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THE VACUUM SYSTEM OF THE IPCR SSC

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Abstract.- The operating pressure of lower than 1 x 10^{-7}Torr is desirable in the median plane of the SSC. The acceleration chamber devided into 8 sections is designed. Pneumatic expansion seals are used between each sections. The total gas load is estimated about 11 x 10^{-3} Torr ℓ/sec after 20 hours pumping. The total pumping speed of more than 11 x 10^4 ℓ/s is needed. Cryo-pumps are used as a main pumping system.

1. Introduction.- The IPCR SSC will be used to accelerate both light and heavy ions. The pressure in the chamber should be sufficiently low to reduce the beam loss due to the collision of the accelerated ions with any gas molecules. The chamber of this type is not generally suitable to evacuate to low pressure. Many ingenious inventions are needed in the designing of the vacuum system.

2. Pressure in the chamber.- Particles may be lost by the collision with gas molecules during acceleration. Provided a number of particles n(0) injected into the chamber decreases to n(x) after travelling a distance of x, the following equation holds

$$n(x) = n(o)\exp(-K\cdot p\cdot \sigma\cdot x)$$

where p is the pressure and K is a constant. σ denotes the collision cross section, which can be approximately given by the electron capture and loss cross section in heavy ion collision. The percentage of beam transmitted was calculated for various ions as a function of pressure. An example for $^{238}U^{37+}$ ion is shown in figure 1. Particles will travel a distance of 1 ∿ 3 km during acceleration in our SSC. If 90 % of the original particles should be extracted from the SSC, then the pressure in the chamber, as can be seen from figure 2, must be kept lower than 1 x 10^{-7} Torr.

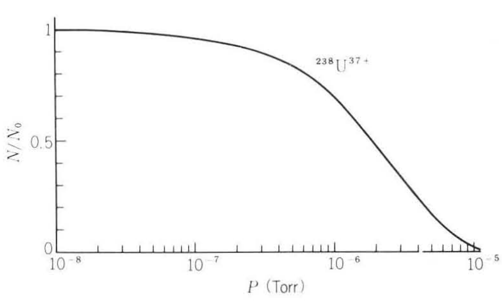

Fig. 1 : Calculated transmission through the SSC for $^{238}U^{37+}$ ions as a function of pressure.

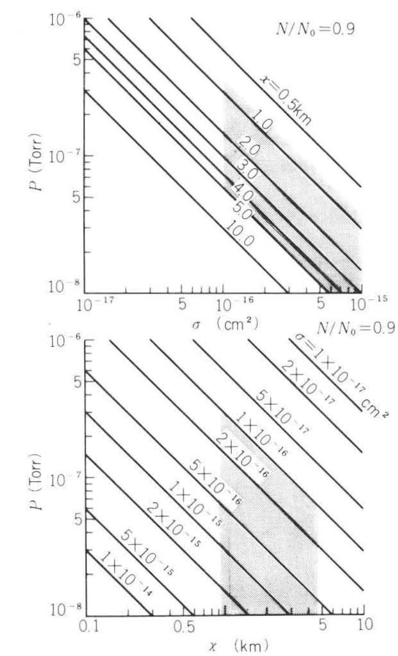

Fig. 2 : Pressure to secure 90 % transmission of the particles as a function of the collision cross section, and the total travelling distance.

3. Structure of the chamber.- The chamber is evacuated to a pressure lower than 1 x 10^{-7}Torr. The problem in evacuation is the evolution of gas from the surfaces of the chamber and equipments in it. Because a large quantity of gases are supposed to evolve from the pole faces, the main coils, and the field trimming coils, these components are placed outside of the chamber. The chamber is divided into 8 smaller sections. The RF resonator sections can be withdrawn backwards from the normal position so that tuning and repair can be done easily. The spaces between each sections are so narrow that the sealing method using a bolt-nut is difficult to employ. Pneumatic expansion seals seem to be much more practical. Models of the seals have been made for the operational testing. As the space available in the pole gap for the chamber is restricted (50 mm), the chamber wall in that place is not thick enough to withstand atmospheric pressure. The chamber at the magnet sections are therefore surrounded with an additional chamber that is

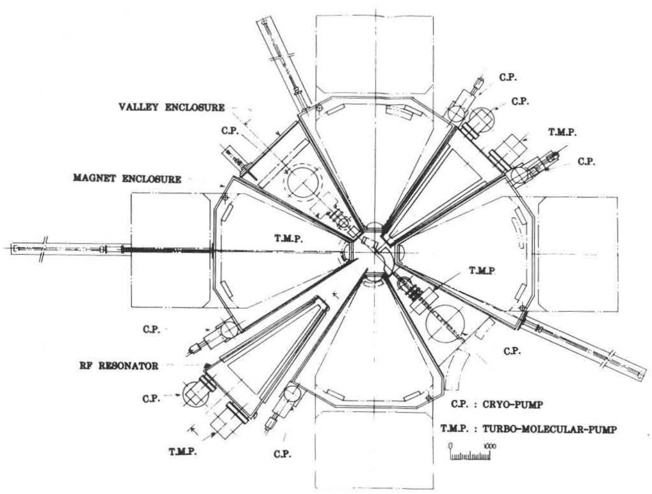

Fig. 3 : Plan view of the vacuum chamber for the SSC

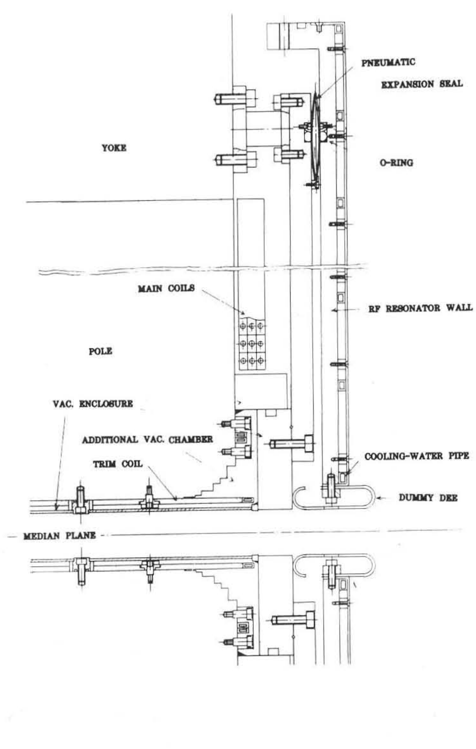

Fig. 4 : Vertical cross section of the vacuum chamber showing the method of sealing between the magnet and the RF resonator sections.

evacuated to about 10^{-1} Torr to lessen the pressure difference both sides of the walls. The analysis of this structural behaviour is in progress using a finite element method. The plan view of the chamber is shown in figure 3, and the vertical cross sectional view showing the connection between the magnet and the RF resonator sections is shown in figure 4. The chamber at the magnet section is also seen in this figure. Geometric characteristics of the chamber are as follows:

total diameter	9 m
height: the valley section	60 cm
the RF resonator section	740 cm
the magnet section	5 cm
the additional chamber	38 cm
total volume	$\sim$65 m^3

4. Vacuum system.- The inner surface areas of the chamber are as follows:

Stainless	$\sim$300 m^2
Copper	$\sim$440 m^2
Elastomer	$\sim$5 m^2
Total	$\sim$750 m^2

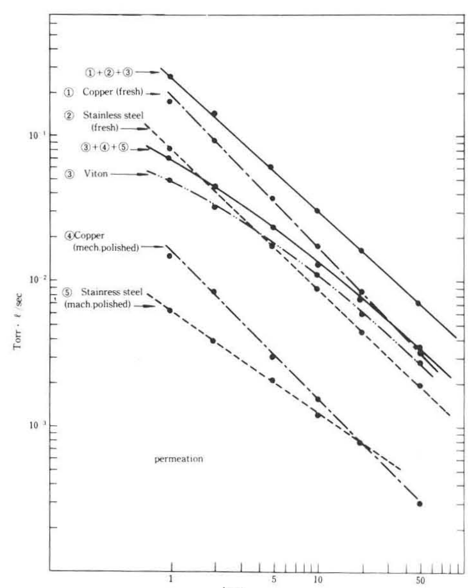

Fig. 5 : Outgassing from the chamber inner wall. Outgassing from any material or component within the chamber is not included.

The gas evolution from these surfaces is shown in figure 5 as a function of time. When mechanically polished copper and stainless steel are used, the total outgassing rate is estimated to be about 8 x 10^{-3} Torr.ℓ/sec^{-1} after 20 hours pumping. Additional gas load from the leakage and the surfaces of components installed in the chamber will be about 3 x 10^{-3} Torr.ℓ/sec. Therefore the effective pumping speed of 11 x 10^{4}ℓ/s is necessary to achieve the required pressure. Cryo-pumps are put at every valley section , every RF resonator , and every space between the magnet and the RF resonator (the total pumping speed is approximately 16×10^4 ℓ/s). It may be possible that 2 to 3 times of the pumping speed is needed. In such case cryo-panels may be used, because the chamber wall area is to narrow to place pumping ports.

The roughing systems which consist of a mechanical booster and a oil rotary pump are located at two valley sections and two RF resonators. After the chamber reaches to about 10^{-1} Torr, the pumping systems proceed to evacuate the additional chambers only.

Safety devices such as a safety valve and a safety interlock system are installed to prevent the thin walls of the chamber from collapsing due to sudden increase of the pressure difference between the acceleration and the additional chamber. A possible layout of the vacuum system is shown infigure 6.

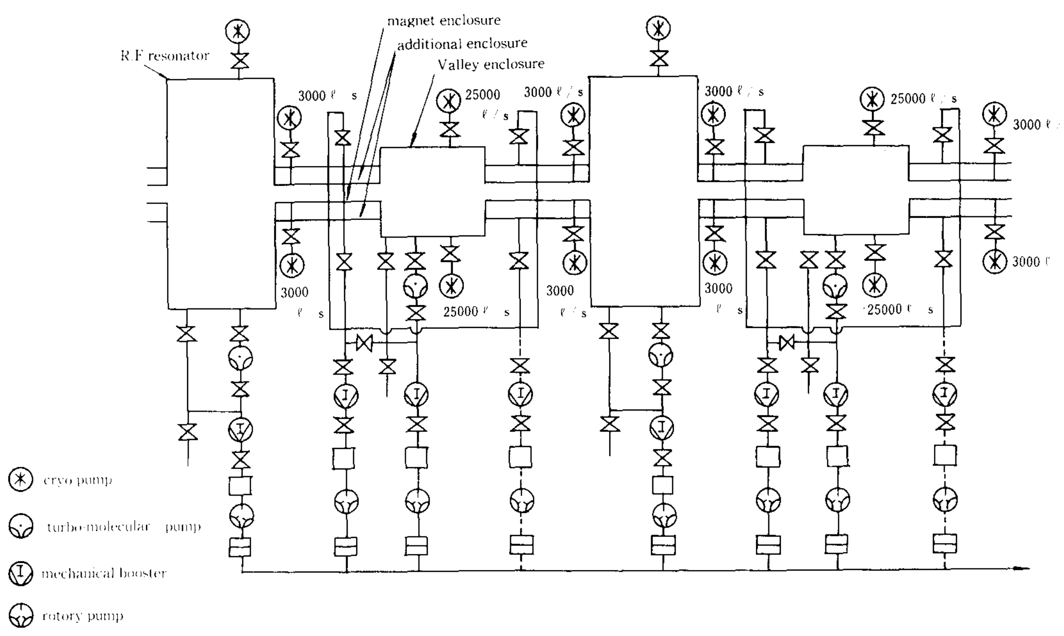

Fig. 6 : Schematic drawing of the vacuum system.