Westinghouse

Three-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 three-stage pump, two additional stages of the ejector nozzle type exhaust in series from the discharge of the first, or diffusion stage, to a back pressure of the order of 20 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. 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 and third stages dealing with higher pressures are a great deal smaller.

To protect the pump from overheating in case of failure of the cooling water, a temperature control switch is clamped on the copper cooling coils, so as to be actuated by the temperature of the water in the coils, thereby opening the electrical circuit to the pump heater. If the heater is not turned off upon failure of cooling water the interior parts will become overheated, burning out the leather gasket seals between stages and possibly warping the metal parts.

CONSTRUCTION

Pump Housing:

Refer to Figure 1. The pump housing consists of a steel tube, the upper part of which is wrapped with 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 bottom of the last stage is connected. This tube is extended along the edge of the cooling coils up toward the pump intake, in order that any mercury vapor tending to be discharged from the pump is condensed and returned to the boiler.

Heater:

The heater consists of a unit using standard heating element wire threaded in a special moulded heat resisting casing. The heater is formed to fit around 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 stages 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 gap is in the right proportion to the opening of the orifice for maximum pumping speed. This nozzle opening is not adjustable.

Each ejector stage consists of a mercury vapor box, a nozzle and an orifice formed between the nozzle and walls of the opening through the partition disc. The three stages are separated by the second and third stage nozzle discs which are sealed to the housing wall with a leather gasket, and which permits the passage of liquid mercury, as it is condensed on the cooled housing walls through small mercury traps.

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 three-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 third stage will produce a vacuum of about 2 millimeters and will discharge against a back pressure of 20 to 28 millimeters. The pump must be backed up with a backing pump which will produce a vacuum of less than 20 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 per cent to 80 per cent 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 the cooling water above 40 degrees Centigrade is used, there is likely to be some passage of mercury from the pump into the discharge.

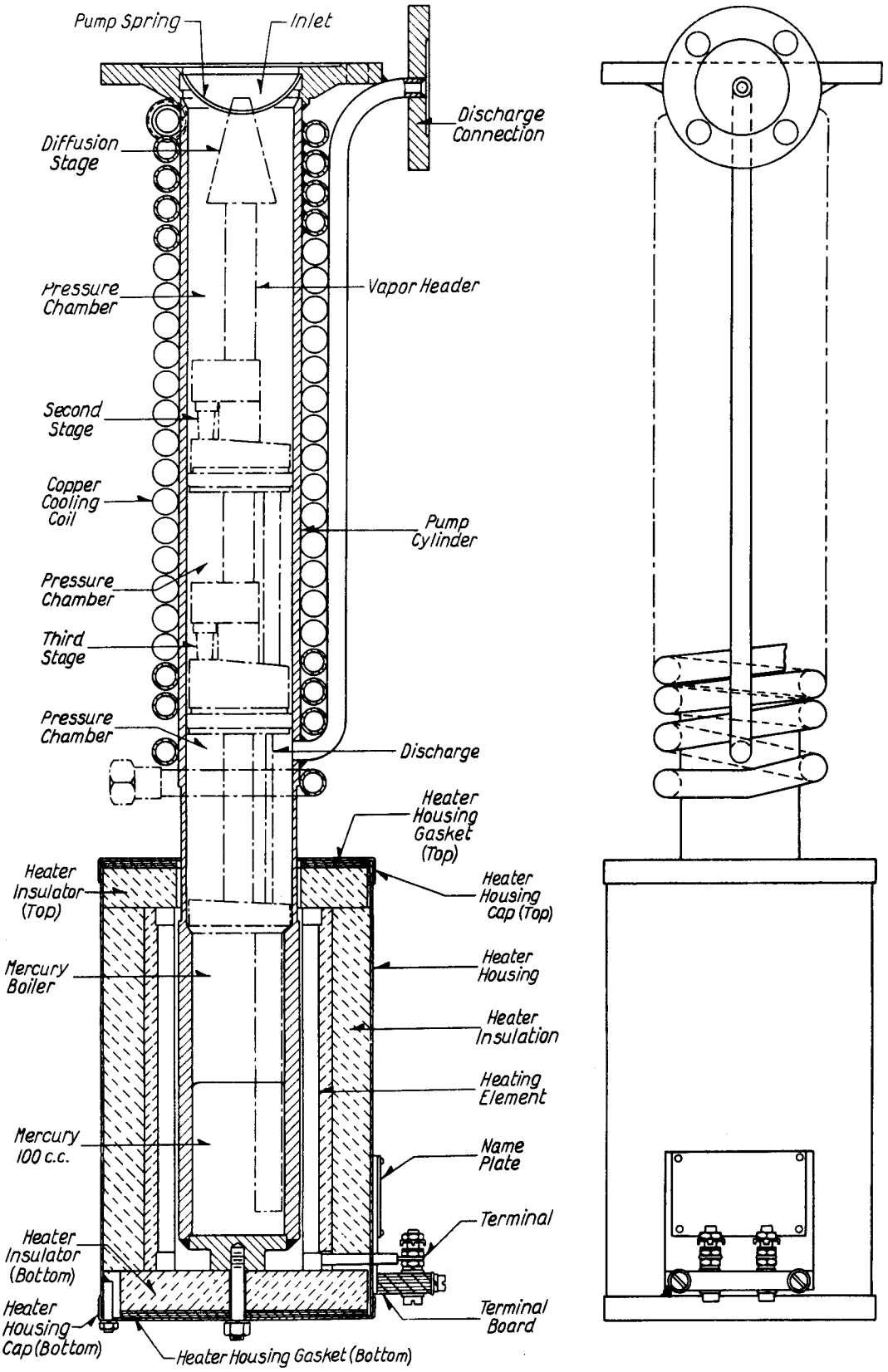

Fig. 1 - Sectional View of Three-Stage Mercury Vapor Vacuum Pump

OPERATION

Starting:

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 5 millimeters, the point at which the manometer will automatically break the circuit to the oil pump motor and cause it to stop, 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.

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. 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.

Shutting Down:

In shutting down the pump, the hand valve directly over the mercury pumps 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 over-heating of the gaskets due to the stored heat in the heater and boiler.

The temperature control switch which is connected in series with the pump heater should be set to open its contact at approximately 43 degrees Centigrade. If the water flow is stopped with the heater connected it requires from 10 to 15 minutes for the water in the jacket to reach the temperature necessary to actuate the switch.

MAINTENANCE

If large amounts 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. The semi-circular wire spring must be forced from the recess in the upper flange and removed. Then the mechanisms may be removed from the pump barrel by a special hook. 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 traps 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 be worn to prevent moisture and oils from the hands coming into contact with the interior parts, which must be kept scrupulously clean.

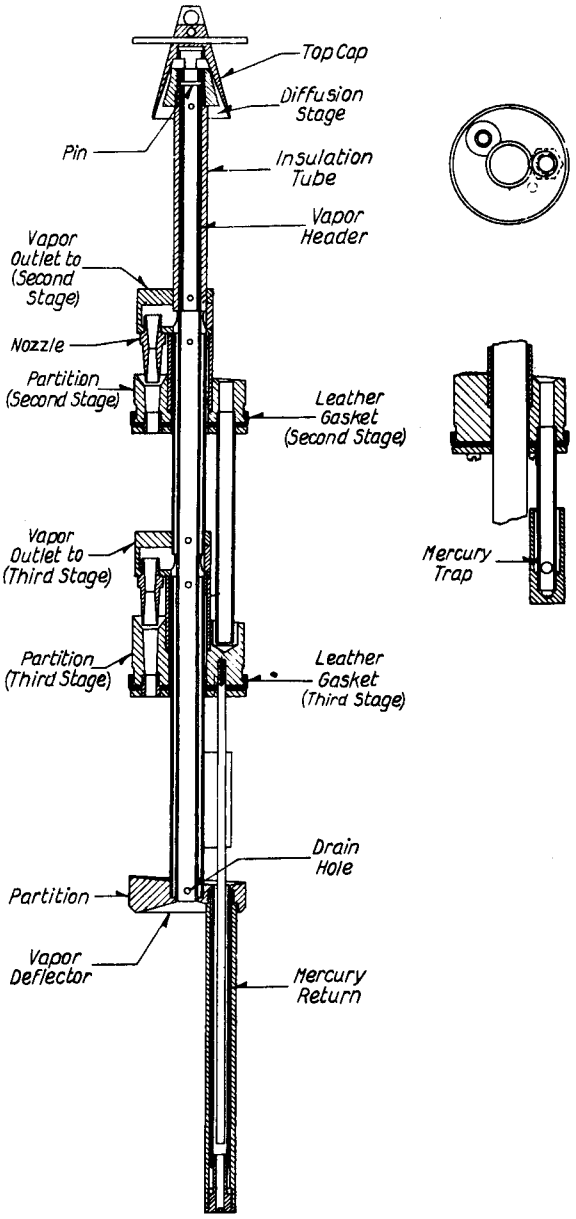

Fig 2 - Sectional View of Pump Mechanism for Three-Stage Mercury Vapor Vacuum Pump

Once every 9 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 pounds.

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 kinds 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.

Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.

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