VACUUM CHAMBER OF THE 10 BEV SYNCHROTRON ELECTROMAGNET

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(presented by E. G. Komar)

As a result of detailed studies and of experiments carried out on models of different structures of annular sections, a variant of a two-chamber structure has been adopted in which the high vacuum chamber is placed in an intermediate fore vacuum volume (fig. 1). The pressure in the intermediate volume is of the order of 1 mm. Hg.

The presence of an intermediate, low vacuum chamber has made it possible to construct a lighter high vacuum chamber, to use thin metal sheets of considerable dimensions for the chamber walls, and to use for the low vacuum chamber such materials as textolite, laminated insulation and standard commercial rubber. Moreover, this has greatly facilitated the sealing of the inner chamber and has reduced the requirements with regard to the quality of the sealing assembly; it has also permitted to reduce the total capacity of the high vacuum diffusion units.

The pole shoes of the magnet are separated from the cores, incorporated in the structure of the chamber and are used for withstanding atmospheric pressure.

The separate pole shoes have made it possible to machine to a greater degree of accuracy the surface determining the shape of the magnetic field in the gap.

The pole shoes are made of the same material as the whole of the magnetic system, i.e. of electrical steel sheets 10 mm. thick. The mechanical rigidity of the shoes is achieved by baking them in varnish and by using six contracting pins and wedges at the edges of the shoes. The insulation of individual sheets is accomplished by means of cardboard gaskets and varnish. The pins and wedges are likewise insulated from the shoe sheets. Every shoe occupies 1/192nd part of the azimuthal circumference. The geometry of the shoe is shown in fig. 2.

The laminated shoe bears the horizontal wall of the forevacuum chamber, and the required vacuum sealing is achieved through the use of a textolite sheet inserted between the shoe and the core.

The shoe pack contains six sheets 40 mm. thick. These are required to make rigid cheeks of a pack, to arrange the threaded holes of the shoe fastening and, as will be shown below, to form a frame for the rubber sealing of the inner chamber sheets.

The side walls of the fore vacuum chamber are made of duralumin sheets 75-60 mm. thick. The walls fix the reciprocal position of the shoes and partly withstand the mechanical loads caused by the atmospheric pressure, by the weight of the upper parts of the magnet system and the magnetic attraction between the shoes. Measurements have proved that the eddy currents arising in the solid walls distort the magnetic field in the gap considerably.

Ports have been milled in the side walls to reduce these distortions. The walls are insulated from the shoes by thin textolite gaskets.

The smooth surface of the side wall, on which sealing rubber is placed, is obtained by filling the intervals between the walls, and the ports in the walls with textolite and laminated insulation liners.

Together with the textolite sheets, the rubber bands placed on the joints of the adjacent shoes form the horizontal vacuum tight walls of the forevacuum chamber. By special wedges the rubber is tightened as required.

The side vacuum tight walls of the chamber are formed by a rubber band put throughout the height of the chamber. The upper and lower edges of the band are bent over on the textolite sheets of the shoes and are tightened by wedge clamps.

Thin sheets of stainless steel, forming the horizontal walls, are the main material of the inner high vacuum chamber. The dimensions of the sheets are 350 × 2000 mm. and they are 0.15 mm. thick. Measurements under dynamic conditions have shown that the sheets of the selected dimensions have no practical effect on the shape of the magnetic field.

Every shoe has three such sheets pressed to the shoe by special laths and bolts.

The vertical walls of the inner chamber are made of stainless steel sheets 4 mm. thick. Oval-shaped branch pipes are welded to the walls (to half of the total number) to couple the vacuum diffusion units, targets and other devices. Each wall envelops two pole shoes azimuthally.

Thick (40 mm.) sheets of the pole shoe together with stainless steel face cover plates and rubber gaskets under them form a circuit on the inner surface of the shoe on which rubber gaskets for sealing the stainless steel sheets are placed. The sealing junction also serves as electrical insulation of the sheet from the pole shoe. The pressure laths are mounted by bolts to the thick sheets of the shoe and to the edge cover plates with a clearance in the joint between the laths equal to 1 mm. The clearance is provided to prevent any closed circuit of the eddy currents.

The pole shoe with stainless steel sheets fastened on it on the side of the inner chamber forms a vacuum tight surface. The sealing between the adjacent shoes is formed by means of a rubber cord with wedge clamp, and between the vertical wall and the shoe by means of a rubber band and bolts.

All rubber sealings of the outer and inner chamber, including that of the thin stainless steel sheets, can be dismounted and assembled without dismounting the magnet system.

Windings correcting the distribution of the magnetic field are placed inside the chamber on fluoroplast bushings.

All the inner parts of the chamber, electrically insulated from one another, are connected during assembly by resistances which ensure the leakage of static charges. The end parts of every quadrant (fig. 3) are terminated in welded connecting boxes which are an extension of the inner chamber and terminal caps for the ante-chamber.

The connecting boxes are designed so as to permit adjustment of the effective magnetic angle of the quadrant; the leads of the pole face windings are concentrated there.

The straight sections of the chamber are all-welded boxes of stainless steel sheets.

The sealing between the connecting and straight sections makes it possible to compensate any inaccuracy of fabrication or assembly as well as thermal deformations of the chamber. The whole of the chamber can be divided into two parts by special dividing gates.

Accelerating electrodes are installed in two straight sections, a guiding system for the injection of the beam being located in one of them. Signal electrodes are in the straight section at the place of the beam extraction.

In the process of construction the dimensions of every part were checked by special appliances and gauges.

The pole shoes were fully assembled in the workshop together with the stainless steel sheets and checked at a special stand (fig. 4) for vacuum tightness.

During the tests a pressure drop was created between the low and high vacuum spaces, equal to 30 mm. Hg and the absence of helium leakage into the high vacuum volume was checked.

Two blocks of the chamber were then assembled, together with the magnetic system (1/48th of the ring); the technological process of mounting the chamber was tested on the blocks, and vacuum and magnetic tests were carried out.

Vacuum tests were carried out on one of the blocks under conditions similar to the operating conditions of the proton synchrotron; about a thousand cycles of rise and drop of the magnetic field were run.

The tests have proved that it is possible to obtain the necessary vacuum and stability of the chamber in the conditions of a varying magnetic field.

The chamber was mounted simultaneously with the assembling of the electromagnet (fig. 5).

The lower shoes were set after the lower girders, cores and electromagnet windings had been mounted. The position of the shoes as to height, radius and azimuth were checked by geodetic instruments; then the side walls of the inner and low vacuum chamber were installed. The walls of the inner chamber were finally braced only after the upper shoes had been mounted. Following this, the assembly of the magnet system was completed and the inner chamber sealed.

Of all the sealings of the inner chamber a preliminary check-up was made only of the one belonging to the pole shoe. The sealing between the walls and the shoe is simple and, when properly pressed, ensures the required vacuum tightness. The sealing between the shoes as well as the T-shaped joint between this sealing and the sealing of the walls (see fig. 6) is complicated and difficult and requires in every case vacuum checking for the quality of performance.

For this purpose special appliances were constructed, namely boxes which were installed inside the chamber on the shoe joints and which set up a small volume along the sealing contour. In the volume a pressure of 150-200 mm. was maintained; a leak detector was connected to the volume, and the outside of the sealing contour, was blown by helium.

Measures were taken for the leak detector to operate with sufficient sensitiveness when the pressure in the volume rose.

All the joints between the shoes were checked in this way.

The sealing of the low vacuum chamber was tested by a helium leak detector with the combined volume of the inner and fore vacuum chambers pumped out.

During the preliminary tests of the annular section quadrants, when the pressure in the low vacuum chamber amounted to 1 mm. Hg, the pressure in the high vacuum chamber was equal $1.3 - 2.2 \times 10^{-5}$ mm. Hg (measurements were made without liquid nitrogen); and $3\text{-}4 \times 10^{-6}$ mm. Hg (when measured with liquid nitrogen).

The inner chamber was pumped out by eleven diffusion pumps instead of twelve. Liquid nitrogen was not fed to the traps.

These results have proved that when using diffusion pumps together with nitrogen traps a vacuum of the order of $4\text{-}6 \times 10^{-6}$ mm. Hg can be obtained after some preliminary pumping has been made. This ensures the normal operation of the proton synchrotron.

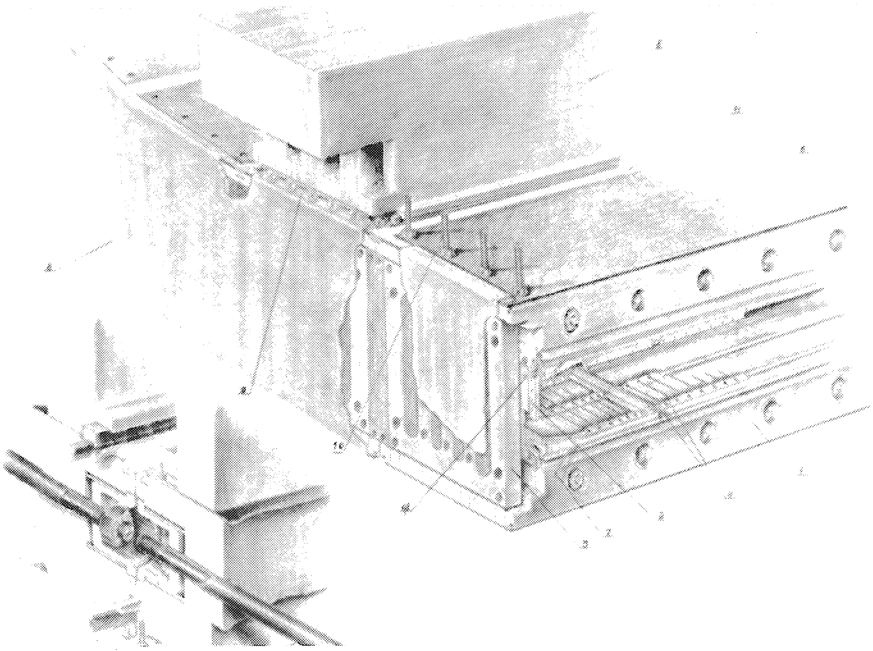

Fig. 1.

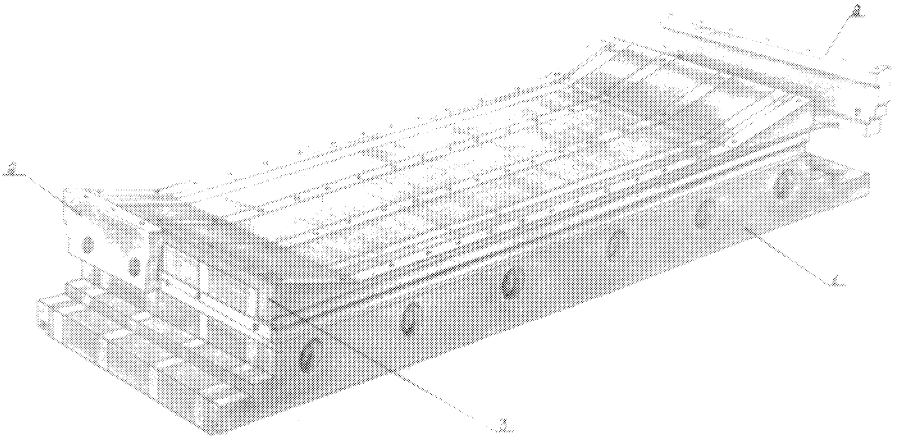

Fig. 2.

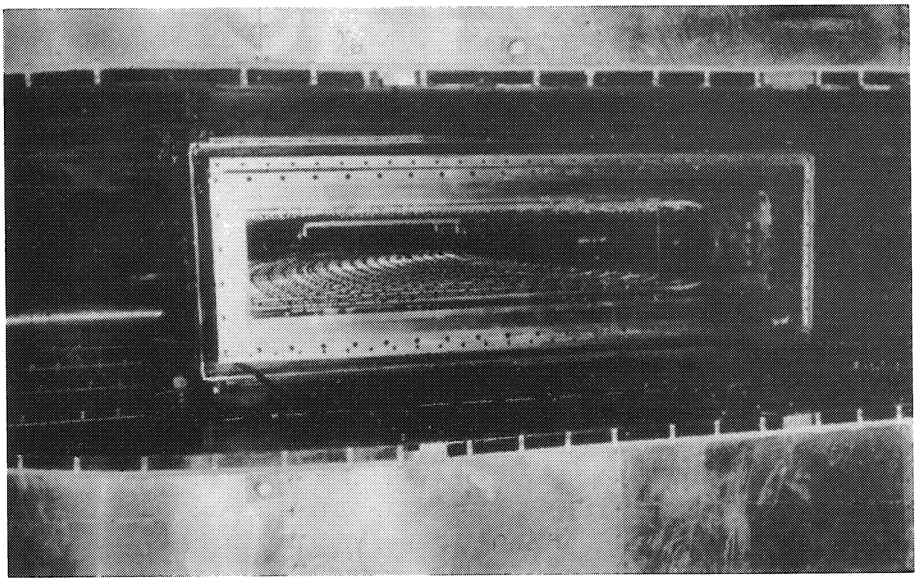

Fig. 3.

Fig. 4.

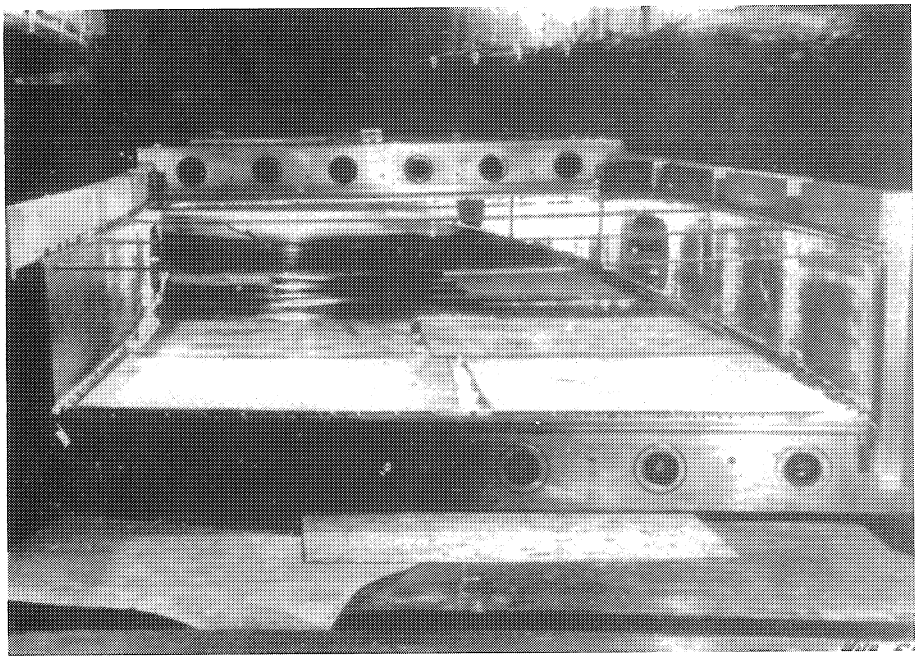

Fig. 5.

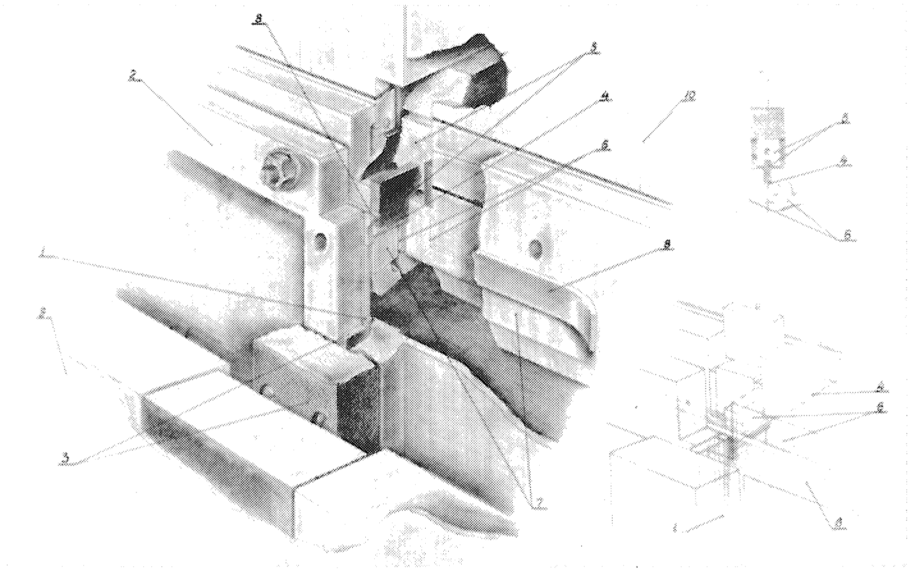

Fig. 6.