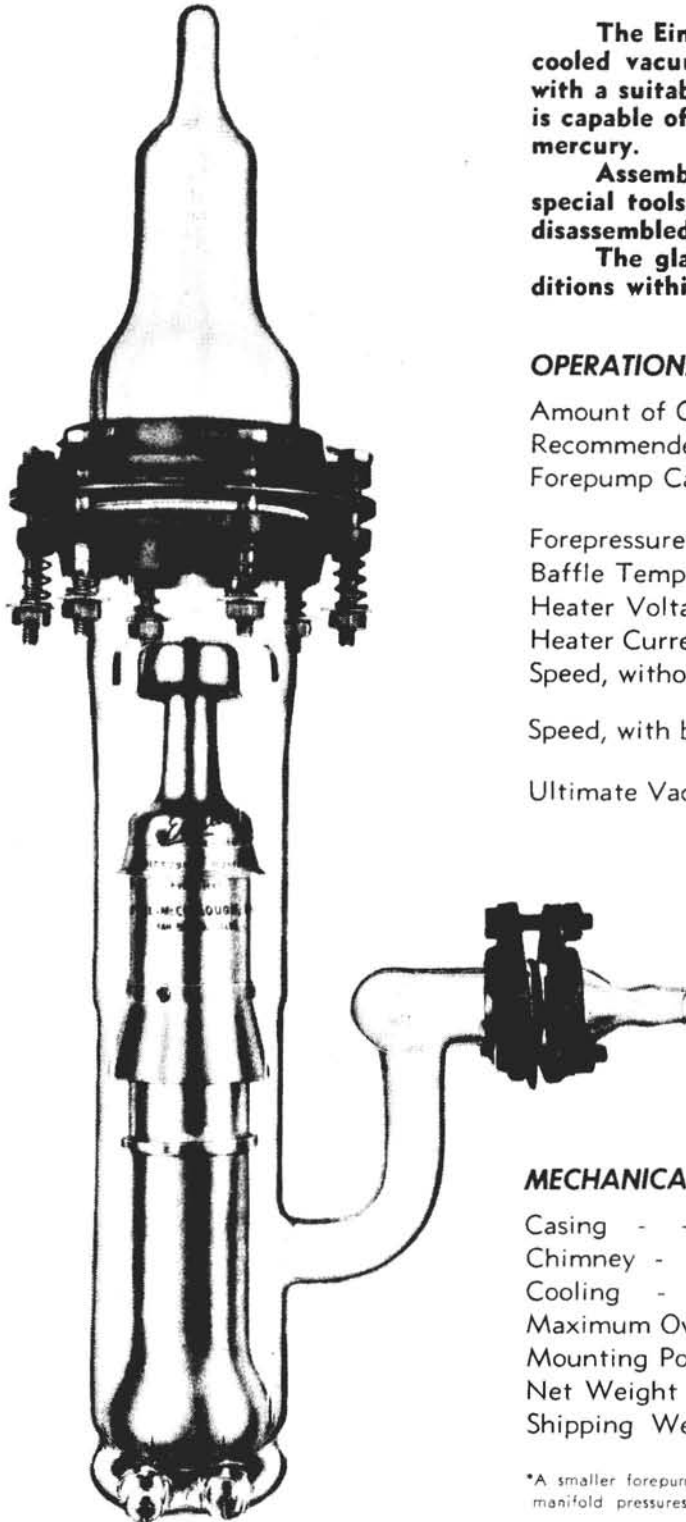


EITEL-McCULLOUGH, INC.

SAN BRUNO, CALIFORNIA



# HV-1 DIFFUSION PUMP



The Eimac HV-1 Diffusion Pump is a fast, triple-jet, air-cooled vacuum pump of the oil-diffusion type. When used with a suitable mechanical forepump and Eimac type A oil it is capable of reaching an ultimate vacuum of  $4 \times 10^{-7}$  mm of mercury.

Assembly of the pump is a simple operation, requiring no special tools or intricate adjustments. It can be completely disassembled for cleaning in five minutes or less.

The glass construction permits rapid inspection of conditions within the pump.

## OPERATIONAL DATA

Amount of Oil	- - - - -	150 milliliters
Recommended Oil	- - Eimac Diffusion Pump Oil, Type A	
Forepump Capacity*	- - - 0.1 to 2.0 liters per second at 0.001 mm of mercury, or less	
Forepressure (maximum)	- - - - -	0.02 mm of mercury
Baffle Temperature	- - - - -	35° C or lower
Heater Voltage	- - - - -	100 to 110 volts
Heater Current (at 110 volts)	- - - - -	1.7 amperes
Speed, without baffle (approx.)*	- - - 67 liters per second at $4 \times 10^{-4}$ to $4 \times 10^{-6}$ mm Hg	
Speed, with baffle (approx.)*	- - - 32 liters per second at $4 \times 10^{-4}$ to $4 \times 10^{-6}$ mm Hg	
Ultimate Vacuum, at 25° C (approx.)	- - - - -	$4 \times 10^{-7}$ mm Hg when using recommended oil.

## MECHANICAL DATA

Casing	- - - - -	Pyrex Glass
Chimney	- - - - -	3 Jet, Aluminum
Cooling	- - - - -	Air
Maximum Overall Dimensions	- - - - -	See Outline Drawing
Mounting Position	- - - - -	Vertical, boiler down
Net Weight	- - - - -	11 pounds
Shipping Weight	- - - - -	16 pounds

\*A smaller forepump may be used, but this will reduce the pumping speed at the higher manifold pressures.

### OPERATION

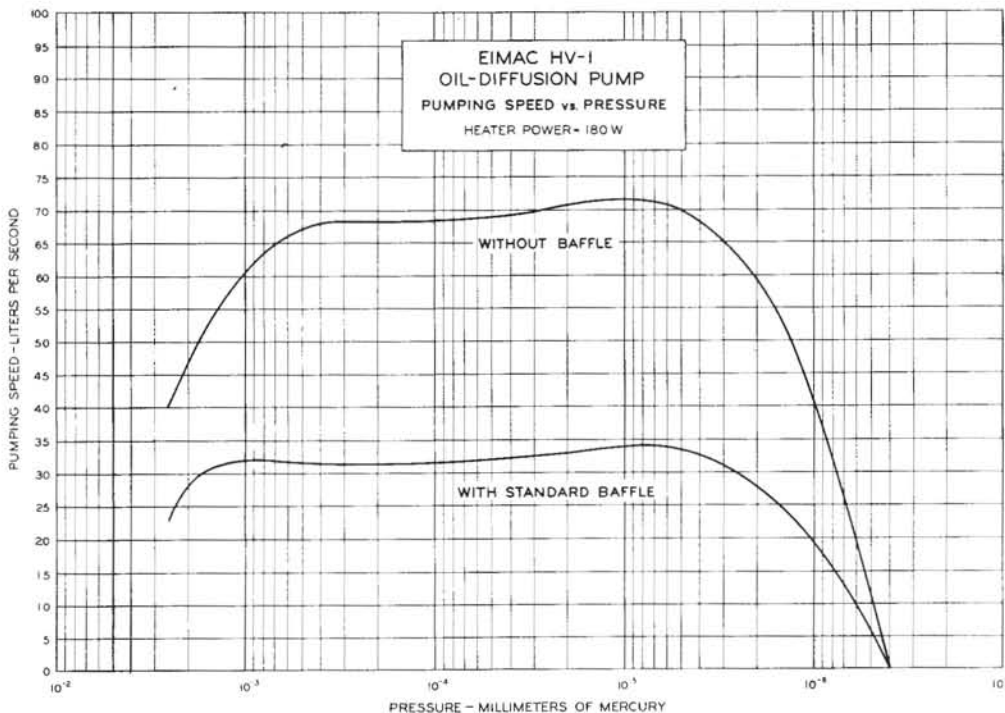
The principle upon which the oil-diffusion pump operates may be explained as follows. The drawing on page three illustrates the accepted theory. Gas to be removed from the high-vacuum system enters the pump at the top, whence it moves into the region of the upper jet. Emerging from this jet is a stream of oil vapor which is generated by the electrically-heated oil boiler at the bottom of the pump. Molecules of the unwanted gas diffuse into this stream of oil vapor and are carried down and out toward the cooler glass-wall of the pump. Upon reaching the glass-wall, the oil vapor condenses to a film of liquid oil which runs down the wall and returns to the boiler. The gas molecules are forced downward by the oil vapor and gas above them and come under the influence of the middle jet, where they are again forced down toward the bottom of the pump by a stream of oil vapor.

in the system are to be avoided wherever possible. A short length of small-bore tubing can cause a considerable reduction in pumping speed.

Pumping speed is also affected by the capabilities of the forepump. The forepump must be able to remove the gas from the system while maintaining the required low pressure at its end of the diffusion pump.

Increased pumping speed may be obtained by operating several HV-1 units in multiple. The number of units which may effectively be used in multiple will be determined by the ability of the forepump to produce the required forepressure, and the ability of the manifold and tubulations to handle the desired pumping speed.

The HV-1 is capable of reaching an ultimate vacuum of  $4 \times 10^{-7}$  mm of mercury. To reach this low pressure, however, it is essential to avoid any contaminant in the high-vacuum system. Water, even in small amounts, or



The curves at the left show the gas handling capabilities of the HV-1 over a range of pressures both with and without a baffle. These curves apply when a forepump with the required capacity is used. The rapid loss in pumping speed at the higher pressures is due to the inability of the forepump to handle the necessary volume of gas. With a larger forepump, the pumping speed would be maintained out to higher pressures.

The process of "packing" the molecules of gas down toward the bottom of the pump is again repeated at the bottom jet. During pumping, as the manifold pressure drops, the amount of oil issuing from the lower jet is sufficient to form a visible ring of oil on the wall of the pump at a point well below the bottom skirt. In this region the concentration of gas is great enough to raise the pressure to a point which will allow a mechanical forepump to effectively remove the gas from the system.

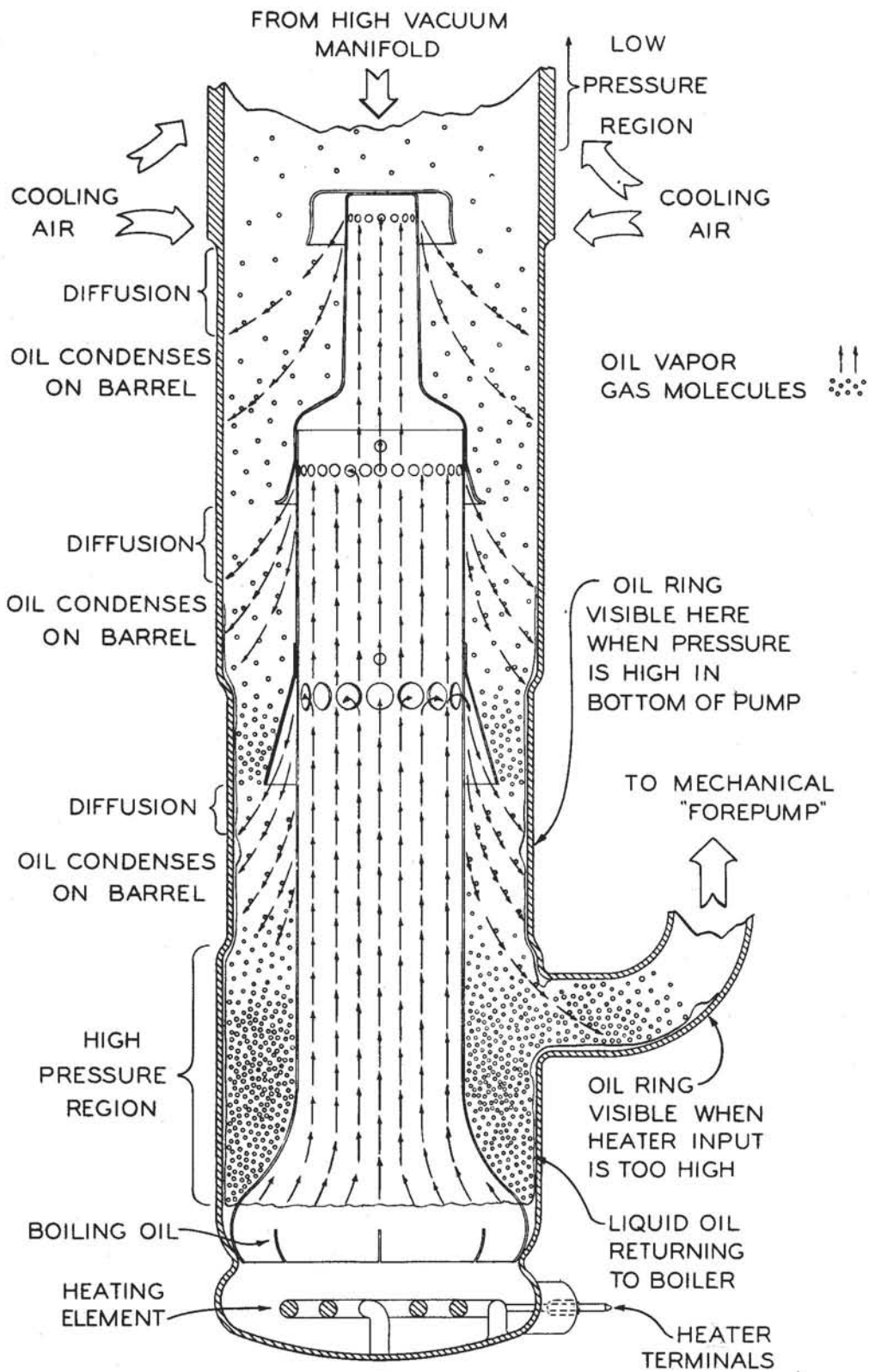
To prevent small amounts of oil vapor from finding their way back into the high-vacuum side of the system, a baffle is often employed between the diffusion pump and the high-vacuum system. In the HV-1 this baffle is a pair of aluminum discs which are kept relatively cool by the pump cooling fan. Oil vapor reaching the baffle condenses and is returned to the boiler. The baffle reduces the pumping speed by about one-half. If there are several bends in the high-vacuum manifold between the pump and the space to be evacuated, the baffle may be dispensed with, as the bends will serve to collect the oil vapor. However, the bends will also reduce the pumping speed. This is well illustrated in the curves. Constrictions

any hygroscopic matter should be carefully excluded. When so located as to be affected by heat, rubber is particularly objectionable, and a poor ultimate vacuum is likely to result if rubber gaskets are used in the diffusion pump. For this reason, Neoprene gaskets are supplied with the HV-1.

In systems employing stop-cocks, valves or gaskets, it is necessary that the stop-cock, valve or gasket lubricant have the minimum possible vapor pressure, because poor lubricants can easily destroy the high-vacuum capabilities of the pump.

### APPLICATION

The HV-1 diffusion pump must be mounted securely, but not too rigidly. A satisfactory method of mounting consists of  $1 \times 1 \times \frac{1}{8}$  inch angle shaped and drilled to pass four of the six spring loaded bolts used to join the large flanges at the top of the barrel (see illustration). When the desired manifold has been sealed to the manifold adapter (914 on outline drawing), the pump is prepared for operation (after rinsing thoroughly as specified under "cleaning") in accordance with the following procedure:



1. Pour 150 milliliters of Eimac Diffusion Pump Oil, Type A, into the pump barrel (917).
2. Insert the aluminum jet assembly (4911) into the pump barrel.
3. Assemble the pump carefully, moistening both sides of each gasket with pump oil, or with a thin layer of heavy-grade "Celvacene," or equivalent grease.
4. Install the pump in its mounting.  
**IMPORTANT: DO NOT START DIFFUSION PUMP HEATER UNTIL FOREPUMP IS IN OPERATION AND SYSTEM IS FREE OF LEAKS, TO AVOID PREMATURE HIGH TEMPERATURE AND DECOMPOSITION OF THE OIL.**
5. After making certain that the forepump is connected to the nipple (8911) through the suitable flexible coupling (vacuum-hose or vacuum type bellows), start the forepump motor. Check the manifold with a Tesla or other high-voltage, high-frequency spark coil for leaks **BEFORE CONTINUING.**

The Tesla coil, with a flexible wire probe may be used to indicate the presence of leaks above the baffle. It is also valuable in estimating pressure in the manifold during the early stages of evacuation. **CAUTION:** Too high a voltage may puncture the manifold at its weak points, i. e. where the glass may be very thin or at a seal-off tubulation. A rough indication for a suitable Tesla voltage is that which will produce a corona of about one-eighth inch on the end of a No. 14 B & S probe wire, visible in the dark only, and a stringy spark not over five-eighths inch to a grounded metal surface.

If the system is known to be free of leaks, the forepump and HV-1 may be started together. However, to protect the system and its oil, the manifold first should be checked with the Tesla coil, with the HV-1 "off." When the cold oil stops bubbling and the pink glow is seen to be diminishing at a normal rate, the system may be assumed to be reasonably tight and the HV-1 may be started.

6. Connect the oil heater terminals via a switch to the source of power. The oil heater voltage should be set to between 100 and 110 volts for best results. An adjustable resistor or an auto transformer of the tapped or continuously variable types is recommended. The current at 110 volts is approximately 1.7 amperes.
7. The baffle assembly and upper end of the pump barrel should be kept cool (35° C or lower) by a small fan or blower (see illustration).

**OIL**—Eimac Type A Diffusion Pump Oil is a special petroleum product carefully processed by Eitel-McCullough, Inc. to afford the high-vacuum desired in diffusion pump work. The ultimate vacuum attainable for Type-A oil is on the order of  $10^{-7}$  mm Hg. Its boiling-point at pressures on the order of  $10^{-2}$  mm Hg is 135° C.

One noteworthy property of this oil is that under normal conditions, no particles of condensed oil will be found deposited in the high-vacuum manifold. This lack of condensation is indicative of the absence of "light ends." Such products of distillation usually must be barred from the high vacuum system by the use of liquid air or charcoal traps which invariably reduce the speed of any system and require extensive maintenance.

**VACUUM GAGES**—To properly evaluate the vacuum conditions at the manifold, a sensitive gage in the desired range is necessary. There are many systems used for this purpose, the most sensitive in the high-vacuum spectrum being the Ionization (or Ion) gage. Its range of usefulness extends from approximately 5 microns to a region in the upper experimental vacuum limits on the order of  $10^{-6}$  microns ( $5 \times 10^{-3}$  to  $10^{-9}$  mm Hg). Recently, tubes and circuits have been developed which con-

tribute to the high stability of this instrument. The Eimac type 100-IG Ion Gage tube is designed to give the maximum internal leakage path, thus avoiding erratic readings due to possible contamination from the system.

**LEAKS**—If the system does not "clean-up" in a reasonable time, considering the nature and size of the manifold and connected chambers, a leak may be looked for by means of the Tesla coil. The probe should be run over the entire surface of the glass work involved. A "fast" leak will be indicated where sparks concentrate at a point on the glass and a pinkish glow takes place within the evacuated space.

Where a slow leak is suspected, before "bake-out"<sup>1</sup> and where the vacuum is high but still not satisfactory, a solvent such as carbon tetrachloride may be applied to the manifold surface with an atomizer, a wad of cotton or brush. If a leak is found, the Tesla voltage will cause a marked bluish glow while the solvent is entering the aperture, or the ion gage reading will indicate increased pressure.

After "bake-out" or when the manifold is too hot for the application of liquids, illuminating gas or hydrogen may be applied to the surface from an unlighted torch. Gas entering the hole will effect the ionization gage reading immediately. A very small leak may be found in this way. If there are no leaks, the manifold and pump assembly is ready for use<sup>2</sup>.

With the manifold at high vacuum, no ionization will be apparent from the effects of a Tesla probe held on the manifold (above the baffle). Below the baffle on the barrel of the HV-1 pump the probe will cause fluorescence of the oil vapors as well as a visible disturbance of the oil flow below the jets. The probe when touched to the HV-1 outlet will show a faint blue-violet glow. If these first two conditions are obtained, but a pinkish glow is present in the outlet, the mechanical pump and its coupling should be checked.

For new oil, or after an oil change, the pump will require about 24 hours of operation to condition the oil for optimum performance. Approximately 15 minutes heating time is required for the HV-1 to reach full efficiency from a cold start.

#### PRECAUTIONS

1—The vacuum system should not be opened "to air" when the diffusion pump is hot, to prevent oxidation of the pump oil. 2—If at any time a white vapor is visible in the HV-1, both pumps should be immediately shut off. The vapor is an indication of forepump failure or a very rapid leak. If the oil has become dark, the system may require complete cleaning. 3—Ground leads should be provided on both flange couplings to prevent the Tesla voltage from puncturing the Neoprene gaskets.

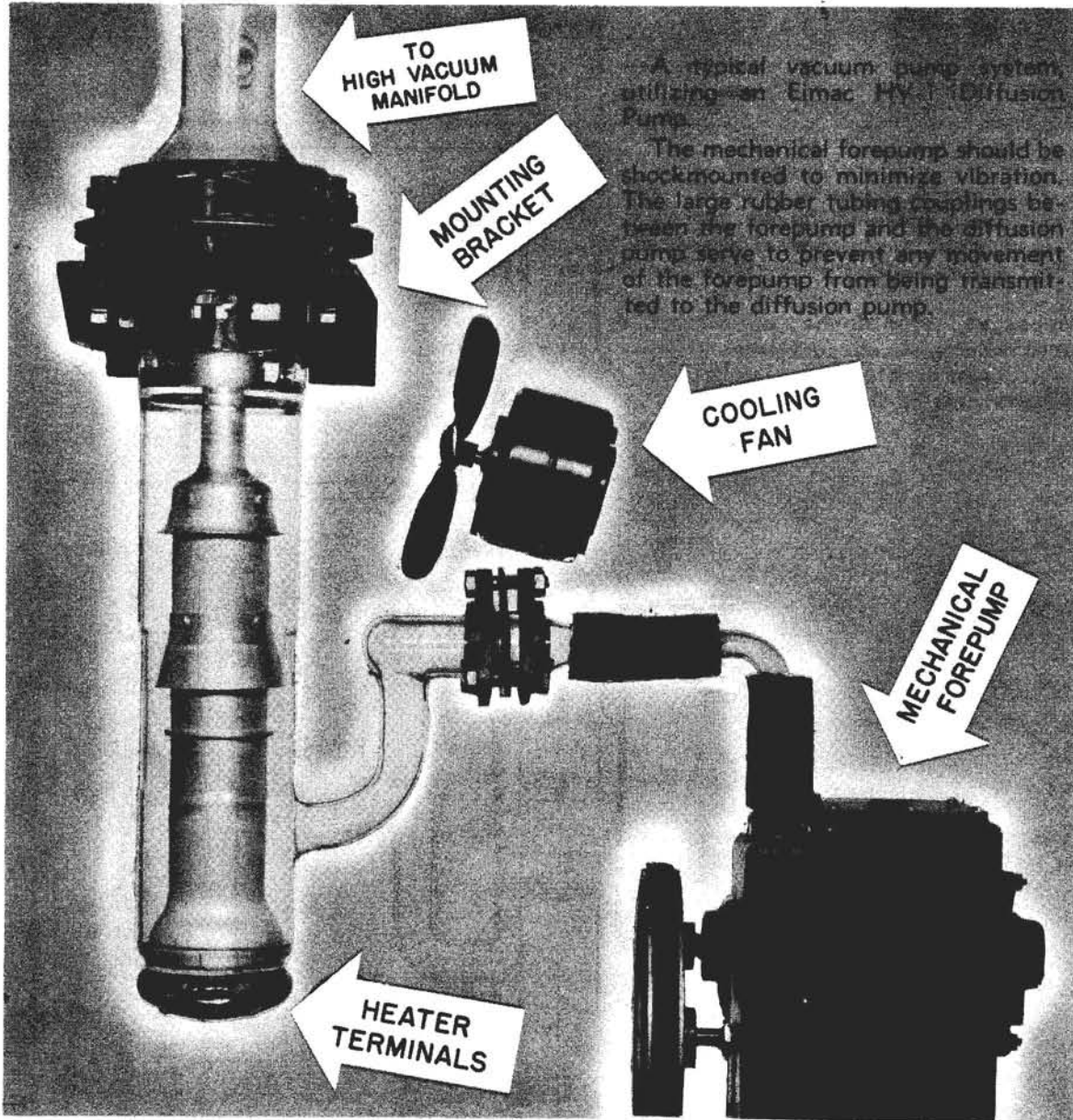
#### CLEANING

Diffusion pumps in continuous use should be cleaned at approximately one-month intervals. The materials and facilities required for cleaning are: Carbon tetrachloride and pentane (or acetone). An oven capable of temperatures up to 500° C will allow complete removal of carbonaceous deposits. The oven should be provided with an air inlet and outlet to allow the products of oxidation to be carried off. An accurate temperature control and indicator are advisable to prevent mishap to the glass parts. Where an oven is not available, steel wool, water and some abrasive cleanser such as diatomaceous earth

<sup>1</sup> "Bake-out" consists of surrounding the manifold and work to be evacuated with an oven. The temperature is then raised and held just under the annealing point for the "softest" glass being used in the system (approximately 500 degrees C for Pyrex). The temperature is maintained for thirty minutes to an hour, or at least until the new glass in the system shows no fluorescence on application of the Tesla voltage. This "cleans up" the glass-ware to a point where it will not normally release further gas. An accurate thermocouple type temperature indicator and heater control are advisable to prevent mishaps to the system during "bake-out."

<sup>2</sup> Contamination in the system such as decomposed oil, or a source of high vapor pressure in the load will give "virtual leaks" or unfavorable maximum vacuum readings.





A typical vacuum pump system utilizing an Eimac HV-1 Diffusion Pump.

The mechanical forepump should be shockmounted to minimize vibration. The large rubber tubing couplings between the forepump and the diffusion pump serve to prevent any movement of the forepump from being transmitted to the diffusion pump.

may be used. The procedure is given in the following paragraphs.

**GLASS HOUSING BARREL**—New housings should be given a rinse with a cup of pentane or acetone and then warm-air dried. (CAUTION: pentane and acetone are inflammable. Keep away from open flames.) Used, dirty housings should have the excess of oil fluid rinsed out with two or three flushings of about one cup (per rinse) of carbon tetrachloride. The last rinse may be saved for the first wash of the following pieces. To remove adhering carbonaceous matter after draining, the housing should be baked out in an oven up to 500° C. If the housing is not too caked, a rinse with pentane or acetone and gentle drying with warm air (in place of baking out in the oven) is sufficient.

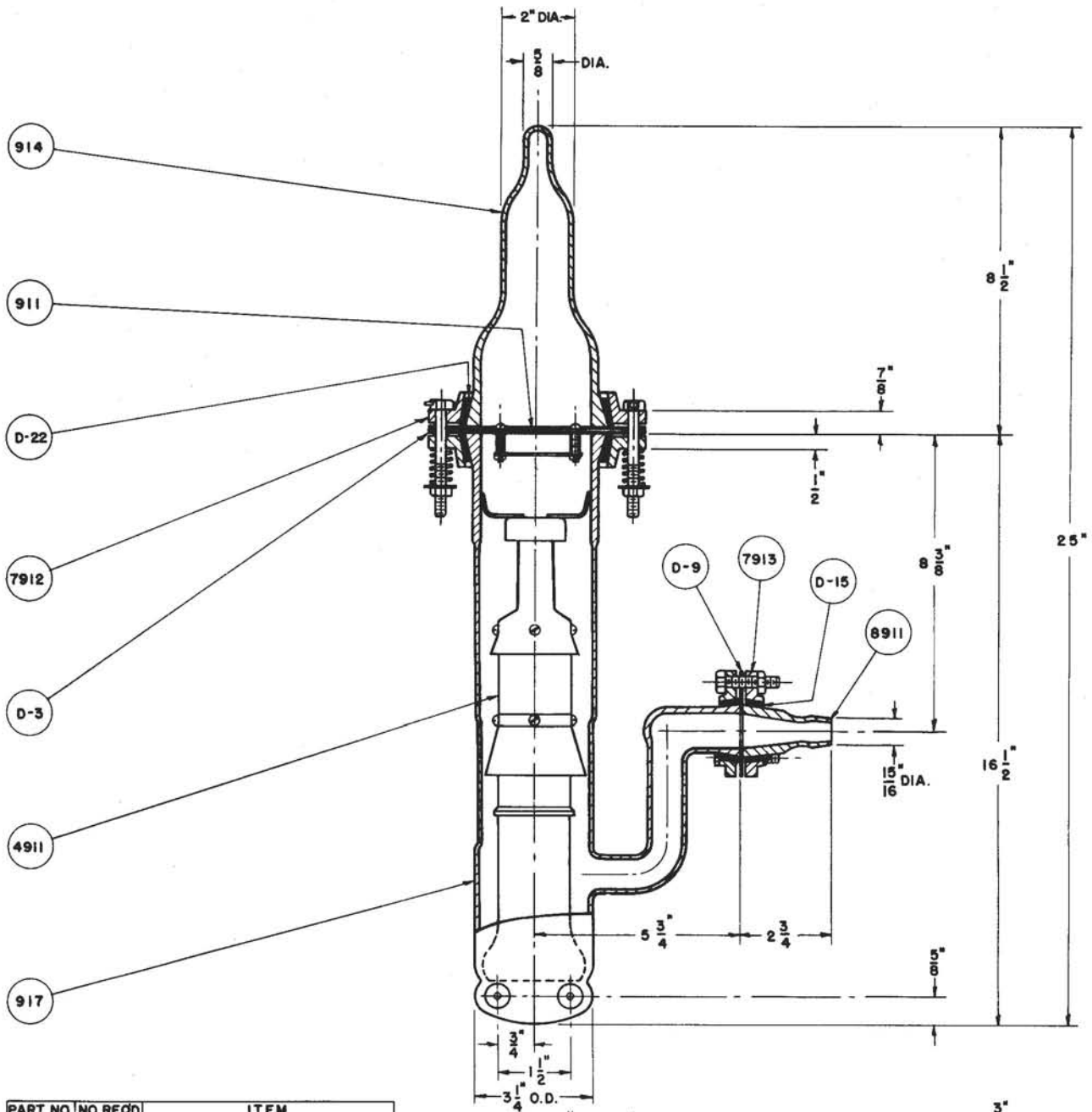
**ALUMINUM JET ASSEMBLY**—The jet assembly may be cleaned at the same time that the glass housing barrel is cleaned by inserting the assembly into the glass housing, pouring in the rinse solution and closing the top opening with a stopper. Agitate the solution by tilting and shak-

ing the pump so that all parts are well washed over. Always remove the stopper and jet assembly after washing, prior to draining, baking or air drying. To further remove hard carbonaceous material, the assembly, less baffle, should be placed in an annealing oven and heated carefully to 475° C, then allowed to cool slowly in air.

**BAFFLE**—The baffle should be disassembled and all parts rinsed three times with pentane or acetone; the last two rinsings must be with clean solution. Follow with warm-air drying.

**NEOPRENE GASKETS**—Wash the gaskets in carbon tetrachloride or alcohol, then wipe with a clean cloth in place of warm-air drying.

**GLASS MANIFOLDS**—Use the same procedure as for the glass housing barrel when feasible. However, usually washing with pure water and alcohol, followed by warm-air drying, may be sufficient because there is less formation of carbonaceous matter here than in the case of the pump housing.



PART NO.	NO. REQD	ITEM
911	1	BAFFLE ASSEMBLY
914	1	MANIFOLD ADAPTOR
917	1	PUMP BARREL ASSEMBLY
4911	1	JET ASSEMBLY
7912	1	3" METAL FLANGE ASS'Y *
7913	1	1" METAL FLANGE ASS'Y *
8911	1	FORE-VAC NIPPLE
D-3	2	NEOPRENE GASKET-3" COUPLING
D-9	1	NEOPRENE GASKET-1" COUPLING
D-15	2	1" INSERT
D-22	2	3" INSERT

\* EACH FLANGE ASSEMBLY INCLUDES NECESSARY FLANGES, GASKETS, INSERTS, BOLTS AND HARDWARE.

