

6. General Engineering

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sary to carry out development work at CERN. There will, of course, be the usual series of acceptance tests, as the sets are manufactured. An order for 68 medium-power rectifiers (between 14 and 75 kW) was recently placed with Oerlikon (Switzerland). The remaining 124 low-power rectifiers (between 2.5 and 15 kW) will be ordered before the end of 1968.

Considerable effort is being made to achieve power supply operation as automatic as possible. Obviously, when so many units are involved, individual setting needs to be avoided. Digital to analogue converters will be used and the supplies will eventually be set via the ISR control computer.

The General Engineering Group offers services, mainly in the field of mechanical engineering, to all the other groups involved in the ISR project. It consists of four sections.

1. The Drawing Office

In close collaboration with the engineers of the various groups, the drawing office designs and establishes the manufacturing drawings of practically all machine components involving mechanical design. It helps to prepare specifications for these items and is often responsible for ordering and following up orders.

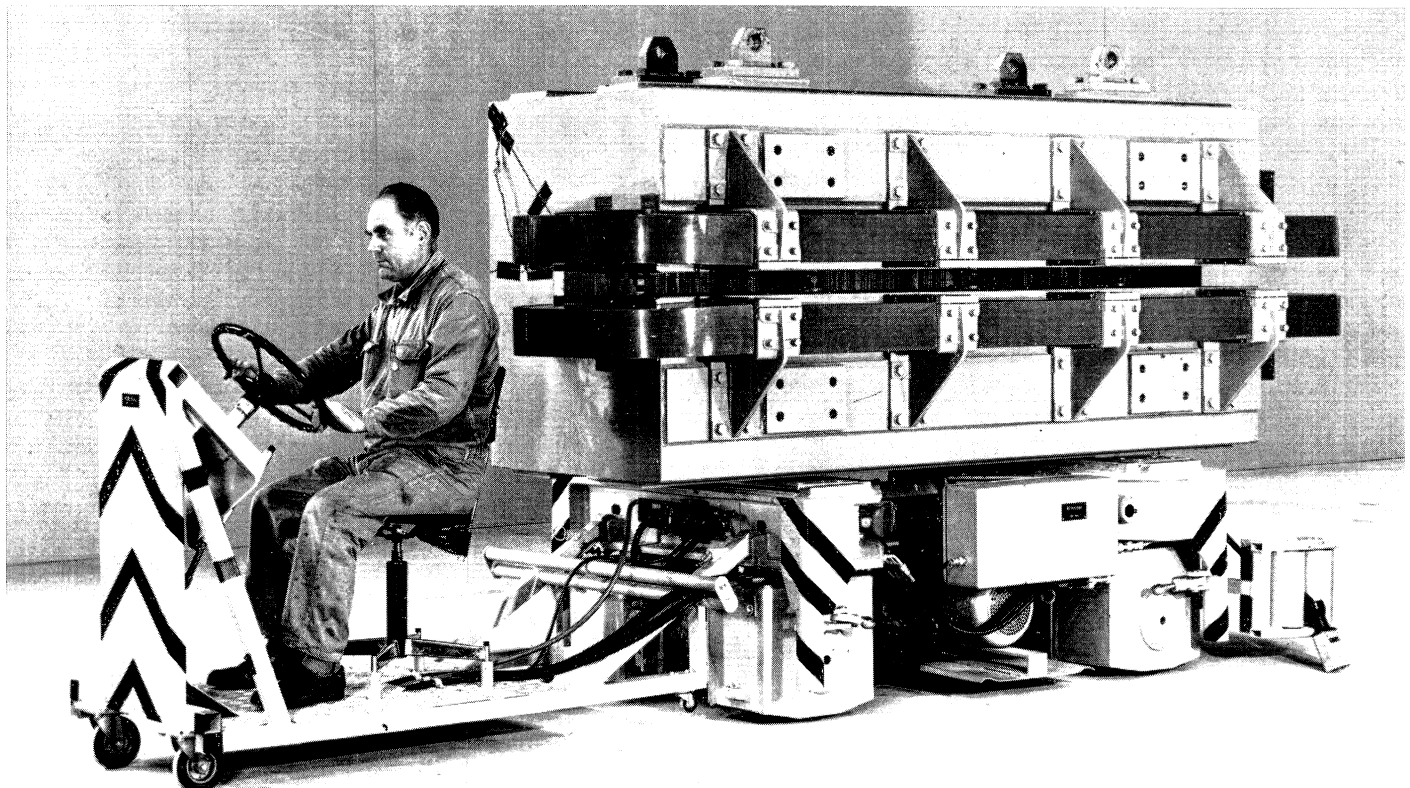
A typical example of a piece of equipment entirely designed by the drawing office is shown in the photograph. It is the special vehicle to transport some 130 bending magnets, weighing up to 20 tons, inside the beam transfer tunnels where no overhead cranes are available. Some of the design parameters were extremely severe: the magnets have to be driven down slopes of up to 12% (equivalent to the steepest mountain passes), stopped with millimeter accuracy, the wheels turned

through 90° and the magnet moved onto its final supports. Important safety considerations had to be taken into account. Each of the four wheels, for instance, is equipped with an emergency brake which would block the carriage in case of a power failure. The vehicle passed a number of factory tests with success at the manufacturers, Von Roll (Switzerland), and has recently been delivered to CERN where it is undergoing further tests before beginning regular operation next year.

2. Mechanical Workshop

It was clear from the beginning, that the construction of the ISR would require a large amount of development and prototype work and a divisional workshop was therefore set up in 1966. It is equipped with modern machine tools, a sheet metal and welding shop, and a tool room, and staffed with highly qualified personnel.

Together with the Vacuum Group it has carried out a lot of development work to find economic and reliable manufacturing methods for ultra-high vacuum components, and has built prototypes of chamber sec-



The extraordinary transport vehicle designed to carry magnets down the transfer tunnels where there are no cranes. It has to protect the magnets from any shock which would disturb its precise assembly and has to descend steep hills since the tunnels rise up from below the level of the ISR. When it reaches the desired position it stops with a precision of 1 mm and then moves exactly at right angles to its initial direction. It stops again with precision and jacks are inserted to lift the magnet clear. It then moves out and the proper magnet supports are put in position.

tions, valves, etc. Large quantities of welding samples, including plasma welding for thin wall stainless steel membranes, have been produced.

For the Magnet Group, the workshop built cutting devices to take samples from steel sheets for permeability measurements, high precision calibrating and measuring coils for magnetic measurements, precision tools for pole profile measurements etc. Furthermore, it carried out a series of qualifying tests on magnet supporting jacks and, recently, a checking section has been set up to make dimensional checks on the large series of magnet components.

For the Radio Frequency Group, it contributed to the construction of r.f. cavity models, pick-up stations, etc.

3. Cooling and Air Conditioning

This section is responsible for the design, ordering, installation and putting into operation of all the cooling and air conditioning installations required in the ISR and beam transfer systems. The work has been divided into the following components:

- a) Air conditioning system of the ISR Ring Tunnel — a total volume of about 140 000 m³. To retain accurate alignment of the machine components, the temperature must be maintained at $20 \pm 1^\circ\text{C}$ which imposes severe requirements on the air distribution and regulation system. A proportional-integral temperature regulator was chosen to satisfy these tight temperature tolerances. The air is recirculated through nine air treatment plants, situated in specially elevated roof structures of the ring-tunnel, and distributed through round ducts of 80 cm diameter. Installation has already started in Octant 3.
- b) Air conditioning system of the beam transfer tunnels — a total volume of about 15 000 m³. The temperature conditions are similar to those in the ring and the same regulation system has been adopted. There will be 14 air-conditioning units, situated in enlarged tunnel sections along the various transfer channels. The installation work is scheduled to start this month.
- c) Re-cooling plant — serving the various

closed cooling water circuits of the magnet systems and the air conditioning systems. Since natural cooling water is rather scarce on the CERN site, a system using water chillers with centrifugal compressors and cooling towers has been adopted. The total design capacity is 26.4 Gcal/h and the cooling water temperatures, at full load will be 13 to 33°C for the magnet systems and 5 to 12°C for the air conditioning systems. The plant will be one of the largest of its kind in Europe.

The tenders for the complete installation have been received and a contract will be placed shortly. Installation will start in May 1969.

- d) Piping system — distributing cooling water to the various users. It includes also the hot water pipes of the air conditioning systems. The installation consists of 22 km of low carbon stainless steel pipes carrying demineralized water to the magnet cooling systems, and 8 km of normal steel pipes for the air conditioning system. Installation will start this month.
- e) Distribution network for general purpose and drinking water, and for compressed air — serving the ISR and beam transfer tunnels. Specifications for these items are in preparation.

4. Coordination and Planning

The group is responsible for the coordination and planning of the installation of the machine. An important part of coordination is already done in the drawing office, to the extent that it must avoid interference between the many components it designs. For this purpose, it executes also the layout and assembly drawings.

Modern planning methods (PERT programming) are employed, using computer programs developed at CERN for the CDC 6600 computer. A first installation programme has been established for Octant 3 and the adjacent service tunnels, where installation work has started. A Technical Committee, with two members from each group, was set up early this year. All constructional aspects involving several groups, and all problems concerning installation are discussed and approved in this committee.

7. Controls

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The ISR project involves a very large complex of sophisticated equipment and requires a considerable effort to study and solve the control problems in detail. A Controls Group was therefore set up about two years ago. Work on self-contained parts of the control system is assigned to project engineers or physicists who link a specific ISR Group with the Controls Group. But general development and standardization of control techniques, such as data acquisition and transmission, and planning of the control cable network, is carried out centrally according to overall requirements.

The location of the storage rings control centre (SRC) can be seen on the Figure. It will be combined with the switchyard (SY) and West Hall (E₁) control centre, to facilitate communication between operators and to avoid duplicated controls for the beam transfer channels.

Safety aspects

The personnel radiation protection system (or access control system) has to take into account four basic modes of operation of the ISR complex, as indicated in the Table. It will subdivide the entire tunnel system into four main zones (see Figure) with either restricted or authorized access, depending on the mode of operation in use.

The radiation safety of the staff working inside one or several zones will be ensured by the following main elements (in addition to the general provision of shielding and radiation warnings):

- remotely controlled access doors and safety keys;
- beam dumps, stoppers and concrete separation walls in the transfer tunnels;
- 'off' status of power supplied to some of the beam transfer bending magnets;
- beam dumping mechanisms in the storage rings.

The first elements to be installed, during the next programmed shut-down of the PS, are dump D1 and stopper ST1, both in front of separation wall W1.

The design study of the ISR access control system has been completed. A model of a typical control and monitoring panel has been built in order to simulate the logic applied to door interlocks.