AUTOMATIC CONTROL OF GAS CIRCULATION AND GAS-FEED SYSTEM FOR ION SOURCE OF 160 CM CYCLOTRON

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ABSTRACT

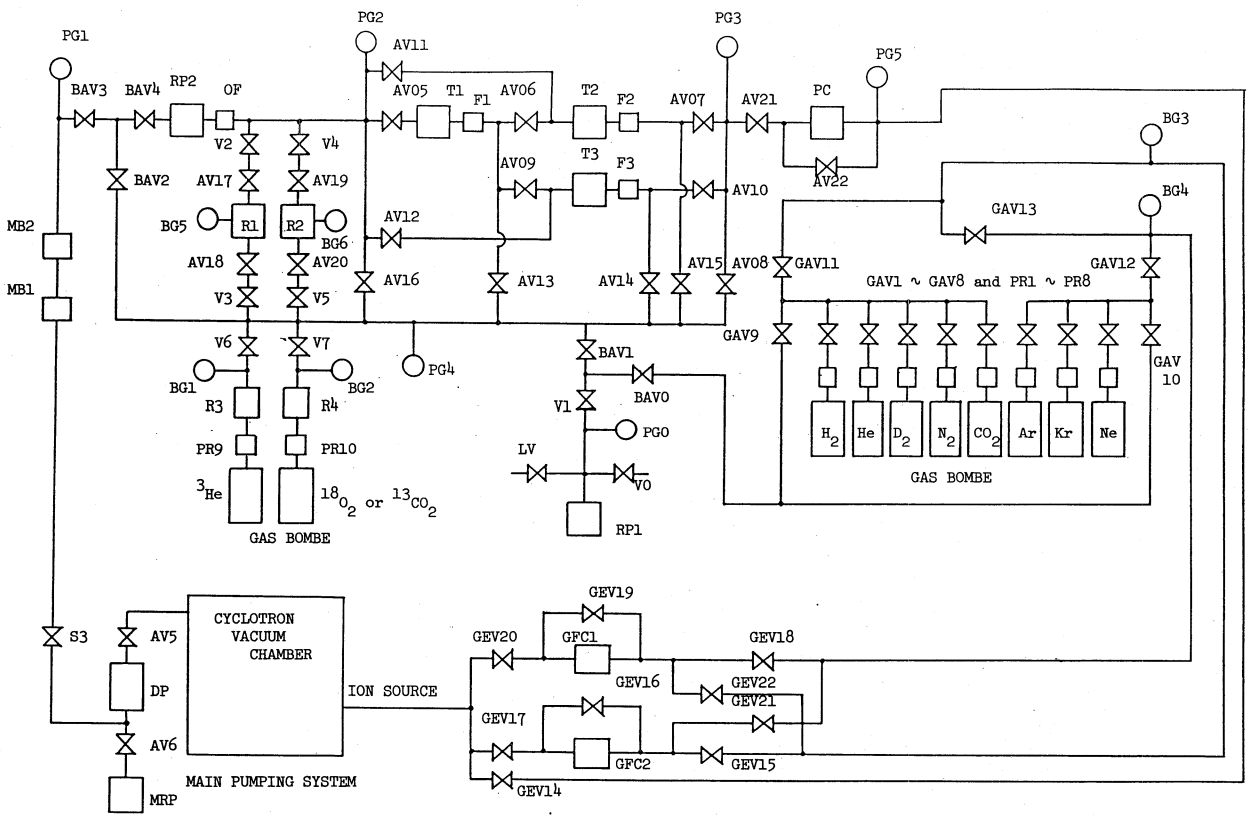
The circulation system and the gas-feed system for the ion source of RIKEN 160 cm cyclotron were newly developed. The circulation system is used to reuse the high cost gases such as ^{3}He, enriched $^{13}CO_2$ and $^{18}O_2$. The gas-feed system is used to feed eight kinds of gas. The system has two gas-feed lines for making gas mix with two gas flow controllers. These system can be operated automatically according to the sequence predetermined by a programmable controller which is made of OMRON SYSMAC M5R having I/O port of max 256 points.

CIRCULATION SYSTEM

The high cost gases such as ^{3}He, enriched $^{13}CO_2$ and $^{18}O_2$ necessitate the use of a circulation system to recover any gas not accelerated or trapped in the cyclotron and to provide its purification for re-use in the ion source. Figure 1 shows a block diagram of the gas circulation and the gas-feed system for the ion source of the cyclotron. The system consists of a vacuum-tight intake and exhaust rotary pump, first charcoal trap, second two charcoal traps T2 and T3, two reservoirs (one is for the ^{3}He gas and another is for other gases such as $^{13}CO_2$ and $^{18}O_2$), several pirani and absolute gauges, a rotary pump for evacuating, many air operated and electromagnetic valves, and a programmable controller.

The system[1] is connected to the ion source in the cyclotron through a pressure controller. Two mechanical booster pumps are connected to the circulation system as main backing from the exhaust of diffusion pumps without evacuating by the backing rotary pump. The gases produced in the chamber are passed through first and second traps by the circulation pump. The first charcoal trap is cooled down below a temperature of -20 °C by four thermoelectric cooling units. Almost water vapour of main component in the residual gases are trapped in this charcoal. Second trap is cooled down by liquid nitrogen. The other residual gases except ^{3}He gas are adsorbed in the second trap.

The system can be automatically operated by one touching with a programmable controller when we select the reservoir and traps. The system is first evacuated and the traps selected are cooled down. After cooling down the traps, the gas is supplied from the reservoir in the system by the circulation pump and circulated to purify through traps in the system. After purification, the gas is sent through pressure controller to the ion



RP1 and MRP: rotary pump. RP2: circulation pump(vacuum-tight intake and exhaust rotary pump).
MB: mechanical booster pump. DP: diffusion pumps of 32 and 14 inch connected in series.
BAV, GAV, AV and S3: air operated valve. V: hand valve. GEV: electromagnetic valve.
R1 ∿ R4: reservoir(R1 and R2: a volume of 15 ℓ, R3 and R4: a volume of 100 mℓ).
T1: thermoelectric cooled charcoal trap.
T2 and T3: liquid nitrogen cooled charcoal trap with baking heater wound. This trap is set in the thermos with the lifter moved by a motor. PR: pressure regulator. PG and BG: pirani and abosolute gauge.
PC: pressure controller(10^{-1} ∿ 10^{2} Torr). GFC: gas flow controller(GFC1: max 5 cc/min, GFC2: max 10 cc/min).

Fig. 1 A block diagram of the circulation and the gas-feed system for the ion source of the 160 cm cyclotron.

source and recovered from the cyclotron to the system. When the experiment is finished, the gas used is recovered into the reservoir by the circulation pump after purification. To remove the gases adsorbed in the traps, the traps are evacuated by rotary pump while heating.

GAS-FEED SYSTEM

This system consists of eight kinds of gas bottle having a pressure regulator, respectively, several air operated and electromagnetic valves, and two gas-feed lines for making gas mix with a gas flow controller. A gas flow controller is composed of a piezoelectric valve PV-10 and a mass flow meter. Figure 2 shows a block diagram of the gas flow controller. The valve PV-10 is operated by an electric pulse with a repetition rate of 100 Hz and an amplitude of 40 ∿ 100 V. By varying the pulse duration from 0 to 50 %, one gas flow controller(GFC1) can be controlled over a range of 0 to 5 cc/min and the other controller(GFC2) from 0 to 10 cc/min. Figure 3 shows a gas flow rate for nitrogen gas versus duty factor of the electric pulse applied to the PV-10.

In the case of mixed gas[2], the main gas is supplied to the ion source through one gas-feed line and the supporting gas is supplied through the other line to produce highly charged heavy ions and to operate stably the ion source in the long time.

The system can be operated by one touching after the gas required is selected. When the switch " START " is pushed on the graphic panel, the system is evacuated and gas is fed to the ion source.

At present, a gas flow rate is manually controlled on the control desk. However, as the device has the interface to control by a micro conputor, it will be controlled by the microcomputor in the future.

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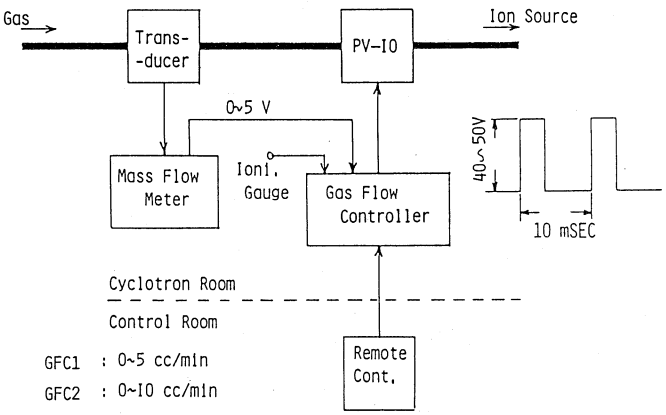

Fig. 2 A block diagram of the gas flow controller.

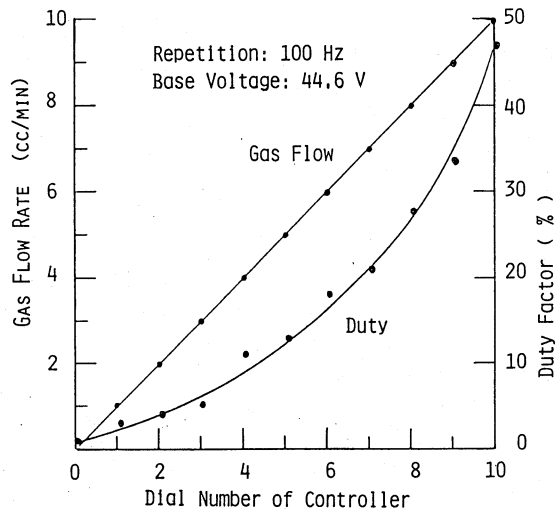

Fig. 3 Gas flow rate for nitrogen gas versus duty factor of the electric pulse applied to the PV-10.