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Gas pressure regulation in a r.f. ion source

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Abstract. An experimental technique by which deuterium gas pressure in a radio frequency ion source is automatically controlled and maintained to its initial set value is described. The accuracy achieved is $\pm 0{\cdot}5\ \mu$ in about $5\ \mu$ gas pressure being used in the r.f. ion source of the neutron generator of this laboratory.

Keywords. r.f. ion source; gas leak valve; gas pressure; deuterium; light-dependent resistance.

1. Introduction

In a neutron generator, which employes D-D or D-T reaction, usually deuterium ions are obtained from a radio-frequency ion source. The stability of the ion current extracted from a radio-frequency ion source depends to a large extent on its gas pressure (Ganguli and Bakhru 1963) and is therefore subjected to change with a long period of pumping. During actual operation of the neutron generator, one cannot know the changes that might occur in the deuterium gas pressure of the ion source, however, its effect is realized while monitoring ion current at the tritium target. The required correction in the gas pressure can then only be made by changing the gas leak rate in the ion source. This often leads to variations in neutron flux which is undesirable for measuring neutron induced reaction cross-sections except when a comparator method (Bhoraskar *et al* 1976) is used. This paper describes a technique by which deuterium gas pressure in a r.f. ion source, once set for a desired deuterium ion current at the target, is maintained for a period of 2–3 hr. Further one can also monitor gas pressure in the ion source while the system is in operation.

2. Experimental

The main parts of the control system are (i) light-dependent resistance (ii) thermal gas leak valve (iii) programmable power supply and (iv) voltage comparator unit. The thermal leak valve, shown schematically in figure 1, is made of non magnetic stainless steel. Its central portion consists of two flanges F_1 and F_2 one at each end of the tube T. The flange F_4 connected to gas cylinder and the flange F_3 to the ion source are tightly fitted to the flanges F_1 and F_2 respectively with gold 'O' rings between the flanges for vacuum sealing. Allen screw L in the tube T presses a stainless steel ball B, through an invor rod R, in the conical hole of the flange F_4 and thereby blocks gas flow to the ion source at room temperature. Since the linear expansion coefficients of invor and

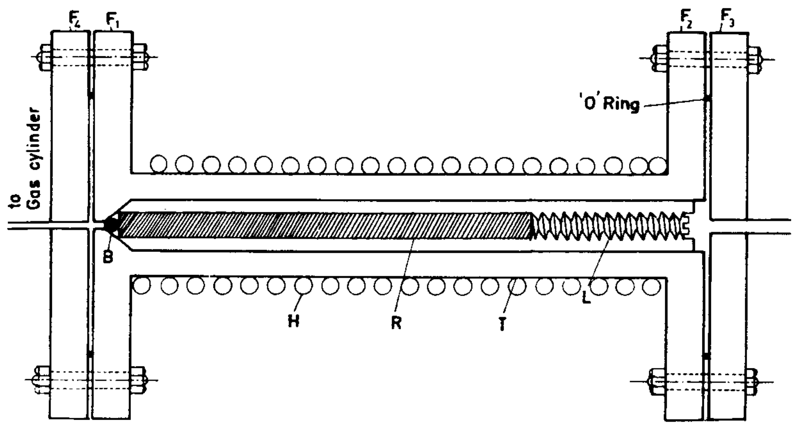

Figure 1. Thermal leak valve.

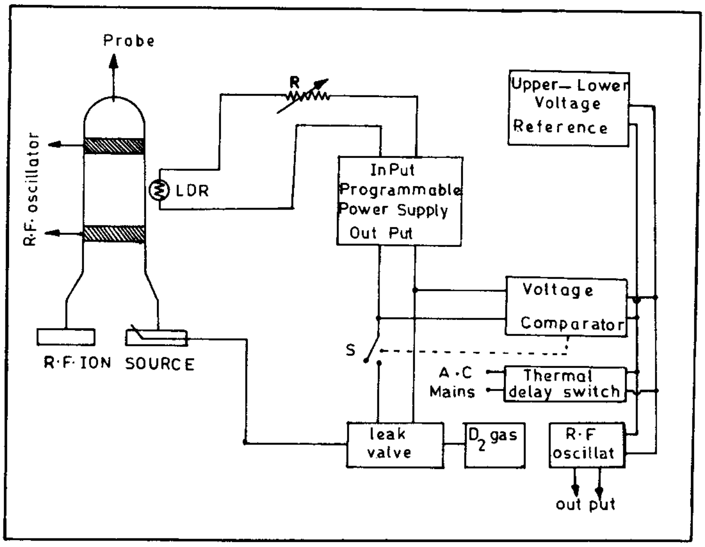

Figure 2. Control system for gas pressure regulation.

stainless steel are different, on heating the valve, gas leaks through the small gap, created between conical wall of the flange F_4 and the stainless steel ball. The rate of gas flow depends on the temperature of the valve and is therefore controlled by suitable adjustment of the current through the heater H, surrounding the central portion of the valve.

The details of the experimental set-up used to monitor and control deuterium gas pressure in the r.f. ion source are shown in figure 2. For pressure sensing, a LDR (light-dependent resistance) is fitted on to a glass bottle of the ion source between the two r.f. electrodes and shielded in such a way that its sensitive area receives light only from the deuterium gas discharge. The LDR is connected, through a potentiometer R to the programming terminals of a power supply (0–30 V D.C.) which provides voltage across the heater of the gas leak valve.

The voltage comparator unit compares voltage of the power supply with voltage levels preset on voltage reference unit. If the voltage across the heater crosses either of the voltage limits, the voltage comparator unit opens the switch S. When the system shown in figure 2 is switched on deuterium gas flows into the ion source. Using a thermal time delay switch, r.f. oscillator and voltage comparator unit are switched on after about 5 min. Initially the desired gas pressure is obtained in the ion source by suitable adjustment of the potentiometer R and then the control system is adjusted to maintain it. Any change in the gas pressure results in corresponding change in the optical intensity of the gas discharge (Harold *et al* 1954) and the pressure error is corrected by the programmable power supply on the basis of the light intensity received by the LDR. Normally the switch S remains closed, however, for extremely undesired deuterium gas pressure (more than 8 μ or less than 2 μ) in the ion source or for malfunctioning of the r.f. oscillator, the switch S disconnects thermal gas leak valve from the power supply.

Before the control system shown in figure 2 was made operative, it was calibrated by making some minor changes. The thermal leak valve was disconnected from the ion source and deuterium gas was introduced into ion source through a precision needle valve. The comparator unit was not used and therefore a large variation in voltage across the heater of the leak valve was allowed. A pirani gauge was connected to the ion source to monitor gas pressure. Figure 3 is a calibration curve showing variation of heater current with gas pressure. The heater current increases with decrease in gas pressure and *vice versa*. The curve is fairly linear around 5 μ gas pressure. The output of the LDR was also separately recorded for different values of pressure. This information was useful in estimating gas pressure in the ion source when the neutron generator (Joglekar 1978) was in operation.

For our experimental work the gas pressure in the ion source was adjusted to 5 μ. Any change in the gas pressure in the ion source could bring the corresponding change in the heater current of the thermal leak valve and thus the preset pressure of 5 μ could automatically be adjusted. The overall accuracy in achieving the preset gas pressure is $\pm 0{\cdot}5$ μ at 5 μ deuterium pressure, which is usually used in neutron generator operation

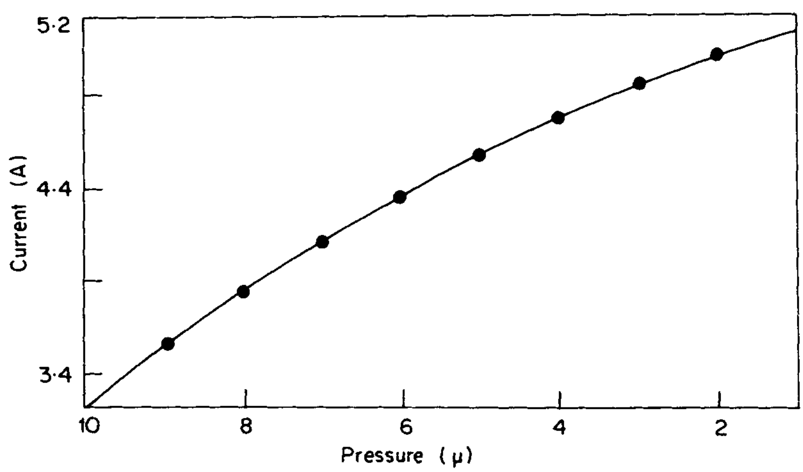

Figure 3. Calibration curve for heater current *vs* deuterium pressure.

of this laboratory. It is our experience that gas flow rate through the thermal leak valve becomes irregular after 3 hr operation and therefore the control system fails to work. However, the present neutron generator works continuously for not more than 2 hr at a time and therefore the reported control system is well suited to control gas pressure in the ion source of the neutron generator.

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