RECONSTRUCTION OF MAIN RING VACUUM SYSTEM IN KEK PROTON SYNCHROTRON

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Reconstruction of the main ring vacuum system of KEK PS was planned and performed last autumn. Most of the beam ducts in the main ring including the ducts of bending sections, Q magnet sections and short straight sections were reconstructed. Main purposes of this work are as follows:

(1) To get large effective aperture.
The effective aperture of the duct is limited by the pole piece gap of the magnet, by the possible width of the duct and by the sagita. The old beam duct for the bending magnet is bent at the magnet center only, while the new duct is bent at three points which were selected so as to minimize the sagita. This design reduced the sagita by a factor of 4, i.e., from 13 mm to 3 mm. In addition, the new duct has a larger aperture than the old. As a result, the overall effective aperture is about 26 % larger than that of the old one (Fig. 1).

(2) To improve the magnetic field.
Strictly speaking, stainless steel is a magnetic material. The relative permeability μ_r of SUS 304L, which is the material of the old beam duct, is about 1.04. If the μ_r of the duct is uniformly 1.04, the effect on the magnetic field is negligible. But this was not in our case. By a cold drawing process, μ_r is much increased locally where the deformation is large. Therefore, we chose SUS 316L as a material of the new duct. With the new duct, the average of μ_r is less than 1.02.

(3) To save the free space in the short straight section.
Many correction magnets, beam monitors and pulse magnets for beam handling are arranged around the main ring. The only spaces for those magnets and monitors are short straight sections each of which is a field free space of about 1.3 m between bending and Q magnets. In the old version, an ion pump was installed in every short straight section and occupied a large space. Short straight section is the only available space for the correction magnets and beam monitors. Most of the new experiments and improvements of the main ring requires a free space in the ring. To prepare wide spaces for the future, the ion pump in every staright section was moved to a narrow space between Q and bending magnets (Fig. 2).

(4) To make the maintenance easy.
In assembling duct units, the work to connect two flanges is a troublesome job and requires a much man power. An application of commercial "chain clamp" (Fig. 3) to the flange connection seems to be promisive for the reduction of man power in the working. In the design of the new duct, we adopted a special type of flange as a standard which is ready to access the chain clamp and also can play as an ordinary one with an additional receiver flange.

Practically, we are allotted a time of about 2 months for the reconstruction (from 21st Aug. to 31st Oct.). By the end of July, most of the components were completed. After about 1 month of cooling time of residual activity of the accelerator, we started the working on 21st of Aug. To minimize the exposure to the residual activity, we surveyed the distribution of residual

activity in the main ring tunnel and made a map of activity distribution. We also paid much cares not to be concentrated the exposure of residual activity to a particular group of the staffs. The reconstruction was completed by the end of Oct. as scheduled. Total man power used in the reconstruction was 370 man x days including the one of outside order.

After the reconstruction, the magnetic fields of the bending magnet were improved remarkably. The sextupole component of the magnetic field was reduced by a factor of about 100. The beam intensity was increased more than 60 %, and was accomplished a new record of 4.05×10^{12} ppp which is twice of the design value.

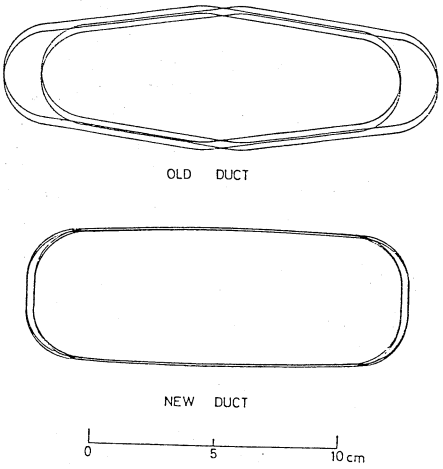

Fig. 1.
Effective aperture of the duct.
upper: old one, lower: new one.

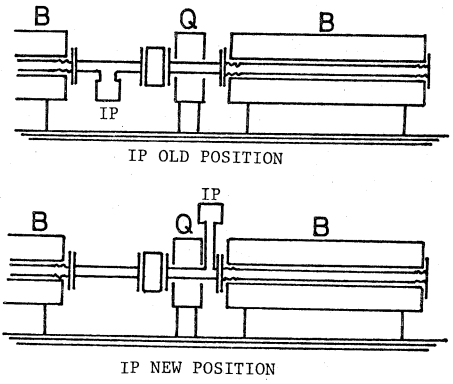

Fig. 2.
Position of the ion pump.

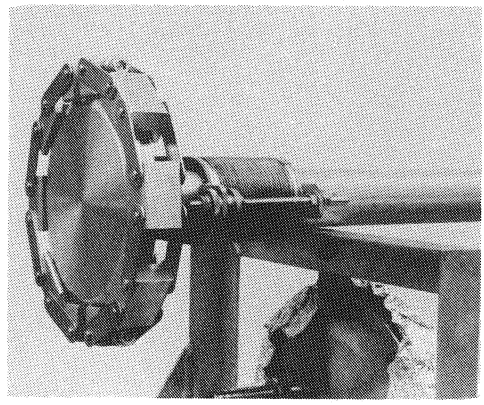

Fig. 3. Chain clamp applied to the flange of new type.