Westinghouse

Two-Stage Mercury Vapor Vacuum Pump

Instructions for Operating

GENERAL

A mercury vapor diffusion pump is capable of evacuating a space to a very low pressure, but will not pump against a high back pressure. The pressure to which a vessel can be reduced with this principle is of the order of a fraction of a micron (One micron is that pressure which will support a column of mercury 0.001 millimeter high, and atmospheric pressure being 760 millimeters, it is 1/760,000 of an atmosphere). The back pressure against which a mercury diffusion pump will exhaust is from 250 to 500 microns. In the two-stage pump a second stage of the ejector nozzle type exhausts from the discharge of the first, or diffusion stage, to a back pressure of the order of 15 millimeters.

In the diffusion stage of a mercury vapor pump a blast of mercury vapor from a mercury boiler is directed against a cooled surface at an angle in the direction in which it is desired that the gas should flow. This vapor is condensed when it strikes the cooled wall and the liquid mercury flows back to the boiler through a trap. In this way there is no vapor flowing toward the gas inlet of the pump and any permanent gas molecules which diffuse into the stream of mercury vapor are carried along and prevented from returning. This principle operates only with rarefied gases. Because of the low pressure of the gas, in order to obtain a reasonable speed of pumping the area of this stage is made large to present a large opening into which the low pressure gas can diffuse.

The second stage, which takes the discharge from the diffusion stage is a nozzle ejector type and this raises the pressure to the order of 15 millimeters. This stage, dealing with gases at a much higher pressure can be made a great deal smaller.

The pump is so constructed that mercury vapor is supplied from a boiler at the bottom of the pump, and is fed to the two stages in parallel. A common cooling system consisting of copper cooling coils provides cooling around both stages and the liquid mercury is returned to the boiler through a series of traps, each having a height sufficient to support the pressure involved. The discharge tube is brought out of the second stage and is extended along the edge of the cooling coils up toward the pump intake, in order that any mercury tending to be discharged from the pump is condensed and returned to the boiler.

CONSTRUCTION

Pump Housing

Referring to Figure 1, the pump housing consists of a steel tube, the upper part of which is surrounded by copper cooling coils. The upper end of the tube is welded vacuum tight to a flange and the bottom end is closed to form the mercury boiler. The flange at the top surrounds the inlet to the pump and is machined to form a gasketed joint with a valve, or connection to the vessel to be evacuated. The discharge connection is a flange into which the tube leading from the second stage is connected.

Heater

The heater consists of a unit using standard heating element wire threaded in a special moulded heat resisting casing. This heater is formed to fit around the outside of the mercury boiler, and is enclosed in a metal container with necessary heat insulation between the heater and the outside of the container. The rating of this heater is 220 volts, 720 watts and can be used on either 25 or 60 cycles. Heaters of different voltage can be provided where required.

Pump Mechanism

The pump interior mechanism is shown in Figure 2. Mercury vapor is admitted to both the diffusion stage and the ejector stage from the center tube leading from the mercury boiler. The openings leading to each of these stages is designed to admit the proper proportions of vapor. The diffusion stage is designed so that the distance from the cooled wall to the diffusion cap is in the right proportion to the opening of the orifice for maximum pumping speed. This nozzle opening is not adjustable.

The ejector stage consists of a mercury vapor box, a nozzle and an orifice formed between the nozzle and the walls of the opening through the partition disc. The two stages are separated by the second stage nozzle disc which is sealed to the housing wall with a leather gasket, and which permits the passage of liquid mercury through a small mercury trap.

The mercury boiler is separated from the last stage by a ground joint between a disc attached to the pump mechanism and an off-set in the pump housing wall.

CHARACTERISTICS

The diffusion stage of the two stage pump will produce a vacuum of a fraction of a micron and discharges against a back pressure of from 250 to 500 microns. The second stage will produce a vacuum of approximately 100 microns and discharge against a back pressure of the order of 15 millimeters. The pump must be backed up with a backing pump which will produce a vacuum of less than 15 millimeters and discharge against atmospheric pressure. The average pumping speed of this pump is between 4 and 5 liters per second when operating under normal conditions, or it will reduce the pressure in a small tank from 100 to 1 micron in less than 10 minutes.

The heater is so designed that voltage variations from 105% to 80% normal voltage will not seriously affect the operation of the pump.

It is desirable that the cooling water discharge be kept below 35 degrees Centigrade but the pump will not fail to operate on account of temperature until the cooling water reaches a temperature of the order of 50 degrees Centigrade. However, if cooling water above 40 degrees Centigrade is used, there is likely to be some passage of mercury from the pump into the discharge.

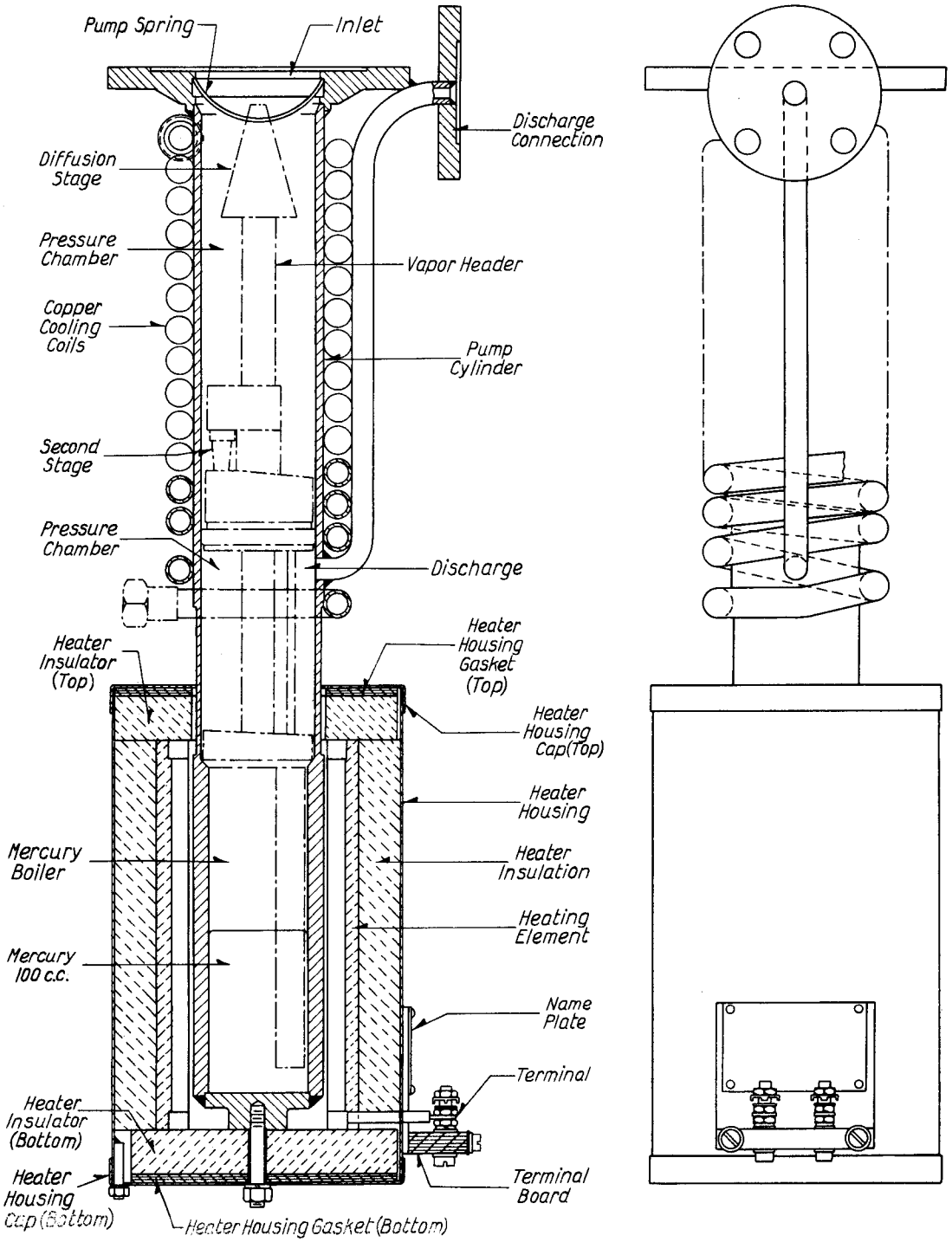

Fig. 1 - Sectional View of Two-Stage Mercury Vapor Vacuum Pump

OPERATION

The mercury vapor vacuum pump should be connected, the inlet flange to the space to be evacuated and the discharge to the backing pump system, with the rubber gaskets provided. The gasket between the inlet flange and the vacuum vessel should be the Vee ring rubber gasket, and the gasket to the backing pump system should be the one of black oil-proof rubber. Before starting, the water must be turned on and adjusted to at least 1/2 gallon per minute. The backing pump must be started first and the space evacuated to the order of 10 millimeters before starting the mercury vapor pump. During this period the gases are drawn through the mercury pump passages with the mercury pump not operating. After this the mercury pump heaters should be turned on and it requires approximately 45 minutes for this pump to take effect. If it is certain that the entire pumping system is in good order, the backing pump and mercury vapor pump may be turned on simultaneously, since during the 45 minutes required for the mercury vapor pump to come up to temperature, the backing pump will have reduced the pressure to a satisfactory value.

Care should be exercised to avoid opening a valve to a high pressure volume while the mercury vapor pump is hot, since a large volume of air passing through a hot pump will cause serious deterioration and a few minutes of atmospheric pressure in a hot pump will cause it to stop operating and the pump must be cleaned. In starting a pump connected to a vessel under atmospheric pressure the valve should be opened before starting. In starting a pump connected to a vessel under vacuum the valve should not be opened until 45 minutes after the heater has been energized.

In shutting down the pump, the valve should first be closed and the heater turned off. The water must be left circulating for one hour to permit the pump to cool before atmospheric pressure may be admitted, and even if the pump is not to be removed, the water should be left circulating for one hour to prevent overheating of the gaskets due to the stored heat in the heater and boiler.

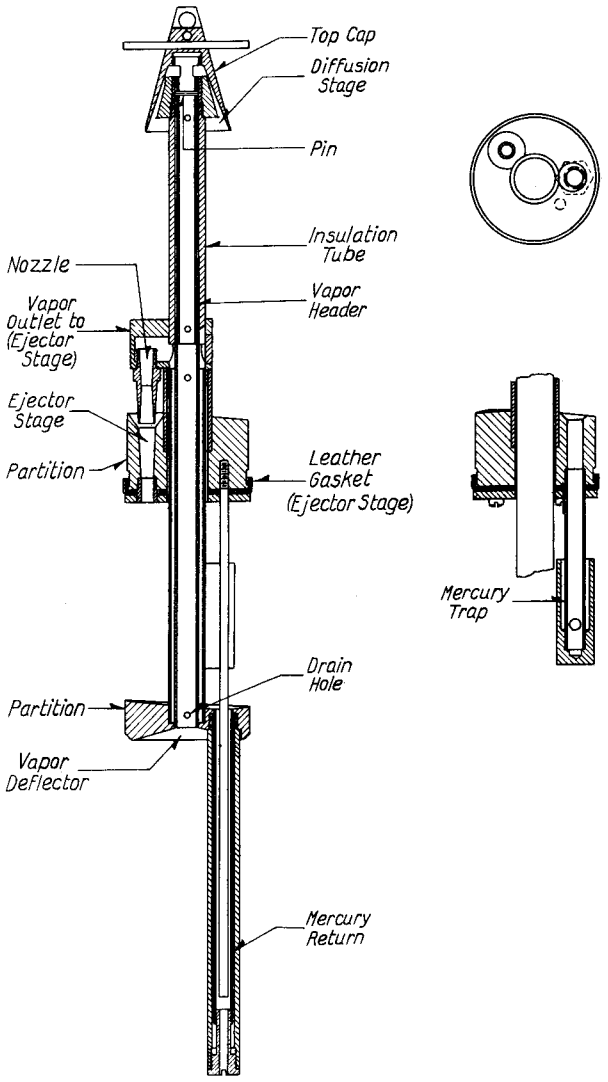

Fig. 2 - Sectional View of Pump Mechanism for Two-Stage Mercury Vapor Vacuum Pump

MAINTENANCE

As described above if excessive quantities of air are drawn through a mercury vapor pump when the pump is at operating temperature, the mercury will oxidize forming mercurous oxides which clog the traps and passages. This will result in sluggish action of the pump and finally stop its functioning entirely. This oxidation might be caused by an air leak in the low pressure system by operation on a system giving off large quantities of gas, or by opening the pump to high pressure while hot.

To clean dirty pumps proceed as follows: After stopping the pump in the normal manner, and it is thoroughly cool, remove the pump from the system by opening the flange connections to the inlet valve and to the discharge line, and removing the water connections. With a special hook, furnished with the pump, remove the pump mechanism from the housing, first relieving the spring on top of the housing, and then lifting the mechanism out. All passages may then be blown out thoroughly with dry compressed air or nitrogen. The leather gaskets should be examined and should be replaced if injured, or if they do not produce a tight fit with the walls of the pump housing. The mercury trap on the last stage should be removed and any collected dirt should be cleaned out. In replacing the trap cover, the clearance between the bottom of the cover and the projecting tube should be 3/32". The mechanism should not be disassembled unless absolutely necessary and in this case great care should be exercised to reassemble it exactly in its original form keeping all clearances the same. In handling interior parts of the pump, cotton gloves should always be worn to prevent moisture and oils from the hands coming into contact with the interior parts, which must be kept scrupulously clean.

Once each nine months the interior parts of the pump should be removed and cleaned out as discussed above. The mercury in the boiler should be poured out and, if dirty, replaced. If the mercury is clean, it may be used again, but the amount should be checked and mercury removed or added to make the amount 100 cc. or 3 lbs.

At the time the interior of the pump is cleaned, the copper cooling coils should be flushed out. If scale is noted in the coils a compound similar to that used in cleaning automobile radiators should be used. The type of compound used will depend upon the kind of scale formed, which may be different with various grades of cooling water.

In case the mercury boiler heater is damaged it must be replaced.

When ordering renewal parts, please give the name of the part wanted and identifying information appearing on name plate attached to the pump housing as to Style Number or S.O. Number, voltage, rating, etc.

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