SOME STRUCTURAL FEATURES OF THE 10 BEV SYNCHROTRON ELECTROMAGNET

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(presented by E. G. Komar)

The general view of the assembled electromagnet is shown in fig. 1. It consists of four quadrants tangentially divided by four intervals each 8 meters long. With an equilibrium orbit radius of 28 meters, the outer diameter of the electromagnet is 72 meters.

The electromagnet consists of 48 equal blocks about 800 tons each. The structure and dimensions of a block are illustrated in fig. 2.

Fig. 3 presents the cross section of the electromagnet, and also shows the top and bottom covers of the vacuum chamber which are used at the same time as pole shoes of the electromagnet.

Each block consists of 20 components : 4 bottom and 4 top radially arranged bars; 2 internal and 2 external supporting pillars and 8 poles. The weight of a component does not exceed 60-ton. Supporting pillars (as shown in figs. 1 and 2) have oval cuts which provide access to the lateral walls of the chamber. One half of these apertures is used for accomodation of pipelines, which run to the vacuum pumps, and the other remains vacant to provide access for personnel into the space between the chamber and the lateral supporting pillars.

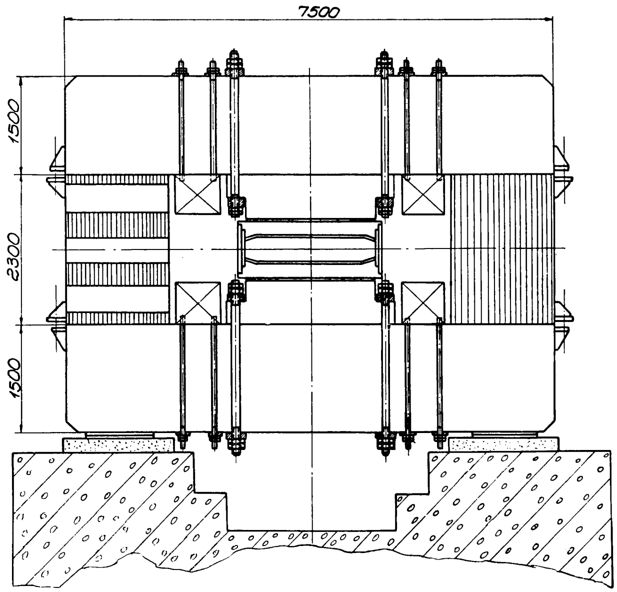

Fig. 3. Cross section of the electromagnet ring.

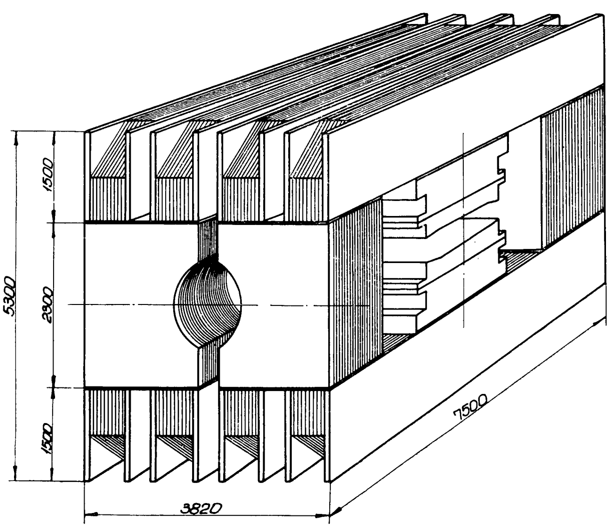

Fig. 2. Block structure (1/48th part) of the electromagnet.

Each component is made of steel laminations each 10 millimeter thick insulated by 1, 2 mm. varnished cardboard. External laminations of each pack are 40 millimeters thick. The packs are tightened by insulated studs passing through them and on the outer surfaces they are additionally braced by steel strips which are welded to each of the laminations. Steel strips are kept only in those places, where they do not cause electric disturbance.

The packs are made of special electrotechnical steel which has smaller coercivity and possibly a more stable value of it throughout the steel volume.

At the greatest value of magnetic induction in the gap of the electromagnet B = 13,000 gauss, the induction in

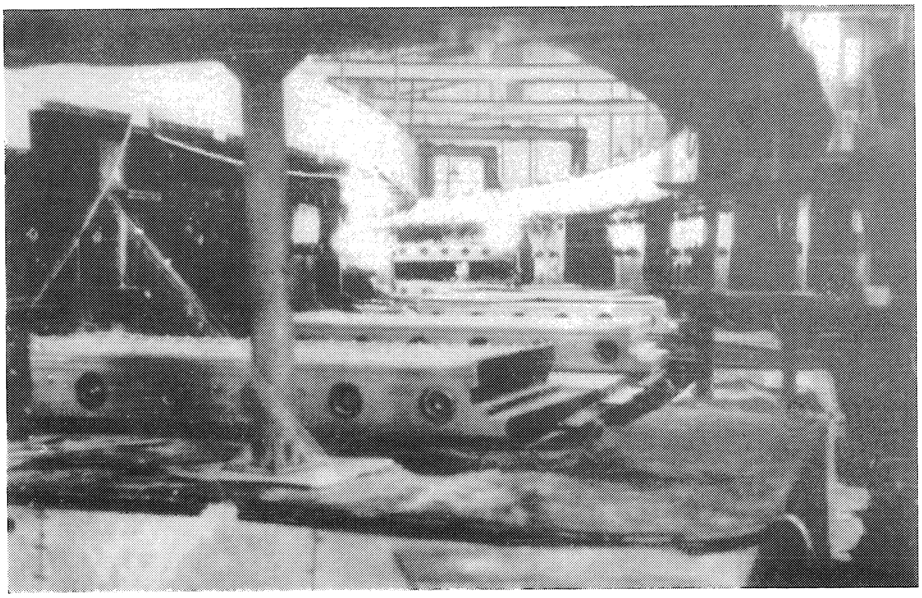

Fig. 1. 10 Bev synchrotron electromagnet in the state of assembly.

the iron reaches a value of the order of 17,000 - 18,000 gauss. 25% of the overall emf of the exciting winding are spent on magnetizing the iron of the magnetic circuit.

At the stage of developing the electromagnet structure model blocks were built and tested on which flux conditions and fringing factors were estimated. These magnetic measurements were carried out once again on an electromagnet block of natural size and for this purpose a special magnetizing winding was manufactured. The fringing factors for different cross-sections of the magnetic path were measured on the same block. The fringing factor was found to be of the order of 1, 4 in agreement with the calculated value.

The same block was used to check experimentally the effect of shorts caused by failure of insulation between laminations. For this certain laminations and whole

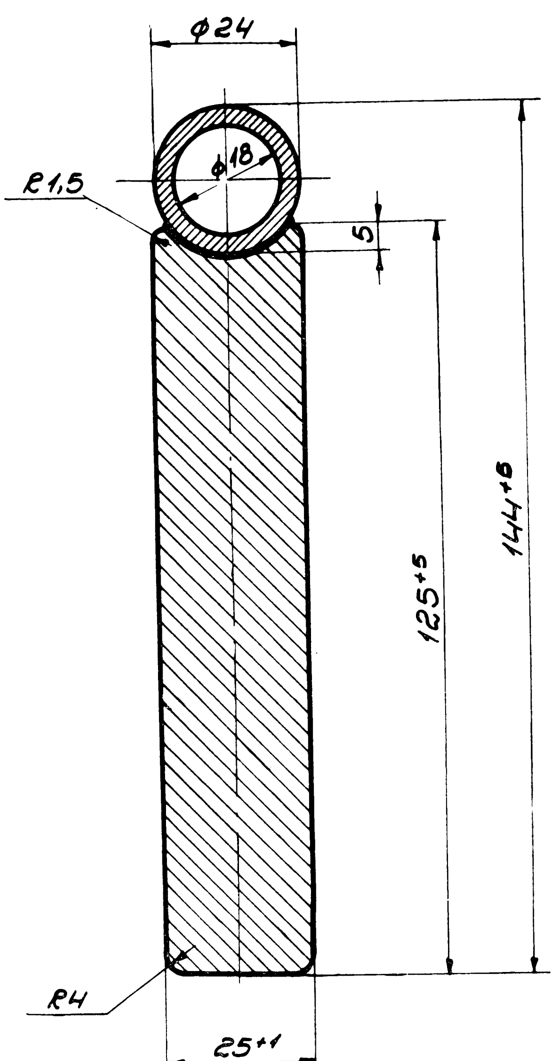

Fig. 4. Cross section of the exciting winding.

packs were shorted simultaneously. It was shown that single local shorts in bars and supporting pillars are unimportant. Only those shorts, which form large electric circuits, have a noticeable effect on the distribution of magnetic field in the magnet gap.

Shorts of laminations in the shoes have a considerably greater effect on the magnetic field.

The gross magnetic flux passing through the exciting winding in the air gap of the electromagnet is 640.10^8 maxwell. When the induction value is the greatest, the stored energy in magnetic field of the electromagnet is $1{,}8.10^8$ jouls.

Each quadrant has an independent exciting winding, which consists of two coils. The copper cross section of the winding is shown in fig. 4.

A water cooling copper tube is soldered to the main rectangular section of a bus-bar. Such a structure allowed to decrease the number of soldered junctions in the water cooling system of the winding. Each coil has 22 turns. The weight of copper in the coil is 57.5-tons. The winding is cooled by water. With a rate of flow of 105 m^3/hr the drop of water pressure is 5 atm.

Lapping and insulating of the exciting winding of the coils was carried out at the site of installation itself. The coils having been insulated by mica band were dried in a special vacuum jacket. Each coil was encased in a light protective duraluminium jacket and firmly fixed on specially designed brackets. The structure allows free lengthening of a winding caused by thermal expansions. The jackets are designed so as to provide the possibility of filling them with nitrogen in case of fire.

The peak voltage of a supply source for the exciting winding is 11,000 V and the peak exciting current is 12,700 amps.

The accelerating winding, which allows us to increase the rate of a rise of the magnetic flux at the beginning of a cycle by a factor of 3 or 4, is also assembled in the same jackets. The cross section of the copper of this winding is 16 mm^2, the peak current is 56 amps and the voltage applied to the accelerating winding is 8000 V.

The electromagnet is mounted on a massive reinforced concrete foundation ring, the cross sectional dimensions of which are 9200 × 3500 mm.

During the installation of the electromagnet a considerable settling of the foundation ring was detected, the unevenness of which reached 10 mm. or more. The measurements made after the installation of the magnet showed, that the unevenness in settling was in conformity with the natural law and gave in the tangential direction the fourth harmonic, which is not dangerous from the point of view of particle oscillations.

Plane adjustment of the bottom blocks during the installation of the magnet was carried out by geodetic

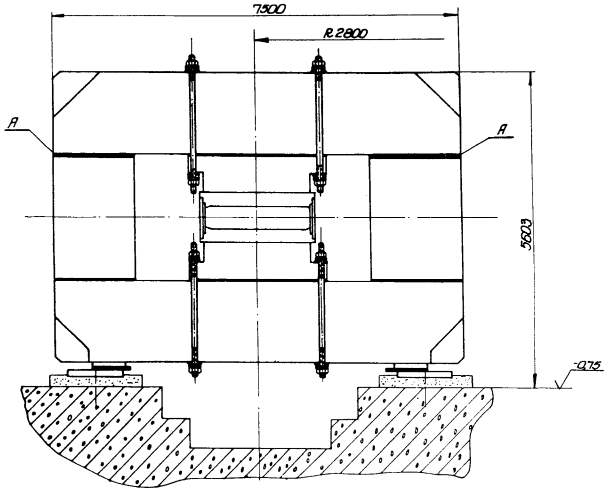

Fig. 5. Scheme of load regulations.

methods. The vacuum chamber which is a part of the magnetic path was assembled by parts together with the electromagnet.

Special attention was paid to the measurement and regulation of mechanical strains arising under the influence of the magnetic field in the vertical walls of the chamber. As shown in fig. 5 the vertical walls of the chamber carry a considerable load under the weight of the top core, top bar and magnetic forces in the air gap. The value of the load on the chamber can be regulated by changing the thickness of interlayers A between the support planes of the top bar an the supporting pillars.

After the installation of the electromagnet and the chamber, mechanical strains, arising in the vertical walls of the chamber at the time of turning on the exciting winding, were measured by special instruments. These strains were kept down to permissible values by adjusting the thickness of the above mentioned interlayers.