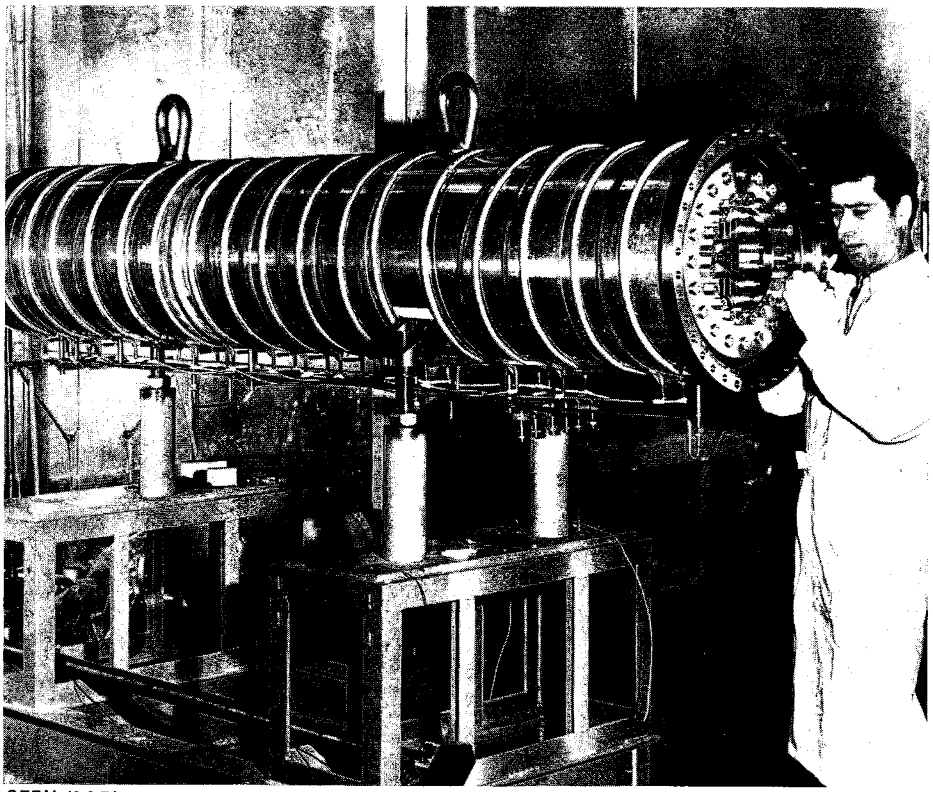
1. break-down of the generators supplying the main ring magnets or a power failure ;
2. a sudden increase in the vacuum pressure ;
3. closing of a sector valve ;
4. high rate of beam loss in the vacuum chamber ;
5. tunnel access doors opening when this could be dangerous.

Some of these causes influence the beams only slowly, and a fairly long reaction time from the dumping system would be sufficient. But others act quickly and the dumping system has been designed to react within milliseconds. The reaction time will include the time taken to signal the fault, to trigger the dump magnet pulse generators and to establish the field in the magnets. The last two operations can be carried out in less than 1 μs. The pulse generators consist of delay lines of 3 ohms impedance which can be charged up to 60 kV and are discharged by triggered deuterium thyratrons.

The dump blocks, 2.5 m long, are made of stainless steel with a core of titanium discs over the first 70 cm. They can also be moved vertically

1. and 2. An ISR beam dump block, made of titanium and steel, viewed along its length from the outside and also looking into its bore. Stored beams are directed vertically into the block during normal emptying of the rings or in case of emergency.

3. A schematic diagram of the layout of the beam dumping system for one ring of the ISR with its four deflecting magnets and dump block.



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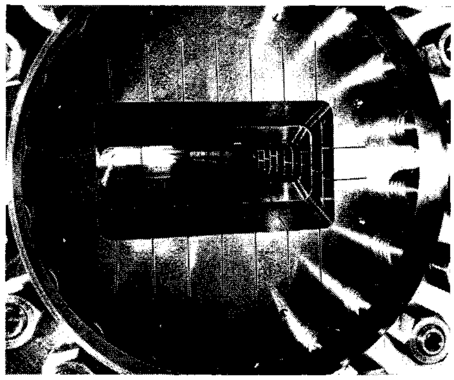

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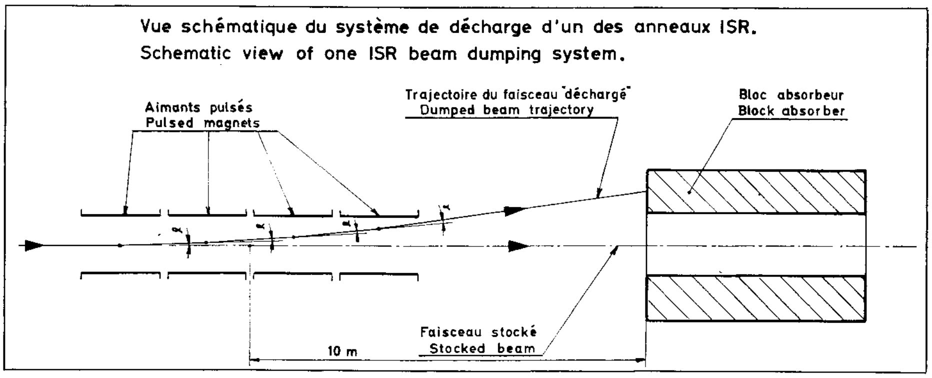

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across the vacuum aperture so that they act as beam scrapers trimming the height of the beams.

Installation of the dumping system in Ring 1 was completed a day and a half before the first tests began in October 1970. Right from the start, it functioned as designed. The system in Ring 2 was ready for the tests in January. Adjustments to the automatic triggering devices and improvements, particularly concerning the development of a resonant charging power supply system to avoid voltage holding problems when the ISR is operating at the highest energies, are being made.

Those ADCs

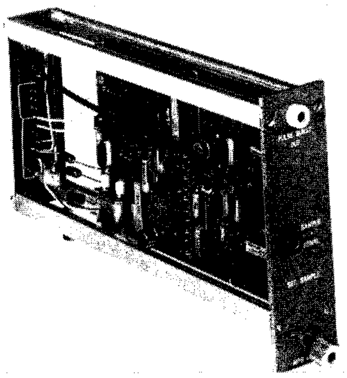
In the English edition of the last issue (page 68) we mentioned some analogue to digital converters, used in data acquisition and control at the PS linac, which are accurate to within one part is a million ! We are not that good, it should have read one part in a thousand. Our mistake provides us with an excuse to say a little more about these converters, developed in the linac group. They are, by now, virtually a mass-produced item (over 120 are in use on the linac, the PS ring and in the PS experimental halls, and some are scheduled for Serpukhov).

The need at the linac is to get hold of many machine and beam parameters within a few microseconds in each second. This can be achieved by using one ADC with a multiplexer in front of it (feeding through, one after the other, the data collected and stored in 'sample and hold' circuits) or by using many ADCs, one for each parameters. The second alternative was chosen because it emerged that ADCs could be made for the same price (total cost for components, assembly and testing is less than 500 Swiss francs per unit) as the sample and hold circuits and could give the same precision. Also, only recently, has industry put units with 1 μs sampling time on the market and their cost is rather high.

Some technical details : In general ADCs can have either a parallel or serial output for their digitized information. With parallel output, each output signifies one bit and therefore the number of outputs determines the maximum possible precision. The data acquisition system must be designed with the desired number of parallel wires from the beginning. With serial output the number of pulses being sent on the single output cable gives the digitized value. An increase in precision means an increase in the number of pulses. Serial output was selected since such ADCs can be simply and cheaply realized. The single output can supply the digitized information to simple numerical ('Nixie') displays, to scalers (which can store and send the information on request to the PS control computer via the 'STAR' system) and to digital to analogue converters (for presentation, for example, using a pen recorder). The displays, scalers and DACs using serial input are about the same price as equivalent units using parallel inputs. The single wire output also makes easier any adaptation for the transmission of signals across

Preparations for brazing an r.f. separator component in a vacuum furnace in the CERN West workshop. The structure has alternating discs and rings requiring tight manufacturing tolerances. It was impossible to machine from a single block ; each disc and ring is machined separately, stacked, and brazed under vacuum.

Below : photo of one of the ubiquitous analogue to digital converters developed in the linac group.



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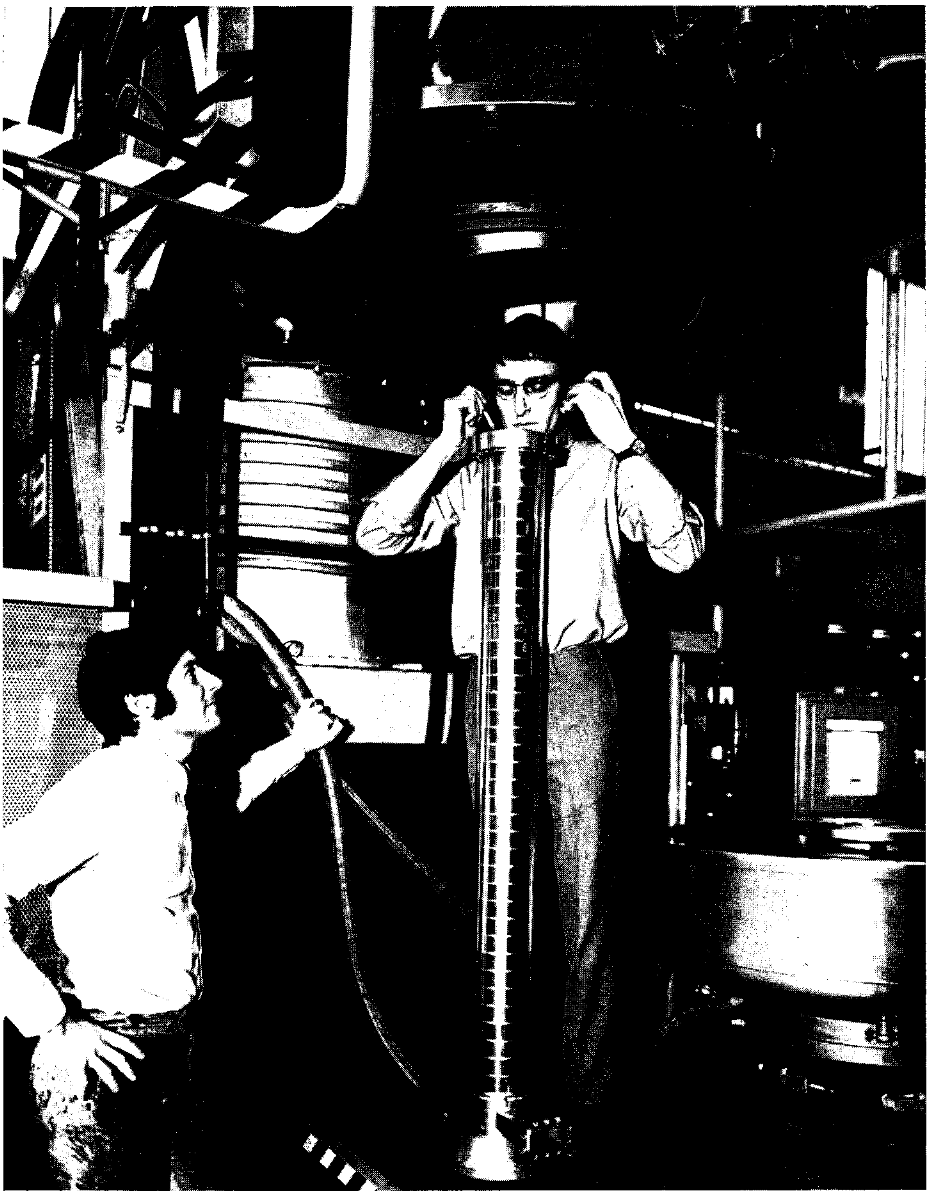
high voltage potentials (via light signals), and separation with pulse transformers. The output can supply long cables and several displays, scalers or DACs in parallel. The disadvantage (which is not important in the linac applications) with serial output is the rather long time (about 1 ms) which is necessary to convert the signals.

About 50 of these ADCs are in use on the linac linked with the PS control computer via the STAR system. Some are used in the control room itself (for example, one serves to spread around the recorded value of the beam intensity to points in the experimental halls). The neutrino beam-line uses six of the units to keep an eye on the pulsed magnet currents. The r.f. separated beam-line in the East Hall also uses six to monitor the pulsed r.f. power. Finally, some will probably move to Serpukhov in a few months time to be used together with the r.f. separator which CERN is providing.



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Linac Booster transport system

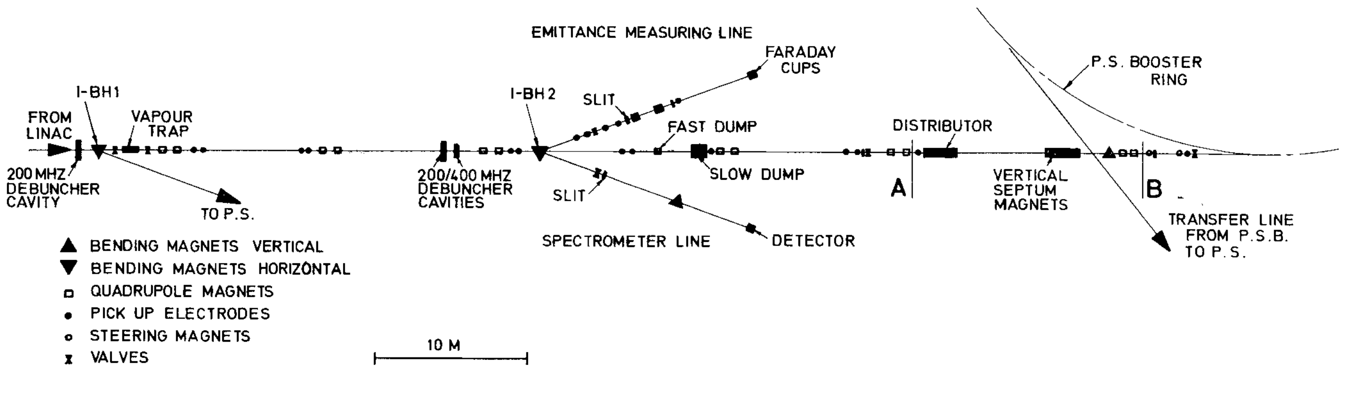
The link between the 50 MeV linac and the 800 MeV Booster is nearing completion. During the shut-down of the PS at the end of last year, many of the components of the beam transport system were installed and beam has been brought to the beam-line where emittance measurements are carried out (see vol. 10, page 279).

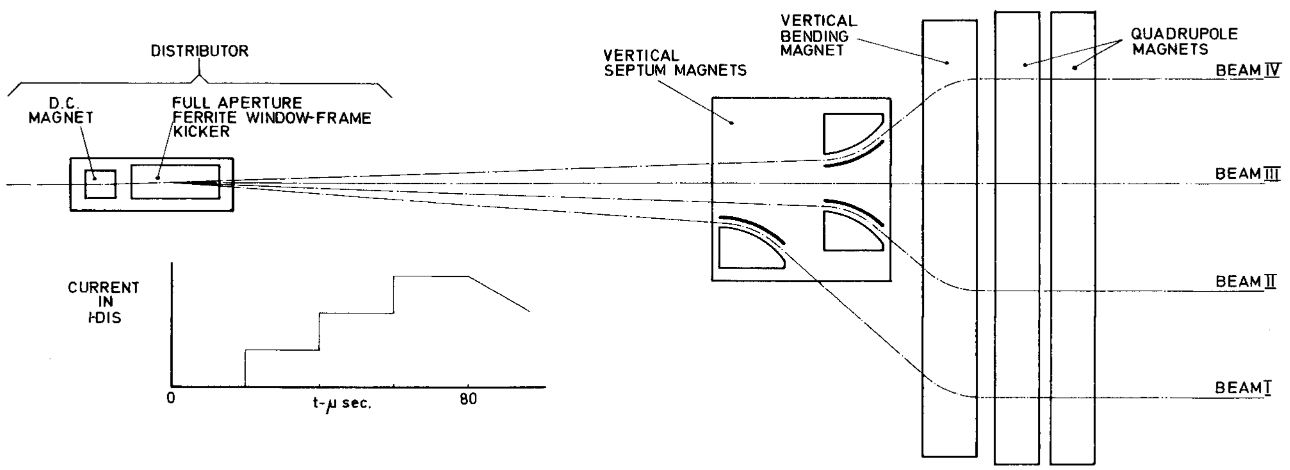
The diagrams illustrate the complexity of the inter-connections in this region. The linac beam can be fed either to the PS or towards the Booster. Along the Booster line two other small lines emerge (for emittance measurement, installed early 1971, and for energy spread measurement, to be installed later). When the beam goes to the Booster it must be distributed vertically to the four superimposed rings.

The pulsed magnet I-BH1 (feeding the PS or the Booster line) is powered by rectangular pulses at the PS pulse rate. As the linac pulses are currently of a frequency of 1 Hz (to be raised later to 2 Hz), and as the PS cycle is about 0.5 Hz, the field pulses in this magnet can be used to supply beam pulses from the linac alternately to the PS and the Booster. This will enable measurements to be made on the line feeding the Booster and in the Booster itself during its entire commissioning period without interfering with operation of the PS.

In addition to this pulsed magnet and the I-BH2, with which beam can be deflected for emittance and energy spread measurement, the line includes conventional bending and focusing magnets and a series of debuncher cavities which will be used to compensate energy spread introduced in the beam, due to space charge effects, over the considerable length of the beam-line.

The last magnets for vertical distribution of the beam before injection into the Booster are a normal magnet, a ferrite kicker magnet, three septum magnets and an unpulsed magnet (to bend the beams into the horizontal direction again). The system can be set to provide single turn or multi-turn injection. For this, the ferrite kicker magnet is supplied with stepped





pulses, with 'flat-tops' varying from 1.6 to 25 μs depending on the number of turns to be injected per ring. The beam is then subject to the influence of septum magnets whose fields result in four diverging directions for the beams, leading to the four rings.

The Medical Service

Since June 1965, the Medical Service has been responsible for surveying the health of the personnel and for sanitary control. It is part of the Personnel Division and so differs slightly from the other services which also deal with prevention and safety (the Health Physics and General Safety Groups).

Various regulations are the basis of one aspect of the activities of the Service. The Staff Rules and Regulations and the CERN Safety Codes lay down a system of medical procedures which ponctuate the career of each member of the personnel : a medical examination on arrival or prior to recruitment, an examination on the resumption of work after an illness, regular examinations to check on occupational diseases and an examination on departure from CERN.

Besides the medical examinations, there are a certain number of additional tests : blood tests, biological tests, audiometric tests and X-rays which are carried out on arrival and periodically as required according to the professional category of the person concerned.

The assessment and regular checking of the professional fitness of staff members form one of the main activities of any industrial medical service. It can enable a man to adapt himself better to his work (or the work to be better adapted to the man) by advice and occasionally by work restrictions as a result of the various examinations and tests mentioned above.

The specific problems of the physically handicapped are also carefully studied. In addition, the Medical Service acts as a consultant in matters concerning general hygiene (environment, drinking water, canteens, etc.) as well as in social problems where the medical factor often plays an important part.

To appreciate the working conditions of the personnel, the doctor frequently visits and studies their places of work. These visits enable closer links to be established with the personnel and lead to a better understanding of the technical problems involved.

The emergency treatment of sick and injured persons is carried out with the Site Security Service which has the appropriate transport facilities (ambulances) at its disposal. A well-equipped central infirmary provides a

Above left : The beam transport system between the linac and the Booster. The I-BH1 magnet can bend beams towards the PS or allow them to continue towards the Booster and both machines can operate independently.

Below left : Vertical distribution of the beam between points A and B in the above diagram. The distributing magnet deflects beams into three septum magnets which cause it to diverge along four different paths after which they are realigned horizontally. The current in the distributing magnet is also shown in the diagram.

Some statistics on the work of the Medical Service in the past five years.

Collecting one of the many thousands of samples on which blood tests are carried out each year.

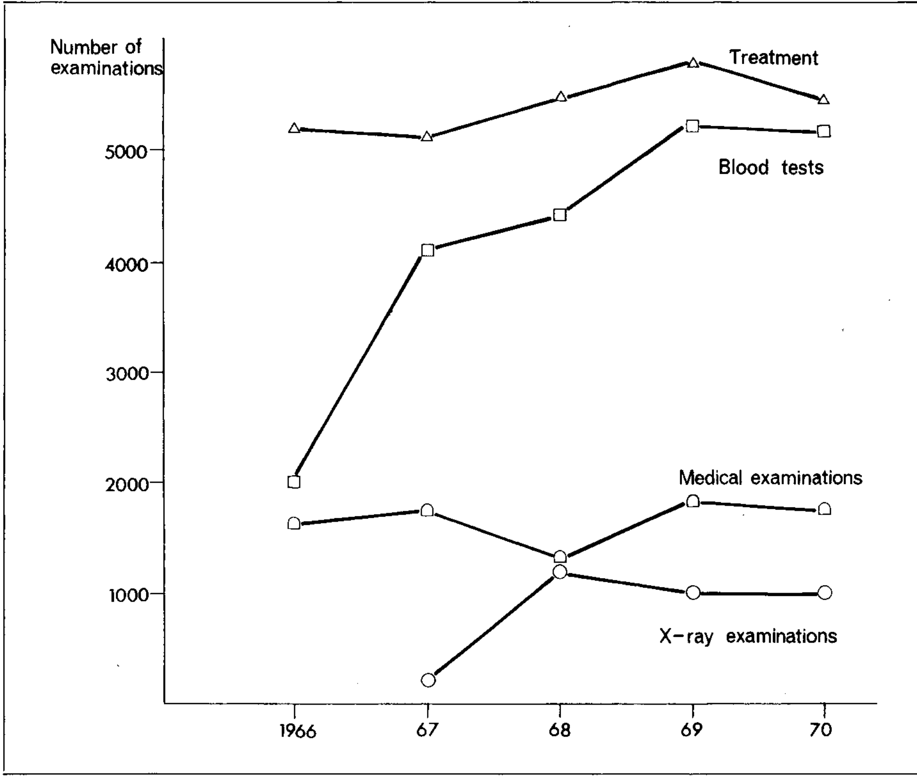
first-aid service for accidents and voluntary first-aid workers are now being trained. As a result of the efficient prevention work carried out by the General Safety Group and the Health Physics Group, the number of accident victims has decreased considerably in recent years.

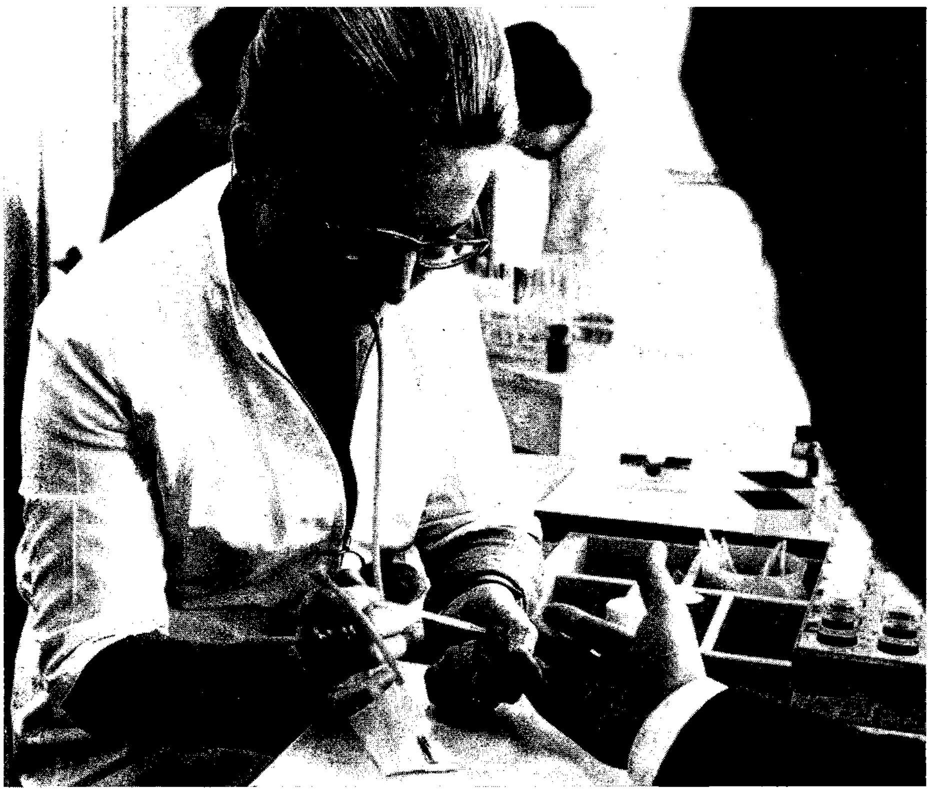
The Medical Service has at its disposal a building containing consulting rooms, a blood test and biological laboratory, an X-ray machine, the infirmary mentioned above, and a secretariat. The personnel consists of trained nurses, laboratory technicians, as well as an administrative staff and the medical officer. (A second doctor is temporarily working in the Service, as a visitor.)

Over the years, it has been possible to run several quite large-scale projects with the cooperation of medical services outside CERN. These were :

— three chest X-ray campaigns in 1966, 68 and 69 (which detected four cases of tuberculosis)
— a cancer detection campaign for female personnel
— a session for blood donors in 1970 (472 donors)
— a BCG vaccination campaign (1500 persons registered) in 1970 and 1971.

New activities are planned for the future to enable the Medical Service to continue to carry out its functions efficiently and to contribute to a better understanding of health problems within CERN.





CERN 121.3.71

Around the Laboratories

Titisee meetings

From 1 to 5 June, a meeting on two-body collisions at high energies will be organized at the Titisee, Black Forest. High-energy collisions on nuclei and particle production are the topics of a second meeting, to be held from 7 to 11 June. That meeting is a Europhysics Conference. Further information can be obtained from the Secretary, Institut für Theoretische Kernphysik der Universität, D 75 Karlsruhe 1, P.O. Box 6380 and from B. Petersson, Research Institute for Theoretical Physics, Siltavuorenpenger 20 b, Helsinki.

BROOKHAVEN
Conversion shut down

A three month shut down of the 33 GeV Alternating Gradient Synchrotron at Brookhaven began in April, the main scheduled work being the connection of the new 200 MeV linac (see vol. 10, page 388) to the main ring. Many other smaller modifications to the AGS will also be carried out and when the machine comes back into action, it is expected to accelerate beams of 5 to 7×10^{12} protons per pulse fairly soon after with the new linac in service.

The linac is performing very reliably. A peak current of 400 mA (about 70 % protons) has been accelerated in the pre-injector which regularly operates at a voltage of 790 kV (the design figure was 750 kV). In the first linac cavity, taking the beam to 10.4 MeV, a peak current of 210 mA has been reached and stable operation is possible with beams of 150 mA for several hours at a time. (For fun, a deuteron beam has also been accelerated through this first tank to an energy of 5 MeV with a 400 keV injection energy. A peak current of 18 mA was achieved.) Performance of the first tank is very important because it is here that most beam blow-up is likely to occur.

Effort in the early months of this year has been concentrated on improving the performance of the remaining eight cavities, progressively optimizing operating parameters. The 200 MeV accelerated current is normally held to less than 20 mA to avoid building up too high induced radioactivity levels, but, for short periods, intensities as high as 90 mA have been accelerated to check beam loading effects. Momentum spread in the 200 MeV beam still requires further fine adjustments of the linac to bring it within the design value. A debuncher is installed between the linac and the ring but funds are lacking for its completion ; the linac may not, therefore, be able to provide its full 100 mA to the AGS initially because of the large energy spread introduced by longitudinal space charge forces in the long transport line to the ring.

The linac can provide ten pulses per second. Most of these pulses are intended for radio-chemistry experiments and the production of large quantities of radio-isotopes. The first radio-chemistry irradiation has already been performed. There is also considerable interest in using the linac for medical treatments with protons, both experimental and clinical.

The new main magnet power supply (manufactured by Siemens) was brought into full service at the end of January. It improves by a factor of two on many of the operating parameters of the initial power supply. The rise time of the magnet field is reduced from 1 to 0.5 s ; the maximum cycling rate (without 'flat top') is reduced from 2 to 1 s. The maximum flat top time at 30 GeV is increased from 400 ms to 4 s. The actual gain in the number of pulses in a given time depends, of course, on the pulse cycle being used but can be as high as 40 %. Further improvements in the conditions provided by the new supply await implementation, including an ability to have adiabatic capture (see vol. 10, page 355).

New r.f. amplifiers have been in operation for over a year but the new r.f. cavities themselves are not likely to be installed until spring 1972 due to late delivery of the ferrite rings. The new vacuum system, with 240 ion pumps, has over a third of the pumps already successfully in use.

BATAVIA
Lighter side

As a change from recording the relentless progress to bring the 200-500 GeV proton synchrotron into action at Batavia, we will cover somewhat at random this month other aspects of the development of the National Accelerator Laboratory. They can be considered 'lighter' aspects but, almost as much as the machine itself, they are typical of the character of the Laboratory.

In the first place, NAL was on the environmental bandwagon before it started moving and part of its policy statement includes a commitment to pursuing a 'firm conservationist path in all of its relationships with nature and natural resources'. Apart from its obvious implications and the careful preservation of features of the site such as streams and trees (plus the planting of many more trees in Arbor Day ceremonies) this has included concern to bring out such features of the Laboratory environment as carried with them the flavour of past history. There are lots of nice touches such as the conversion of an old farm barn to serve as the Laboratory conference hall, the use of the names of the indigenous Indian tribes (Potawa-

1. A model of the 'central laboratory building' which is to be constructed at the National Accelerator Laboratory, Batavia. It is sixteen stories high and will house offices, laboratories, computers, restaurant, and lecture rooms. It is being built right next to the accelerator — the Booster pond is vaguely visible in the foreground.

2. Power poles of the 345 kV transmission lines bringing power into the Laboratory.

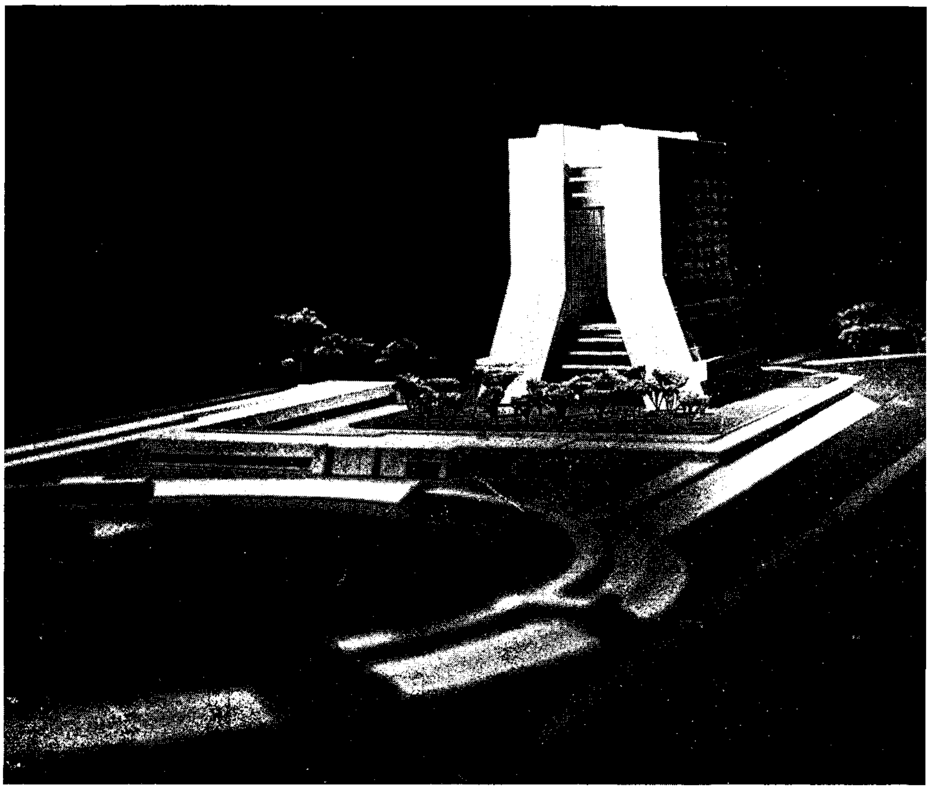
tomi, Blackhawk, Winnebago, etc.) for street names in the NAL village...

To balance this respect for the past, there is the recognition that, in terms of natural beauty, the Batavia site is not among the more outstanding of God's gifts to man. The design of the Laboratory has therefore leaned particularly heavily on making the site as attractive as possible. This probably reflects also the character of the Director, R.R. Wilson, who has no mean reputation as a sculptor and who brings aesthetic considerations prominently into design decisions.

Two results of this can be seen in the photographs. The first one shows a model of the 'central laboratory building' or 'core building' for which excavation started last December. (With the present rate of funding money has been allocated so far only for the basement level.) The need was to provide around 36 000 m^2 of floor space for offices, laboratories, library, computer centre, restaurant, lecture rooms, etc.

The building, designed by A.H. Rider, will be sixteen stories high in the shape of an inverted Y slit down the middle, with each half treated as a separate tower linked to the other by a series of 'walkways'. The top seven stories of each tower will be vertical and parallel. Each will rise from a separate foundation on caissons driven some 20 m down to bedrock and will be about 17 m wide and 70 m long at the base. Between the two flared bases will be a gallery (about 26 m wide with a large A-shaped window 25 m high at one end) where people will be able to stroll among gardens and think elevated thoughts.

The second photograph shows the elegant 'power poles' used to bring in electrical power from the transmission lines, along the eastern boundry of the site, to the master substation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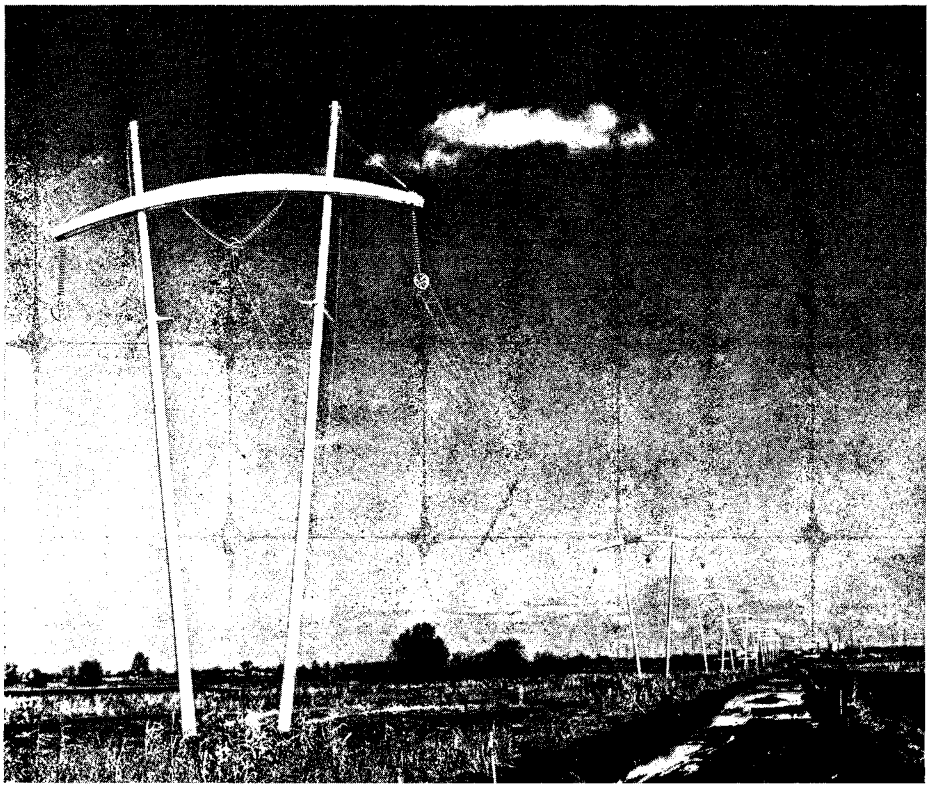
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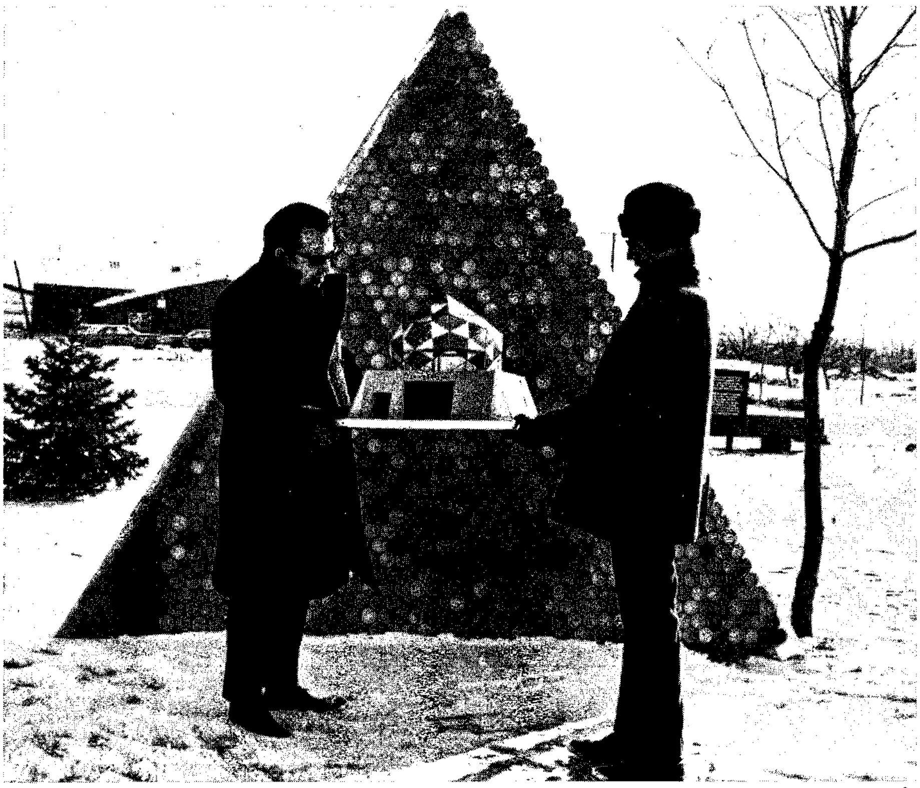
3. *Being displayed is a model of the building to house the 15 foot hydrogen bubble chamber at Batavia. The geodesic dome, to be constructed from triangular sections of 3 m side, may use panels built of empty beverage cans. The two proponents of this idea, R. Sheldon (left) and H. Hinterberger, are holding the model with one of the canned panels in the background.*

4. *A piece of canned panel. The cans have their tops and bottoms removed, so that they pass light, and are bonded to thin glass fibre reinforced plastic sheets.*

over two miles away. The power comes in at 345 kV, three-phase, 60 Hz and is transformed down to 13.8 kV for distribution around the site.

The power poles were designed by R.R. Wilson. They are modified H-structures built of two long wooden poles connected by two curved cross-arms. Each pole is about 30 m long sunk 5 m below ground and carrying the three power lines about 20 m above ground level. Despite their utilitarian function they are very easy on the eye.

A different subject, though related in terms of making a contribution to the solution of environmental problems is an idea on the use of empty cans in the construction of building panels. The idea emerged while thinking about materials for a geodesic dome to sit on top of the 15 foot hydrogen bubble chamber building. It was put forward by R. Sheldon (who went to NAL from Rutherford and has been involved with the main ring magnets) and developed together with H. Hinterberger (who is NAL Director of Technical Services).



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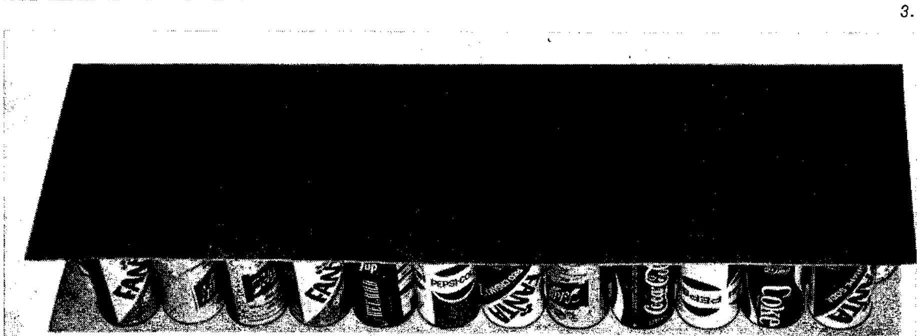

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The idea is to use empty beverage cans as the core material in building panels. Thanks to standardization of sizes, cans carrying a variety of different labels will all fit together to serve the same purpose. The tops and bottoms are knocked out of them (by a specially developed machine which clears a thousand cans an hour), so that they pass light, and they are assembled into panels by bonding thin glass fibre reinforced plastic sheets over the open ends (see photographs) forming a sandwich about 10 cm thick.

First of all, such panels are cheap (a good starting point for any decision at NAL) since their main component, the normally discarded cans, is free. They have proved to be extremely sturdy and well able to withstand wind and snow loads. They are also light and easily handled and can be assembled into panels of virtually any desired shape. If they are used for the geodesic dome of the bubble chamber building they will be in equilateral triangles of about 3 m side. Just as a bonus, they rid the environment of empty cans. Following an appeal for cans, they have been pouring into the Laboratory by the thousand. NAL may well win extra renown as the home of a million pop cans.

Environment again. In 1969, NAL acquired five buffalo to form the nucleus of what it is hoped will grow to a small herd which will eventually be free to graze within the 2 km diameter circle of the main ring. There have since been further additions and the buffalo have become one of the 'tourist attractions' of the site.

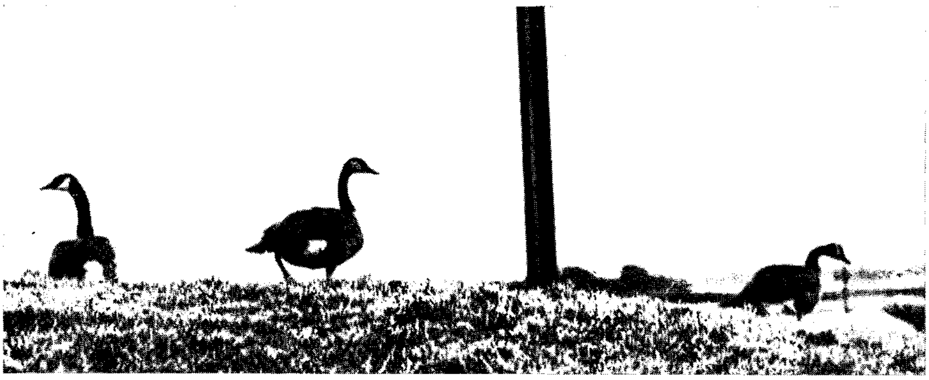
Over 100 years ago great herds of

5. *Some members of the buffalo herd at Batavia.*

6. *Comparative newcomers — three Giant Canada geese who are also making their present home at Batavia.*

(Photos NAL)

5.



6.

bison roamed the western plains of America, their number being estimated at around 20 million in 1850. Relentless hunting ate into this number until at one time it had reached a crisis figure of around 550. Preservation efforts have redeemed this situation and the present population is tens of thousands — some of them are alive and well and living at Batavia.

Recently they have had animal competition. At the end of last year, ten Giant Canada geese (note the international collaboration) were brought to make their home at the NAL site. The bird is native to Illinois, where it returns for the breeding season, and it migrates as far North as the Arctic Circle. The geese have a powerful homing instinct and return to the area in which they were hatched to build their own nests. Thus the birds hatched at NAL this spring may well be regular visitors in the winter and spring months to come.

Like the bison, the Giant Canada was in danger of extinction some years ago. An Illinois committee has been set up to supply geese to enthusiasts who agree to protect and nurture the birds. In providing such a home, NAL hopes that flocks of other species of bird might decide that what suits the Giant Canada suits them and might also visit the site during their migratory manoeuvres.

To conclude this article on non-machine aspects of life at Batavia we will mention a topic which should not perhaps figure under a heading 'Lighter side' because its importance in modern American life would be difficult to exaggerate. Another of the policy statements of the Laboratory is 'to seek the achievement of its scientific goals within a framework of equal opportunity and of a deep dedication to the fundamental tenets of human rights and dignity'.

This policy has been pushed hard both in dealings with manufacturers of machine components (opening factories to the negro population) and inside the Laboratory (where special programmes have been implemented to train members of minority groups from the Chicago area for skilled jobs).

In the May issue we may well be back with the accelerator for the last magnet rolled into the main ring on 16 April.

DUBNA Experiments

The size of a pion

At the Serpukhov 76 GeV proton synchrotron, an international group of scientists is studying pion-electron scattering, following a proposal by Dubna physicists. Those taking part include Soviet, Polish and Rumanian physicists from Dubna, physicists from Serpukhov and American physicists from the University of California at Los Angeles.

The aim is to determine the dimensions of the pion. Similar attempts have been made in the past but either the measurements were carried out at an energy level which was too low to produce a significant result, or the analysis of the data was inconclusive.

In the Serpukhov experiment, pions with a momentum of 50 GeV/c scatter on electrons as they traverse a hydrogen target. Due to the high energy of the particles, the momentum transfer can be very high and the experimental result could give a value for the pion radius accurate to within a few per cent. Eighteen magnetostrictive wire chambers are used to record the particle trajectories, hopefully picking out sparks 1 mm apart. The accuracy with which the particle momentum is measured would then be as high as

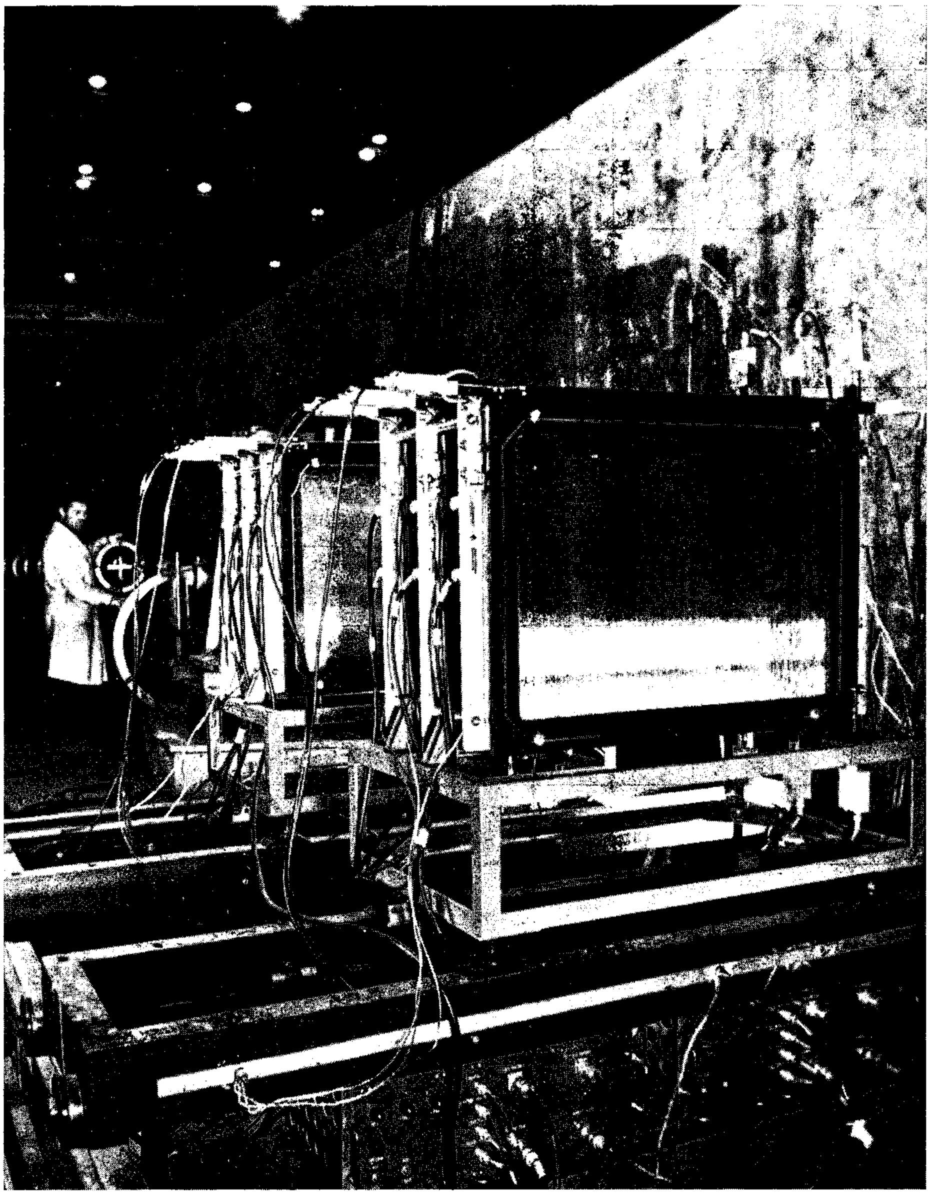
The detection equipment for studying the regeneration of short-lived neutral kaons from the long-lived variety, set up in the experimental hall of the 76 GeV proton synchrotron at Serpukhov. The decays into pions, occurring in the vacuum tube visible in the background, are recorded by the wire chambers.

0.2 %. The experimental equipment is in operation and the group is collecting data.

A popular model (vector dominance) predicts a pion radius of 0.64×10^{-13} cm. Unfortunately, this model also assumes that the pion radius is equal to the proton radius and yet the experimental value for the latter is 0.81×10^{-13} cm. If the preliminary data which have recently been obtained in colliding-beam experiments at Frascati are confirmed, then the pion may prove to be a 'point-like' particle measuring much less than 0.64×10^{-13} cm. The experiment at Serpukhov hopes to contribute to resolving these conflicts.

Regeneration of neutral kaons

A group of physicists from Dubna are performing an experiment at Serpukhov to study the regeneration of short-lived from long-lived neutral kaons on hydrogen over the energy range 10 to 40 GeV. A study of the regeneration at high energies provides a convenient way to investigate the behaviour of the amplitude difference of the K^0p and $\bar{K}^0p$ interaction and to check the Pomeranchuk theorem. By studying the interference pattern which occurs behind the hydrogen regenerator and which is conditioned by the interference from the transmission and CP violation amplitudes, it is possible to investigate not only the energy dependence of the modulus of the amplitude difference but also the phase of the amplitude.



The experiment is being performed on a neutral beam coming off at 1°. The particle detectors record the two pion decays of the kaons occurring after the neutral kaons are passed through a 3 m hydrogen target. The detectors consist of a magnetic spectrometer, having 18 two-coordinate spark chambers with magnetostrictive read-out and an on-line computer, and 2 electron and 2 muon detectors for the identification of K_{e3} and K_{l3} decays. The experimental data are recorded on magnetic tape and undergo final processing at Dubna.

The equipment came into operation in July 1970, just before the Kiev Conference, and approximately 1000 kaon decays into two pions were recorded, giving a very preliminary set of results which caused quite a stir at the Conference since they were so different from what is expected. Another series of measurements was carried out in December and the group are now attempting to increase the statistics. At the same time, the analysis of the data obtained in the summer is being completed.

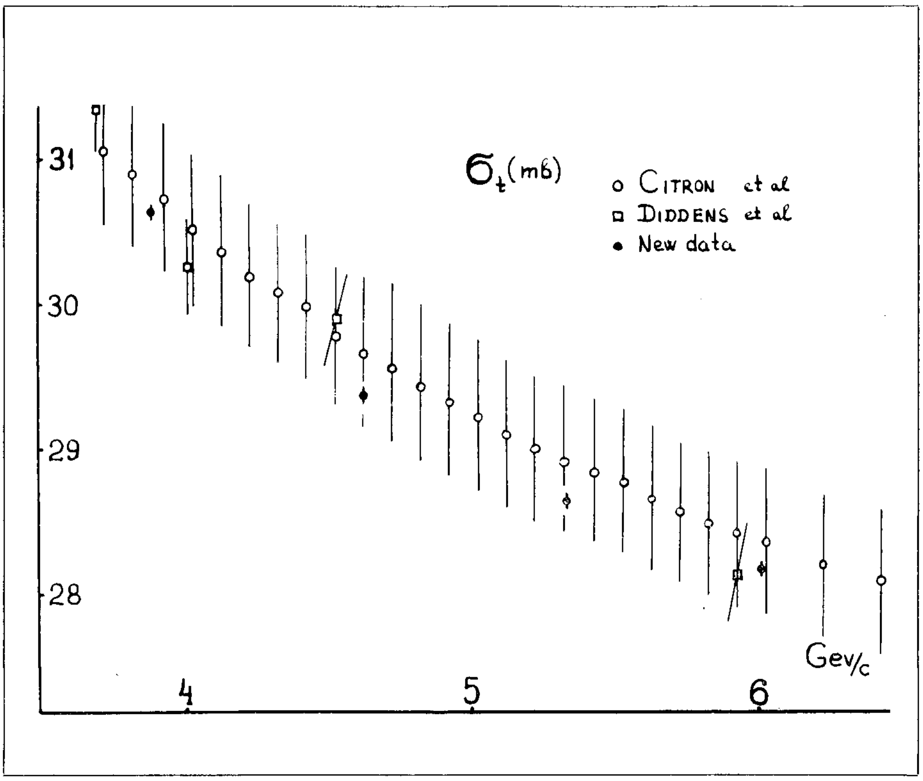
Negative pion-proton interactions

The total cross-sections of negative pion-proton interactions are being measured at the Dubna 10 GeV synchrophasotron in the 4 to 6 GeV energy range with a systematic error not exceeding 25 microbarn.

The work is based on a new method for measuring the scattering angle of particles from their Vavilov-Cherenkov radiation. The primary pion beam was determined by a self-collimating Cherenkov counter and the particles which traverse the scattering material without undergoing an interaction, or which are scattered at small angles, were measured by a Cherenkov hodoscope. The ring-shaped image of Vavilov-Cherenkov radiation was fixed in the hodoscope's focal plane by a system of diaphragms and mirrors. The maximum displacement was selected by a specially designed electronic instrument. The Cherenkov hodoscope ensured an angular resolution of 2.5 mrad and a resolution time of 100 MHz. A specially designed liquid hydrogen target having flat windows and with the hydrogen density stabilized to 0.04 %, was used as the scatterer.

The results of the measurements are shown in the graph and are compared with other data. The errors include systematic errors.

Results from the highly accurate measurement of total cross-sections for negative pion-proton interactions carried out at the 10 GeV synchrophasotron at Dubna. Previous measurements are also plotted.



Element 105

This information concerning element 105 was written by V.A. Biryukov : In February 1970, G.N. Flerov's group announced that element 105 had been discovered at Dubna ('Spontaneous fission of the isotopes of elements 103 and 105', JINR P7-4932, 1970).

The work was carried out on the 310 cm cyclotron using an intense beam of neon ions (^{22}Ne) and a target of Americium (^{243}Am) to yield the heavy element 105. A study was made of the spontaneous fission of the new element. The angular distribution of the recoil atoms was studied to confirm the synthesis of an element with z = 105. (This method had already been successfully used to confirm that a spontaneously fissionable isotope with half-life of 0.1 s belongs to kurchatovium, element 104, synthesized at Dubna in 1964.)

In later experiments, use was made of the formation mechanisms of the new spontaneously fissionable isotope with half-life 1.8 ± 0.6 s and it was shown that the atomic number of this isotope was 105.

Following the experiments to investigate spontaneous fission, the behaviour of the chlorides of element 105 was studied using gas chromatography. It was established that this element corresponds in terms of its physico-chemical properties to ekatantal (i.e. an element coming below tantalum in the periodic table and displaying similar chemical properties).

By knowing the life-time of the new element's isotope, it was possible to make a very rapid study of the alpha-decay branch. It was shown that an isotope with a half-life of approximately 1.5 s emits alpha particles with an energy ranging from 8.9 to 9.2 MeV. The cross-section for the formation of the alpha-radioactive isotope of element 105 is approximately 2×10^{-33} cm^2.

In April 1970, it was announced that element 105, with a half-life of 1.5 s, had been synthesized at Berkeley. The results obtained by the American physicists confirmed both the synthesis and properties of the new element. Flerov's group propose that element 105 be named after Niels Bohr.

TRIUMF Project progress

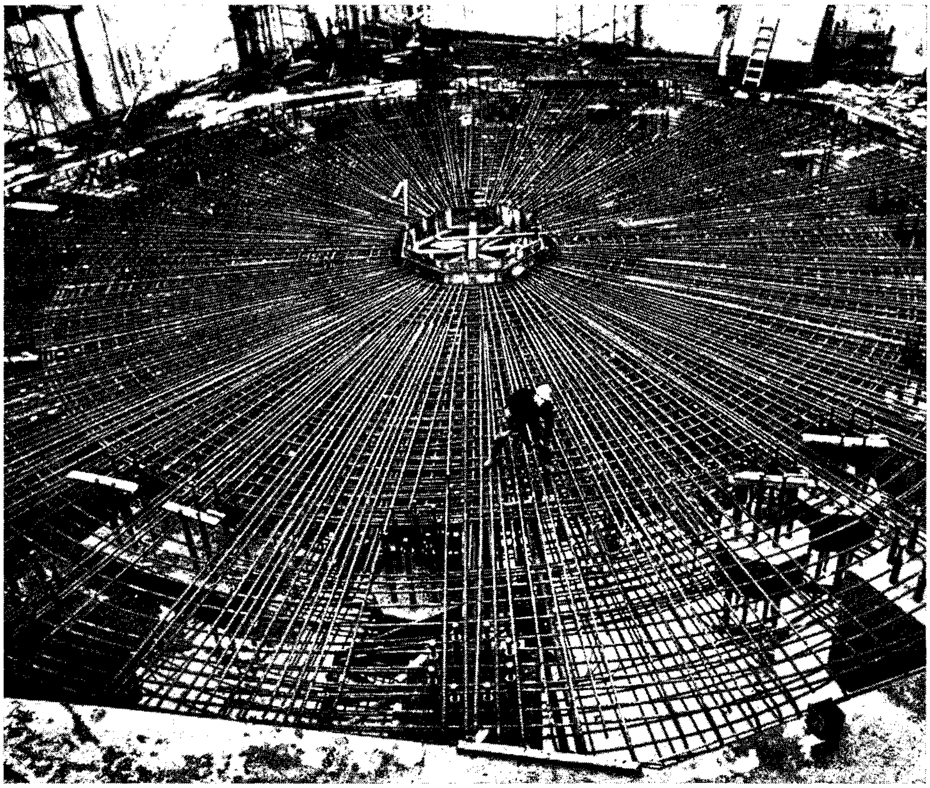
The 500 MeV cyclotron project, TRIUMF, being built at the University of British Columbia, Vancouver, Canada, has now reached the stage

The reinforcing steel which interlaces the concrete structure under the TRIUMF cyclotron building. This sub-structure is now virtually complete.

(Photo Vancouver Sun)

Assembly under way at prototype r.f. accelerating cavities for the TRIUMF cyclotron in a test vacuum chamber. This vacuum chamber is to serve as the vacuum chamber for the 'centre region cyclotron' which will be assembled by the end of May.

(Photo TRIUMF)



where the machine building is taking shape, major contracts have been placed and some machine components are beginning to arrive.

The building sub-structure is virtually complete. Within the last six months about 20 000 m^3 of concrete have been poured. The reinforcing steel (shown in the photograph) in the sub-structure which will be under the cyclotron weighs almost 2000 tonnes. Construction of the superstructure began on 1 March. The first steel columns have been erected and the first roof beams are in place giving an impression of how large the building is going to be.

The first of the six magnet sectors is being assembled at the manufacturers and is scheduled for delivery to Vancouver by June. (For details of the magnet design see vol. 10, p. 88.) The contract for the main magnet coil has been placed ; the coil is to consist of extruded aluminium conductor of about $5 \times 45\ cm^2$ cross-section with two cooling channels.

The contract for the cyclotron support structure has also been placed. It has two main functions — to support the vacuum chamber when it is evacuated and to lift the top half of the magnet so that there will be access to the interior of the cyclotron for maintenance. Construction of the vacuum chamber has started and the bulk of the work on this component is scheduled to be carried out as from June of this year within the accelerator building itself. This is because the assembled chamber will be too big to be transported through the streets of Vancouver.

The first ion source has been delivered and commissioned. It is providing in excess of 2 mA of negative hydrogen ions within the specified emittance. Tests on r.f. accelerating cavities have successfully achieved the specified 100 kV accelerating voltage and more com-

1. *The ion-source end of an accelerator is often its most photogenic section. The need to hold off something like three quarters of a million volts gives the equipment its science-fiction look. The injector shown is that at Los Alamos which has been reliably providing protons for many months for tests with tank 1 of LAMPF.*

missioning tests are scheduled for the end of May when the 'centre region cyclotron' will be completely assembled.

LOS ALAMOS LAMPF Progress

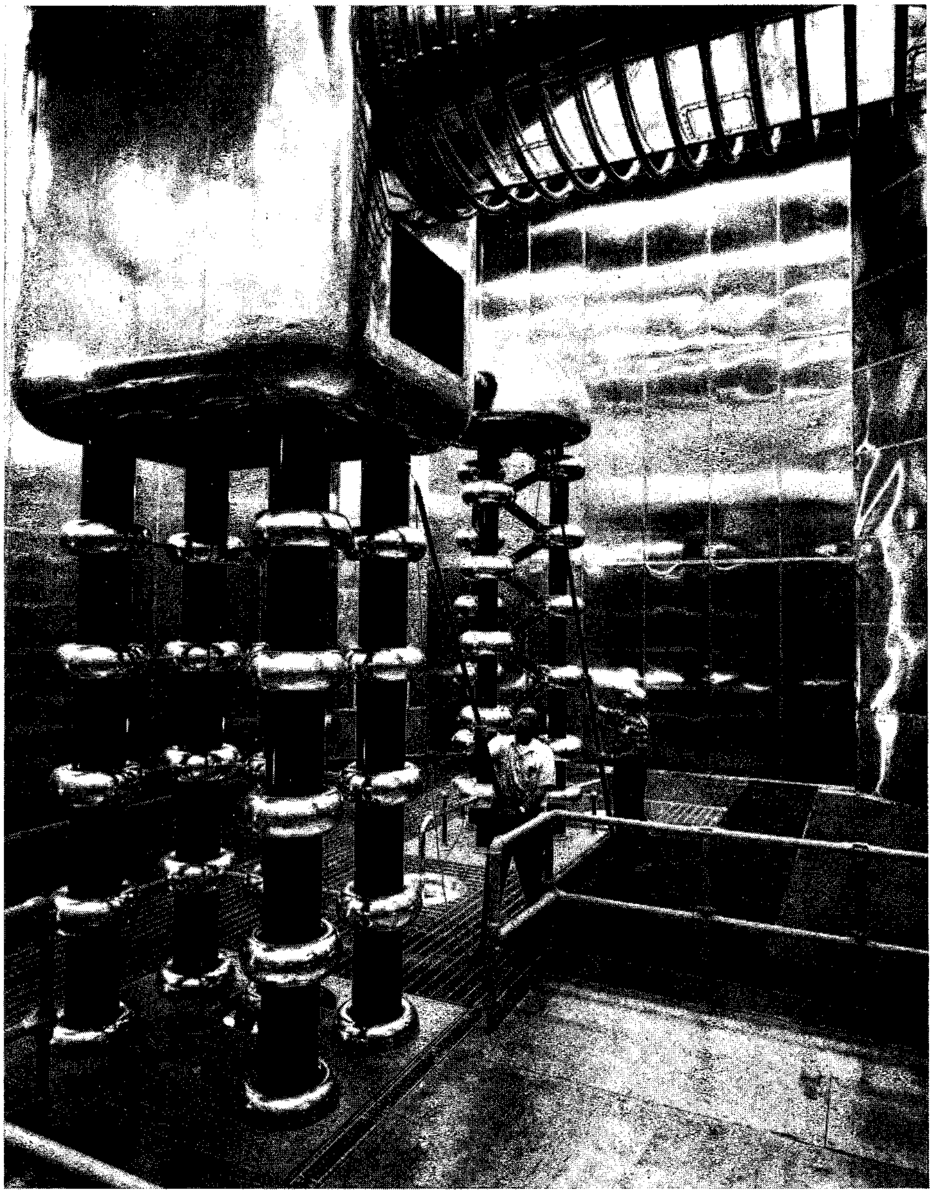
Construction of the 800 MeV linear accelerator, LAMPF, at Los Alamos (described in vol. 8, page 132) is still on schedule to yield its first beams in July 1972. It is hoped to have 100 MeV beams from the second section of the accelerator (the post-coupled drift-tube linac following the injector) in the summer of this year. The third section (the side-coupled linac) will come progressively into service, with 211 MeV beams planned for the autumn.

The first of three Cockcroft-Walton injectors (to provide protons, polarized protons and negative hydrogen ions) has been in regular operation feeding the first tank of the drift-tube linac since June of last year. Problems were encountered due to the high power requirements (needed to cope with the 6 % duty cycle with potential for climbing to 12 %) and have been solved. Good lifetimes for the ion sources have been achieved and low-emittance proton beams can be provided reliably to the linac.

The philosophy of extensive computer control has had its first practical test in the course of the operation of the injector and tank 1 and has emerged in good shape. The central control computer will be heavily involved in the 100 MeV beam tests scheduled in a few months' time.

Tests with tank 1 were halted in January to bring in tank 2. The four tanks of the second section are all now installed and drift-tube alignment and tank tuning are completed. The tuning procedure (involving a small on-line computer) by adjustment of the post-couplers so as to have maximum tank stability to known frequency perturbations has worked very well. The r.f. system to power these tanks is complete and high power r.f. tests are under way.

Over 40 % of section three, the side-coupled linac, is in place in the machine tunnel and about half the related r.f. system is installed. As reported before, the side-coupled accelerator structure with klystron amplifier powering system was first tested with an 'Electron Prototype Accelerator'. The performance of the EPA was refined to an exceptionally high level. It was shown that side-coupled linacs with feedback control could give beams with energy stabilities and energy spreads less than 0.1 % at reasonable cost. For high beam power (10 to 20 mA continuous beam) they are likely to be cheaper than a cryogenic accelerator of



1.

2. Part of the side-coupled section of LAMPF now installed in the machine tunnel. This new type of accelerator structure looks as if it will prove very successful and has already been taken up by industry.

3. Aerial view of the LAMPF site where the building housing the machine (which is about 850 m long) is virtually complete. We are looking from the injector end along the machine to the experimental areas.

(Photos Los Alamos)

2.

3.

equivalent performance and they avoid the refrigeration problems.

Several companies in the USA have adopted this new type of accelerator structure, invented and developed at Los Alamos. More than a dozen such electron accelerators, in X-ray machines with energies of 4 MeV or higher, are already in operation in hospitals. Several dozen more are under construction.

Some experiments will probably be set up to take particles just as soon as they are available but the experimental programme is likely to begin in earnest as from the beginning of 1973. LAMPF will accelerate protons (design average current 900 μA) and negative hydrogen ions (design average current 100 μA) simultaneously. The two beams will be divided in a 'beam-switchyard' where the negative ions will be deflected to experimental areas B and C for nucleon physics research and for high resolution proton spectroscopy. The proton beam will continue forward to area A.

Various beam-lines are being designed. The most advanced, in terms of the design being complete and magnets being ordered, is the stopped muon channel to provide intense muon beams at energies up to 250 MeV and with muon polarizations greater than 50 %. A low energy pion channel is designed to provide intensities up to 1.5×10^9 positive pions per second at energies up to 300 MeV. The design of other beam-lines is still under way.

BERKELEY ERA higher energy injection

Research on Electron Ring Accelerators at the Lawrence Radiation Laboratory is temporarily halted while the electron injector is extended to give an energy of about 4 MeV into the compressor compared with the previous 2 MeV. Experiments are likely to start again around the end of May with the injector designed to be capable of providing 4.25 MeV electron beams of 1000 A in 40 ns bursts at a rate of 1 per second.

Just prior to the shut down there were a few days of experiments with new beam surroundings (new side plates, etc.) in Compressor IV to continue the systematic study of the phenomena influencing the formation of compressed rings of high intensity. The results were inconclusive and will need a few more weeks of observation when the injector is back in action to sort things out.

To conclude on an optimistic note for ERA enthusiasts : The experiment on energy loss in passing through a periodic structure (see February issue page 51) which was carried out at the Stanford 20 GeV electron linear accelerator gave a result in excellent agreement with the calculations of E. Keil. Electrons were accelerated to 2 GeV and allowed to drift through the remaining part of the accelerator structure. Their energy was measured as they emerged and showed a loss of about 45 MeV. This agreed with the calculations (knowing the size of the bunches, the accelerator structure, etc.) and tells us that we can now predict energy loss from this source and that such loss will not be serious. (Since at 2 GeV the gamma of the electrons is already very high, any gamma dependence gives no cause for worry, in contradiction to some earlier predictions.)

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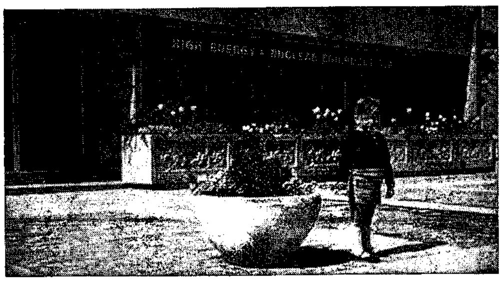

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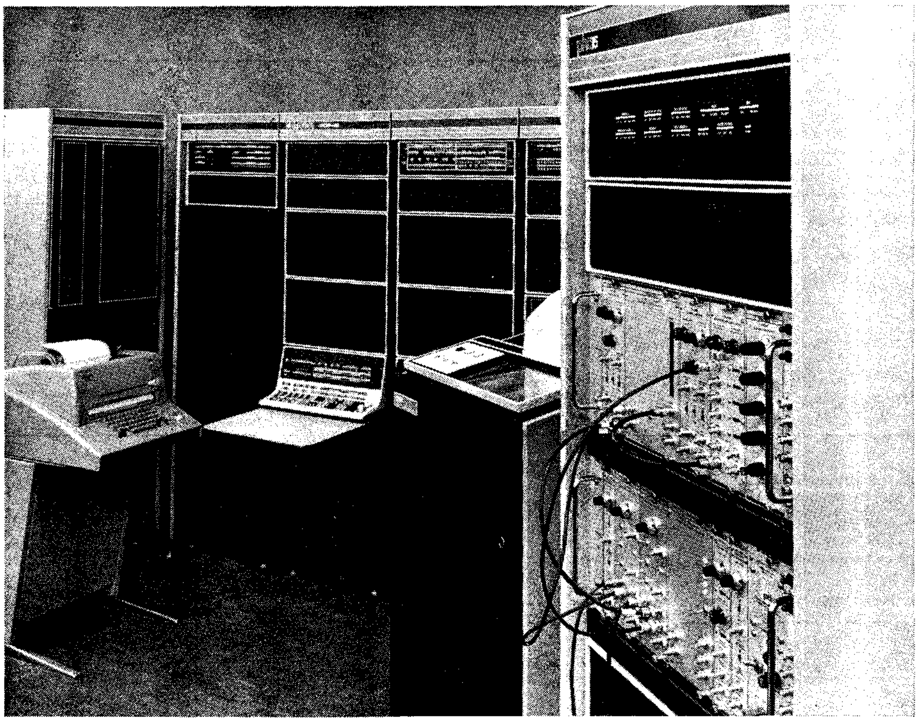

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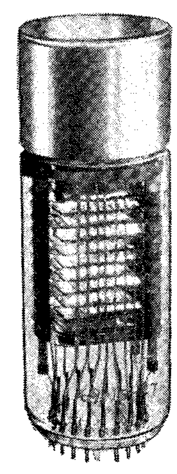

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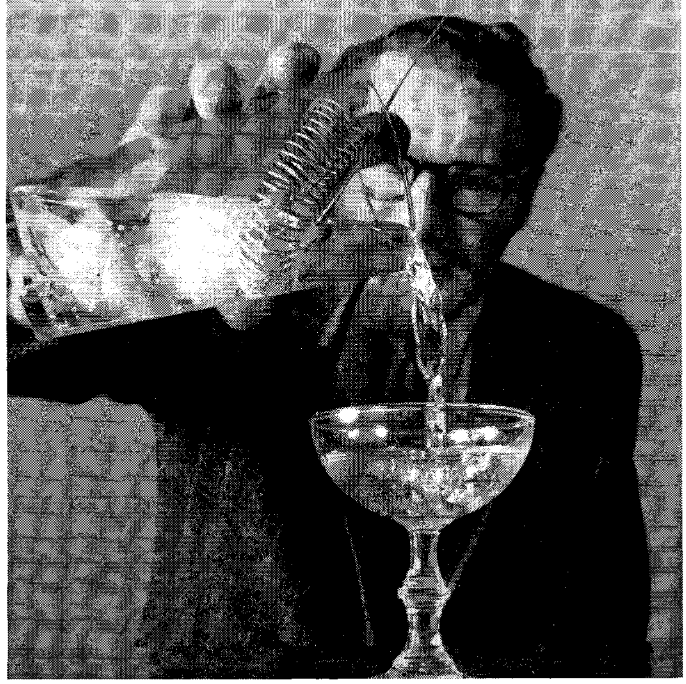

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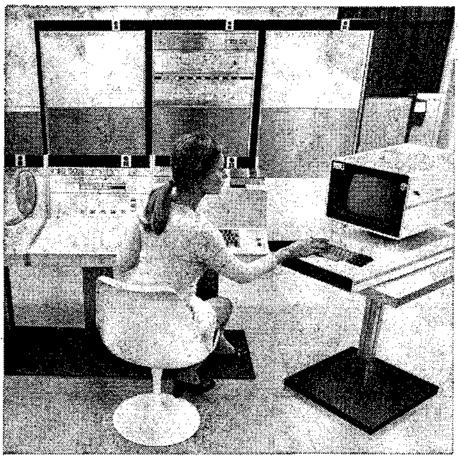

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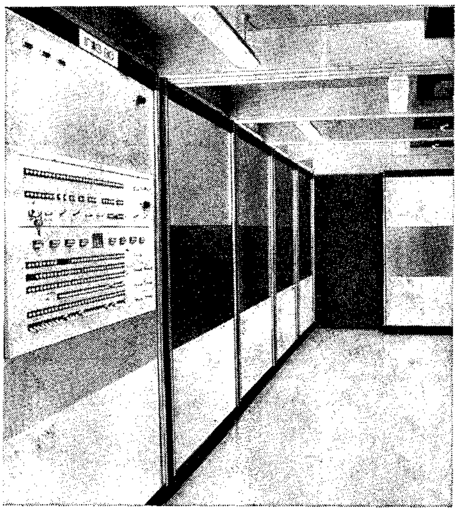

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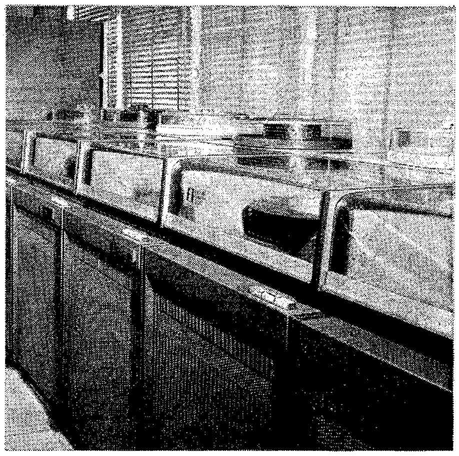

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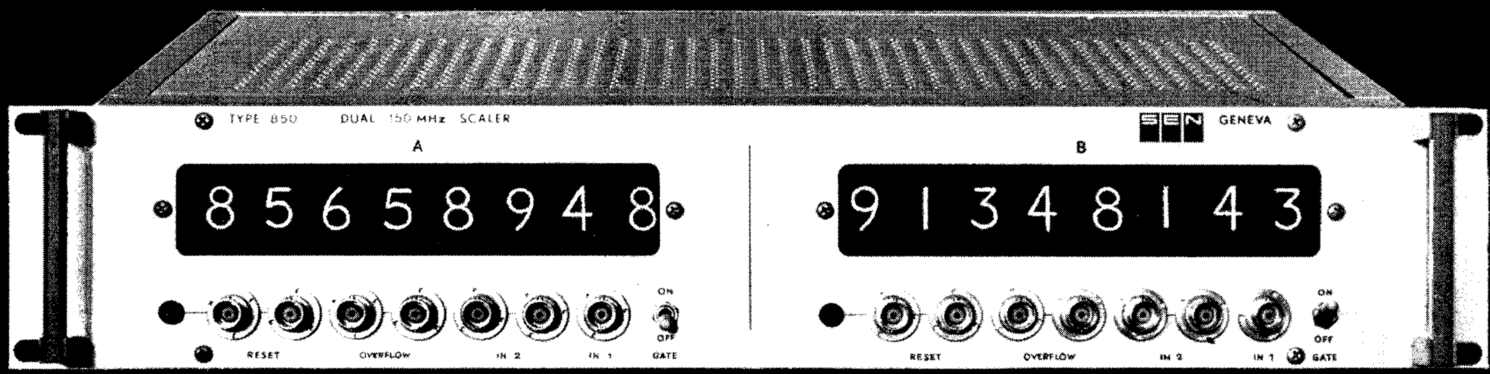

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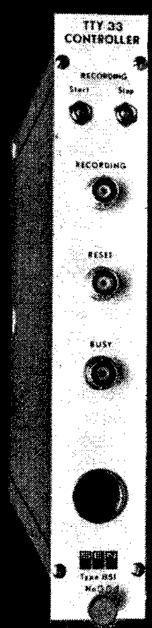

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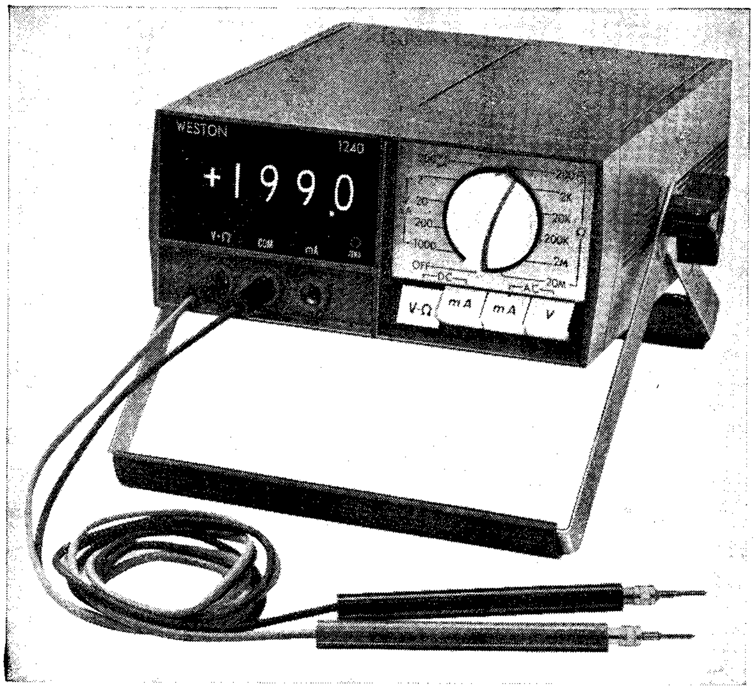

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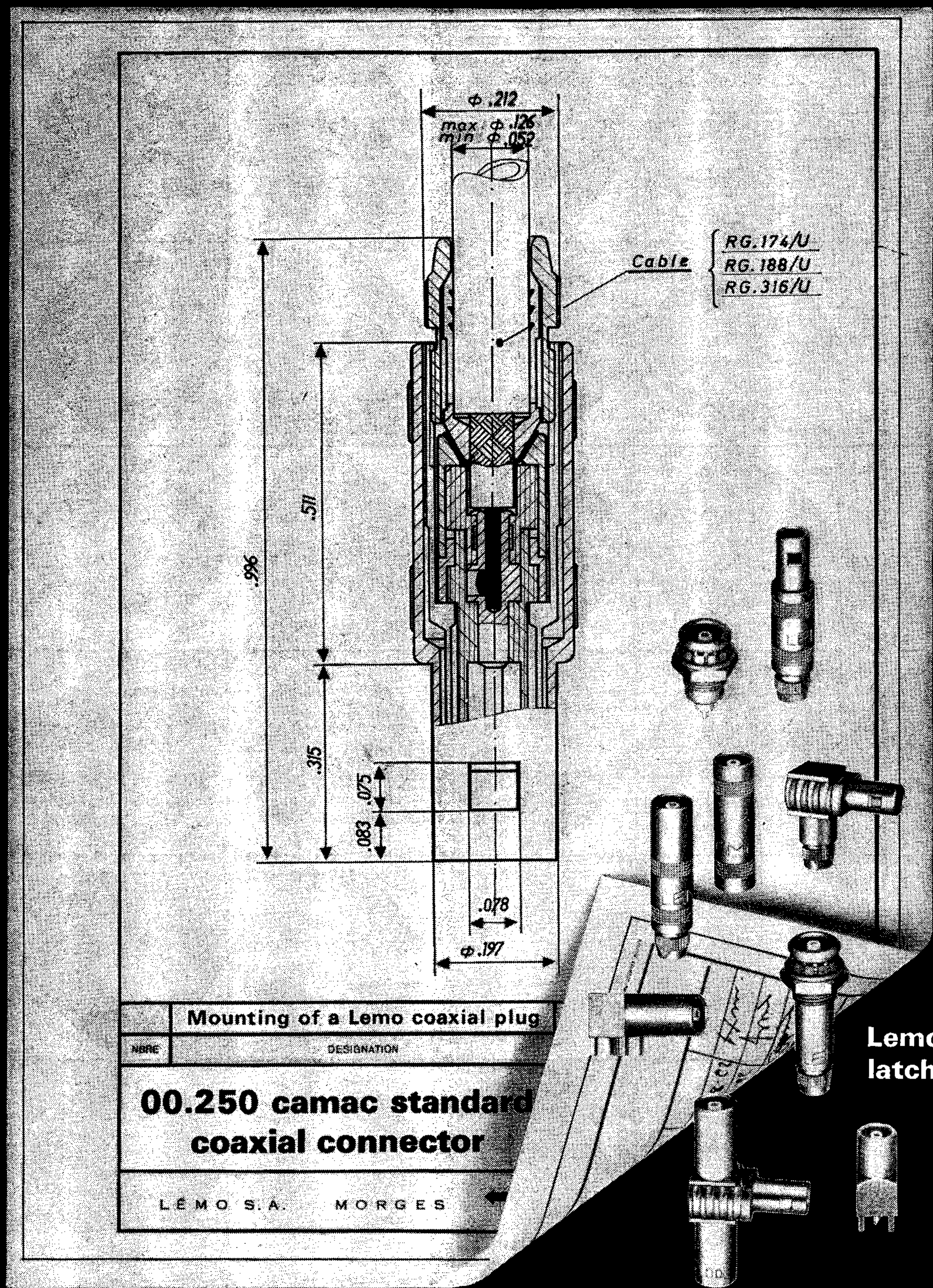

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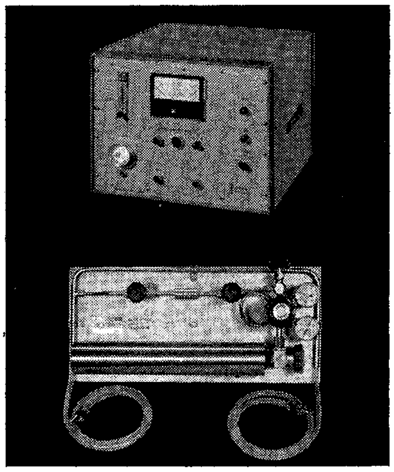

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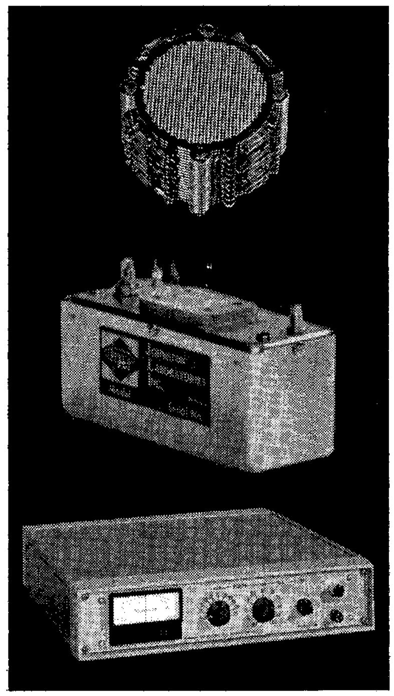

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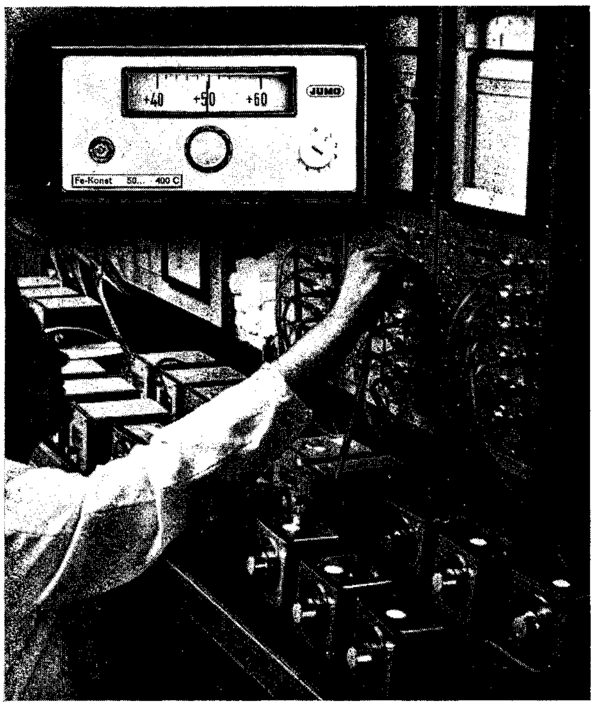

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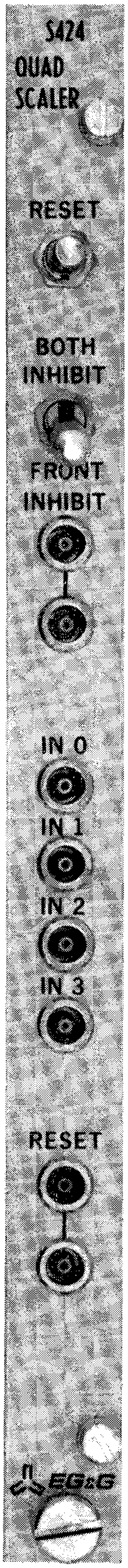

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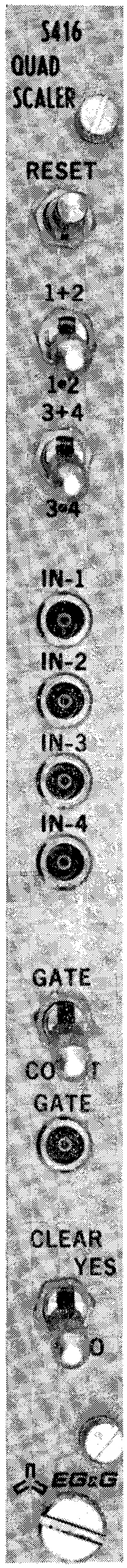

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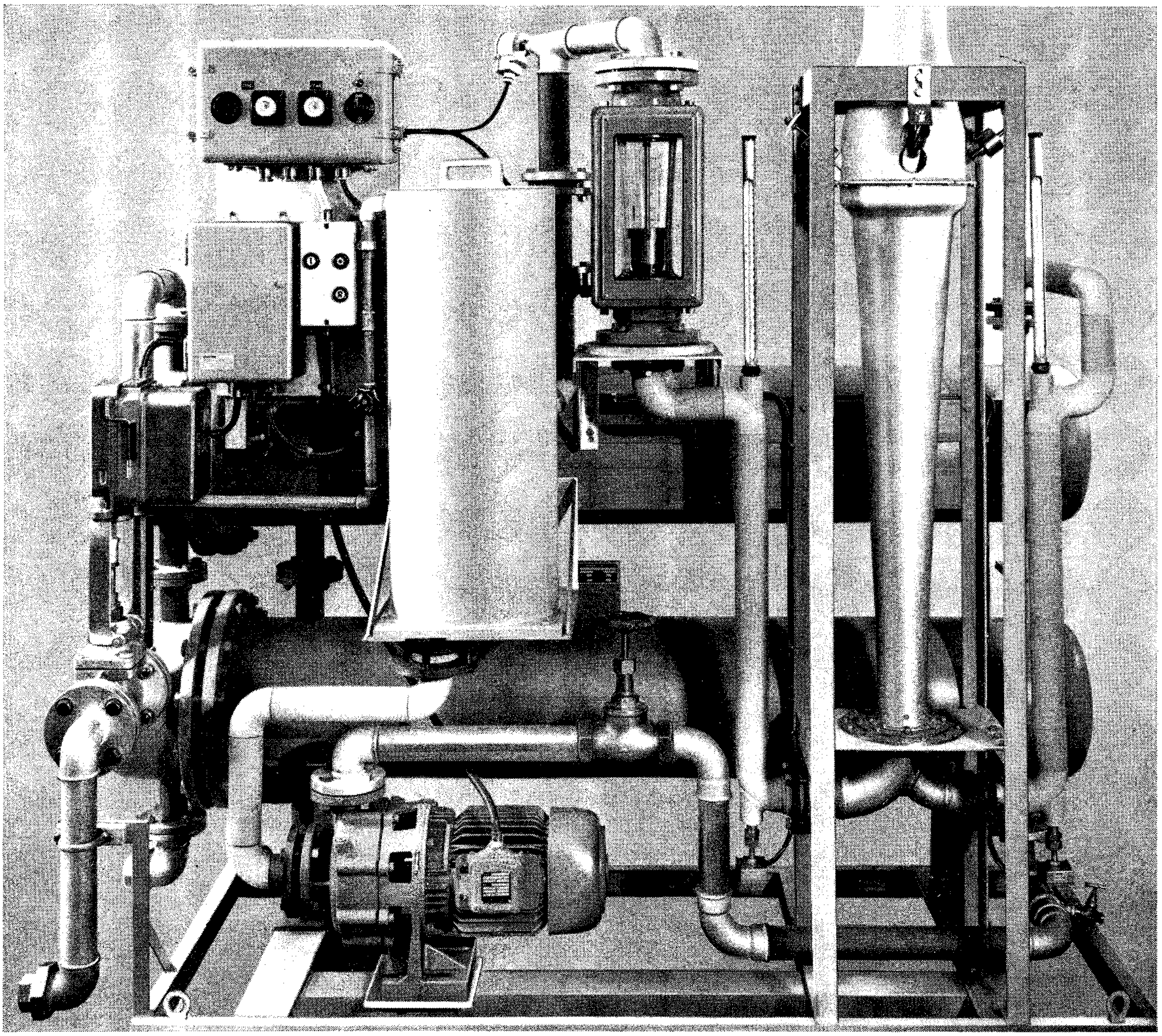

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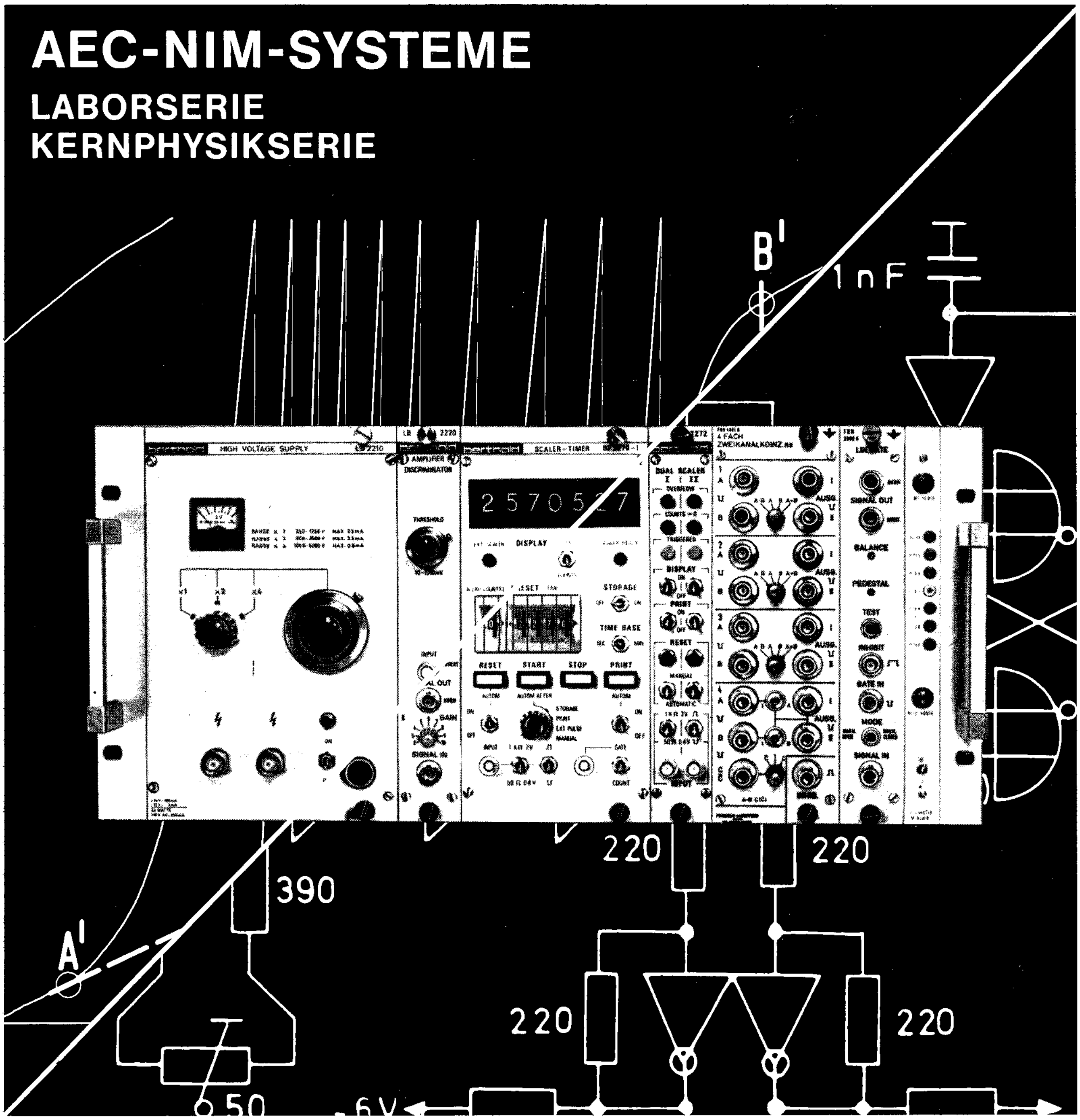

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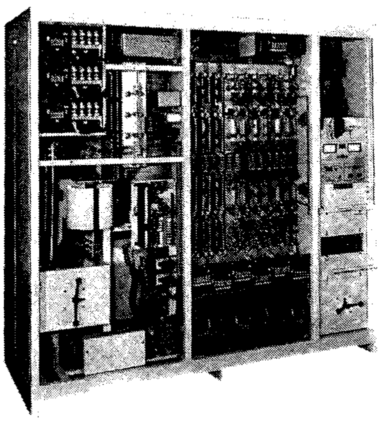

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