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An Improved Gas Circulation Pump

Isao YASUMOTO and Keizo NAGAI*

Department of Chemistry, Yonago Technical College, Yonago 683

**Department of Electrical Engineering, Yonago Technical College, Yonago 683*

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Synopsis. A gas circulation pump made of glass has been constructed, which works at less than one atmosphere. The pumping speed of the present pump is approximately 4 l/min.

The study of the gas-solid reactions on the surface of catalysts requires in many cases a technique for circulating gas in a closed system.

This report will describe an improved design of a gas circulation pump[1-4] and present some experimental results performed with this new pump. The design was found to be satisfactory and to have a number of advantages, such as:

(1) The pump works at any pressure less than one atmosphere.

(2) A high pumping speed can be obtained.

(3) Piston overshooting does not occur.

(4) The pump can be baked at 500 °C. The pressure of 1×10^{-5} Torr is obtainable.

(5) Modern electronics can be applied to the switching circuit of the pump.

The pump consists of a cylinder, a piston with a coil, and four sets of valves with coils of the same design (Figs. 1 and 2). The cylinder is a Pyrex tube 18 mm in inside diameter and 66 cm in length and is placed horizontally. The closely fitting piston is a piece of Pyrex tube enclosing a ferrite rod 12 mm wide and 100 mm long.

The coil for the piston consists of 10000 turns of an enamelled copper wire 0.5 mm in diameter and is fixed on a slider, which is driven on rails by means of a reciprocating slider-crank mechanism with a 50 watt DC servomotor. The piston accordingly makes a smooth back-and-forth motion over the distance of about 53 cm at the repetition rate set at 15 cycle/min without danger of overshooting. The exciting current for the coil was found to be about 0.4 amperes (corresponding to 30 W). The rise in the temperature of the cylinder during a continuous operation was negligibly small.

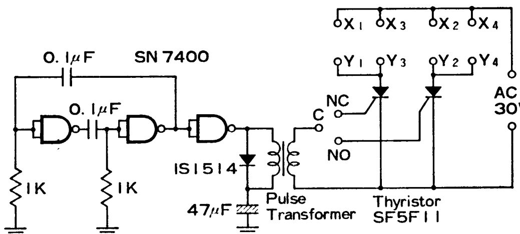

Fig. 2. The switching circuit. C, NC, and NO-terminals of the switch. X_i and Y_i; terminals.

The valve has a glass bulb which encloses a ferrite rod 4 mm wide and 22 mm long (Fig. 3). The bulb

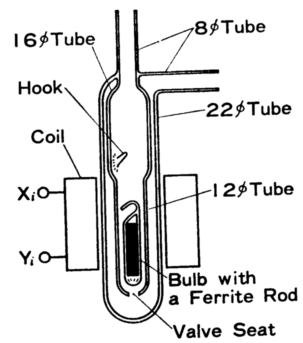

Fig. 3. The schematic sketch of the valve. X_i and Y_i; terminals of the coil.

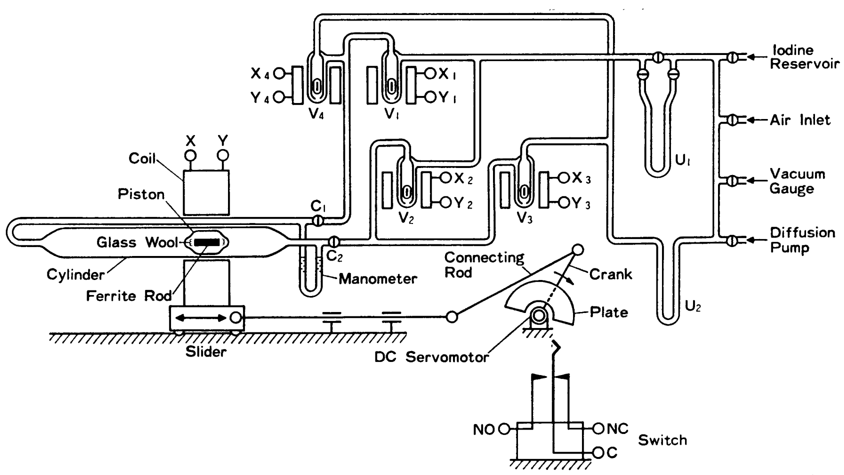

Fig. 1. The circulation pump with the vacuum line.
X, Y, X_i and Y_i; terminals of the coils. C, NC, and NO; terminals of the switch. V_i; valves. U_i; traps. C_i; taps.

end and the valve seat are ground together to form a ball joint of about 7 mm in radius.

The coil for the valve consists of 5000 turns of an enamelled copper wire 0.5 mm in diameter. The proper exciting current was about 0.5 amperes (corresponding to 15 W) and the rise in the temperature around the valve was approximately 5 °C after a prolonged operation.

The concerted action of the valve system with the motion of the piston is achieved by attaching to the crank shaft a semicircular plastic plate which pushes the lever of a switch, owing to its thickness, during one half period of time. A triggering signal turns thyristors on. The current through each thyristor excites alternately two pairs of coils: V_1 and V_3, and V_2 and V_4.

To bake out the pump the bulb is raised with the coil and hung on a hook, and then the five coils are all removed.

The pump works at any pressure of gas in theory, but at low pressure the migration of gaseous molecules by diffusion predominates. For the purpose of investigating this phenomenon, the series of procedures described below were repeated.

Dry air of a certain pressure is admitted into the apparatus (Fig. 1) as a carrier gas for iodine vapor. The apparatus is equipped with two traps, U_1 and U_2: the former is filled with a quantity of sublimed iodine and cooled in a Dry Ice–acetone mixture and the latter is left at room temperature. The U_2-trap is then dipped in another Dry Ice–acetone mixture and cooled. When the refrigerant which cools the U_1-trap is removed, the temperature of iodine in the U_1-trap gradually rises to room temperature. Iodine vapor, flowing from the iodine trap, reaches the U_2-trap, either downstream *via* the circulation pump or directly upstream by diffusion, and condenses there. The lengths of these paths are roughly in the ratio of 8 to 1. Several minutes after, the refrigerant which cools the U_2-trap is removed, and the U_2-trap is photographed (Fig. 4).

Runs 1, 2, 3, and 4 were carried out under the pressures of 300, 100, 15, and 1 Torr of air, and their iodine deposits in the left arm of the trap were denser

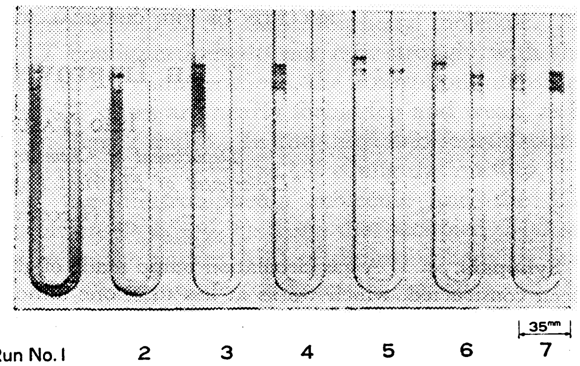

Fig. 4. The photographs of the U_2-trap containing iodine deposit.

Run No. —pressure of air: 1—300 Torr, 2—100 Torr, 3—15 Torr, 4—1 Torr, 5—0.4 Torr, 6—0.3 Torr, 7—0.1 Torr.

than in the right one. However, a new deposit appeared in the right arm in run 5, in which the pressure of 0.4 Torr of air was used. It looked as dense as the left arm deposit in run 6, which was done under the pressure of 0.3 Torr of air. The right arm deposit was denser than the left one in run 7, in which the pressure of 0.1 Torr of air was used; the diffusion of gas would have a considerable share in this case.

To estimate the circulating power of the pump, air was admitted into the apparatus up to 50 Torr. The circulating air was cut off by closing the taps of C_1 and C_2 and the pressure difference between the spaces in the front and the rear of the piston was measured with a manometer, while the piston was pulled slowly in one direction by the coil. The pressure difference was found to be roughly 14 Torr.

References

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