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Renovation of a Westinghouse Mercury Vapor Vacuum Pump

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Discription of the pump:

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 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 type 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 raefied 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. The pump housing consists of a steel tube, the upper part of which is wrapped with copper cooling coils. The uppper 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 located in the steel tube housing. 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 are 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 nozzel 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.

Progress Report on Pump: The first thing that has been done was taking the pump and mounting the two parts to a metal supporting table. Then cleaning the whole thing. Next the motor on the rotary oil-sealed vacuum pump was changed from a 220 Volt, three phase to a 110 Volt motor and using gears geared down to about the right RPM. This motor was mounted to the side and connected by a belt. It has a spring applying pressure and if anything mechanical fails the belt should begin to slip. Once this was done the valve was closed and a vacuum pumped. Pumping this vacuum showed that the manometer was not free from air so it was taken off and the air was removed. It was replaced and worked better. Again the system was evacuated and it showed evidence of leaks.

I than began taking apart different stage connections and checking them to see what condition the gaskets were in. I then put them back on after a good greasing down with vacuum grease. I emptied mercury from the mercury trap and also the three way valve. The back up pump is now in working condition. The connection onto the system was cut level and taken off to be threaded for a permanent connection. A water system was rigged up using rubber tubing and copper connections. The hold up now is on 220 Volt electricity and a diagram of how to connect it to the temperature guage so as not to ruin the whole pump system. Westinghouse has been written asking about this matter but as of yet no word. The next step would be building a panel for operation and learning more about the two guages the McLeod vacuum gauge and the hot wire pressure gauge. Most of the work so far has just been slow mechanical work of loosening bolts and checking for any defects, greasing the joints and putting them back together. With a little help from Westinghouse and work the pump should be ready for use.

Diagram of Pump