DESIGN OF THE VACUUM SYSTEM OF THE RIKEN SSC

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ABSTRACT

The operating pressure of $3 \sim 4 \times 10^{-8}$ Torr is required in the median plane of RIKEN SSC. To realize the pressure, the vacuum chamber and the vacuum system are now being designed. The vacuum chamber consists of eight separate chambers. The flanges between these chambers will be sealed with metal O-rings and double elastomer O-rings. Cryopumps and cryopanels of total pumping speed ($\sim 12 \times 10^4$ ℓ/sec) are used as a main pumping system.

INTRODUCTION

Building for the RIKEN SSC and four sector magnets have been completed. Two types of RF resonator cavities were investigated and finally the resonator having a movable box as a frequency-changing device was adopted. Furthermore the design of the vacuum system is now in its final stage and fabrication of the vacuum chambers will soon be started. Status of the design is described in the following sections.

VACUUM CHAMBERS

The vacuum chamber consists of eight sections, that is, four magnet chambers, two RF resonator chambers and two valley chambers. Each magnet chamber is fixed to each sector magnet. RF resonator chambers and valley chambers are movable on rails. The magnet chambers and valley chambers are made of stainless steel, and the resonator chambers are made of stainless steel and copper claded stainless steel. Since a space is limited, it is impossible to make the chamber walls thick enough to withstand the atmospheric pressure when they are under vacuum. The walls are, therefore, supported at the outerside of them to prevent some part of the chamber wall from deflecting. The total volume of the chambers shown in Fig. 1 is $\sim 25^3$m . Total area of the inner surface is $\sim 310^2$m :

Stainless steel	~ 150 m^2
copper	~ 160 m^2
elastomer	~ 3 m^2

MAGNET CHAMBER

The magnet chambers are evacuated through both a valley chamber and a resonator one because pumps can not mounted on them. Cross-sectional view of the pole edge section is shown in Fig. 2. Since the outgassing rates of mild steel and insulating materials are high, the pole pieces of the magnet and the field trimming coils are covered with stainless steel plate of 4 mm thick and kept under low vacuum. A safety valve operating mechanically is installed to prevent the plate from collapsing owing to the pressure difference between two regions. A model of the valve shown in Fig. 3 was fabricated and its performance was investigated.

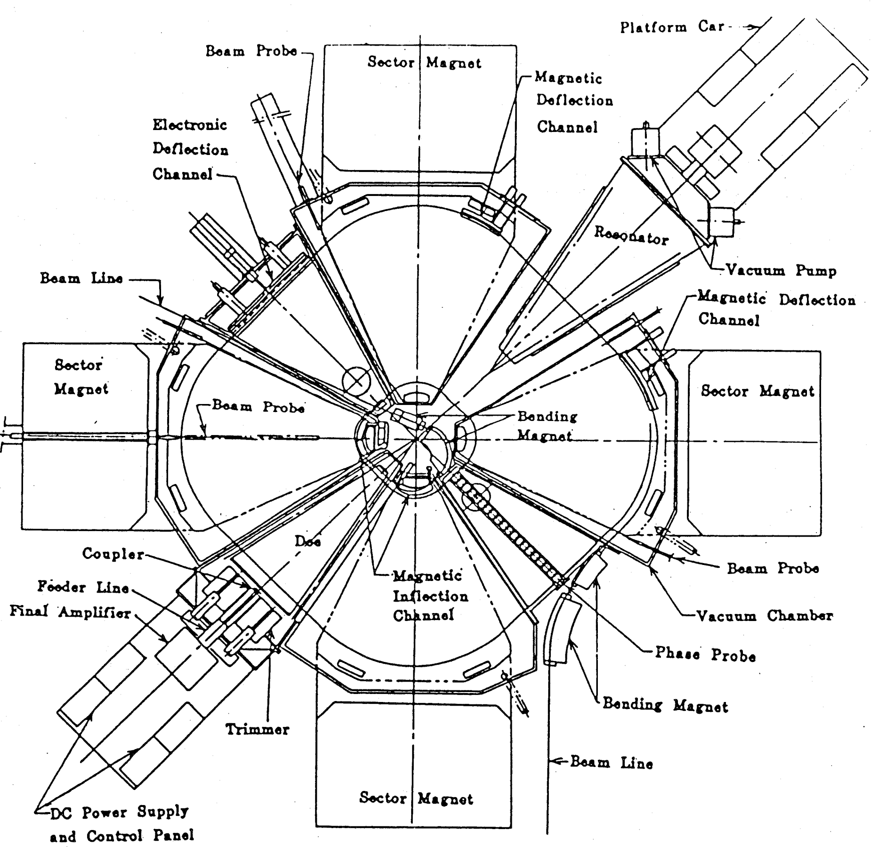


Fig. 1 A plan view of the vacuum chamber of RIKEN SSC.

RF RESONATOR CHAMBER

New RF resonator of total height 2.1 m was designed. Bird's-eye view of the resonator is shown in Fig. 4. The resonator has two movable boxes to vary a resonant frequency. A trimmer and a coupler are inserted from the backside. The backside plate is made of copper clad stainless steel and has many small holes for evacuating the resonator chamber. Two cryopumps and a turbo-molecular pump are mounted on the rear panel behind the plate. Two cryopanels are put inside of the stems to evacuate inside of the dee.

VALLEY CHAMBER

Three cryopumps are mounted on the top of the chamber. A turbo-molecular pump with an isotation valve and a flange for connecting a low vacuum system are mounted on the bottom of the chamber.

SEALING BETWEEN THE CHAMBER

We decided to use a welded bellows sealing method, as is shown in Fig. 5, to seal between the chambers. Flanges with a welded stainless steel bellows are welded at either side of the resonator chamber and the valley chamber. Flanges between eight chambers are bolted together to compress a metal O-rings or a double elastomer O-rings.

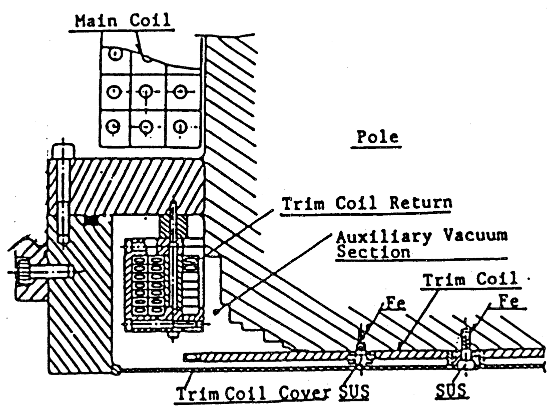


Fig. 2 Cross-sectional view of the pole edge section. Pole surface and trim coils are enclosed in auxiliary vacuum and separated from high vacuum chambers. The main coils are in the atomosphere.

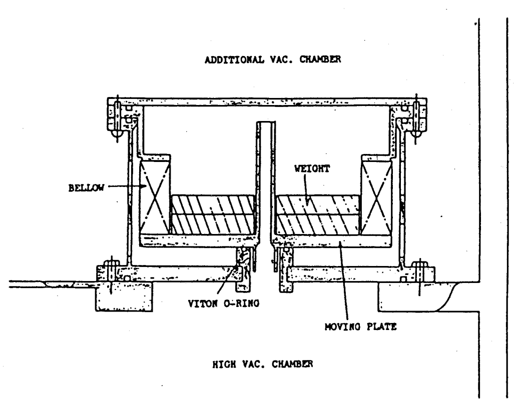
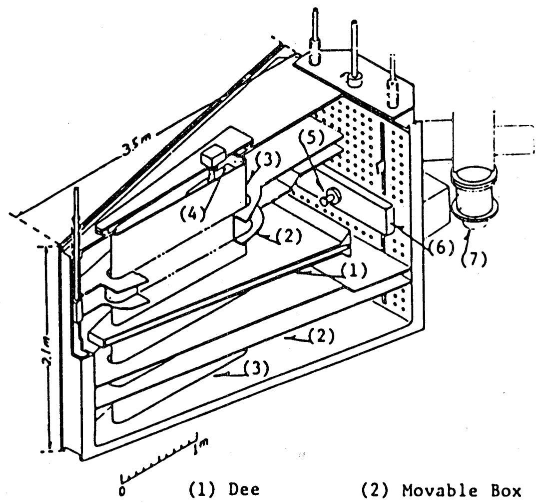


Fig. 3 A fabricated model of the safty valve.



(1) Dee (2) Movable Box
(3) Stem (4) Cryopanel
(5) Coupler (6) Trimmer
(7) Vacuum Pump

Fig.4 A bird's-eye view of the RF Resonator for the SSC

PUMPING SYSTEM

Design of the pumping system had almost finished. As shown in Fig. 6, the system consists of two low, four high and an ultra-high vacuum system. The low vacuum system consists of a roots pump of pumping speed 2600 m^3/h and a rotary pump of pumping speed 4900 ℓ/min. Coarse pumping is done through each valley chamber. The pumping down time from atmospheric pressure to 10^{-1} Torr is ∿20 minutes. High vacuum system consists of a turbo-molecular pumps of pumping speed 5000 ℓ/s and a rotary pump of pumping speed 2000 ℓ/min. These pumps are mounted on resonator chambers and valley chambers.

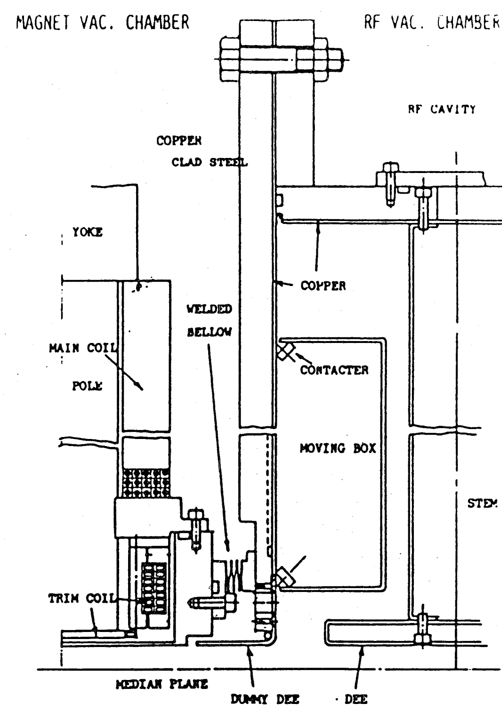
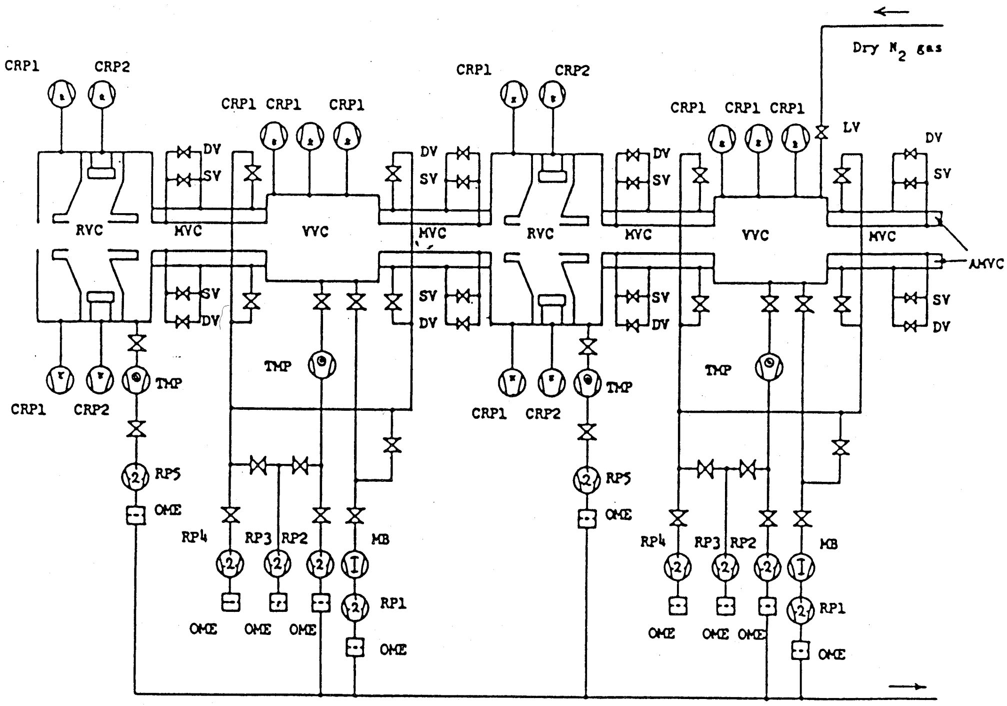


Fig. 5 Sealing method using a welded bellows.



RVC: RF resonator vacuum chamber. MVC: magnet vacuum chamber. VVC: valley vacuum chamber.
AMVC: additional magnet vacuum chamber.
RP: rotary pump, RP1: 3000 ℓ/min, RP2 and RP5: 2000 ℓ/min, RP3: 1000 ℓ/min and RP4: 610 ℓ/min.
MB: roots pump of 2600 m^3/h. TMP: turbomolecular pump of 5000 ℓ/sec.
CRP1: cryogenic pump of 10^4 ℓ/sec. CRP2: cryogenic panel of 5000 ℓ/sec.
SV: safty valve (mechanical). DV: differential valve (air operated). LV: leak valve.
No marked valve: air operated. OME: oil mist eliminator.

Fig. 6 Schematic lay-out of the pumping system.

The pumping down time from 10^{-1}Torr to $\sim 10^{-6}$ Torr is $\sim$20 hours. The ultra-high vacuum system consists of ten cryopumps of pumping speed 10000 ℓ/sec for N_2 and four cryopanels of pumping speed 5000 ℓ/sec for N_2. They are mounted on resonator chambers and valley chambers without isolation valves. The ultra high vacuum system starts to operate at the pressure below 10^{-6} Torr. An additional vacuum system consists of two rotary pumps of pumping speed 610 ℓ/min and is for evacuation of the additional magnet vacuum chambers (a low vacuum region of the magnet chambers) to the pressure below 10^{-1}Torr. Total gas load in the vacuum chamber is estimated $\sim 12 \times 10^{-3}$ Torr ℓ/sec after 100 hours continuous pumping. Application of ECR (electron cyclotron resonance) discharge cleaning to the magnet chambers and glow discharge cleaning to the valley chambers is planned to reduce the gas loads. By applying these techniques, we think that total gas load become below 4×10^{-3} Torr ℓ/sec. Thus the ultimate pressure will be of the order of 10^{-8} Torr.