pump especially developed for this service. The usual unit consists of a compact assembly of air and water removal units driven by one motor and furnished complete with receiver, separating tank and full automatic controls mounted as an integrated unit on one base.

Practically all of such return line vacuum heating pumps make use of the returned condensate to operate either as a liquid piston or as a jet to withdraw the air, and in many cases the condensate, from the return line. Such hydraulic evacuating devices may be classified as:

a. Water ring centrifugal displacement pumps.
b. Water piston pumps.
c. Stationary water ejector pumps.
d. Rotary water ejector pumps.

The evacuating element is generally combined with a centrifugal water impeller for the delivery of the condensate to the boiler or feedwater heater.

The assembled units may be further grouped under two general classifications:

a. Those which perform the function of air separation under atmospheric pressure.
b. Those which perform the function of air separation under a partial vacuum.

Pumps coming under the first classification remove both the air and condensate from the returns by means of the hydraulic evacuator and deliver both to a separating tank under atmospheric pressure. From this tank the air and non-condensible vapors are vented to atmosphere while the condensate is removed and delivered to the boiler by means of the built-in boiler feed pump impeller.

In the second classification, the air and condensate are first separated under vacuum by means of the receiver which is directly connected to the returns. The hydraulic evacuator withdraws only the air and non-condensible vapors from the top of the receiver and delivers them to atmosphere. The built-in condensate pump impeller removes the condensate from the bottom of the receiver and delivers it direct to the boiler or feedwater heater.

Under special conditions such as returning the condensate to a high pressure boiler or the furnishing of large air removal units for high vacuum systems, it is customary to supply separate motor driven air and water pumps. Steam turbine drive is also frequently used where high pressure steam is available. There are also special steam turbine driven units which are operated by passing the steam to be used in heating the building through the turbine with only a 2 to 3 lb drop across the turbine required for its operation.

For rating purposes[3] vacuum pumps are classified as *low vacuum* and *high vacuum*. Low vacuum pumps are those rated for maintaining 5½ in. mercury vacuum on the system, and high vacuum pumps are those rated to maintain vacuums above 5½ in.

The vacuum that may be maintained on a system depends upon the

[3]A.S.H.V.E. Standard Code for Testing and Rating Return Line Low Vacuum Heating Pumps. (A.S.H.V.E. TRANSACTIONS, Vol. 40, 1934, p. 33).

relationship of the operating air capacity of the hydraulic evacuator at the vacuum and temperature of the returns to the air leakage rate into the system. It is particularly essential on high vacuum installations that the system be tight and that steam be prevented from entering the return lines through leaky traps, high pressure drips, etc.

Vacuum Pump Controls

In the ordinary vacuum system the vacuum pump is controlled by a vacuum regulator which cuts in when the vacuum drops to the lowest point desired and which cuts out when the vacuum has been increased to the highest point. This is done largely to eliminate the constant starting and stopping of the vacuum pump which would occur if the vacuum were maintained constant. In addition to this control, a float control is included which will automatically start the pump whenever sufficient condensation accumulates in the receiver, regardless of the vacuum in the system. A selector switch is usually provided to allow operation at night as a condensation pump only, also to give continuous operation if desired.

There are several variations to the above control, especially as concerns the control of the vacuum maintained on the system. This may be accomplished by some form of coordinating control which maintains the vacuum of the return system in a pre-determined definite or varying relationship to the system supply pressure.

Piston Displacement Vacuum Pumps

Piston displacement return vacuum heating pumps may be either power or steam driven. They should be provided with mechanical lubricators and their piston speed in feet per minute should not exceed 20 times the square root of the number of inches in their stroke. They are usually supplied with an air separating tank, open to atmosphere, placed on the discharge side of the pump and at an elevation sufficiently high to allow gravity flow of the condensate to the boiler. If the boiler pressure is too high for such gravity feed then an additional steam pump for feeding the boiler is desirable. The extra pump is sometimes avoided by using a closed separating tank with a float controlled vent. In both arrangements, the air taken from the system must be discharged against the full discharge pressure of the vacuum pump. In the case of high or medium pressure boilers, it is better to use the atmospheric separator and the second pump.

In figuring the required displacement for such pumps, a value of from 6 to 10 times the volumetric flow of condensation is used for average vacuums and systems. However, as in the case of return line vacuum heating pumps, the displacement is largely dependent upon the tightness of the system, the efficiency of the traps and the vacuum that is desired to be maintained.

TRAPS

Traps are used for draining the condensate from radiators, steam piping systems, kitchen equipment, laundry equipment, hospital equipment, drying equipment and many other kinds of apparatus. The usual functions of a trap are to allow the passage of condensate and to prevent the