Date of Issue: October 31, 1951

Report Number: K-833

Subject Category: CHEMISTRY - GENERAL

26359
39691

MAGNETIC PUMPS FOR CORROSIVE GASES AND LIQUIDS

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CLASSIFICATION CANCELLED
DATE <u>8-28-52</u>
For The Atomic Energy Commission
<i>William A. Stanger</i>
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ABSTRACT

A magnetically operated pump has been constructed and used successfully to pump a mixture of uranium hexafluoride and hydrogen fluoride gases at pressures up to 175 psia. and temperatures up to 100°C.

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INTRODUCTION

The first magnetically operated corrosive gas pump used in this laboratory was a copper and nickel adaptation of the glass pump used by Porter, Bardwell, and Lind (5). Pumps of this design using monel and nickel have been constructed and successfully used to circulate uranium hexafluoride, fluorine, hydrogen fluoride, and mixtures of these gases.

A disadvantage of the original design was that no appreciable pressure difference could be maintained by the pump. Modifications to be described in this report have resulted in a pump which will maintain a pressure difference of 150 mm. of mercury at flow rate of 600 cc. per minute.

Pumps of this design may also be used with liquids providing the materials of construction are resistant to corrosion by the liquid.

DESIGN AND CONSTRUCTION

These pumps may be operated either by electromagnetic or permanent magnetic fields. Use of the electromagnetic field is more convenient since movement may be achieved by merely interrupting current to the coil; however, a moving permanent magnetic field allows smoother and more reliable operation in addition to eliminating completely the heating effect due to current flowing in the coil.

The original design, shown in figure 1-A, consisted of a copper cylinder containing a hollow nickel piston. Any non-magnetic metal such as brass, monel, or stainless steel may be used for the cylinder; however, the piston must be made of a ferromagnetic material such as iron or nickel. The piston contained a disc type, gravity operated, check valve fastened near the bottom. The cylinder contained a similar valve. These valves should be made of a nonmagnetic material so that their operation will not be affected by the magnetic field. It should be noted that this pump causes gas to flow only on the up stroke of the piston.

Figure 1-B shows the design of a modified pump. Pumps of this type have been previously described in the literature (2,4); however, they were unsuitable due to their glass construction. The hollow piston has been replaced by a solid one which allows greater force to be exerted on the gas. Two external sets of valves have been provided which allow gas to be pumped on both the up and the down stroke of the piston. Since these valves are not in the magnetic field they may be made of nickel. A simplified design is shown in figure 1-C in which only one set of valves is necessary. Since gas movement is obtained only on the up stroke with this pump the flow rate is reduced by one-half.

A further modification, shown in figure 1-D, is advantageous if electromagnets are used since it allows replacement of the coils without taking the pump apart. It should be noted, however, that some sacrifice in maximum differential pressure which the pump will maintain must be made with this design due to the increased distance between the piston and the outside wall.

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ALTERNATE PUMP DESIGNS

FIGURE 1

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PUMP FOR CORROSIVE GASES

FIGURE 2

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DETAILS OF CHECK VALVE

FIGURE 3

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A pump using the design of figure 1-D has been constructed and used to pump mixtures of uranium hexafluoride and hydrogen fluoride gases. Pressures up to 175 psia and temperatures above 100°C. have been used. A detailed drawing of this pump is shown in figure 2. Materials of construction were nickel and monel; all connections were welded. Four horseshoe Alnico magnets were used to move the piston; these were driven by a 1/50 horse power, 1725 RPM motor through a 1 to 25 reduction gear box and an eccentric crank. This produced a 6 inch pumping stroke 142 times a minute.

Figure 3 shows details of the disc type, gravity operated, check valves. These valves are constructed of nickel and require less than 2 mm. of mercury pressure difference for operation.

OPERATION

A limited investigation of the characteristics of this pump has been made using air at atmospheric pressure.

Air flowing from the outlet of the pump was discharged below the surface of either water or mercury in a large graduated cylinder. The distance of the point of discharge below the surface of the liquid was taken as the pressure difference produced by the pump. A wet test meter connected to the intake of the pump was used to measure the flow rate. Data taken in this manner are presented in table I and figure 4.

Intermittent operation of this pump in a system containing uranium hexafluoride and hydrogen fluoride over a 2 month period has proven satisfactory except when uranium hexafluoride has been allowed to condense in the pump overnight. Vaporizing the solid and gently tapping the pump barrel have always restored pump operation.

TABLE I

VARIATION OF PUMPING EFFICIENCY WITH PRESSURE DIFFERENCE
(Pump of Figure 2)

Pressure Difference, mm.	Flow Rate, Std. cc./min.	Pumping Efficiency*
0	1960	99.5
28	1620	83
51	1460	75
76	1310	67
108	958	49
133	746	38
171	500	26
179	0	0

*Based on a theoretical maximum flow rate of 1970 cc./min. Using a piston diameter of 0.425 in., a 6 in. stroke, 142 strokes/min.

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PUMPING RATE AND EFFICIENCY AS A FUNCTION
OF PRESSURE DIFFERENTIAL
(Discharge at atmospheric pressure)

FIGURE 4

SUGGESTED IMPROVEMENTS

In applications where larger rates of flow at higher pressure differentials are the prime considerations, the following modifications are suggested:

- (1) Use the design of figure 1-B.
- (2) Use a soft iron piston encased in nickel.
- (3) Use a large, hollow, cylindrically shaped, Alnico magnet.
- (4) Increase the number of strokes per minute, the length of stroke, and the diameter of the piston.

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Experimental work completed May, 1951.

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