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1 MV ACCELERATOR STRUCTURE FOR CLUSTER INJECTOR

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Introduction

For the acceleration of cluster ions the Gesellschaft für Kernforschung (GfK), Karlsruhe, Germany, needed an accelerator structure of fairly high complexity. Since the accelerator proper was to be as small as possible it was decided to enclose the whole system into pressure vessels and insulate the active parts with sulfurhexafluoride (SF_6) insulating gas. It was further decided that all the auxiliary devices to operate the ion source like power supplies and cooling units should be put into a separate tank. This meant that the whole structure would be divided up into three interconnected pressure vessels, one for the power supply, one for the accelerator and one for the ion source supply devices (intermediate tank). The accelerator should be able to accelerate ions to an energy of 1 MeV with a beam current of up to 120 mA. For maintenance purposes it should be possible to open each tank without removing the gas from the other two. This means that all three units had to be separated by gas tight bushings. During the design stage the main features of the accelerator structure were discussed and reviewed in close cooperation with GfK.

Special Features

1 MV Bushing

to separate the gas volumes two bushings capable of holding a voltage of 1 MV and a pressure difference of 4 atm. were designed. They were vacuum-cast with Araldite into a conically-shaped double-walled mould. One of them was tested with oil up to a pressure of 56 atm. were it broke showing that a big enough safety margin was available. To keep the voltage distribution under control 20 electrode rings were fitted on the outside of the bushing with grading resistors insuring a linear voltage distribution on the surface.

Grading Resistor for Accelerator Tube

Since the loading on the electrodes of the accelerator tube from stray ions and backstreaming electrons was not known a grading resistor with a rather high current of 10 mA, dissipating therefore 10 kW of power, was designed. A square chimney type insulating structure next to the accelerating tube was filled with freely hanging resistors and cooled with a forced stream of SF_6 gas of 60 m^3 per hour. The SF_6 gas after passing through the resistor chimney shows a temperature rise of 37 degrees. To keep heat from transmitting from the resistors to the accelerator tube a second chimney was interposed between the two and a forced gas flow upheld in it.

Liquid Gases

Since the ion source is cooled by liquid nitrogen and helium an air lock was designed to permit filling of the cryostat (built by GfK) of the ion source without removing the insulating gas. During operation the liquid will start evaporating and after approx. one hour the pressure is so high that it has to be removed. The voltage will be switched off and the gas will be removed through a gas line in the intermediate tank. In order that this gas line holds the 1 MV voltage afterwards again it has to be pumped out and filled with SF_6 gas. This whole process is completely automatic.

Power in High Voltage Terminal

To be able to run all the different power supplies, control units, pumps for cooling liquid a motor generator set of 40 kVA with an insulating drive shaft was incorporated in the intermediate tank. Since reduction gears are rather noisy and require maintenance it was decided to couple the motor and the generator directly without reduction gears at both ends of the shaft. Since the insulating distances under 4 atm. of SF_6 are relatively short it was possible to design an insulating drive shaft that runs at 1500 revolutions per minute and stays below the critical frequency.

Power Supply

The 1 MV power supply with a maximum current of 120 mA that was part of this accelerator structure was described earlier.[1]

Cooling

To dissipate the heat produced in the three tanks the SF_6 insulating gas was used as heat transport medium. Each tank has a gas circulator with its corresponding water-cooled heat exchanger at earth potential. For the cooling of the ion source a liquid Freon is used which is cooled in a separate heat exchanger at high voltage. To be able to make trial runs with the ion source the system must be able to run with the tanks open. An auxiliary heat exchanger is fitted to the ion source supply terminal to take over the heat dissipation in place of the SF_6 gas.

Tanks

The volume of the three tanks together is approx. 45 m^3. This makes the SF_6 gas filling rather expensive and special care was taken to keep the leakage rate smaller than 1.0 μTorrl/sec. This gives an integral loss of less than 5 % per year which is acceptable.

Control System

For the control of the various working parameters a special telemetry system was built. It transmits signals from earth to high potential and vice versa. Wherever possible, mechanical isolating rods are used for operating the ion source supply units from the centralized control facility. The working parameters of all units operating at high potential are displayed on a window allowing monitoring by a TV-system. For monitoring fast transients a high speed fibre optic transmitting system with a frequency-bandwidth from zero to 10 MHz is incorporated in the intermediate tank. Special attention had to be paid to the protection of the electronic equipment in case of arcing in the accelerator tube.

References

1. G. Reinhold, R. Gleyvod, Megawatt HV DC Power Supplies, IEEE Transactions on Nuclear Science, Vol. NS 22, 1289 (1975).

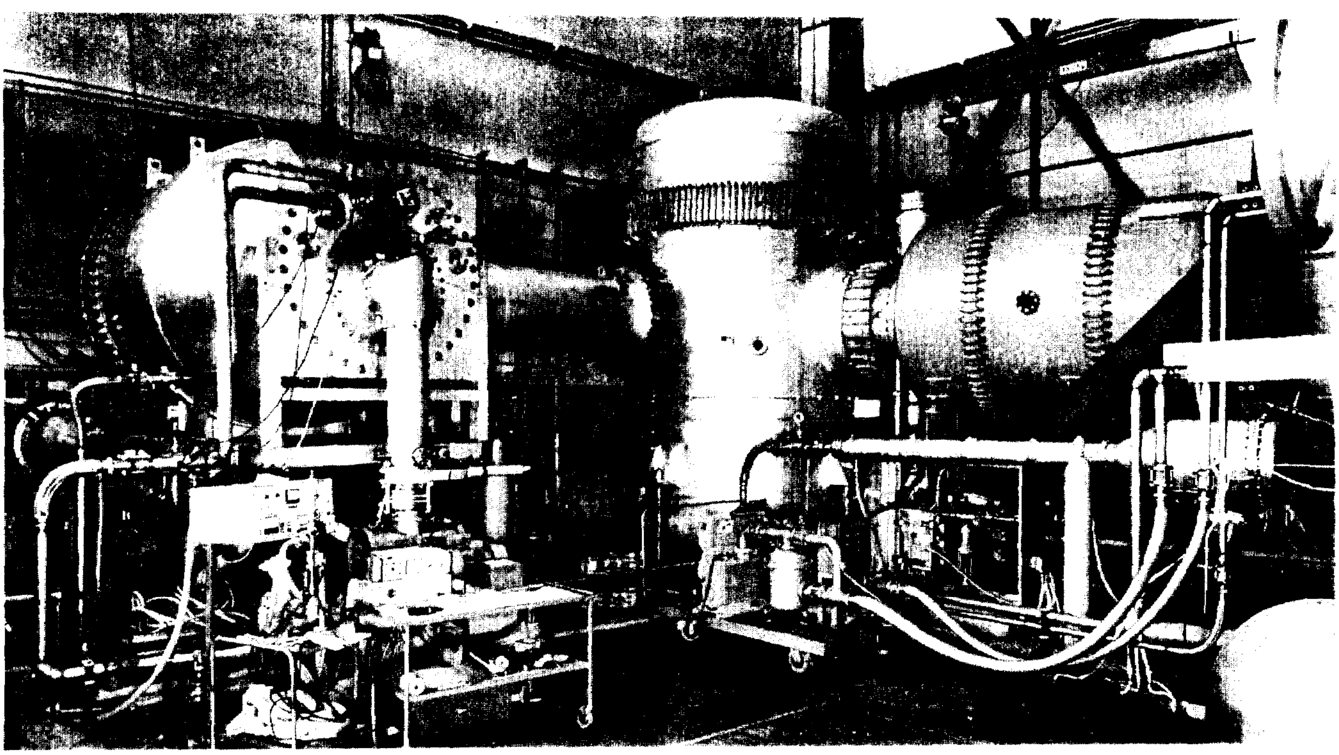

Fig. 1. Overall view of Accelerator Structure showing from right to left Power Supply, Intermediate Tank and Accelerator Tank.

Fig. 2. Accelerator Structure seen from above showing Gas Lock on the Accelerator Tank.

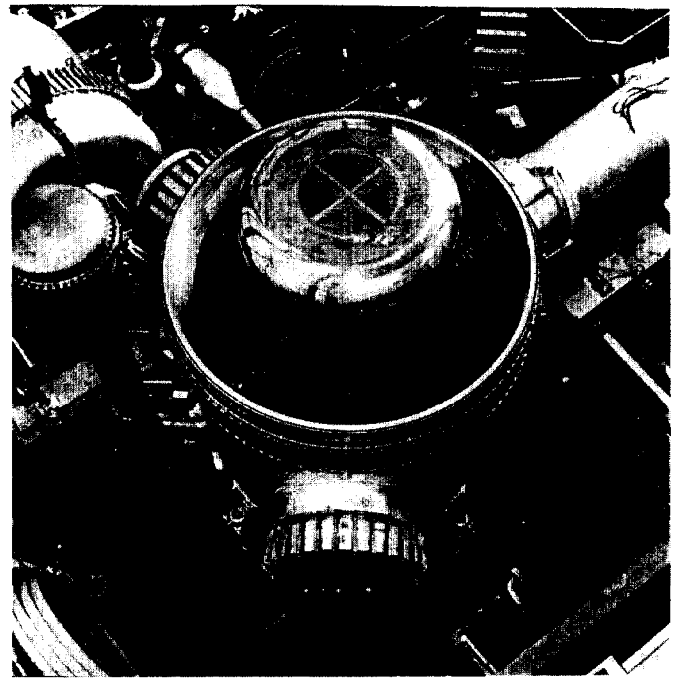

Fig. 3. Intermediate Tank open showing Ion Source Supply Terminal and gas-tight 1 MV Bushing.

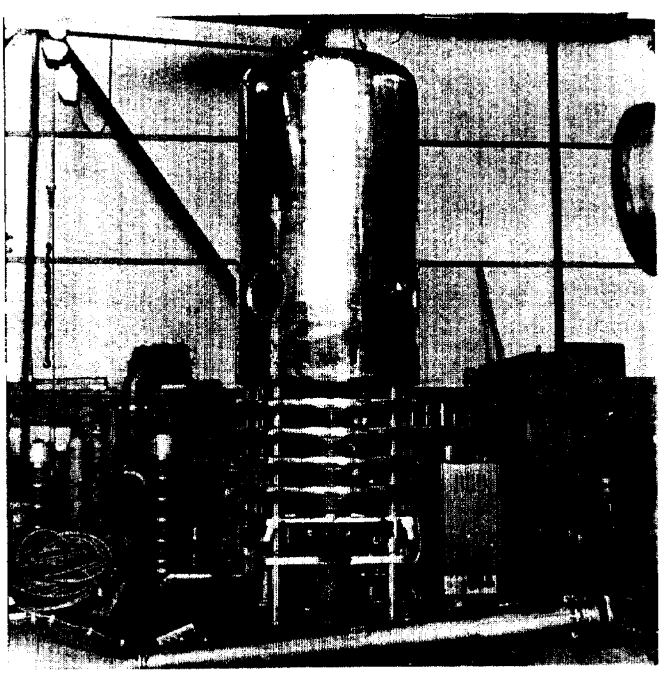

Fig. 4. Ion Source Supply Terminal with insulating Structure Cooling Line and Control Rods.

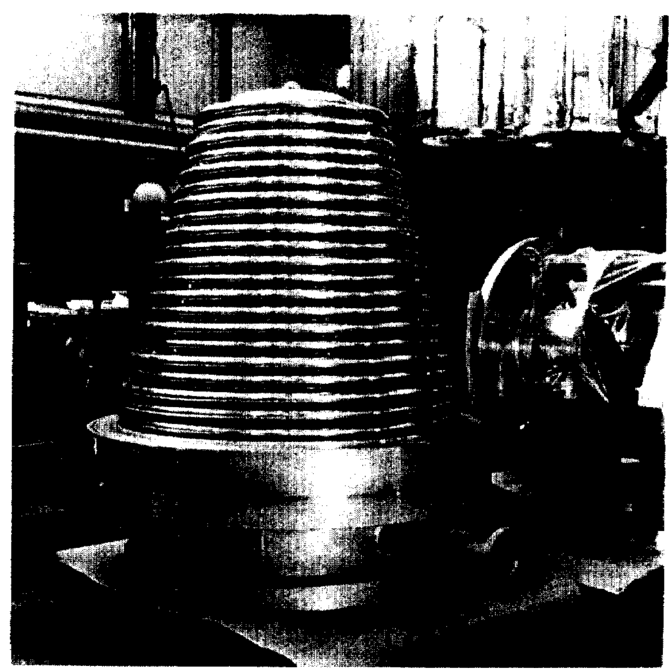

Fig. 5. 1 MV Bushing with Electrodes and Grading Resistor.