

News from abroad

TRIUMF

The Canadian government announced, in April, initial grants amounting to \$1.3 m for a cyclotron to be built at the University of British Columbia. The project is known as TRIUMF, an acronym for TRI-University Meson Facility since it was initially proposed by three Universities — Victoria, Simon Fraser and British Columbia. The University of Alberta joined the group in 1967. TRIUMF is intended to provide an advanced instrument for intermediate-energy physics to serve particularly the scientists on the West Coast of Canada.

Together with the Zurich cyclotron (which will be covered in a future issue) and the Los Alamos linear accelerator (see page 132), TRIUMF will be a major centre for meson physics research as from about 1974.

By incorporating two comparatively recent advances in cyclotron technology, it will be able to produce protons in the energy range 200-500 MeV with a beam intensity a thousand times higher than at existing equivalent machines. Research

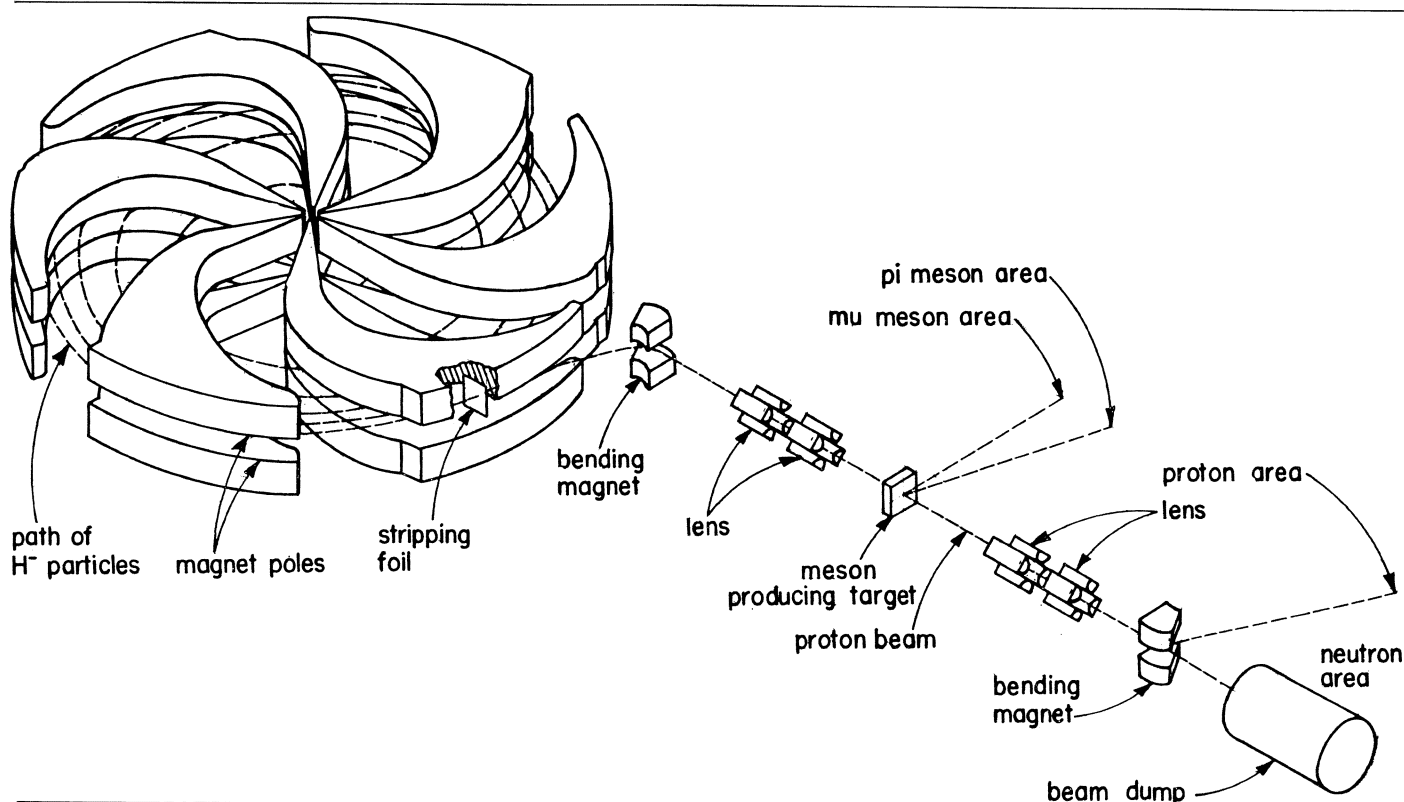
will be possible using the proton beam itself, intense beams of pions and muons and a high flux of thermal neutrons. TRIUMF also has the great advantage that all these beams can be produced and used simultaneously (see Figure).

One of the two advantages which yield the higher performance figures for the machine is the use of sector-focusing. This involves replacing the conventional cyclotron magnet by specially shaped magnet sectors which introduce strong (or alternating-gradient) focusing and maintain a constant revolution frequency for the particles so that the r.f. accelerating frequency can also be held constant (rather than adjusting to the revolution frequency as in the synchro-cyclotron).

The second development involves producing and accelerating a beam of negative hydrogen ions (H^-) rather than protons. In the ion source an electron is added to the hydrogen atom and it is this negative ion which is injected into the cyclotron. When the desired energy has been reached, the ion is stripped of its two electrons by being passed through a

very thin foil (for example, 0.00004 cm beryllium), thus releasing the proton. The advantage in this procedure is that, since the protons are of opposite charge to the accelerated ions, the magnetic field of the cyclotron bends the protons out of the machine. This circumvents one of the major problems of cyclotrons which accelerate protons — the problem of extracting the protons. Extraction efficiencies on proton cyclotrons rarely exceed 50%, while TRIUMF will achieve 99%. Overall efficiencies of TRIUMF will be at least 80% at full energy, rising to 95% at lower energies, the losses arising from dissociation of the negative hydrogen ions and not from the extraction process.

Negative ion cyclotrons require, however, a bigger magnet and a lower vacuum (almost 17 m overall diameter and 10^{-7} torr in TRIUMF) than their proton equivalents. The idea of H^- cyclotrons has been developed principally at University of California, Los Angeles where it was first shown to work in 1961. (50 MeV machines accelerating H^- ions are now in operation at UCLA and at Manitoba.) The design of TRIUMF



A schematic diagram of TRIUMF. The way in which meson, proton and neutron research, can be carried out simultaneously can be realized from the lay-out of the extracted beam-line.

A 1/20 scale model of the TRIUMF magnet. Four Canadian Universities are now involved in this cyclotron project — University of British Columbia is responsible for the cyclotron itself, University of Victoria for the beam-transport system, Simon Fraser University for the neutron dump facility, and University of Alberta for one of the large experimental areas and the computing and data handling facilities.

owes a lot to a similar proposal from UCLA which was turned down in favour of the higher energy Los Alamos linear accelerator.

A few further features of the machine are as follows. Because of the need for high vacuum, the ion source, with a 10 mA output current, is external to the cyclotron and the beam is injected axially at 200 keV. The r.f. system operates at a frequency of 23.8 MHz (the rotation frequency is 4.76 MHz) and gives a maximum energy gain per turn of 400 keV. There are six magnet sectors, each weighing 580 tons, providing a field rising to 5.93 kG at the 500 MeV orbit. The macroscopic duty cycle of the machine is 100%.

The total cost of the 'meson-workshop' to be built around TRIUMF is estimated as \$27 million and the machine is expected to be in operation by 1974.

Weston Easter Egg *

The fertility of the group working on the American 200 GeV project continues to be made manifest — they have laid an egg

and are looking at it. A proposal to include a storage ring in the main ring tunnel was resurrected by R.R. Wilson over Easter week-end and became known as the Easter Egg.

The purpose of the Easter Egg is to ease the problems of injection into the main magnet ring and to take the pressure off the booster, the most difficult component of the new generation of accelerators. The machine design described in CERN COURIER vol. 8, page 31, involved a fast-cycling 10 GeV booster operating at 15 Hz. Thirteen pulses from this booster fill the circumference of the main ring in 0.8 s, during which time the magnetic field is held constant at about 500 g. This stage in the magnet cycle is known as the 'injection platform'.

If a storage ring, operating with a fixed magnetic field of 500 g, were included in the main ring tunnel, it could be fed continuously with protons from the booster (over the whole magnet cycle) and injection into the main ring would be a straightforward transfer from the storage ring. There would be no need for an injection

* We have just learned from NAL that the Egg has been dropped.

platform and the booster could operate at a lower repetition rate (5 Hz). While retaining the design intensity of 1.5×10^{13} protons per second (running without flat-top), the storage ring would make it possible to reduce the number of protons per pulse or to increase the time for acceleration (since the 0.8 s filling time would be eliminated). The lower repetition rate of the booster would more than halve the cost of its radio-frequency system and go a long way towards financing the storage ring itself.

The addition of the Easter Egg adds a further stage to the machine but it is a very easy stage to design and construct though injection and ejection into and out of the egg may be complicated.

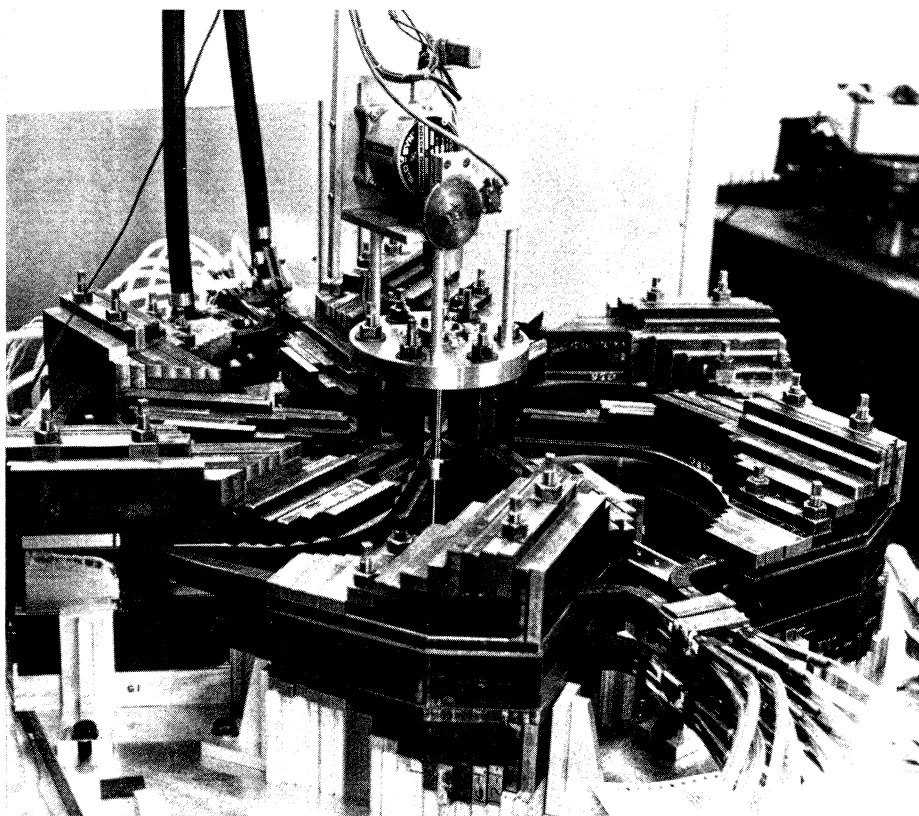
It could consist of an iron box of rectangular cross-section strung up from the roof of the main ring tunnel with simple magnets (coils wrapped around to provide the bending and focusing fields) with no precise alignment.

A first look at the Easter Egg in relation to the 300 GeV design indicates that, because of the different acceptances built into the two machines, it would not be as interesting for the European machine. The Egg may not prove fertile for the American machine either, but it is an interesting idea and is yet another reminder that the excitement really begins when the project team finally gets down to the detailed design of the accelerator.

Logic from Rutherford

On 27-29 May, an exhibition of equipment from eight UK firms was held at CERN under the auspices of the Scientific Instrument Manufacturers Association (SIMA). It included exhibits of instruments for low temperature work, high vacuum conditions, radiation measurements and fast electronics, and examples of superconducting materials.

Among the fast electronics exhibits was the Miniature Logic System manufactured by Elliott Process Automation Limited which has evolved from the work of an electronics section at the Rutherford Laboratory led by P. Wilde. (This is the work referred to in the last issue of CERN COURIER, page 107.) The section was



confronted with the task of developing fast electronics, to cope with the very high rates at which counter and spark chamber experiments accumulate data, at a time when no appropriate system was commercially available from Europe.

In many experiments now being carried out at particle accelerators, hundreds of electronic units can be involved in distinguishing the required event from a host of others, in controlling the firing of spark chambers, in feeding information on the good events to a computer and so on. The electronics take the decisions involved in performing these various operations and are often referred to as the logic. In order to take advantage of the high speeds and multiple detection capabilities of modern detectors, and of the insatiable appetite of modern computers, the logic has to be fast — making decisions on a nanosecond timescale.

The Rutherford system overcomes two limitations in speed. It uses tunnel diodes and tunnel rectifiers, capable of operating at rates up to 180 MHz, for the stages where the fastest logic is needed, reverting to transistors (capable of up to about 80 MHz) only for stages where slower speeds are acceptable. It also reduced the physical distances over which pulses had to be passed. The importance of this can be realized from the fact that transferring pulses from place to place eats up time at the rate of about 5 ns per metre.

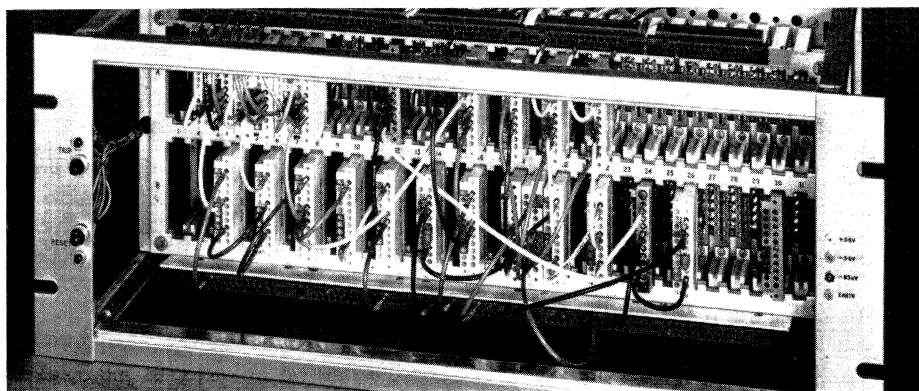
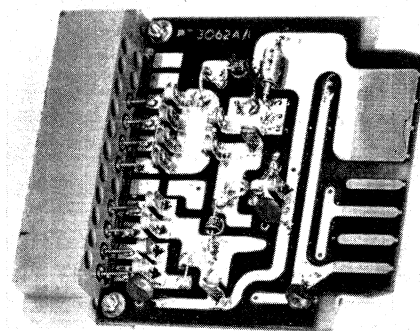
The electronic circuits in the system are standard but what is new is the way in which they can be packed together to form an extremely compact and versatile assembly. Individual circuits are mounted on miniature cards $8 \times 6 \text{ cm}^2$ and up to 62 of the cards can be stacked vertically in a rack unit which supplies stabilized power to each card via connections on the back edge. Connections between the circuits are made with miniature co-axial cables.

The system was first used (with success) in an experiment at the Rutherford Laboratory to measure asymmetries in negative kaon scattering on polarized protons. The team was led by J. Thresher who will also lead a team coming to CERN in the Autumn bringing eight racks of the Miniature Logic System with them.

One of the cards, $8 \times 6 \text{ cm}^2$, carrying a circuit used in the 'logic' developed at the Rutherford Laboratory. The commercial version has small changes particularly in its connection supports.

A front view of one of the rack units showing how the cards are slotted in, a maximum of 62 per rack, with very short leads connecting the individual circuits.

(Photos Rutherford Laboratory)



CERN Stores

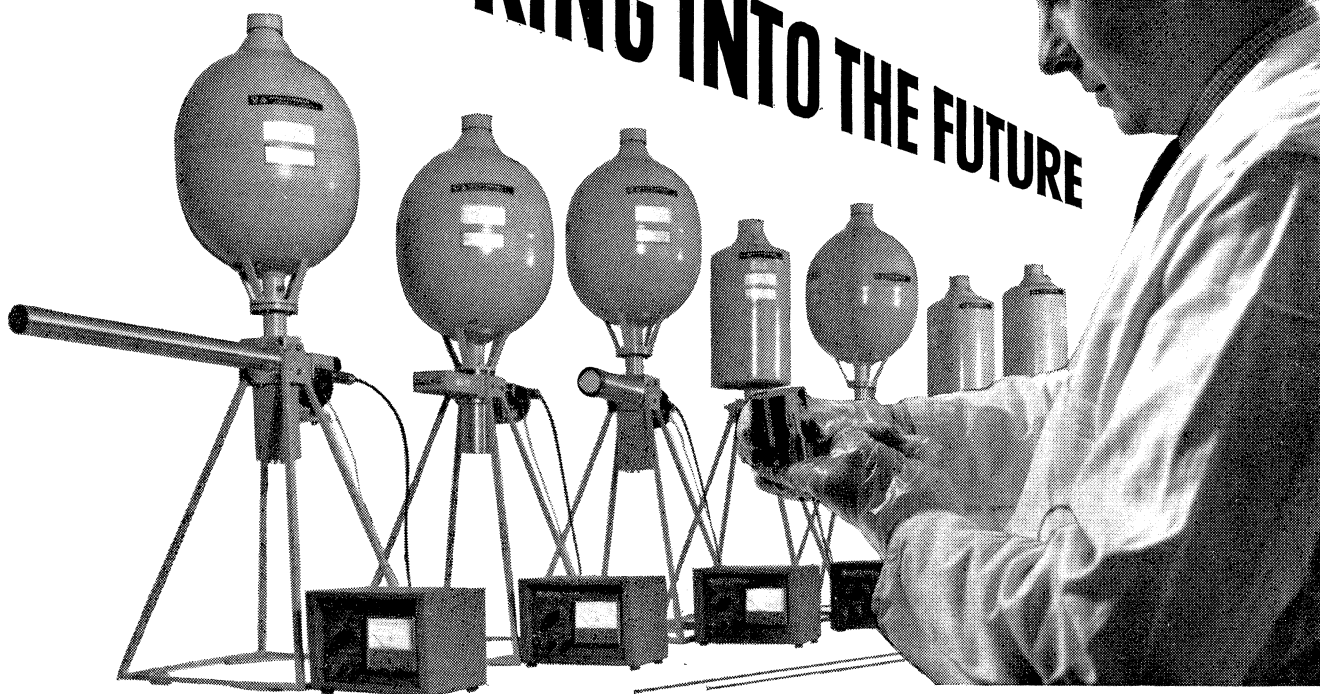
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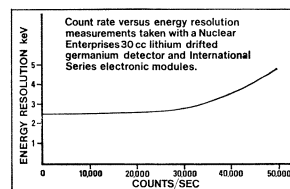
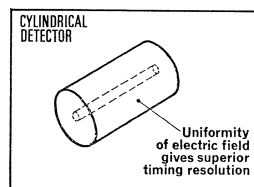
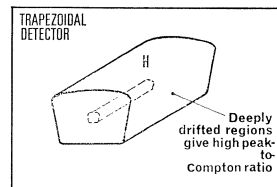
LOOKING INTO THE FUTURE



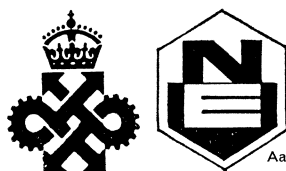
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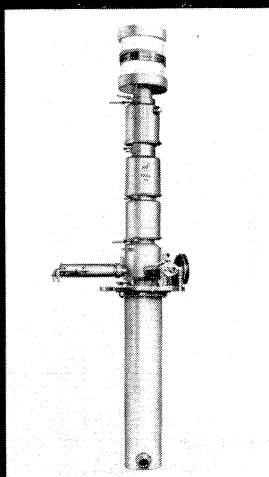
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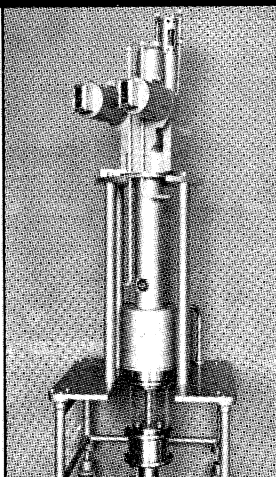
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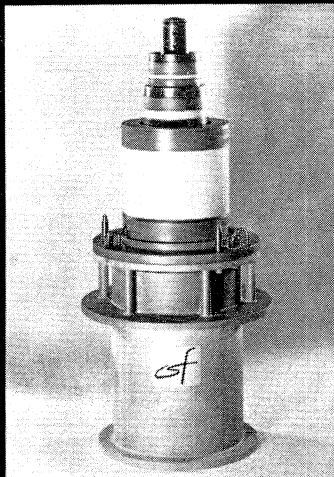


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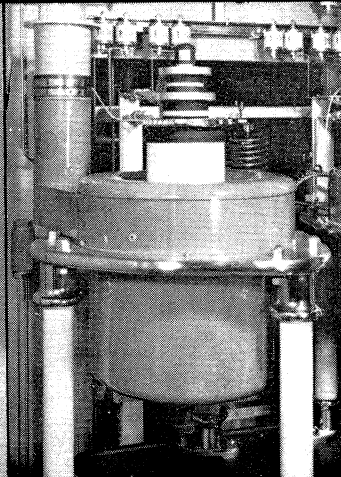


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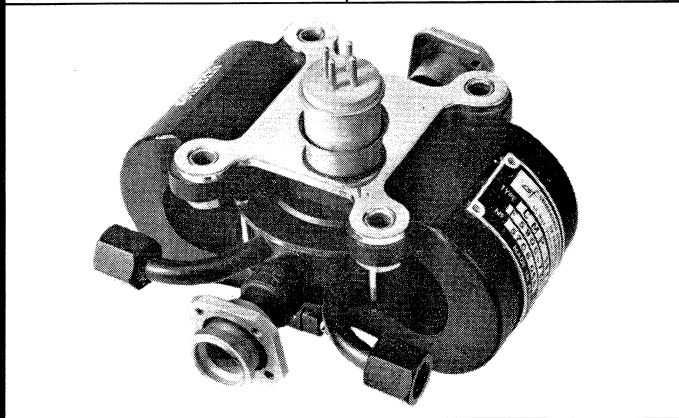
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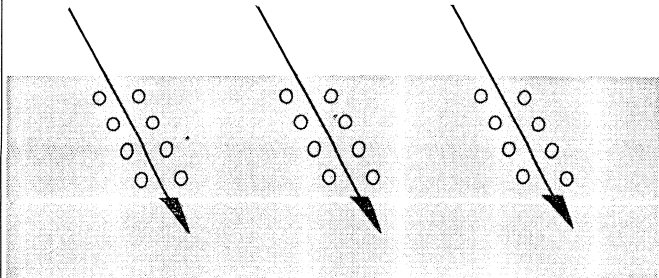


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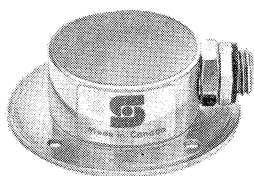
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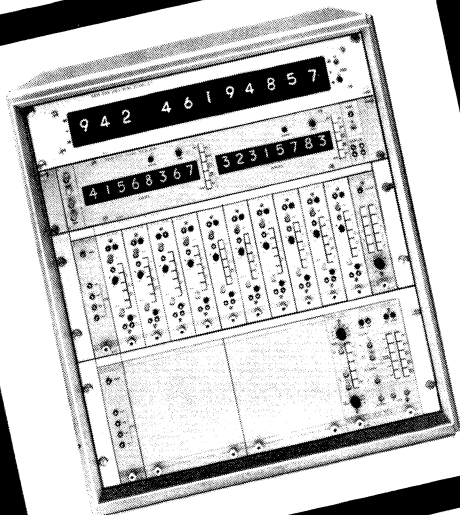
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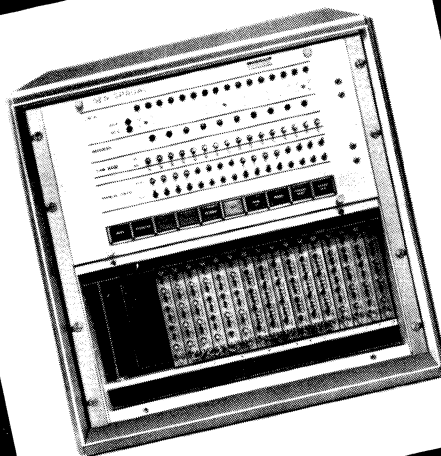


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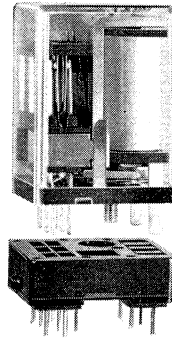
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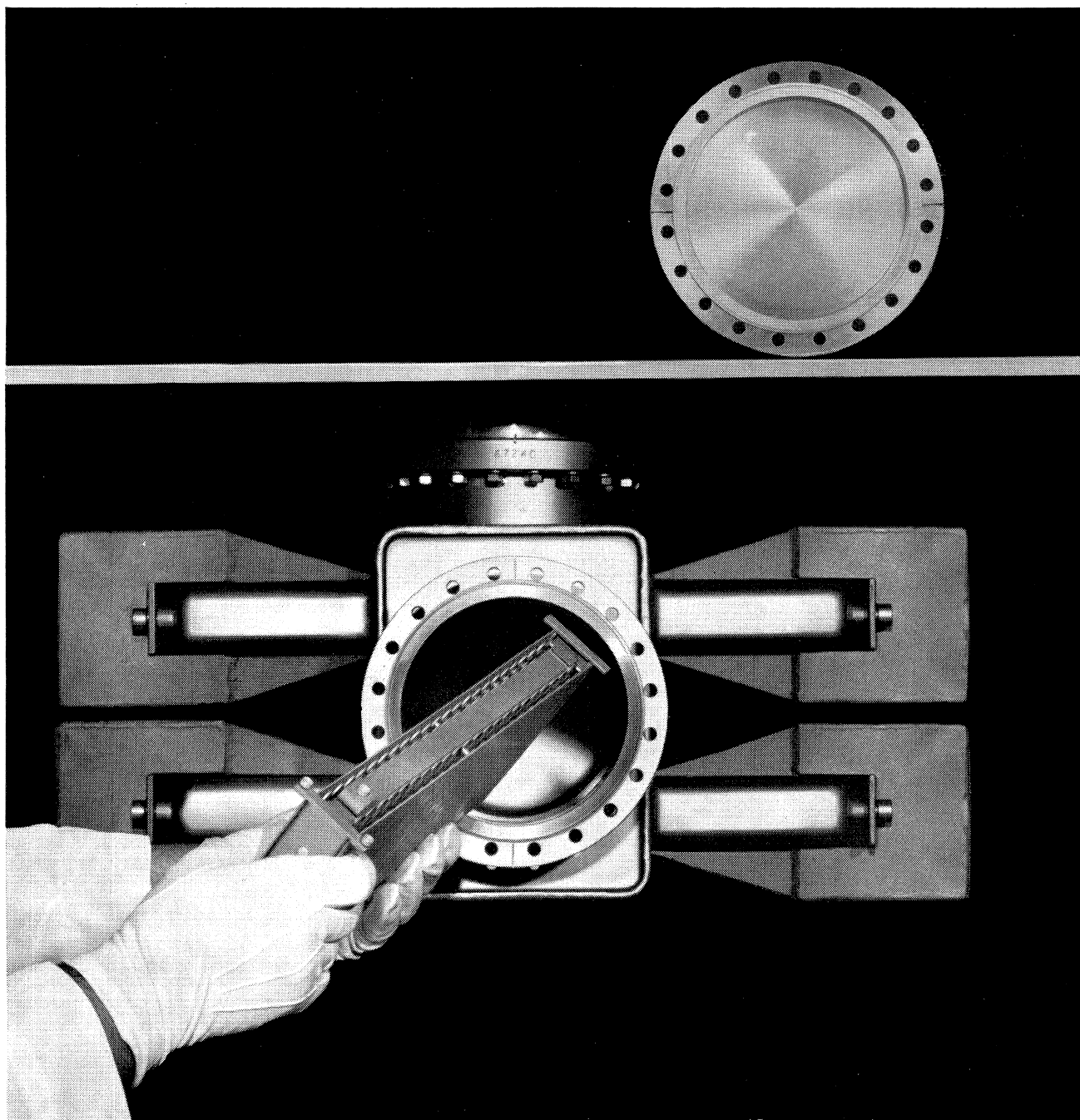
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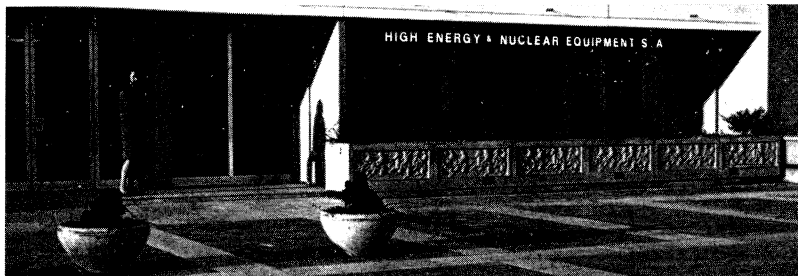
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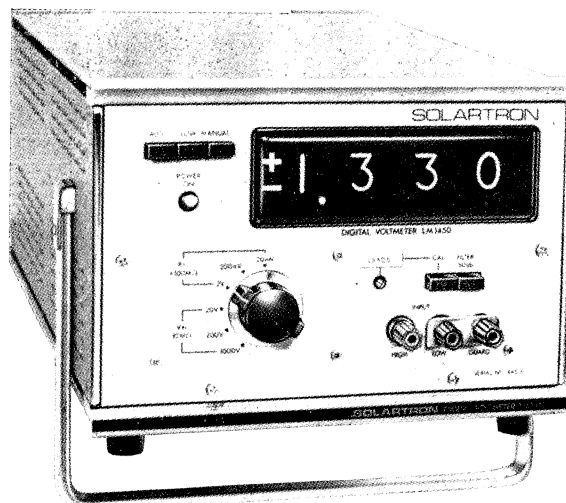
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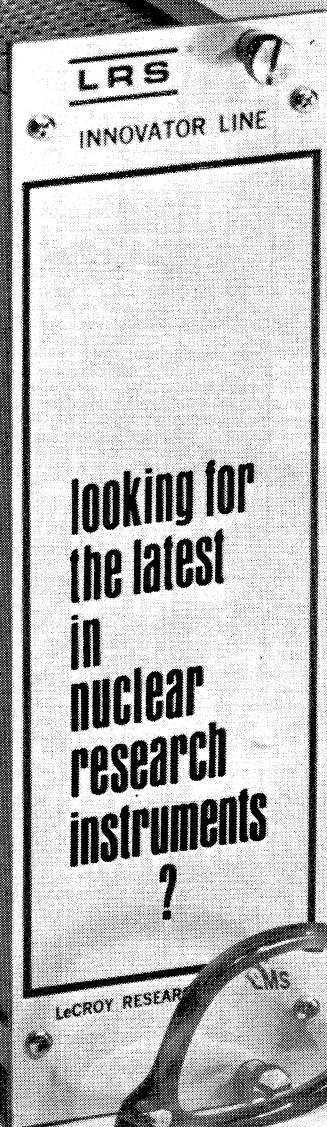
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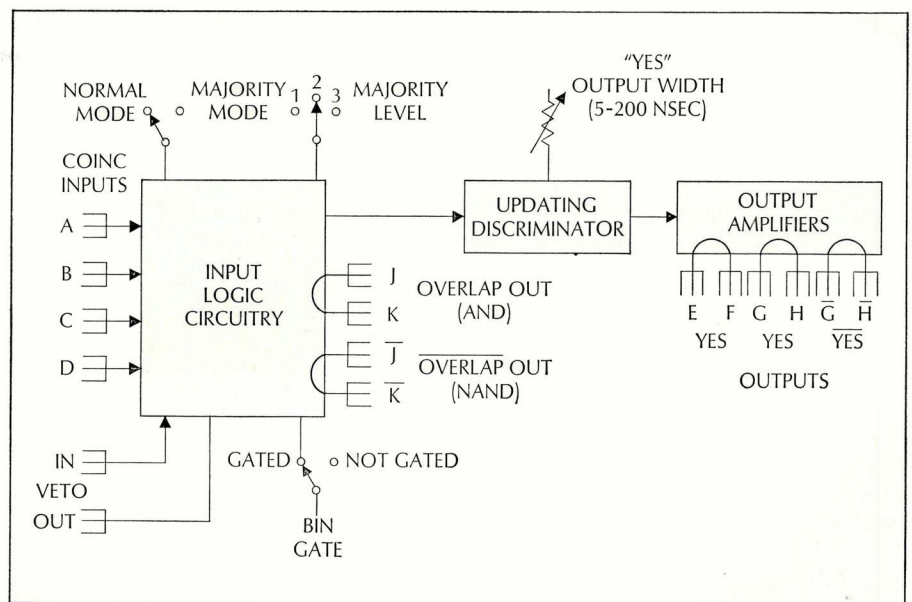
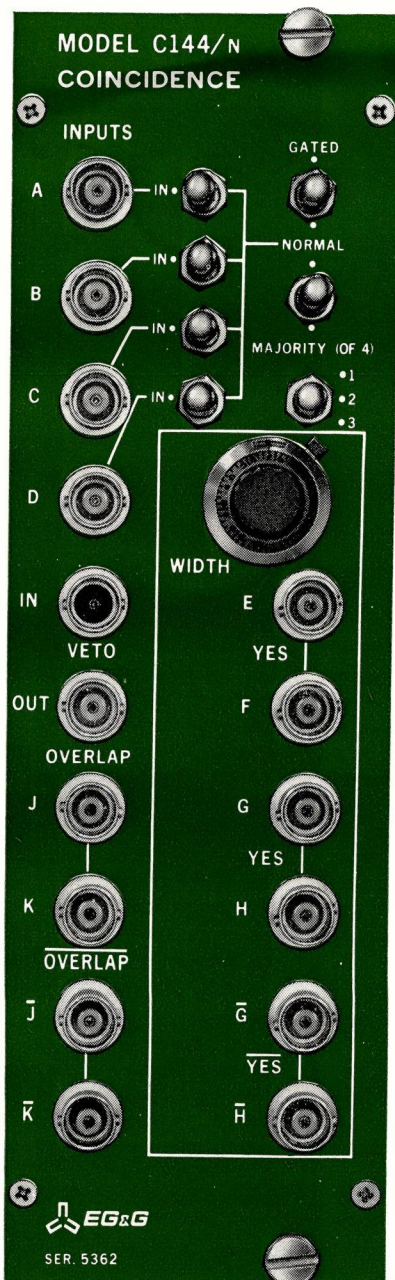
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Four direct-coupled coincidence inputs. Front panel locking toggle switches select participating inputs in NORMAL mode; all inputs participate in MAJORITY mode. Input pulse pair resolution better than 5 nsec. Direct-coupled, protected VETO input operates in both NORMAL and MAJORITY modes; buffered VETO output. Dual OVERLAP output provides AND signal; Dual $\overline{\text{OVERLAP}}$ provides NAND signal. Minimum input required for full OVERLAP output < 2 nsec. Switch selected bin gating. NORMAL or MAJORITY, op-

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The HIDAC system is kept up-to-date even in some years by the permanent introduction of new modules, which helps to automatise 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 μ s 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, 'doscope-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.