HOFFMAN PACKLESS RADIATOR VALVE

HOFFMAN AIR VALVE

MAIN VENT

STEAM SUPPLY MAIN

FLOW →

SAFETY FACTOR

STATIC HEAD

A

TOTAL PRESSURE DROP

PRESSURE DROP OF SYSTEM

BOILER WATER LINE

BOILER

WET RETURN

# Steam Heating Application Manual

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# INDEX

# STEAM HEATING SYSTEMS

## CHAPTER 1 --- BASICS OF STEAM HEATING

### Operating Principles

The thermodynamic properties of steam make it an excellent medium for the transfer of heat from a source to a point of use.

Where steam is used for space heating, a boiler is used as a source of heat. The boiler generates steam which is delivered to the heating units by appropriate piping systems. There are a number of piping systems in use and the simplest of these, a one-pipe system, is shown in Figure 1. This system will be used to describe the principles involved in the operation of steam heating systems.

Pressure Drop in a One-Pipe Steam System

Figure 1.

Fig. 8
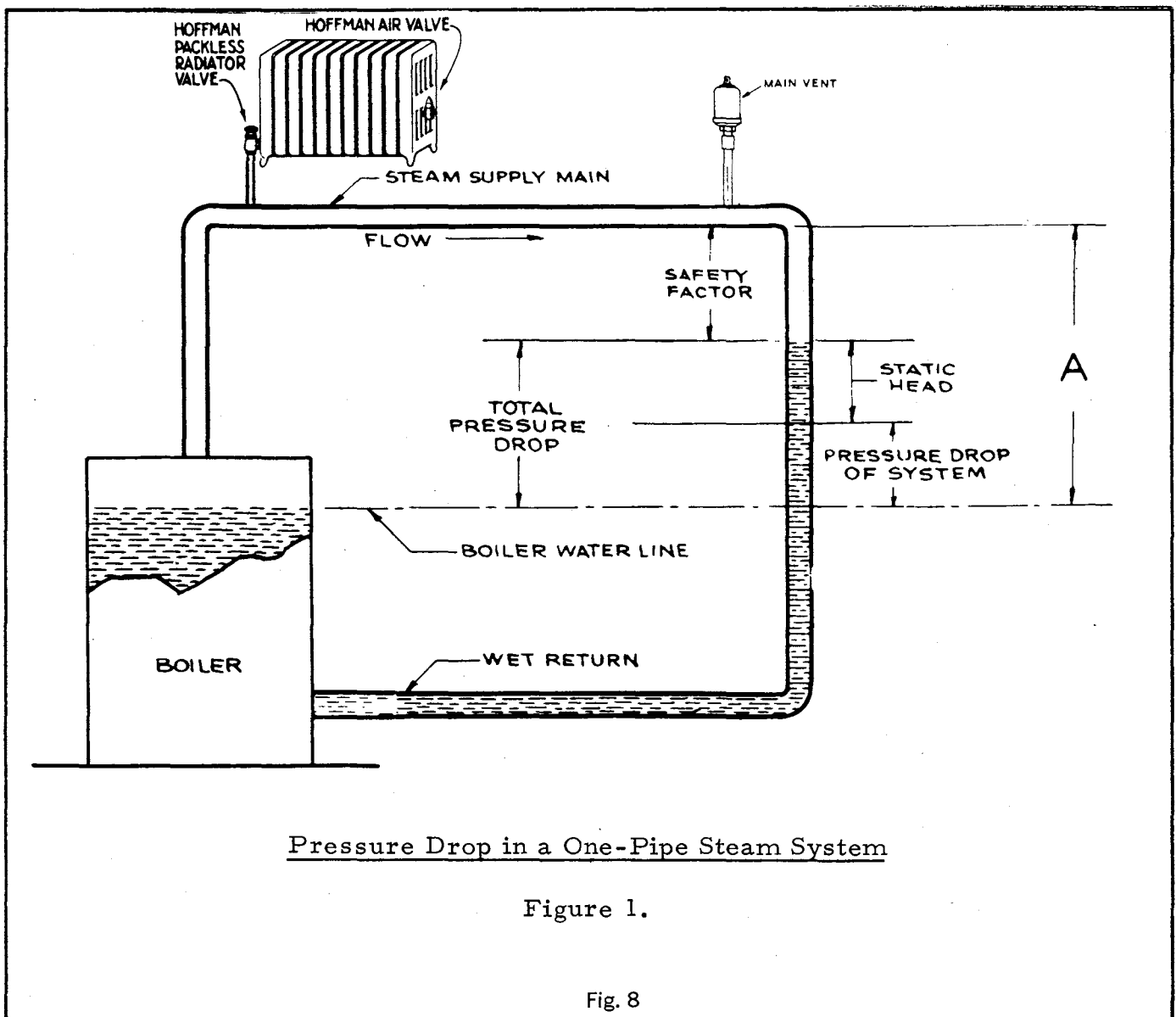
Before being placed in operation, the system is filled with water to the boiler water line. This water level will be the same in the boiler and the vertical leg of the return line before the boiler begins steaming. The steam space of the boiler and the system will be filled with air and additional air will be driven out of the boiler water when it is heated. This air interferes with the flow of steam to the radiators.

Thermostatic air vent valves are placed at each radiator and the end of the supply main to allow the air to be purged by the steam as it fills the system. These vents are normally open and close off as the hot steam reaches them.

Steam enters the radiators and condenses as it gives up its heat to the spaces in which they are installed. This condensate returns to the supply main by means of the same pipe supplying steam to the radiators. In the system being described, steam and accumulated condensate flow in the same direction down the supply main to its end. Here it drains into the vertical leg of the return main.

The point of highest pressure in a steam system is at the boiler, where steam is being generated. The pressure in the system radiators tends to drop as the steam they contain condenses. It is this pressure differential which causes the steam to flow from the boiler to the radiators.

Steam will flow through the system at a rate depending upon the pressure differential existing between the boiler and the end of the steam piping. This available pressure difference will be used up in overcoming the friction of the steam moving through the piping. This is called the system pressure drop.

The condensate moving through the return piping toward the boiler also encounters piping pressure drop and energy must be made available to move this liquid.

The energy required to overcome these pressure drops is provided by the steam pressure generated by the boiler. The pressure in the steam space will be higher than that at the end of the steam piping by an amount equal to the total system pressure drop.

Reference to Figure 1 will show how this affects the relative water levels in the boiler and in the vertical leg of the system return piping. The higher pressure in the boiler causes the water to rise in this pipe, which is exposed to the lower pressure existing at the end of the system. The water column will rise until its weight just offsets the existing pressure difference between these two points.

As the drawing shows, the head provided by the height of this column consists of the steam system pressure drop and the static head needed to overcome the pressure drop in the condensate return line.

Standard practices have been established in steam system design which assign certain practical values to system pressure drop. These have the effect of establishing minimum values for dimension "A" as shown in the system drawing. This dimension reflects the height of the end of the steam supply main above the boiler water line. This height includes the total system pressure drop plus a safety factor to insure that flooding of the steam supply main will not take place.

For small systems having a total heat loss of not more than 100,000 BTUH, piping is sized on the basis of 1/8 psi pressure drop each for the steam and condensate piping. The height of dimension "A" is calculated as follows on this basis:

| | | |
|---|---|---|
| System Pressure Drop (1/8 psi) | = | 3.5" of Water |
| Static Head (1/8 psi) | = | 3.5" of Water |
| Safety Factor (Twice the Static Head) | = | 7.0" of Water |
| Total Height | | 14.0" of Water |

For systems of this size, it is common practice to make the minimum distance for dimension "A" not less than 18.0".

For systems with heat losses greater than 100,000 BTUH, assume that the steam piping was sized for a pressure drop of 1/2 psi and the return for 4.0" of water column. The calculation of dimension "A" is as follows:

| | | |
|---|---|---|
| Pressure Drop of System (1/2 psi) | = | 14" of Water |
| Static Head | = | 4" of Water |
| Safety Factor (Twice Static Head) | = | 8" of Water |
| Total Height | | 26" of Water |

It is standard practice for a system based on 1/2 psi pressure drop to make the minimum distance for dimension "A" not less than 28".

Definitions and Terms

The components comprising a steam heating system are referred to in certain well defined terms. Some basic terms are indicated on the one-pipe system drawing shown in Figure 2, which elaborates on Figure 1.

The Steam Boiler - Steam boilers are fabricated of either steel or cast iron. Figure 3 illustrates a steam boiler fitted with the necessary trim. A sight glass is provided for visual observation of the boiler water level. A relief

valve protects the boiler from damage should excessive pressures occur. The burner is operated from a pressurestat set to open its contacts at a specified pressure.

A low water cut-off wired in series with the burner control shuts down the burner should the boiler water level drop to its cut-out setting.

Steam heating boilers are usually of the low pressure type, with maximum working pressures to 15 psig. They are selected on the basis of their net ratings, in terms of thousands of British Thermal Units per hour. Larger boilers are sometimes rated in terms of horsepower, with 33,475 BTUH being equal to one horsepower.

It has also been common practice to rate steam boilers in terms of the amount of radiation which they will serve. Steam radiation is rated on the basis of square feet of equivalent radiation (abbreviated EDR), with 1 sq. ft. being equal to 240 BTUH.

Header·               -     Boilers, depending upon their size, have one or more outlet tappings. The vertical steam piping from the tapped outlet joins a horizontal pipe called a "Header". The steam supply mains are connected to this header.

Steam Supply     -     The steam supply main carries steam from the header
Main                      to the radiators connected along its length. In the case of one-pipe systems, it also carries the condensate from these units back to the drip connection. When the condensate flow in the supply main is in the same direction as the steam flow, as illustrated, the system is called a parallel flow system.

Risers               -     The vertical pipe carrying steam to the radiator from the supply main is called a riser. In the case of the one-pipe system in the illustration, the riser also drains condensate from the radiator back to the supply main. In one-pipe systems, the horizontal run-outs connecting the main to the riser must be pitched up to the radiator to make this drainage possible.

Heating Units    -     As shown in Figure 4, steam systems use convectors, cast iron radiators, wall fin tube and similar heat output units.

4

Drip Connections  -  Where piping carries both steam and condensate, it is often desirable to drain off the condensate at various points to expedite steam flow. This condensate is drained off to a return line by a connection called a "drip". For example, in Figure 2, the steam supply main is dripped into the dry return, which in turn is dripped into the wet return.

Dry Return  -  The dry return is that portion of the return main located above the boiler water level.

Wet Return  -  The wet return is that portion of the return main located below the boiler water level. It is always completely filled with water and does not carry air or steam as does the dry return.

Hartford Loop  -  This is a piping arrangement designed to prevent complete drainage of the boiler should a leak develop in the wet return. The wet return is connected to an equalizing line between the supply and return opening of the boiler. This connection is made about 2" below the normal water level of the boiler.

Should a leak develop in the wet return, the boiler water level will drop a maximum of 2". This keeps the heat transfer surfaces of the boiler immersed in water, preventing the damage that could occur with the firing of a dry boiler. (Refer to Figure 2.)

Air Vents  -  Steam cannot circulate or radiators heat until air has been vented from the system. Thermostatic air vents, some of which are pictured in Figure 5, must be installed on each radiator and at the end of each steam main.

Radiator Valves  -  The steam supply to the system radiators is controlled by a radiator valve. Each radiator must be equipped with an angle pattern radiator supply valve of the type shown in Figure 6.

The terms discussed in this section are those needed in order to understand the operation of simple, one-pipe steam heating systems. These terms will be elaborated upon in the sections dealing with other system types.
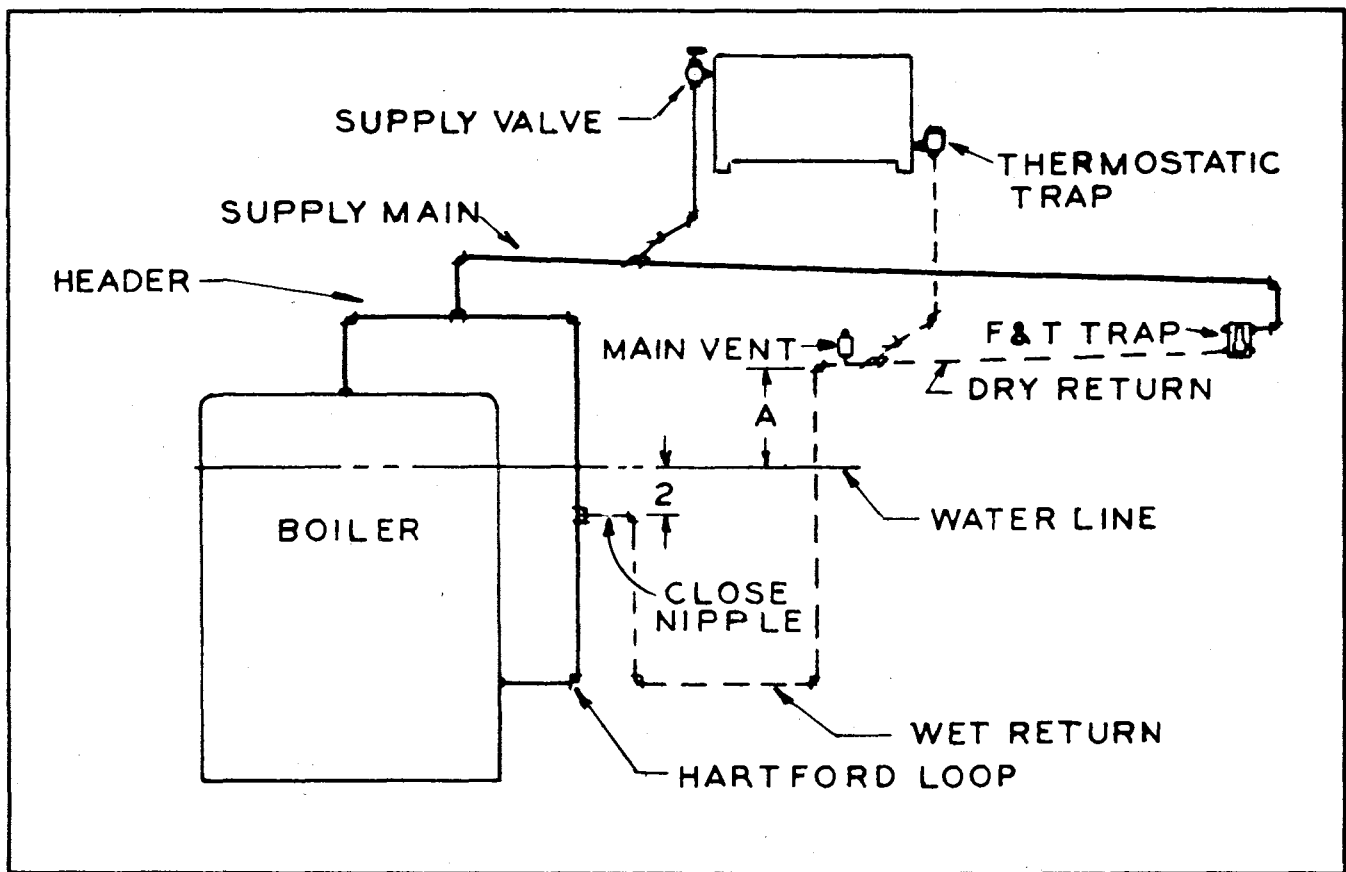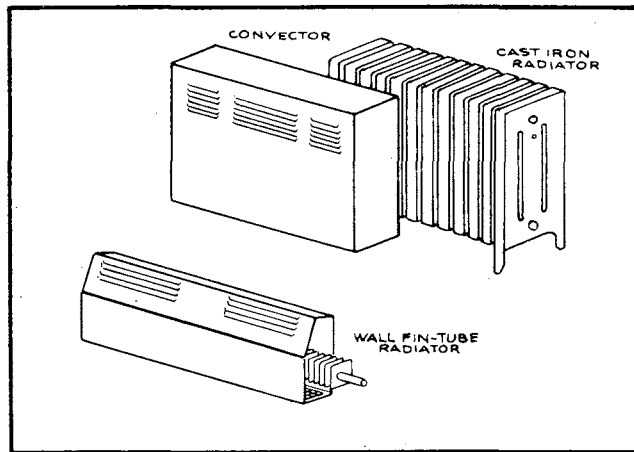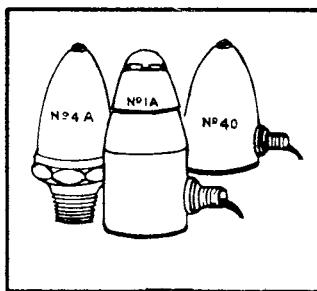
One-Pipe Parallel Return System
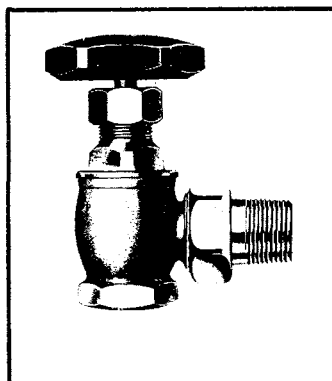
Figure 2.
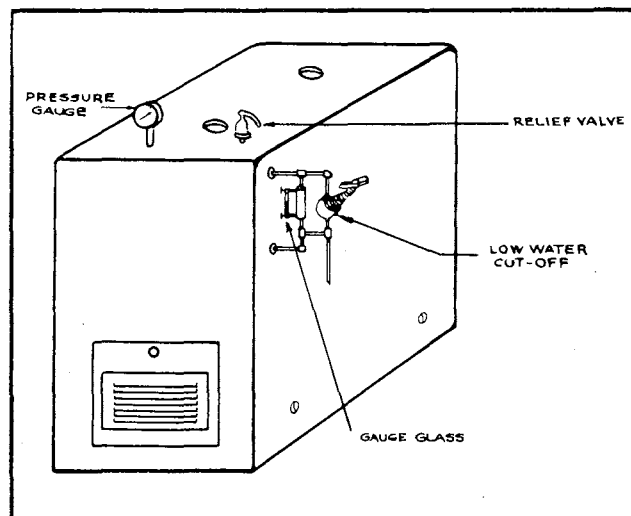


Steam Boiler Controls

Figure 3.

Steam Radiation

Figure 4.



Radiator Vents

Figure 5.



Typical Steam Supply Valve

Figure 6.

## CHAPTER 2 --- STEAM SYSTEM TYPES

Steam heating piping systems are classified by the manner in which the steam and condensate is handled. One-pipe systems use common piping for both. Two-pipe systems use separate piping for the steam and condensate. There are variations of each of these system types which will be explained in this section.
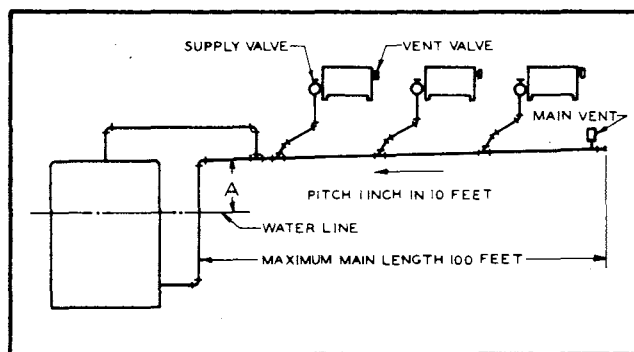
## ONE-PIPE SYSTEMS

One-pipe systems of the type just discussed which return condensate directly to the boiler are called Gravity Return Systems. Where there is insufficient height to maintain dimension "A" at its prescribed minimum, mechanical means must be provided to return the condensate. In the latter event, a condensate pump is used for this purpose.

An important factor in the operation of one-pipe systems is the pitch of the steam supply and dry return mains. They must be pitched at least one inch in 20 feet in the direction of condensate flow. No pitch is required for wet returns. The following examples describe the various one-pipe system types.

## Counter-Flow System

This system is shown in Figure 7. The condensate flows in a direction opposite to that of the steam. Because of this, the main must have a pitch upwards and away from the boiler of at least one inch in 10 feet.



One-Pipe Counter-Flow System

Figure 7.

The steam main must be one size larger than that which would be used for other types of one-pipe systems. Dimension "A" must be of sufficient height to return condensate to the boiler as previously discussed. The use of this system type is usually confined to small residential systems.

## Parallel Flow System

This is the system discussed in Chapter 1. Steam and condensate flow in the same direction in the horizontal steam and return mains. Figure 8 shows this system with a wet return from the end of the steam main and Figure 9 shows a dry return from this point. In either case, dimension "A" must be sufficient to provide for gravity return of the condensate. This system is used in larger buildings of single level construction.
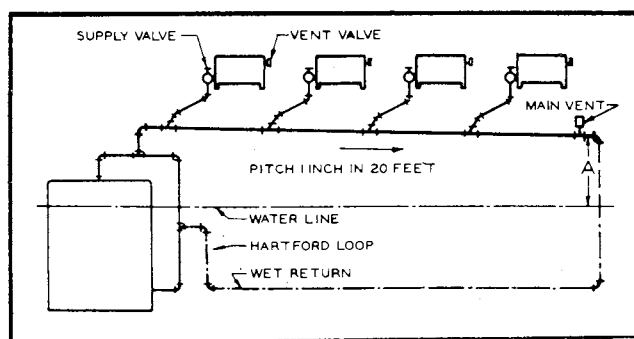


One-Pipe Parallel Flow System
Wet Return

Figure 8.
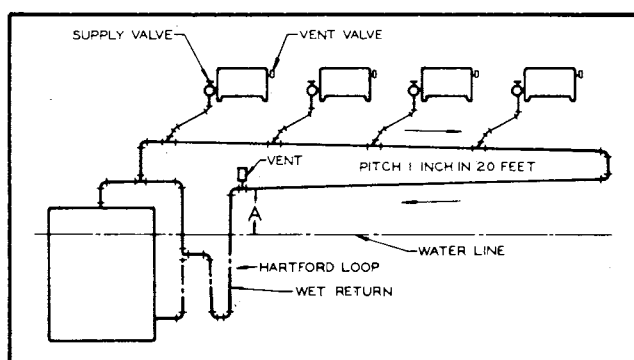


One-Pipe Parallel Flow System
Dry Return

Figure 9.

## Parallel Flow Upfeed System

This system type is installed in multi-story buildings. Steam is distributed upwards from a basement supply main. This main pitches down from the boiler and its end is dripped to the wet return. See Figure 10.



One-Pipe Parallel Flow Upfeed System

Figure 10.

Steam is led to the radiators by upfeed risers, which also drain off condensate. Note that the heel of each riser is dripped into the wet return, which relieves the supply main of the condensate from the radiation supplied by the riser.

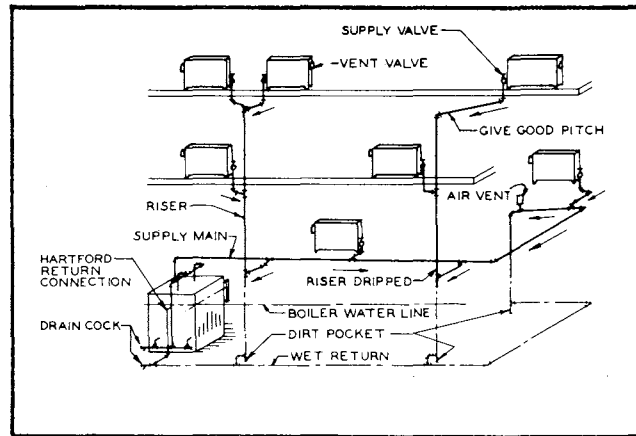The upfeed branch connections to the first floor radiators are not individually dripped, discharging their condensate directly into the steam supply main. This condensate is dumped into the wet return by the drip connection at the end of the supply main.

## Parallel Flow Downfeed System

When a one-pipe system distribution main is overhead, such as in a ceiling or attic space, it is known as a downfeed system. The downfeed risers have steam and condensate flowing in the same direction, as shown in Figure 11.

To insure good condensate drainage, all downfeed risers should be taken off the bottom of the supply main. The main vent may be installed at the end of the supply main or on the downfeed risers below the first floor as an optional location. When installed on the risers, the vents must be installed so that dimension "A" is sufficient to prevent water from entering them. These vents have integral floats which will close off the vent should water enter them.

10

One-Pipe Parallel Flow Downfeed System

Figure 11.

## Mechanical Condensate Return Systems

Where there is insufficient available height to maintain dimension "A" at the proper level, the use of a condensate pump becomes necessary.

This device consists of a reservoir open to atmosphere into which the return line discharges its condensate. A centrifugal pump is also a part of this device. This pump discharges condensate from the receiver into the boiler. A float operated switch in the receiver cycles the pump to return the water to the boiler as it accumulates at this point.

Figure 12 shows a condensate pump during the operating cycle. The float has tripped the pump switch and the pump is discharging through a check valve into the boiler. When the condensate level in the receiver drops to the cut-off level of the float switch, the pump stops. Boiler pressure causes the check valve to close, preventing backing up of boiler water into the receiver, as shown in Figure 13. A gate valve is provided in the condensate pump discharge line to permit servicing the pump without draining the boiler.



Condensate Pump -- Pump on

Figure 12.

11

Condensate Pump -- Pump Off

Figure 13.

A one-pipe pumped return system appears in Figure 14. Note that the end of the steam supply main is fitted with a float and thermostatic trap. This trap allows air and condensate to leave the main at this point but prevents the loss of steam. The outlet of this "F" and "T" trap is connected to the receiver to permit gravity drainage of condensate to take place. The connecting pipe is called a "no pressure return" because of this gravity flow.
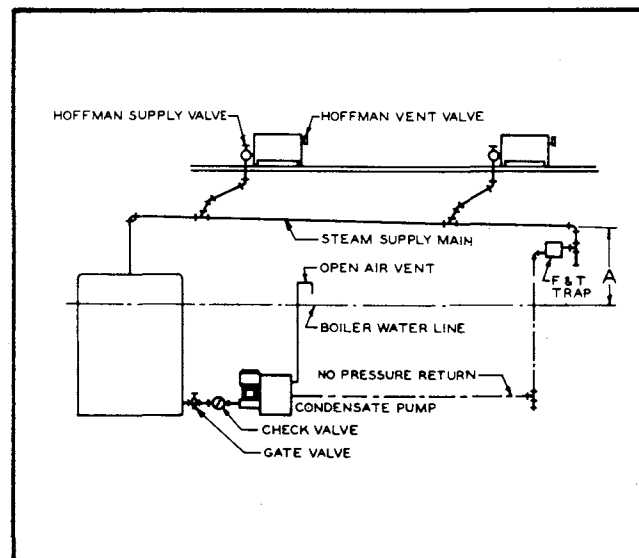


One-Pipe System with Condensate Pump

Figure 14.

The manner in which an "F" and "T" trap performs its function is illustrated in Figure 15. Air, steam and water enter the body of the trap. The normally open thermostatic air vent allows air to pass but, closes off when hot steam reaches it. The float-operated valve modulates to allow condensate to drain off as it enters the trap body. In this manner, both air and condensate from the system are discharged to the receiver
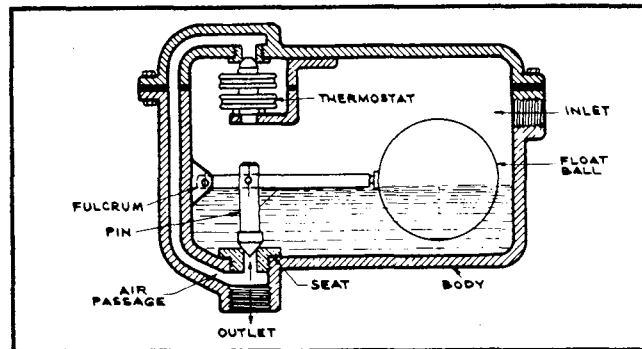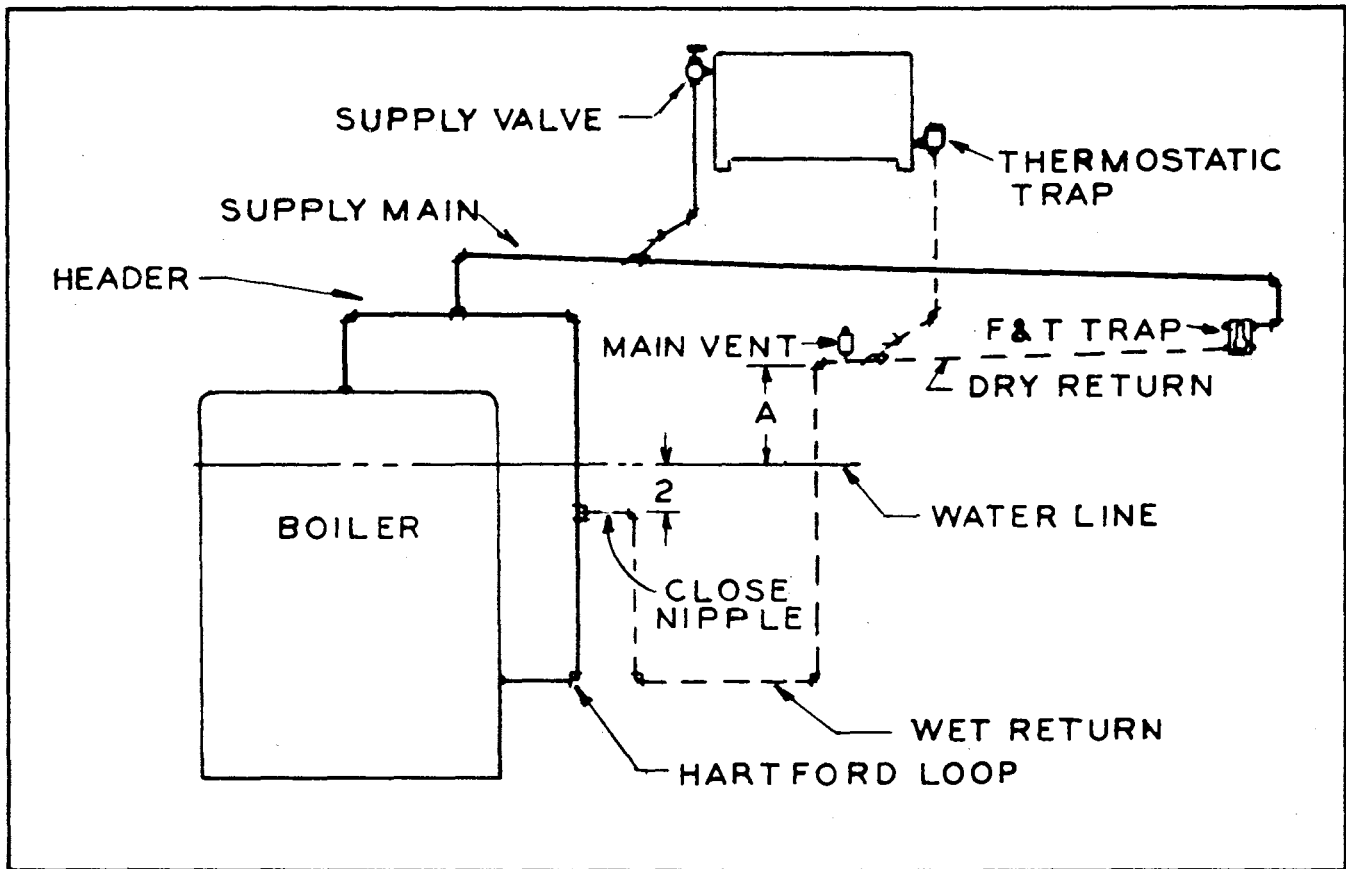


Float and Thermostatic Trap

Figure 15.

## TWO-PIPE SYSTEMS

Two-pipe systems differ from one-pipe systems in that the steam and condensate are carried in separate lines. The steam lines supply steam to the radiators, which discharge their air and condensate to the return lines. Traps are used at each radiator and at the end of each supply main to prevent the entry of steam to the return lines.

### Gravity Return Systems

A two-pipe gravity return system is pictured in Figure 16. Steam enters the radiator from the supply riser, pushing air out the return opening through a thermostatic trap. These traps differ from the "F" and "T" type in that they are strictly thermostatic in their operation. These traps are normally open as shown in Figure 17. Air or condensate can pass through the trap freely. Should steam begin passing through it, the operating bellows or diaphragm assembly expands, closing off the trap. The trap at the top of the illustration is a bellows type. The other is a balanced pressure diaphragm type. Its thermal element consists of diaphragms arranged to form connecting cells which expand in the same manner as does a bellows.

SUPPLY VALVE

THERMOSTATIC TRAP

SUPPLY MAIN

HEADER

MAIN VENT

F&T TRAP

DRY RETURN

A

WATER LINE

BOILER

2

CLOSE NIPPLE

WET RETURN

HARTFORD LOOP

Two-Pipe Gravity Return System
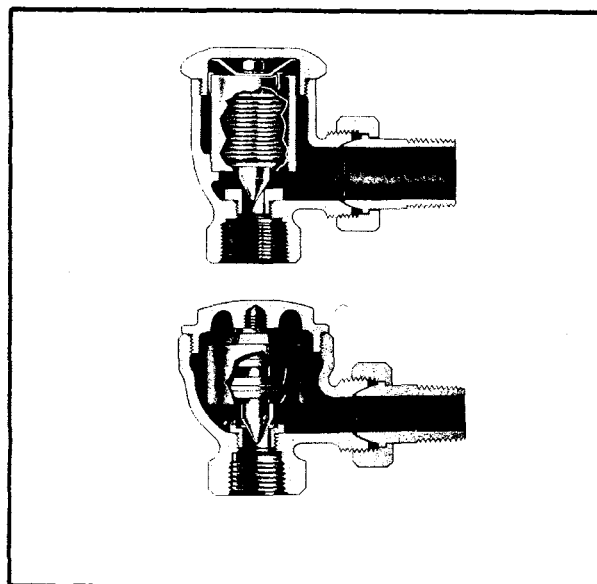
Figure 16.



Typical Thermostatic Traps

Figure 17.

Thermostatic traps tend to hold back condensate if it is very hot and close to saturation temperature, opening when the condensate cools a bit. This is no problem in a radiator which has the volume to hold excess condensate. However, where rapid drainage of condensate is important, "F" & "T" traps are a better choice since the float valve is not affected by temperature and dumps condensate as it accumulates.

How this affects the choice of traps is shown in Figure 16. A thermostatic trap discharges air and condensate from the radiator into the dry return main. Since this trap discharges air from the radiator, a separate air vent is not needed here. The end of the steam supply main is dripped into the dry return through a fast acting "F" & "T" trap.

Condensate in the steam supply line is generated due to steam condensing within it, principally on the start-up cycle. This condensate must be drained quickly to permit the free flow of steam to the radiators.

The dry return is dripped to the wet return as shown, with a Hartford Loop connection at the boiler. A main vent is installed at the end of the dry return for the purpose of discharging the air accumulating at that point. A cut-away version of a vent designed for end of the main installation is shown in Figure 18.
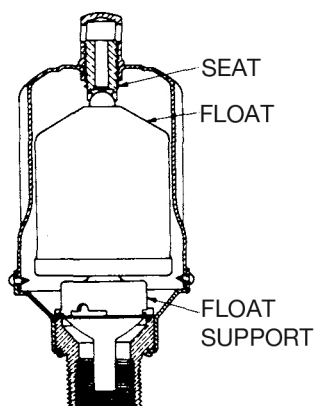


Main Vent

Figure 18.

The vent is normally open. Should water enter the valve, the float will rise from its support and seal off the valve port. Should steam enter the vent, a volatile liquid in the float support will vaporize and cause its flexible top member to expand. This will also close off the vent.

During normal system operation, condensate from the system drains from the various traps to the wet return, while the main vent discharges accumulated air. Dimension "A" must be great enough to provide the gravity head needed to return condensate to the boiler. A water column 28" in height is required to return condensate against a boiler pressure of 1 psi, which limits gravity return systems to operating pressures between 1/2 to 1 psig in most cases.

## Mechanical Condensate Return Systems

Installations having insufficient elevation of the dry return over the boiler water line to provide gravity condensate return must be equipped with a condensate return pump.

A two-pipe upfeed system of this type is illustrated in Figure 19. Thermostatic traps at each radiator and the "F" & "T" trap at the end of the steam supply main discharge air and condensate to the receiver through the no pressure return.
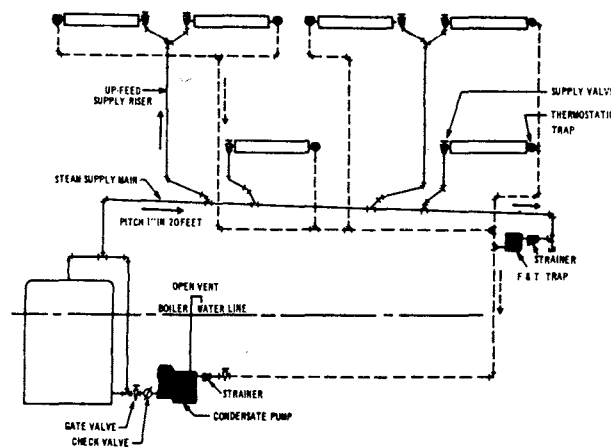


Two-Pipe, Upfeed System with Condensate Pump

Figure 19.

Where two-pipe downfeed systems are used, it is necessary to drip the ends of the supply risers to the no pressure return as shown in Figure 20. Condensate accumulates at these points and must be drained off. Air must be vented to insure steam flow. "F" & "T" traps are recommended for this application because of their ability to quickly discharge air and condensate.
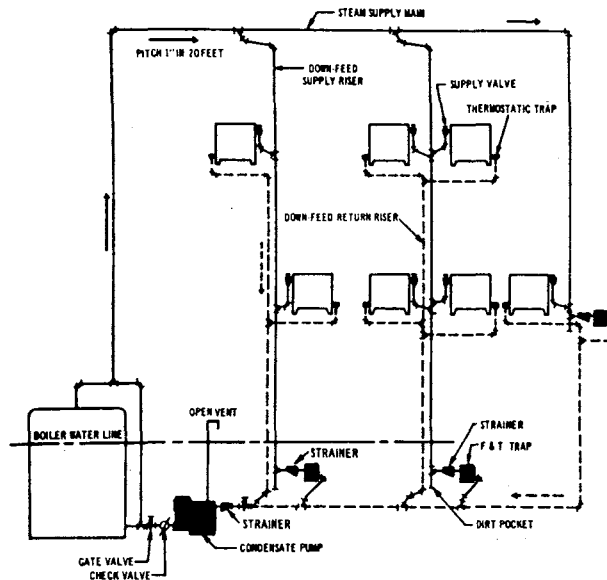
Two-Pipe, Downfeed System with Condensate Pump

Figure 20.

## Vacuum Systems

When two-pipe systems become large and involve the use of long piping runs, large volumes of air are present. If this air is not quickly expelled, it interferes with steam flow to the radiators. The result is slow warm-up and sluggish return of the condensate to the boiler.

The boiler water level will fall due to lack of condensate return, causing the make-up water feeder to begin supplying additional water. As the system warms up, the normal rate of condensate return will be established and this can cause flooding of the boiler steam space.

One method used to overcome this steam distribution problem and its adverse condensate return effect is to use a vacuum pump for the quick elimination of air from the system. These pumps are designed specifically for steam heating systems. They are rated to handle a definite quantity of air at an average vacuum of 5-1/2" $H_g$ with a condensate temperature of $160^\circ$ F. prevailing. The pump is normally controlled to cut in at 3" $H_g$ and at out at 8" $H_g$.

Figure 21 shows a vacuum pump installed on a two-pipe downfeed system. The pump acts to keep a vacuum on the system return lines and also to return accumulated condensate to the boiler. During the steaming cycle, the pressure in the steam mains and radiators will be higher than that in the return mains, allowing good condensate drainage.
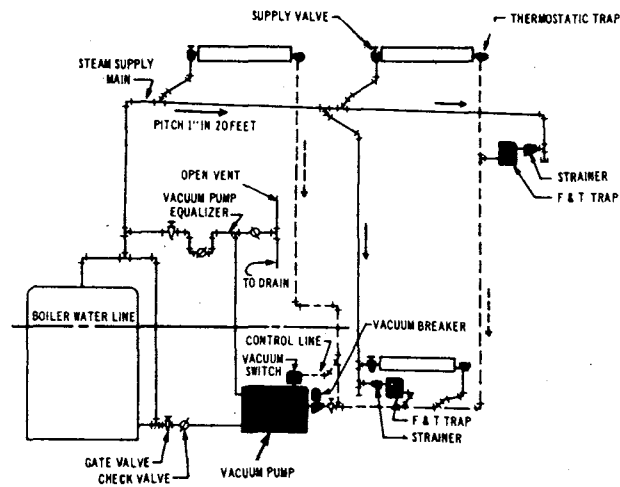
Typical Two-Pipe Vacuum System

Figure 21.

On the boiler off cycle, the steam condensing in the supply side of the system can cause a vacuum to form. This vacuum can be higher than the return line vacuum, preventing condensate from flowing to the pump. An equalizing line between the vacuum pump and the steam supply line allows the system pressure to equalize should this take place.

As shown in Figure 21, this equalizing line is taken off the overflow stand pipe of the vacuum pump. A check valve in the drain from this line prevents loss of vacuum during the operating cycle. A check valve in the vacuum pump equalizer line is closed as long as the steam side pressure is greater than the return pressure. Should the steam side pressure drop below the return line pressure, this valve will open and allow these pressures to equalize.

The vacuum switch which actuates the pump senses the pressure at the end of the vacuum return as shown in the drawing. The operation of the pump will be adversely affected if the induced vacuum is pulled to too low a level. A vacuum breaker, usually set to open at about 15" $H_g$, is installed at the inlet of the vacuum pump. This will open and admit air should the vacuum drop below its setting.

18

Some of the components used in steam heating systems have already been discussed in explaining system types. A more detailed explanation of these and other system components will be given in this Chapter.

## Radiator Supply Valves

The choice of radiator supply valves for a system is governed by the system type involved.

## One-Pipe Systems

Steam must enter and condensate leave the radiator through a common port. The valve must therefore be installed at the bottom of the radiator and have a port large enough to accept both flows. The valve cannot be throttled as this would restrict condensate drainage. It must either be wide open or closed.

A typical valve for one-pipe systems is shown in Figure 22. This is an angle type valve. Straightway pattern valves cannot be used for one-pipe systems because they do not permit adequate two-way flow of the steam and condensate. The stem of the valve illustrated is of the packing type. These valves are also furnished in the packless type, sealed with a bellows or diaphragm.
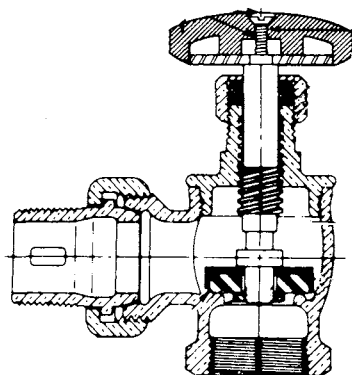
Radiator Supply Valve
Packed Stem Type

Figure 22.

## Two-Pipe Systems

Radiator supply valves for two-pipe systems may be angle type or straightway. They are available as modulating valves as well as the ordinary shut-off type.

Figure 23 illustrates a packless type valve, applicable to either one or two-pipe systems. This type is especially desirable on vacuum return systems, since there is no possibility of air leakage past the stem. This valve uses a diaphragm stem seal. The valve illustrated in Figure 22 may also be used on two-pipe systems.



Radiator Supply Valve
Packless Type

Figure 23.


VENT VALVES

These valves, used for the elimination of air from one-pipe steam systems, are classified into two general types as follows.


Radiator Vent Valves
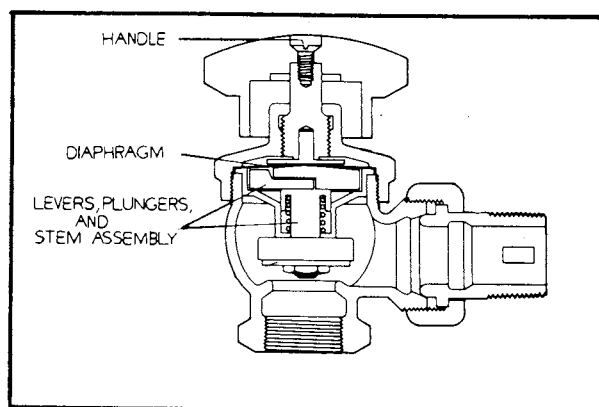
These valves are available in a wide range of air venting capacities. They are furnished in special constructions depending upon whether they will be used in non-vacuum systems.

For non-vacuum systems, the valves are of the "open" type. Their venting ports are open to atmosphere unless either water or steam enter their bodies, in which case the vents will close off. A typical open vent is shown in Figure 24. This vent operates in the same manner as the end of the main vent discussed in Chapter 2 and pictured in Figure 18. These vents are furnished with either non-adjustable or adjustable venting rates. The vent in Figure 24 is of the adjustable type.

Large one-pipe systems often heat at a very uneven rate on start-up. The first radiators off the main will vent their air first and heat quickly, with those at the far end being the last to vent and heat. If adjustable vents are used, the venting rate of the first radiators can be set lower than that of the far end radiators resulting in better heat distribution. Small systems, where this is not a problem, may use vents with non-adjustable air ports.

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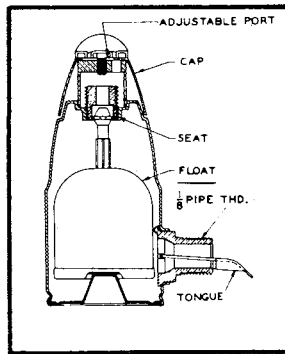
Adjustable Type Radiator Vent

Figure 24.

Vacuum type systems require vents which will not admit air if the radiator is under vacuum. They are essentially the same as the non-vacuum type with one exception; they have a check valve in the vent port. Figure 25 shows a vent of this type.
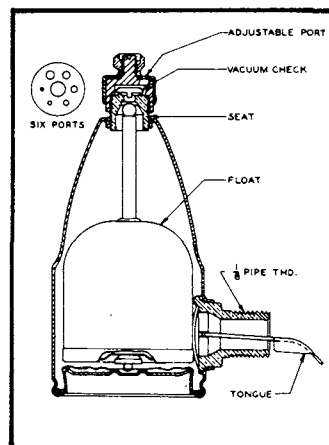


Adjustable Type Radiator Vent
For Vacuum Systems

Figure 25.

The vent illustrated is of the adjustable type. Any one of six venting rates is made available by rotating the disc containing the venting ports until the desired port is over the vent opening. A check valve in the vent port closes off if a vacuum occurs in the radiator. This prevents the entry of air. These vents are also furnished without the adjustable venting feature.

## End of Main Vents

The major difference between these and radiator vents is the venting rate. End of main vents have a much larger venting rate than radiator vents.

End of main vents are furnished for either open or vacuum operation, the difference being in the check valve furnished with the vacuum vent. The construction of an open type vent was shown in Figure 18 and a vacuum type is shown in Figure 26. This vent employs a bellows to close off the port on steam entry but in other respects its operation is similar to that of the vent in Figure 18.
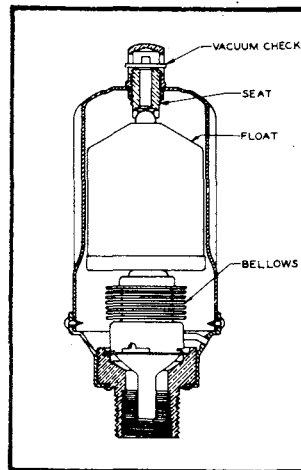


End of Main Vent
Vacuum Type

Figure 26.


## TRAPS


### Thermostatic Traps

Thermostatic traps are the most common of all types used in two-pipe steam heating systems. The operating principle of this trap was discussed in Chapter 2 and two types are pictured in Figure 17. Other thermal elements, such as a series of diaphragms or special cells made for diaphragms are also used.

The temperature at which a thermostatic trap will open is variable but is always the required number of degrees below the saturated temperature for the existing steam pressure. In addition to being installed on radiators, they are used as drip traps and to handle condensate from unit heaters.

It is necessary to use a cooling leg between the equipment or drip and the thermostatic trap. This is simply an adequate length of pipe to cool the condensate sufficiently to open the trap and discharge the condensate.

Thermostatic traps are provided in angle, straightway, swivel and vertical patterns and may be used on applications from vacuum to high pressure steam.

## Float Traps

Float traps are used to discharge condensate at points where air is not a problem. They are the same as an "F" & "T" trap except that the thermostatic element is not provided. For example, if the cover of the "F" & "T" trap in Figure 15 were removed and replaced with a plain cover, the result would be a float trap. The discharge from a float trap is continuous as the float tends to throttle the pin or valve in the seat port.

In some cases, a thermostatic vent is installed in a bypass line around the inlet and outlet of the valve body for venting air.

## Float and Thermostatic Traps

This trap combines the features of both types just discussed. The operation of the valve was explained in Chapter 2. Since the condensate discharge of float and float and thermostatic traps depends entirely on float action, a cooling leg is not required where they are used.

"F" & "T" traps are widely used for dripping the end of steam mains, the heels of upfeed steam risers and the bottom of downfeed steam risers. They are also excellent choices for handling the condensate from unit heaters, unit ventilators and coils which are a part of air handling systems.

## Inverted Bucket Traps

This trap type is able to handle condensate at any temperature up to the saturated temperature corresponding to the steam pressure at the trap inlet. It is used for commercial applications in the medium to high pressure range. Typical applications are clearing steam distribution lines of condensate and draining heat exchangers, unit heaters, cooking kettles, etc.

Figure 26 shows the operating principle involved. A bucket trap must be primed with water before being placed into operation. The bucket will be dropped because of the air vent hole in its upper portion. With the bucket in this position, the discharge port of the valve is open and it vents the air and condensate entering the trap. The air passes through the vent in the bucket on its path through the trap.
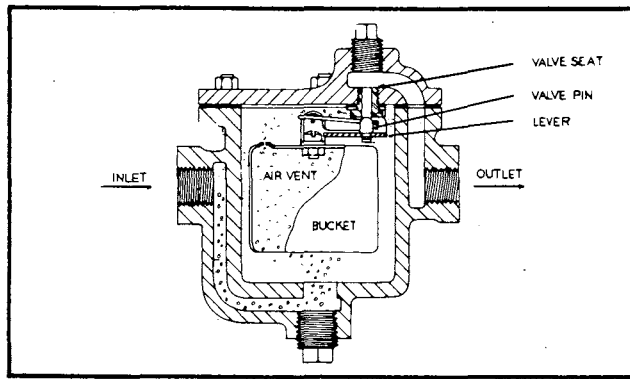
Inverted Bucket Trap

Figure 26.

When the condensate has been cleared, steam now enters the bucket. The steam fills the bucket, causing it to rise and close off the trap discharge port. The trap will open again when condensate enters and condenses the steam in the bucket.

The bucket now becomes buoyant and rises, closing off the discharge port of the valve. Additional condensate entering the body of the trap will now condense the steam in the bucket, causing it to drop and discharge the condensate. The bucket continues to rise and fall in this fashion, discharging the condensate as it accumulates.

Since the discharge port of the bucket trap is wide open during its venting cycle, its capacity for a given port size is greater than that of float type traps which modulate their discharges.

Upright Bucket Traps

These traps have an upright bucket as shown in Figure 27. The bucket floats as condensate enters the valve body, closing the discharge port. As condensate continues to enter, it will spill over the top of the float and cause it to drop. The condensate then rises up the discharge tube and is expelled through the outlet. Air at the top of the trap is expelled through the vent hole in the discharge tube.

The bucket regains its buoyancy when the condensate is discharged and rises, closing off the discharge port. This cycle continues as long as condensate continues to enter the trap. Inverted bucket traps do not require priming, as the bucket will rise and close off the discharge port as soon as condensate enters the trap.
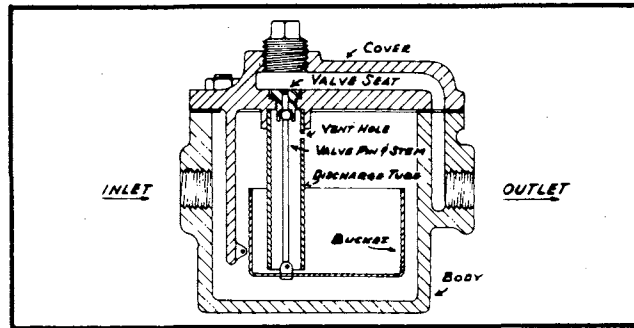
Upright Bucket Trap

Figure 27.


# Thermodynamic Traps

The principle of this trap is shown in Figure 28. Should air and condensate be passing through the trap, it will flow to the trap outlet in a path described by the directional arrows. The flow first passes through the outer heating chamber, then through a central port and out passageways around this port. A disc check valve, called the "controlled disc", is opened as this takes place.
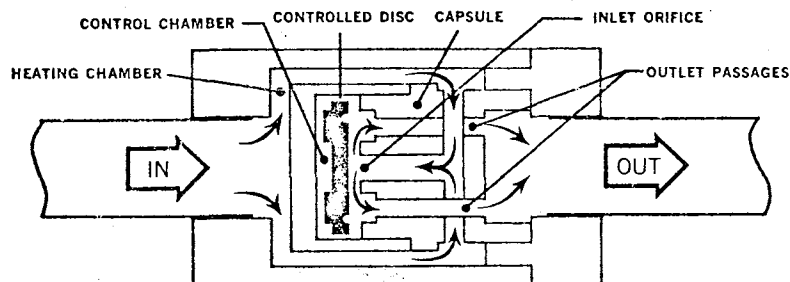


Thermodynamic Trap

Figure 28.

Steam enters the trap through the heating chamber, raising the temperature of the control chamber as it does so. Steam leaving the orifice at high velocity tends to lower the pressure existing at that point. Steam also enters the control chamber behind the controlled disc. The area of the disc on the control chamber side is greater than the disc area which covers the inlet orifice, causing the disc to close off due to the pressure differential.

Heat from the steam at the trap inlet maintains control chamber temperature and pressure, keeping the controlled disc in the closed postion. Should condensate enter the trap, the control chamber will be cooled and the pressure of the steam holding the controlled disc closed will now be lower than that at the inlet orifice and the controlled disc will be pushed open. The trap will continue discharging condensate until steam again reaches the inlet orifice and causes the cycle to repeat.


Condensate Pumps

The construction and operational principles of condensate return pumps were discussed in Chapter 2. Figures 12 and 13 illustrate this discussion. The construction of these pumps is modified for special applications where needed. Some of these applications will be discussed here.


Underground Condensate Pumps

When the return mains from a steam system are below the equipment room floor or lower than the inlet of a conventional horizontal condensate pump, underground type pumps are used. The construction of such a pump is shown in Figure 29.
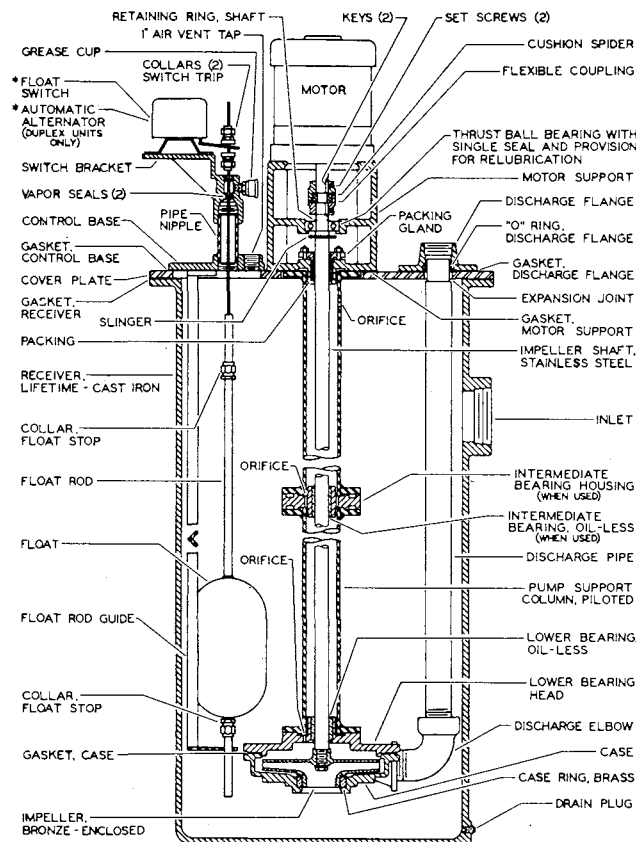


Underground Type Condensate Pump

Figure 29.

26

The pump assembly consists of a cast iron receiver which is installed below grade. The system condensate return empties into this receiver. The float switch cycles the pump to return condensate to the boiler. These units are furnished in both open and vacuum-tight construction, the latter being used with vacuum systems. A separate vacuum pump is required where underground condensate pumps are used.


Vacuum Pumps

Vacuum pumps may be used for the single purpose of producing a vacuum on the system, or they may be dual purpose types, producing vacuum and returning condensate to the boiler.

A vacuum pump is shown in cross-section in Figure 30. The pump is off and condensate is draining into the receiver, or lower tank.



UPPER TANK
AIR ~~~~
WATER ⟶

1- OPEN VENT          6- PUMP
2- PILOT VALVE        7- CHECK VALVE
3- DISCHARGE VALVE    8- INLET TO PUMP FROM RETURNS
4- TO BOILER          9- STRAINER
5- VACUUM JETS        10- FLOAT SWITCH FOR STARTING PUMP MOTOR
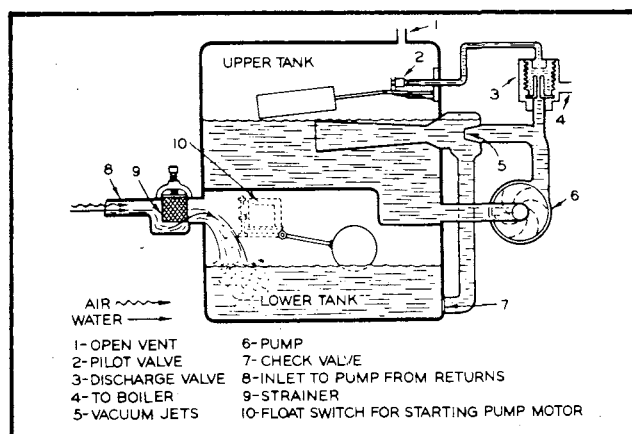
Jet Type Vacuum Pump
Pump Off

Figure 30.


When the receiver level riser to the cut-in setting of the float switch, the pump is started. As shown in Figure 31, this circulates water from the upper tank through the vacuum jets and back to the upper tank. With the induced pressure at the jet, water and air from the lower tank are drawn into the upper tank. Air is discharged through the upper tank vent. The upper tank water circulated to produce vacuum is called "hurling water".

While the pump is operating in this mode, its discharge to the boiler is held closed by a bellows type valve, actuated by the pressure of the pump as shown in the drawing. This valve will keep the pump discharge closed until the pressure in the bellows is relieved by opening the pilot valve. The pilot valve opens when the water level in the upper tank rises sufficiently to activate the float which controls it.
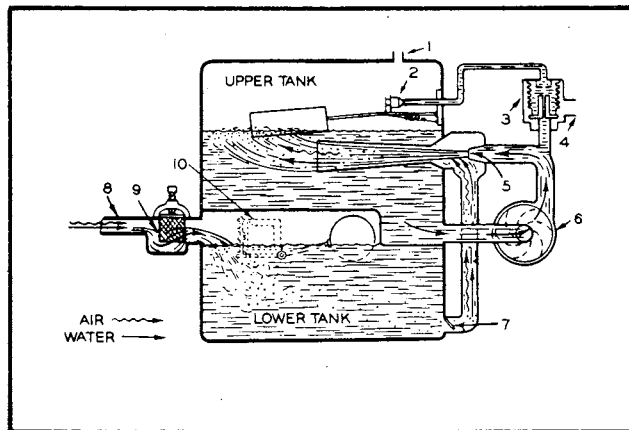
Jet Type Vacuum Pump
Transfer of Condensate to Upper Tank
Vacuum Being Drawn

Figure 31.


When the water level reaches this point, the pilot valve opens as shown in Figure 32. The pressure on the discharge valve bleeds off and condensate is delivered to the boiler. The pump continues to run until the lower tank is scavenged and its float drops to the off position. As the pump stops, the check valve at the lower tank closes due to the vacuum in the lower tank.
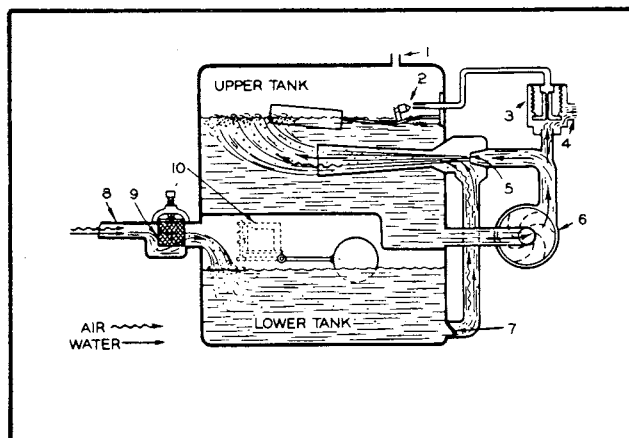


Jet Type Vacuum Pump
Condensate Discharges to Boiler
Vacuum Being Drawn

Figure 32.


While the pump is operating to discharge condensate to the boiler, it is also drawing a vacuum on the system. It is possible for this vacuum to drop to a level that would cause pumping problems. For this reason, a vacuum breaker set to open before this takes place is usually installed at the vacuum pump inlet.

The pump may be called upon to operate by the system vacuum switch, even though there is no need to return condensate. Should the system vacuum rise to the cut-in setting of the vacuum switch, the pump will recirculate upper tank water, drawing air from the lower tank through the vacuum jets until the vacuum switch is satisfied.

The vacuum switch and float switch are electrically connected in parallel to provide for controlling the condensate and system vacuum independently as described.

Other vacuum pump constructions using the jet vacuum producer are available. One of these is shown in Figure 33. Notice that separate condensate return and vacuum producer pumps are employed. Combinations of this type are used in larger systems requiring higher vacuum, large air capacity or where the condensate must be discharged to high pressure boilers.
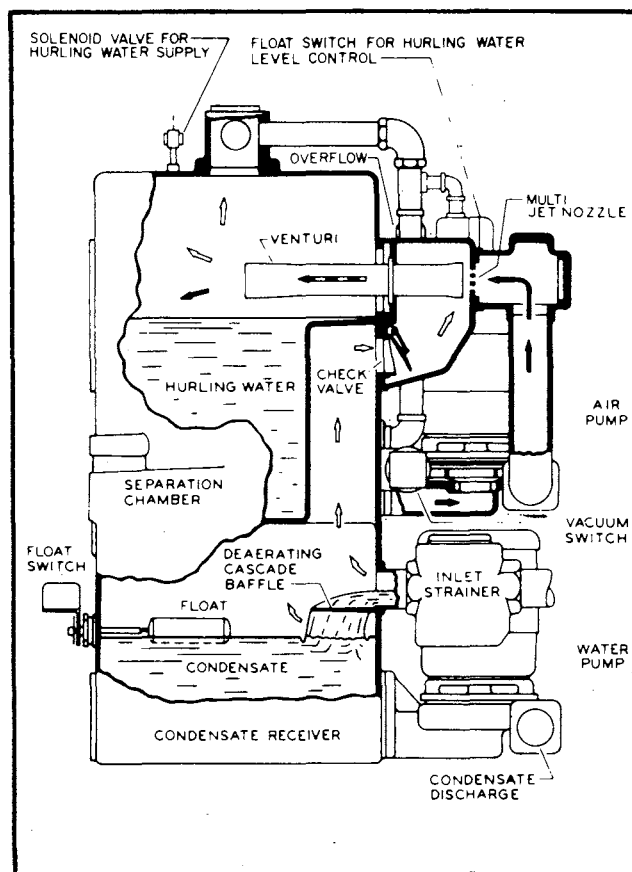


Jet Type Vacuum Pump
Two Pump Type

Figure 33.

The hurling water supply is separated from the condensate and is maintained by a solenoid valve actuated by a float switch. Where high vacuum is to be maintained, the hurling water is sometimes maintained at some predetermined maximum limit. This is done by using a thermostat in the separation chamber to admit cooling water as needed through the solenoid valve. An overflow connection maintains the hurling water at the proper level.

The hurling water pump is cycled by an electric switch actuated by system vacuum. This vacuum is drawn through a connection to the condensate receiver. A check valve at the vacuum connection outlet closes off when the hurling water pump shuts down, maintaining the system pressure differential.

Condensate drains into the receiver, with the water pump discharging from this point to the boiler. A float switch in the receiver actuates the water pump.

## Boiler Accessories

Steam systems lose some water during operation due to venting, blow-down and possible leakage. As a result, provision must be made for the addition of make-up water. The boiler must also be protected from damage should a low water condition occur while the boiler is being fired.

The accessories used to automatically perform those functions are boiler water feeders, low water cut-offs or a combination of both in one control.

Some systems add make-up water to the condensate receiver and use a water level sensing switch on the boiler to actuate the boiler feed pump to bring that water to the boiler. This switch is known as a pump control. Both low and high pressure steam systems incorporate this type of make-up arrangement.

A steam boiler with a water feeder and pump control is shown in Figure 34.



CITY WATER SUPPLY
SAFETY FEEDER
CHECK VALVE
PUMP CONTROL
BOILER WATER LINE
PUMP CONTROL LEVEL
FEEDER CLOSING LEVEL
BY PASS
DIRECT FEED TO BOILER
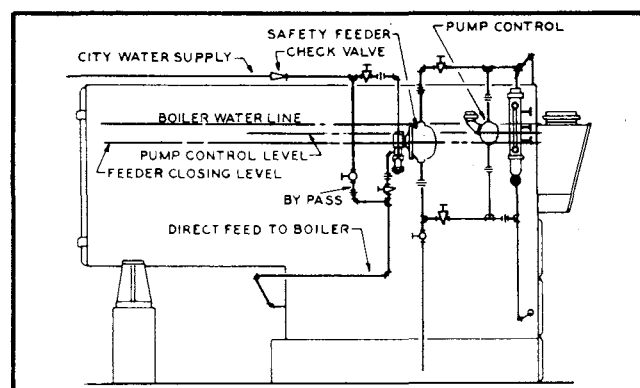
Steam Boiler Controls
Typical Installation

Figure 34.

A combination water feeder and low water cut-off is shown in Figure 35. This is installed in an equalizing line on the boiler so that the float can sense the boiler water level.

Heavy duty float for high pressure service.

Dependable low water cut-off switch.

All working parts isolated from heat of float chamber.

Ingenious toggle multiplies float power at instant of closing or opening.

Slot and roller construction assures straight thrust of valve stem.

Heavy duty hydraulic bellows, built for higher pressures, eliminate packing. Special spring-cushioned bellows for higher steam pressure service.

Large, accessible, built-in strainer protects feed valve.

Combination Water Feeder and Low Water Cut-off

Figure 35.

A make-up water feeder does not act to maintain the normal boiler water line, which should be at the center of the gauge glass. On initial firing, the water level tends to drop somewhat below normal until the condensate begins to return and provision must be made for this in establishing the feeder operating level. A marker on the float bowl casting indicates the feeder closing level. Feeders are usually installed with the closing level 2" to 2-1/2" below normal water line, but not lower than 1" of water in the gauge glass.

Should the boiler water level drop below this point, the float of the feeder will drop and open the valve. Water enters through the strainer, stopping when the feeder closing level is reached. The valve as just described would comprise a make-up water feeder.

A low water cut-off switch can be added to such a water feeder to make it a combination control. A linkage from the float lever operates this switch so as to open its contacts on a drop in boiler water level. A drop in boiler water level to 3/4" below the feeder operating level causes this switch to open and shut down the burner until the water feeder re-establishes a safe operating level. A rise in water level of 1/2" over the cut-off level causes this switch to make its contacts and restart the burner.

Low Water Cut-offs

Some boilers require separate low water cut-offs. One of these is shown in Figure 36. The control should be installed so as to have the cut-off level marker on the float bowl about 1/2" higher than the lowest visible point in the sight glass. The control will shut down the burner when the boiler water reaches this level and restart it on a 1/2" increase in boiler water level over this point.
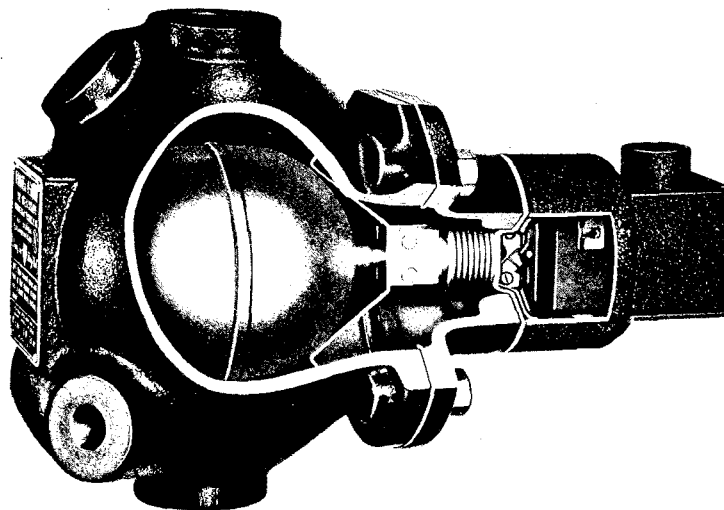
Low Water Cut-off

Figure 36.

Pump Controls

Pump controls are usually furnished with auxiliary switches which also enable them to function as low water cut-offs. An example of such a control is shown in Figure 37. The control has two mercury switches each of which operates independently. One starts and stops the boiler feed pump, the other serves as low water cut-off and alarm switch.
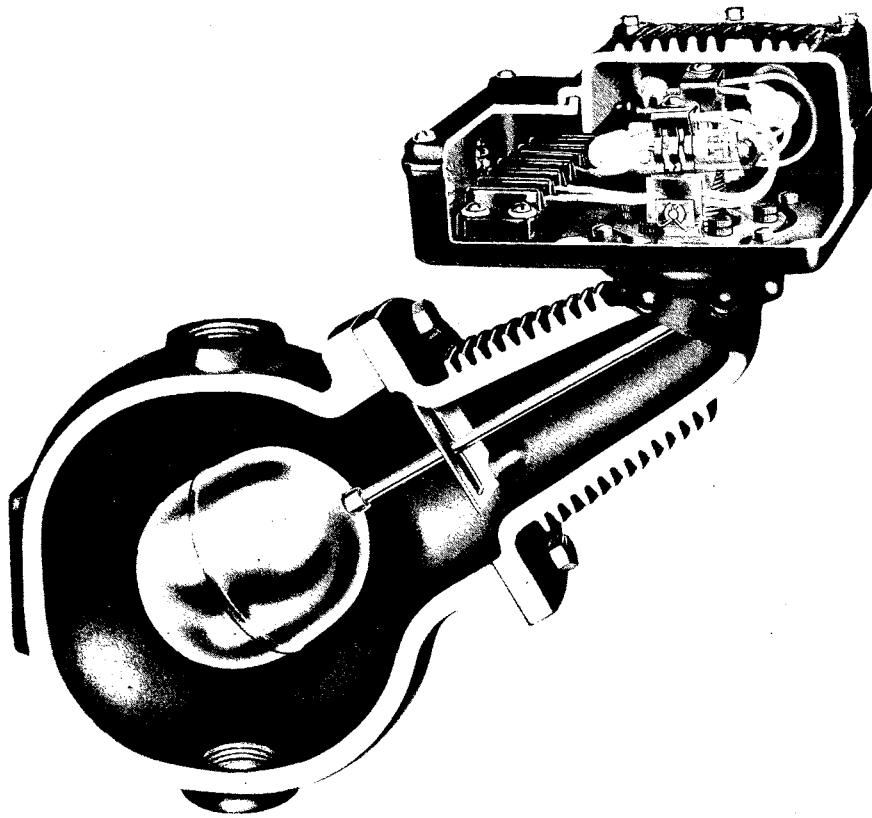
Pump Control and Low Water Cut-off

Figure 37.

        A marker on the float bowl casting indicates the low water cut-off level.
When used as a pump control, the marker should be about 1-1/2" to 2" below
the normal boiler water level but never lower than 3/4" of water in the gauge
glass.  The boiler feed "cut-off" level will be 1-1/2" above the marker and
the "pump-on" level will be 3/4" lower than this.  Where the boiler feed pump
is operated by a pump switch, a make-up water feeder is installed in the re-
ceiver.

        With this arrangement, the pump switch and low water cut-off act
to control condensate return to the boiler and also to shut down the burner
should a low water condition occur.  As the need for make-up water appears,
this will show up as a drop in the water level in the receiver.  The make-up
water feeder located at this point will then add water as needed to insure that
there will always be a reservoir of water for the pump.

## Electric Water Feeders

In addition to strictly mechanical water feeders, electrically operated water valves are used to supply make-up water directly to low pressure steam boilers under 5,000 sq. ft. of radiation. These valves are actuated by a low water cut-off switch.

The construction of an electric water feeder is shown in Figure 38. A solenoid coil, available for 24 or 115 volt operation, opens the valve in the manner shown when it is energized, causing water to be added to the boiler. Any low water cut-off with the proper auxiliary switch can be used to operate the valve.

Button for manual feeding

Removable end plate for easy wiring

Powerful iron-encased coil

Packless (bellows) construction

Large integral strainer

Compound leverage, spring loaded, for powerful opening and closing

McDonnell self-centering roller provides straight-thrust valve action

Stainless steel valve

Large streamlined waterways
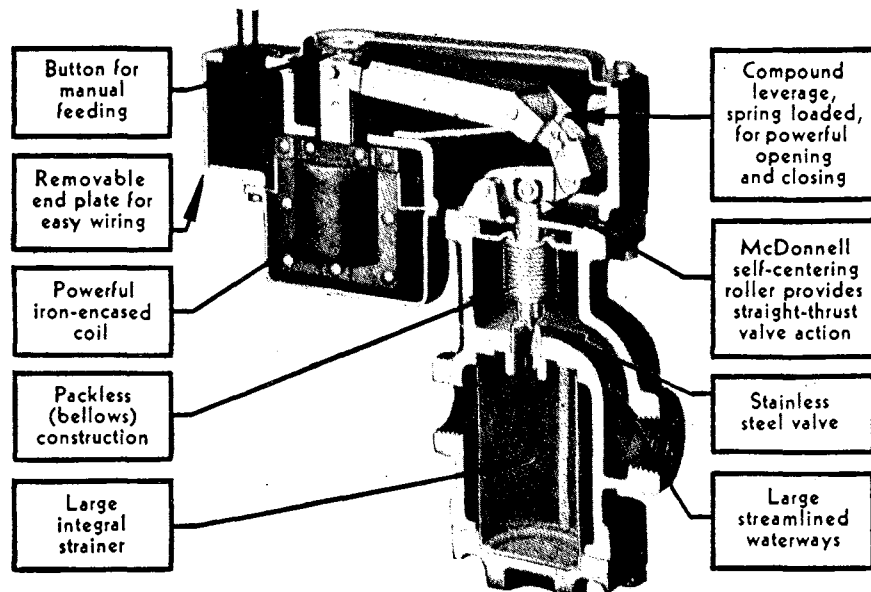
Electric Water Feeder Valve

Figure 38.

The low water cut-off level marker on a properly installed low water cut-off will be about 1/2" above the lowest visible point in the sight glass. Should the water level fall to within 1/2" to 3/4" of the marker, the auxiliary switch will close its contacts. The electric water feeder will open adding water to the boiler. The cut-off level of the switch is 1/2" to 3/4" higher than the cut-in level and the electric water feeder will close when this boiler water level is reached.

## Strainers

Boiler water contains a great amount of sediment. It is important that larger particles be kept out of the working parts of boiler controls. Strainers, either integral or external, are extensively used for this purpose. A good example of an integral strainer is given in the combination control pictured in Figure 35.

External strainers are available in many shapes and sizes to fit various applications. One thing they must all have in common is accessibility of the strainer for cleaning and provision for blow-down of accumulated sediment. The most commonly used steam strainer is the "Y" type, pictured in Figure 39. These strainers are furnished with either mesh type or perforated metal screens in a wide variety of openings.
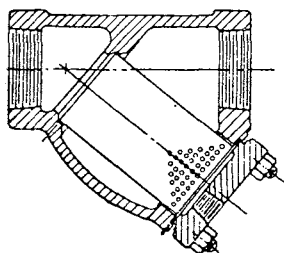


Typical Steam Strainer

Figure 39.

The tapping in the strainer cover permits installation of a blow-down valve. The strainer screen may be removed for inspection or replacement by taking off the screen cover. In smaller strainers, the access cover is screwed into place. Strainers are identified by line size and the mesh or perforation size required.

## Pressure Regulating Valves

Steam heating systems do not always receive steam from a boiler installed on the premises. Often the boilers are in a remote area, generating steam at a higher pressure than can be used in the heating system.

Where this is done, the pressure of the steam must be reduced before it is introduced to the heating system. Pressure reducing valves are used for this purpose. These valves have the capability to reduce the pressure of fluids from a high initial pressure to a controlled lower pressure. The fluids may be of any type, such as steam, air, water or fuel gases.

Pressure reducing valves operate on the principle of balancing the controlled pressure against a known, adjustable pressure. This is usually accomplished through the flexing action of a diaphragm, which controls flow through the valve port through an appropriate linkage. The construction of these valves follows a number of patterns, depending upon the results to be accomplished.

Figure 40 illustrates the operating principle involved. Controlled low pressure is sensed by the diaphragm through a "feeler pipe". A needle valve in this line acts as a damper to prevent rapid pressure fluctuations. The controlled pressure acts to close the valve while the spring tends to open it. It therefore follows that the controlled pressure can be regulated by varying the spring pressure and a means is provided for doing this. A bypass is usually installed around the valve to permit manually controlled flow should the valve require service.
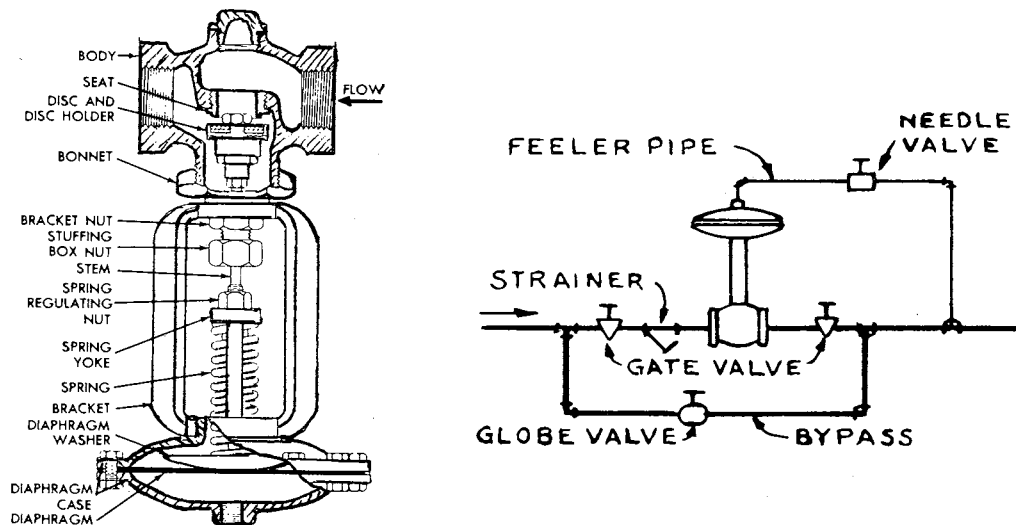


Typical Diaphragm Type Reducing Valve Composition Disc

Figure 40.

Valves are always installed so as to permit the disc to close _against_ the higher inlet pressure. Flow in the reverse direction causes "valve slam" or "chatter" on closing. The valve disc in Figure 40 is a single-seated composition disc type. Composition disc valves are limited to the control of inlet or initial pressures not to exceed 50 psig.

Where higher pressures are to be controlled, metal to metal valves are employed. Figure 41 shows this construction.
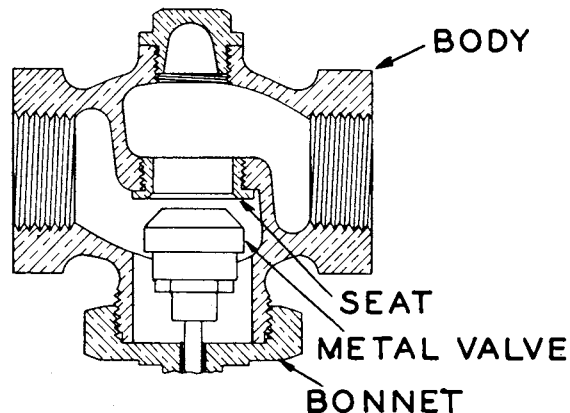


Single Seated Valve Construction
Metal Seat and Disc

Figure 41.

Valves are also furnished in double seated construction. Two ports and two discs are used to provide balanced hydraulic pressures on the valve stem. As shown in Figure 42, water entering the valve body provides a closing force on one disc and an opening force on the other. The lower disc is a bit smaller than the upper to provide clearance for inserting it into the valve body. The difference in disc areas results in a very small pressure unbalance when the valve is closed.
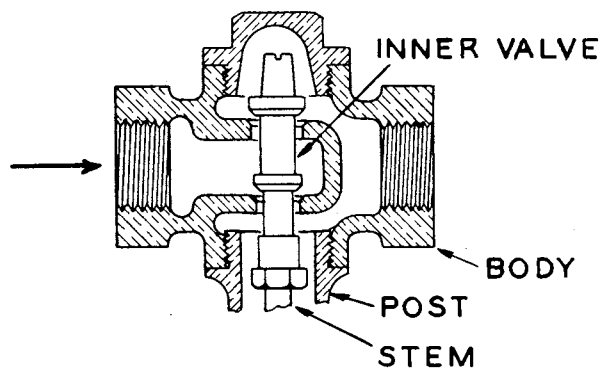


Double Seated Valve

Figure 42.

Fully balanced valves can be constructed by using the principle illustrated in Figure 43. This is a single seated valve with an internal pilot operating the main disc. A drop in controlled pressure causes the pilot valve to open its port. Fluid entering the port pushes the piston upward, opening the main valve. The areas of the main valve disc and the piston are the same, resulting in balanced valve action.



PISTON TYPE
VALVE

BODY

SEAT

PILOT VALVE
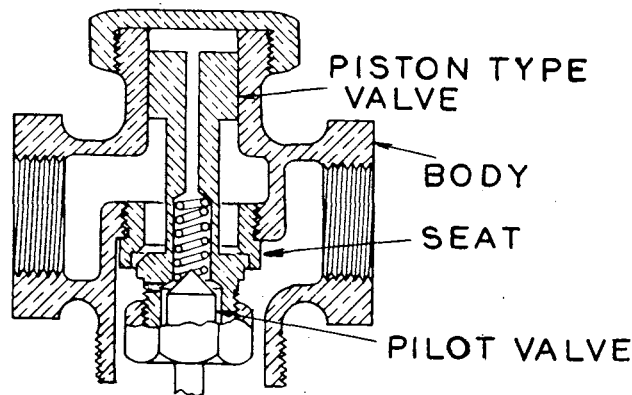
Internal Pilot Operated Valve

Figure 43.

Another commonly used single seated valve is the ball type with spring return shown in Figure 44. The ball valve is held closed by its return spring and pushed open by the valve stem on a drop in the controlled pressure. The valve shown in the illustration is of the self contained type, with the controlled pressure acting on the bottom of the diaphragm against the spring pressure at its top.

The required opening and closing of the valve has an effect on the forces acting on the diaphragm. The spring pressure varies as the diaphragm flexes and this effects valve regulation. The internal pilot port area is small. This permits reasonably low spring rates which do not vary the controlled pressure as much as those required for direct acting valves.

Another approach to closer pressure regulation is the use of a weight and lever to provide the needed operating force. Figure 45 shows a lever type pilot operated valve. The controlled pressure is adjusted by moving the weight as needed on the lever. The relatively constant pressure exerted by the weight and lever coupled with the sensitivity of the pilot valve provides close control. Weight and lever valves are usually limited to applications with reduced pressures under 15 psig. For higher reduced pressure on the diaphragm, the weight and lever required becomes impractical. Regulation also suffers because of the heavy friction load on the fulcrum pins.

REGULATING
SCREW AND
LOCK NUT

SPRING CASE

SPRING

DIAPHRAGM

STEM

BODY

SEAT

BALL
VALVE

BOTTOM
SPRING
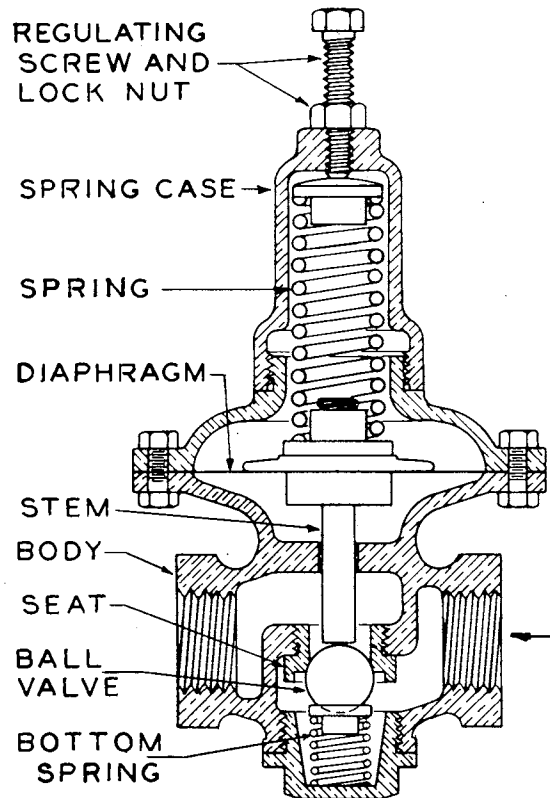
Ball Type Spring Return Valve

Figure 44.

Single seated valves are always used where absolutely tight shut-off, called "dead end service", is required.  They can also be used for "continuous flow" service.

Double seated valves have greater capacities than single valves for a given line size.  Because of their service - balanced construction, they do not require as much power for operation.  This allows for the use of smaller diaphragms.  They cannot, however, be used for "dead end" operation. These valves allow a slight amount of leakage in the closed position due to the difficulty encountered in getting both discs to seat simultaneously.  For this reason, their application is best confined to load conditions which are constant and variable in nature.

TOP BONNET

MAIN VALVE

BODY

MAIN SEAT

PILOT VALVE
AND STEM

VALVE BONNET

BRACKET

STUFFING
BOX NUT

WEIGHT & LEVER

DIAPHRAGM CASE

DIAPHRAGM
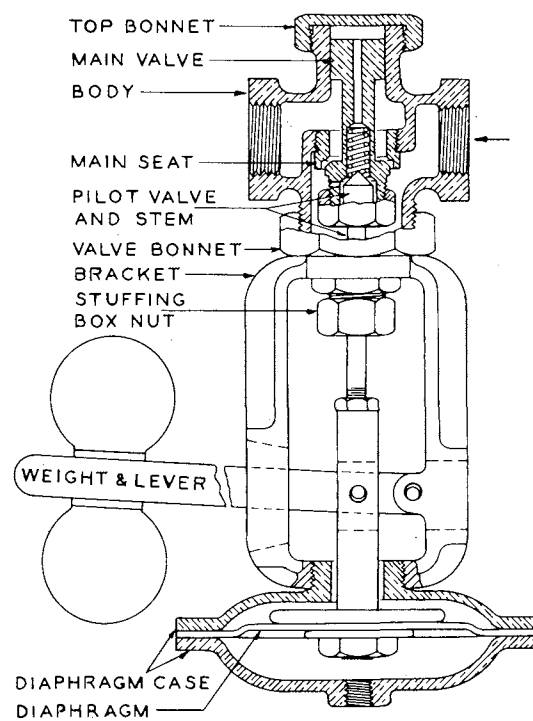
Internal Pilot Operated Weight and Lever Valve

Figure 45.

Steam boilers are furnished in a large variety of sizes and types. This discussion will deal with those designed for primary application in steam heating systems. Such boilers are usually classified into residential and commercial types.


## Low Pressure Boilers - Rating Basis

All steam boilers for pressures not exceeding 15 psig and all hot water boilers for pressures not exceeding 160 psig are classified as low pressure boilers by the ASME Boiler Code. Maximum operating temperature for either type is limited by the code to $250^{\circ}$ F.

Low pressure steam boilers are rated by the following organizations:

| | |
|---|---|
| Gas Fired Boilers - | American Gas Association (AGA) |
| Cast Iron Boilers - | Gas Appliance Manufacturers Association (GAMA) |
| Packaged Firetube - Boilers | Packaged Firetube Branch of American Boiler Manufacturers Association (ABMA) |

Various methods for rating boilers were developed within the industry to provide for proper sizing of boilers to specific load requirements. For many years it was common to specify boiler capacity in terms of "boiler horsepower", with 1 HP being equivalent to 33,475 BTUH. This practice was established when boilers were used primarily for furnishing steam to engines.

When these boilers were applied to heating systems, the term "Square Foot of Equivalent Direct Radiation" came into widespread use for rating boilers. This is defined as the amount of surface that will emit 240 BTUH at a steam temperature of $215^{\circ}$ F. and a room temperature of $70^{\circ}$ F. Steam heating boilers have come to be rated in terms of the square feet of radiation (EDR) that they are capable of handling.


## Published Boiler Ratings

The boiler rating constitutes the manufacturer's stated capacity of a boiler in accordance with industry imposed limiting conditions. The ratings of interest in applying the boiler are:

## Gross Boiler Output

The gross boiler output signifies the total heat available from a boiler operating under the limitations of rating code for which it is stamped. The gross output is never referred to as a rating, since it includes an allowance for pick-up and piping tax in addition to the actual radiation load.

The piping tax is an arbitrary allowance to compensate for the heat losses imposed on a system by a normal amount of insulated piping. The pick-up allowance is an arbitrary allowance to compensate for the additional load imposed during warming up periods. This allowance varies with the rating agency involved.

## Net Boiler Rating

The net boiler rating is the actual heating load that a boiler is capable of handling. It includes:

    1.    All connected radiation at design temperature, as
          determined by accepted practice.

    2.    The estimated heat required by a connected water
          heater or other connected appartaus.

Adding the piping tax and pick-up load allowance to the net rating provides a total which is the Gross Boiler Output.

Net ratings are derived by applying a divisor to the Gross Boiler Output. The Gross Boiler Output is derived by testing the boiler under the conditions required by the rating association.

For example, boilers rated by the SBI arrive at the net rating by dividing the Gross Output by 1.333. A boiler with a Gross Output of 1,800,000 BTUH is determined by test, would have a net rating of:

$$1,800,000 \div 1.333 = 1,350,000 \text{ BTUH}$$

Converting to EDR, we have a neting rating of:

$$1,350,000 \div 240 = 5,625 \text{ Sq. Ft. EDR}$$

SBI catalog ratings are based on the net load. These ratings are obtained from the manufacturer's catalogs, from published SBI ratings or from recommendations of the Mechanical Contractors Association of America. Unless the system contains an unusual amount of bare pipe or the nature of the connected load in such that the normal allowances for pick-up are inadequate, the net load rating is used for selecting the boiler.

Where unusual circumstances apply, the load should be calculated taking all factors into consideration and the selection based on the gross output.

Like steel boilers, cast iron boiler net ratings are available from manufacturer's catalogs. They may also be obtained from published tables of the IBR or Mechanical Contractors Association of America. These published net ratings may be used for selecting the boiler unless the system has more than the average amount of bare pipe or the nature of the connected load is such that normal allowances for package load and piping tax do not apply. In such a case, the selection is best made on the basis of the gross output.

Packaged Firetube Boiler ratings as published by the American Boiler Manufacturers Association are Gross Output ratings. The entire connected load should be calculated, including the Radiation Load, Hot Water Supply Load, Pick-up Load and Piping Tax. The total of these loads is then used to select the boiler based on the Gross Output.

## Boiler Construction

Although there are a great number of individual boiler types in use, they can be classified into three general categories:

1.  Fire Tube Boilers
2.  Water Tube Boilers
3.  Cast Iron Boilers

This discussion will be confined to these principal types.

## Firetube Boilers

One of the most widely used boilers of this type is the horizontal return tube type shown in Figure 46. The combustion gases move along the bottom of the boiler on the first pass and return through the firetube on the second.
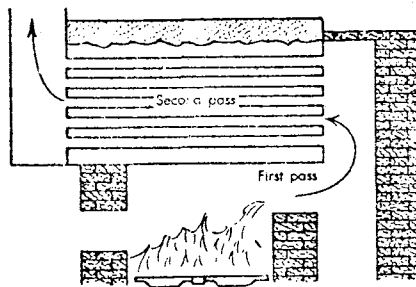


Horizontal Firetube Boiler

Figure 46.

The water circulation patterns in two types of horizontal return tube boilers is shown in Figure 47.



Staggered Tube
Arrangement

Baffled Parallel
Tube Arrangement
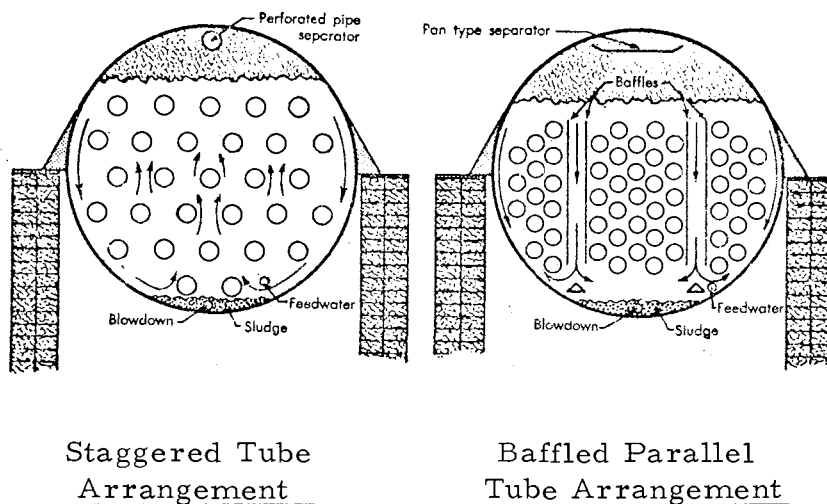
Water Circulation in Horizontal Return
Tubular Boiler

Figure 47.

During World War II, the need for a compact shipboard boiler resulted in the development of the Scotch Marine Boiler in Scotland. The basic construction consists of a large firetube in which the combustion takes place, surrounded by smaller firetubes through which the combustion gases travel. Figure 48 shows the basic principle involved.
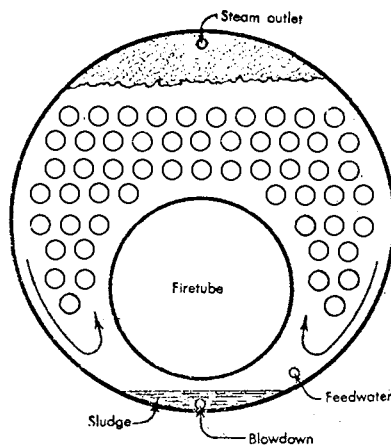


Basic Construction
Scotch Marine Boiler

Figure 48.

Many variations of the Scotch Marine Boiler have been developed. Typical constructions are shown in Figure 49. In the three pass category, a number of designs are used that are basically firebox types as distinguished from the internal furnace type. One of these is shown in Figure 50. This boiler has a flat bottom and vertical sides going into an arched crown sheet that forms the top.



WET-BACK, TWO-PASS, OIL- OR GAS-FIRED

DRY-BACK, TWO-PASS, OIL- OR GAS-FIRED
CORRUGATED FURNACE

WET-BACK TOP, TWO-PASS, OIL- OR GAS-FIRED

DRY-BACK, TWO-PASS, COAL-FIRED

DRY-BACK, THREE-PASS, OIL- OR GAS-FIRED

DRY-BACK, THREE-PASS, OIL- OR GAS-FIRED
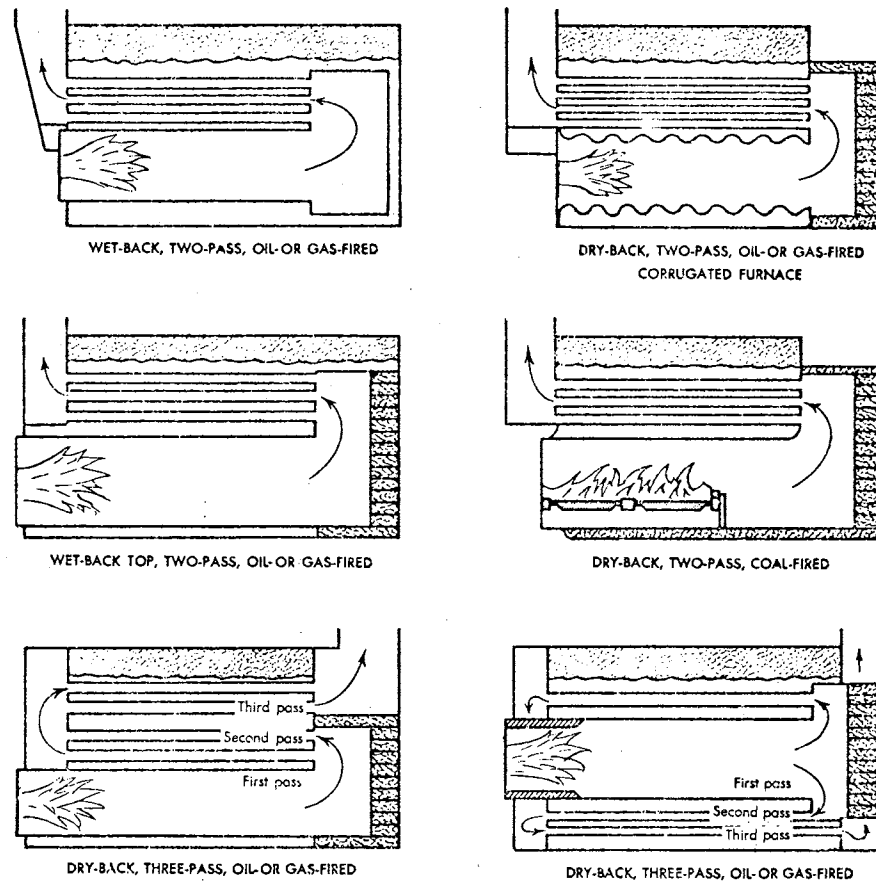
<u>Marine Scotch Boiler Types</u>

Figure 49.

The Scotch Marine Boiler is particularly adaptable to the package concept. This is furnished complete with fuel burner, draft fan, feed water pump and other needed accessories. Figure 50 is typical of such packaged boilers.

Scotch Marine Boilers are rated according to standard SBI rating methods.
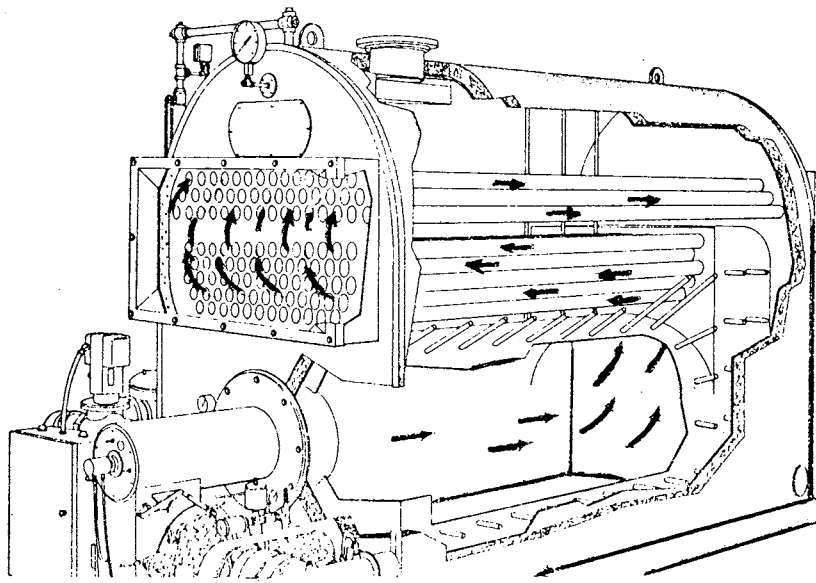
Scotch Marine Boiler
Three Pass Construction

Figure 50.


Another boiler type commonly used in heating installations is the short firebox boiler illustrated in Figure 51. The front portion of the shell sits over the furnace. Combustion gases pass through the short tubes of the first pass and exit via the second pass above the first pass. These are furnished as either brick-set or waterleg types. The boiler shown is brick-set with a steel jacket fitted over the boiler.

The waterleg type has waterlegs on each side of the firebox as shown in Figure 52. in place of the brick lining.

Another boiler popular for large apartment and institutional heating is the compact firebox type illustrated in Figure 53. This is a three pass boiler including the first pass through the combustion chamber. The boiler illustrated is a waterleg type with a refractory combustion chamber for oil firing. These boilers are also furnished as brick-set types.
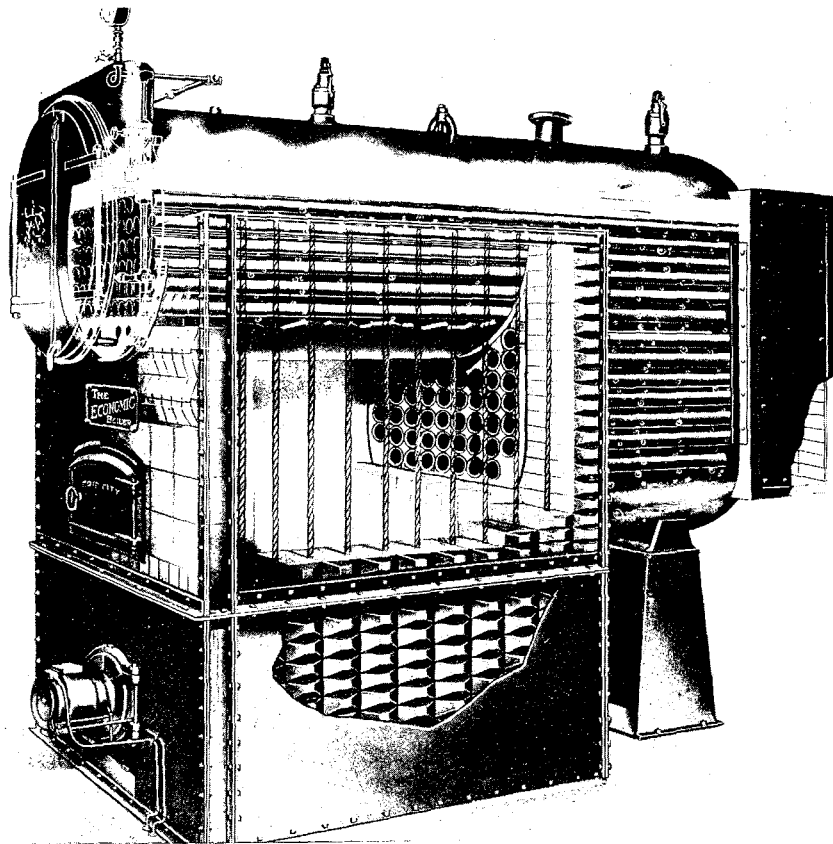
Short Firebox Boiler
Brick-Set - Steel Encased

Figure 51.
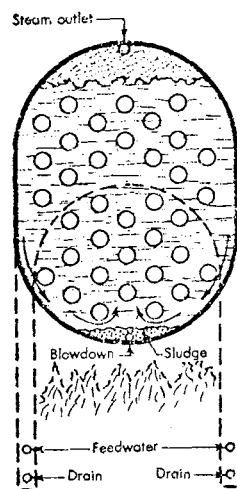


Waterleg Type
Short Firebox Boiler

Figure 52.

47
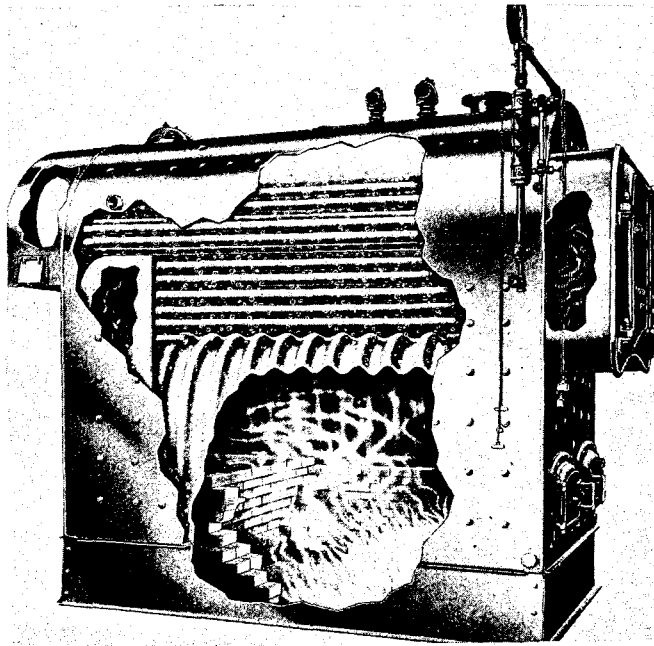
Compact Firebox Boiler

Figure 53.

## Water Tube Boilers

Water tube boilers are used primarily as large, high pressure boilers. Some steel water tube boilers are found in the low pressure (15 psi) heating field in smaller sizes.

A limited discussion of this boiler type is in order because of the small number of these installations in the heating field.

Figure 54 shows a cross section of a horizontal straight tube boiler, detailing the circulation. Combustion gases pass over the steel boiler tubes, heating the water within them. The heated water and steam flow to a header or drum, from which the steam is drawn. This boiler type is sometimes furnished as a packaged type. One is illustrated in Figure 55.
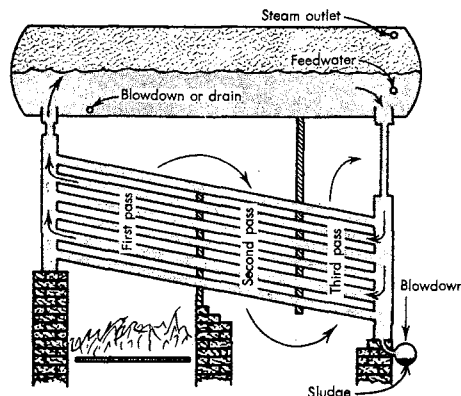


Horizontal Straight Tube Water Tube Boiler

48
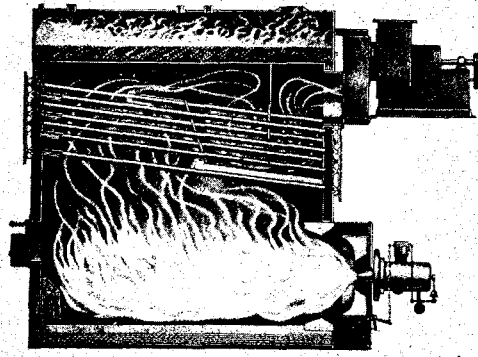
Figure 54.

Packaged Water Tube Boiler

Figure 55.


Larger steam generators are furnished with water wall construction as shown in Figure 56. The boiler shown has two headers. Water flow is from the lower to the upper drum, with steam being generated in the tubes as the water rises through them. The steam is then taken off the upper drum or header. These larger steam generators are often furnished as packaged units.
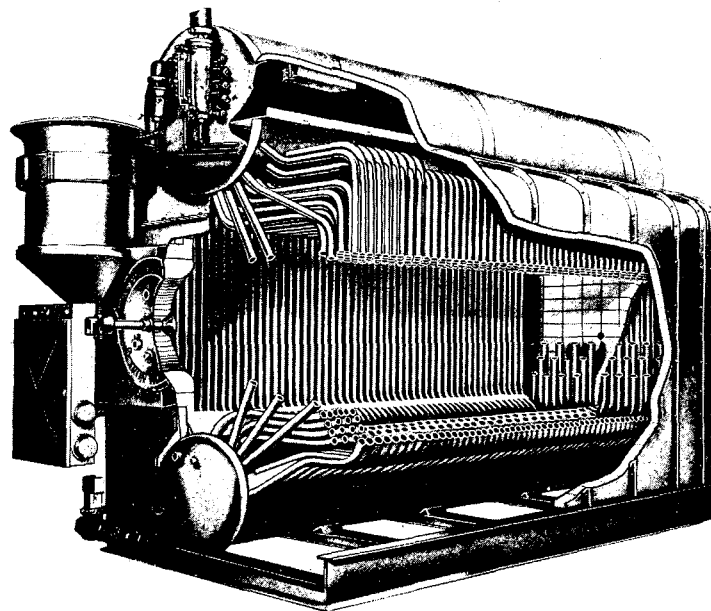


Water Wall Type Water Tube Boiler

Figure 56.

## Cast Iron Boilers

Cast iron boilers are constructed in two general types:

1.      The round boiler, used primarily for residential applications.

2.      Sectional boilers, used for all applications.

Cast iron boilers are used primarily for low pressure systems; up to 15 psig for steam and 30 psig for water. A sectional boiler of the push-nipple type is shown in Figure 57. The vertical sections are connected at the bottom waterlegs and at top center by push-nipples. The sections are drawn together by tie rods. The tie rod ends and one of the tie rods can be seen in the illustration.
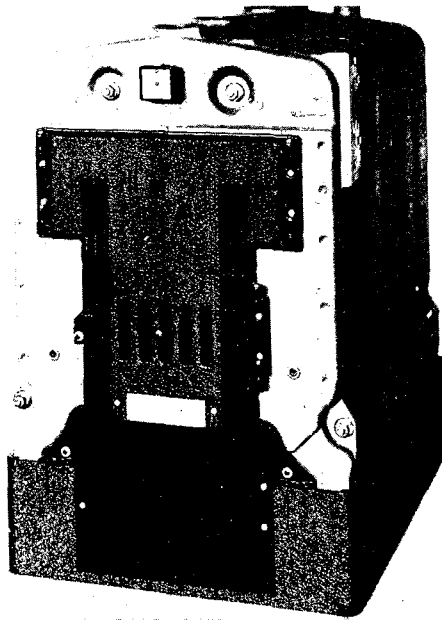


Cast Iron Boiler
Vertical Section Push Nipple Type

Figure 57.

Large cast iron boilers are often of the external header or drum type. One of these is shown in Figure 58. The cast iron sections are individually connected to the header drums with screwed nipples. This permits quick replacement of a damaged section without dismantling the boiler. The appearance of this boiler type when completely assembled is shown in Figure 59.
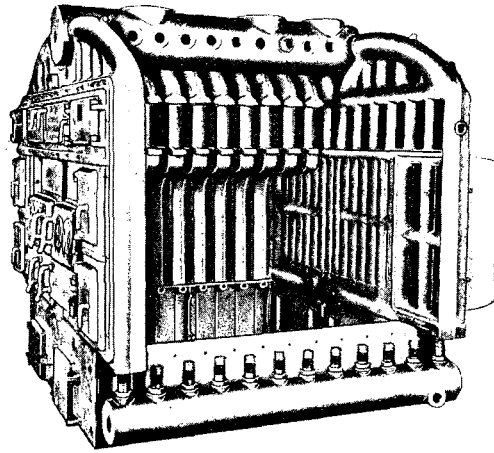


Cast Iron Boiler
Vertical Section External Header Type
Partly Assembled

Figure 58.
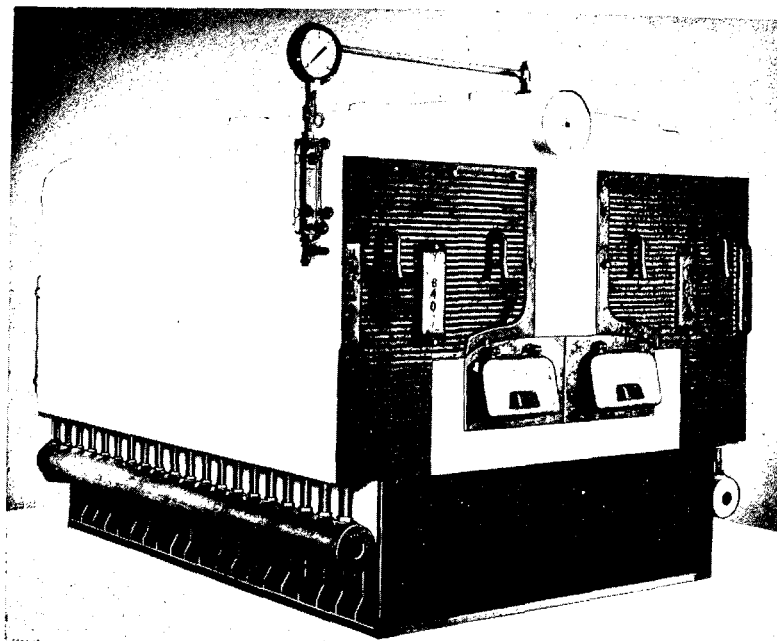


Cast Iron Boiler
Vertical Section External Header Type
Completely Assembled

Figure 59.

The selection of the proper steam control for a given application requires the consideration of a number of variables. The control type involved also deserves separate consideration. These factors will be explained in this chapter, taking the controls in the same order in which they appeared in Chapter 3.

## Radiator Supply Valves

Four factors should be considered in the selection of a radiator supply valve:

1. System Type
2. Operating Pressure
3. Pipe Size
4. Body Type

## One-Pipe Systems

Any angle pattern, non-modulating valve may be used. The valve should be full riser size and installed as shown in Figure 60. If the system is fitted with vacuum type radiator vents, the valve should be of the spring loaded packing or packless type to prevent loss of vacuum past the valve stem. Conventional packing type valves may be used where non-vacuum systems are involved.



UPFEED CONNECTION TO RADIATOR.
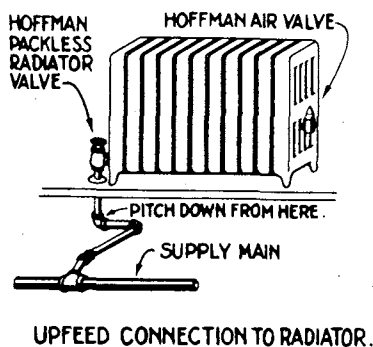
One-Pipe Steam System
Upfeed Radiator Connection Detail

Figure 60.

## Two-Pipe Systems

The supply valve must be full riser size. Vacuum systems should be fitted with spring-loaded packing or packless type valves. The standard packed type construction may be used on non-vacuum systems.

The valve body configuration may be of the type which best fits the job piping requirements. Figure 61. shows an angle type valve installation. Modulating type valves may be used where control of the radiator output is desired. These open fully with one turn or less and are equipped with a dial and pointer for visual regulation.

HOFFMAN SUPPLY VALVE

HOFFMAN TRAP.

SUPPLY MAIN    RETURN MAIN.
UPFEED CONNECTIONS TO RADIATOR.
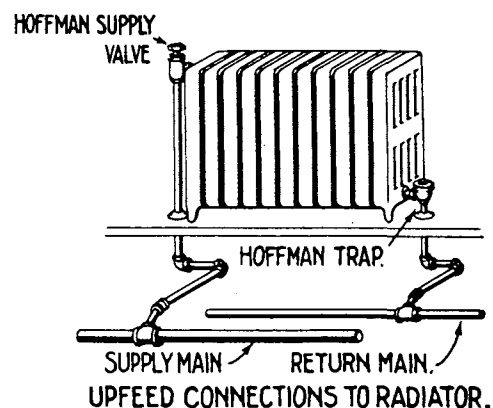
Two-Pipe Steam System
Upfeed Radiator Connection Detail

Figure 61.

## Vent Valves

The choice of vent valves requires that the following factors be considered:

1.    Type of Equipment to be Vented
2.    Operating Pressure
3.    Maximum Working Pressure
4.    Venting Rate Required
5.    Vacuum or Non-Vacuum System

Radiator Vents

Vents used with conventional free standing cast iron radiators are of the angle type, being screwed into a side tapping of the radiator as shown in Figure 60. The vent must be rated at an operating pressure equal to or greater than that of the system. Radiator vents have two pressure ratings:

1. Operating Pressure - The maximum pressure at which the vent will perform its function.

2. Maximum Pressure - The maximum pressure that can be applied to the valve.

The venting rate may be adjustable or non-adjustable. The non-adjustable type are used where the steam distribution on start-up is no problem. Adjustable vents should be used on systems where variations in circuit lengths result in similar variations in venting of system air. Under these circumstances, the radiators more remote from the boiler will be the last to heat. The installation and proper adjustment of adjustable vent valves results in a better balanced system.

One-pipe systems that operate at atmospheric pressure to pressures of about 2 - 3 psig use open type vents. As the steam in the system condenses on the off cycle, these vents allow air to be drawn into the system. This air is vented on the next firing cycle.

One-pipe systems which operate in the vacuum range during a portion of their heating cycle have been in use for many years. These systems operate well when coal-fired. When enough heat is present in the fuel bed, the system operates at above atmospheric pressure. As the fire diminishes; the rate of steam generation decreases. Check valves in the radiator vents prevent air from being aspirated as the steam condenses and a gradual vacuum forms in the system. The decreased pressure allows the continued production of steam at a lower temperature. The radiators remain warm over a longer period of time, resulting in good temperature control.

The system, commonly called a "vapor vacuum system" does not lend itself well to gas or oil fired boiler operation. During mild weather the firing cycles may be too short to allow the steam to completely purge the system of air. On the off cycle, this air will expand as the system drops to a vacuum, often to the extent that it will creep into the mains. Repeated short cycling in this fashion will result in an air-bound system with poor heat distribution.

For this reason, the use of vacuum type radiator vents with one-pipe oil or gas fired systems is not usually recommended.

Vents with convector radiators are of the straight shank type, installed as in Figure 62. The nature of this radiator type makes it necessary to install the vent at its top. In order to provide quick venting, an air chamber should be installed. The air collecting in the chamber will permit cooling of the thermostatic element in the vent, necessary for proper venting action. This illustration also points out the need for pitching the radiators in one-pipe systems to the riser.
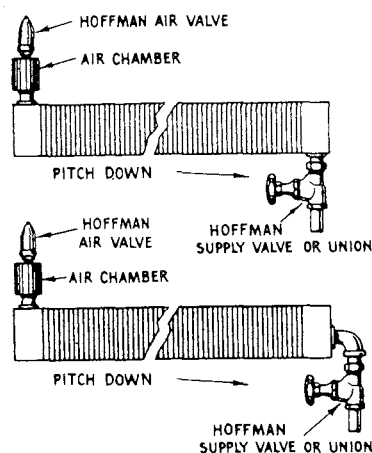


One-Pipe Steam System
Upfeed Convector Connection Detail

Figure 62.

## Main Vents

Main vents are always of the non-adjustable type, as their function is to remove air as quickly as possible. They are available in various venting capacities to fit the requirements of small, medium and large size systems. As a rule, their venting capacity is so described in the catalog information.

These vents are of the straight shank type. The shanks are both tapped and threaded for either male or female installation. The usual size is 1/2" female by 3/4" male on the shank of the vent. Figure 63 shows a typical installation. The connecting nipple should be at least 6" to 10" long to provide a cooling leg for the vent.
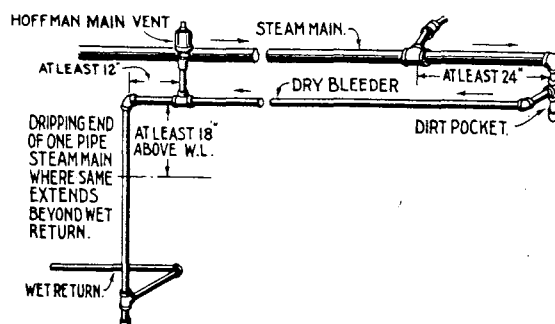
Typical End of Main Vent
Installation Detail

Figure 63.

## Unit Heater Vents

Vents designed especially for use with unit heaters are available. These should be installed as shown in Figure 64, with the vent top level with the top of the unit heater. The 12" drop leg on the return provides enough water head at this point to insure opening of the check valve and provide good condensate drainage.
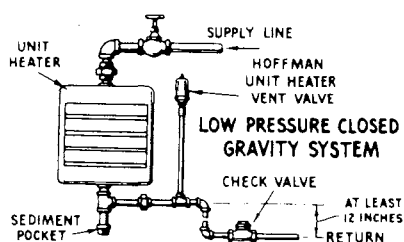


Typical Unit Heater Connection Detail

Figure 64.

Unit heater vent valves are constructed for higher working pressures than are conventional radiator vents. Unit heaters are often installed on high pressure systems, making this necessary. Figure 65 shows an installation of this type. A bucket trap is used here for rapid condensate removal, with a separate air vent to insure quick venting.
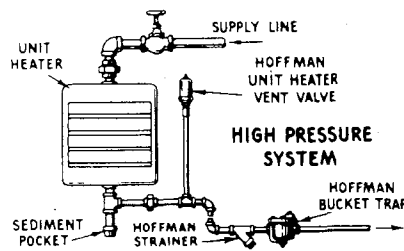
Typical Unit Heater Connection Detail

Figure 65.

## Traps

When determining the proper trap to be used for an application, consideration must be given to a number of factors. The trap type which best fits the application is determined first. Then consideration is given to the pressure differential across the trap, its working pressure and the amount of condensate to be removed.

## Thermostatic Traps

Thermostatic traps perform well where they are used on equipment with large internal volume. Although they are furnished for low, medium and high pressure applications, they are used primarily in the low pressure range. Figure 60 shows the most common application, at the radiator outlet.

They are also commonly used to drip risers and return mains. Typical installations are shown in Figure 66. It is important that a cooling leg be used as shown in the illustration where this is done.
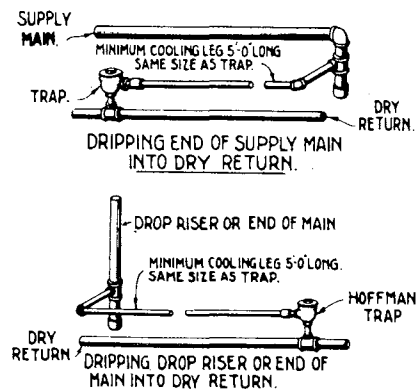


Two-Pipe --- Steam
Trap Installations

Figure 66.

Typical trap selection tables are shown in Figure 67. As a selection example, assume a trap is to be used to drip the end of a downfeed supply riser with a pressure differential of 2 psi and a connected radiation load of 170 sq. ft. The chart tells us that a 17C 1/2" trap will handle 235 sq. ft. at this condition. We would use this trap with the proper body type to fit the riser situation.

**CAPACITY TABLE — FOR LOW PRESSURE THERMOSTATIC RADIATOR TRAPS**

| TRAP NO. | PATTERN | SIZE (IN.) | CAPACITY — SQ. FT. EDR* | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | DIFFERENTIAL PRESSURE ACROSS TRAP — PSI | | | | | | | |
| | | | ¼ | ½ | 1 | 1½** | 2 | 5 | 10 | 15 |
| 17C | Angle | ½ | | | | | | | | |
| | Swivel | ½ | 85 | 120 | 165 | 200 | 235 | 370 | 530 | 640 |
| | Vertical | ½ | | | | | | | | |
| 8C | Angle | ¾ | 165 | 230 | 330 | 400 | 465 | 730 | 1050 | 1300 |
| | Straightway | ¾ | | | | | | | | |
| 9C | Angle | 1 | 290 | 410 | 580 | 700 | 810 | 1280 | 1840 | 2300 |

**MEDIUM AND HIGH-PRESSURE TRAPS**
Capacity Table — Pounds of Condensate Per Hour

| TRAP NO. | PATTERN | SIZE (IN.) | DIFFERENTIAL PRESSURE — PSI | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 5 | 15 | 25 | 50 | 100 | 125 |
| 8 | Angle | ½ | 125 | 225 | 300 | 490 | . . . . | . . . . |
| | Straightway | ½ | | | | | | |
| 9 | Angle | ¾ | 225 | 350 | 450 | 650 | . . . . | . . . . |
| | Angle | 1 | 325 | 500 | 625 | 850 | . . . . | . . . . |
| 8H | Angle | ½ | . . . . | . . . . | 300 | 490 | 650 | 720 |
| | Straightway | ½ | | | | | | |
| 9H | Angle | ¾ | . . . . | . . . . | 450 | 650 | 875 | 950 |
| | Angle | 1 | . . . . | . . . . | 625 | 850 | 1125 | 1250 |

Figure 67.

Float and Thermostatic Traps

These traps are divided into two categories for rating purposes. Low pressure traps, operating at pressure differentials up to 15 psi, are rated at their net ratings. This net rating makes the needed provision for warm-up and no safety factor need be applied. On the other hand, medium and high pressure traps are rated gross. A safety factor must be applied for peak loads. It is common practice to double the operating load to arrive at the peak load for selection purposes. Figure 68 shows typical rating tables.

## CAPACITIES LOW PRESSURE

The capacity ratings of these low pressure traps (max. 15 PSI) are NET RATINGS based on the code established by the Steam Heating Equipment Manufacturers Association (SHEMA). Code ratings provide for overload conditions, such as warming up period. No safety factor need be applied.

| LOW PRESSURE TYPES and NOS. | | CONN. SIZES | PRESSURE DIFFERENTIALS IN LBS. PER SQ. IN. | | | | | | | | LOW, MEDIUM and HIGH PRESSURE WEIGHTS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Float & Thermostatic | Float | | 1/4 lb. | 1/2 lb. | 3/4 lb. | 1 lb. | 2 lbs. | 5 lbs. | 10 lbs. | 15 lbs. | NET | SHIPPING |
| | | | CAPACITIES IN POUNDS WATER PER HOUR | | | | | | | | | |
| 53-FT | 53-F | 3/4" | 70 | 100 | 120 | 140 | 200 | 210 | 220 | 230 | 7 lbs. | 7 lbs. 4 oz. |
| 54-FT | 54-F | 1" | 175 | 250 | 300 | 350 | 500 | 525 | 550 | 575 | 7 lbs. | 7 lbs. 4 oz. |
| 56-FT | 56-F | 1 1/4" | 425 | 600 | 735 | 850 | 1200 | 1260 | 1320 | 1380 | 12 lbs. 10 oz. | 13 lbs. 8 oz. |
| 57-FT | 57-F | 1 1/2" | 850 | 1200 | 1470 | 1700 | 2400 | 2520 | 2640 | 2760 | 19 lbs. 6 oz. | 20 lbs. 10 oz. |
| 58-FT | 58-F | 2" | 1775 | 2500 | 3060 | 3550 | 5000 | 5250 | 5500 | 5750 | 38 lbs. 12 oz. | 39 lbs. 12 oz. |

## MEDIUM & HIGH PRESSURE

The capacity ratings of these medium and high pressure traps are GROSS RATINGS. To provide for peak loads, such as warming up periods, a safety factor must be applied. Peak loads frequently are twice the hourly condensate rate.

| MED. and HIGH PRESSURE TYPES and NUMBERS | | MAX. PRESS. | CONN. SIZES | PRESSURE DIFFERENTIALS IN LBS. PER SQ. IN. | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Float & Thermostatic | Float | | | 1/2 lb. | 1 lb. | 2 | 5 | 10 | 15 | 20 | 25 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 125 |
| | | | | CAPACITIES IN POUNDS OF WATER PER HOUR | | | | | | | | | | | | | | | | |
| 540-FT | 540-F | 30 | 3/4" or 1" | 300 | 405 | 530 | 890 | 1210 | 1485 | 1705 | 1885 | 2010 | — | — | — | — | — | — | — | — |
| 541-FT | 541-F | 60 | 3/4" or 1" | 195 | 265 | 360 | 580 | 770 | 990 | 1110 | 1210 | 1290 | 1430 | 1560 | 1680 | — | — | — | — | — |
| 542-FT | 542-F | 125 | 3/4" or 1" | 110 | 145 | 200 | 320 | 430 | 520 | 605 | 650 | 690 | 755 | 835 | 880 | 950 | 1000 | 1035 | 1080 | 1190 |
| 560-FT | 560-F | 30 | 1" or 1 1/4" | 600 | 880 | 1205 | 1845 | 2560 | 3230 | 3715 | 4100 | 4405 | — | — | — | — | — | — | — | — |
| 561-FT | 561-F | 60 | 1" or 1 1/4" | 360 | 485 | 660 | 1020 | 1430 | 1740 | 1980 | 2200 | 2420 | 2670 | 2910 | 3135 | — | — | — | — | — |
| 562-FT | 562-F | 125 | 1" or 1 1/4" | 200 | 250 | 310 | 455 | 635 | 775 | 915 | 1010 | 1150 | 1270 | 1380 | 1460 | 1575 | 1680 | 1760 | 1865 | 2110 |
| 580-FT | 580-F | 30 | 1 1/2" | 2045 | 2625 | 3660 | 5660 | 7890 | 9440 | 10590 | 11360 | 12095 | — | — | — | — | — | — | — | — |
| 581-FT | 581-F | 60 | 1 1/2" | 1075 | 1300 | 1700 | 2600 | 3750 | 4350 | 4750 | 5050 | 5400 | 5960 | 6500 | 6950 | — | — | — | — | — |
| 582-FT | 582-F | 125 | 1 1/2" | 550 | 750 | 1150 | 1650 | 2250 | 2800 | 3200 | 3440 | 3700 | 4000 | 4350 | 4800 | 5020 | 5380 | 5700 | 6000 | 6600 |

Figure 68.

The tables show differential pressures. What is meant by this term is explained in the following examples:

1.    Return Back Pressure - Assuming a steam supply pressure of 50 psi and a return back pressure of 20 psi, the differential pressure would be 30 psi.

Steam Supply Pressure          50 psi
Return Back Pressure          20 psi
Differential Pressure          30 psi

59

2.  Vacuum Return - The differential pressure of a trap dis-
    charging into a vacuum return is the sum of the supply
    pressure and the pressure in the return.

    | | |
    |---|---|
    | Supply Pressure | 6 psi |
    | Pressure in Vacuum Return is | |
    | 8" Mercury (8 c .49 psig)  = | 4 psi |
    | Differential Pressure | 10 psi |

3.  Lift to Overhead Return - Float and Thermostatic traps
    are often applied to discharge condensate into overhead
    return lines.  The amount of available lift depends upon the
    differential pressure.  1 psi is equal to 2.3 ft., but it is
    customary to two feet of water column for each psi to allow
    for piping pressure drop.  For example:

    | | |
    |---|---|
    | Supply Pressure | 50 psi |
    | Back Pressure | 20 psi |
    | Differential Pressure | 30 psi |

    The maximum lift will be  30 x 2 = 60 ft.

## Selection Example

Select an "F" & "T" trap for a system with 10 psi supply pressure.
The back pressure is 6" mercury column.  The condensate load is 1,000 lbs.
per hour.  Pressure differential:

| | |
|---|---|
| Supply Pressure | 10 psi |
| Vacuum Return (6 x .49 psi) | 3 psi |
| Differential Pressure | 13 psi |

A trap is required for 1,000 lbs./hr. at 13 psi differential pressure.
This is a low pressure trap (under 15 psi) and no safety factor is required. Re-
ference to Figure 53 indicates that the closest selection would be a 560-FT trap
with a capacity of 1,320 lbs./hr. at 10 psi differential.

Traps are never selected by pipe size.  They are selected for capa-
city and should be installed with piping at least full size of the selected trap
opening.  The 560-FT trap has 1-1/4" openings and should be so piped.

## Inverted Bucket Traps

These traps are sized using the same selection procedures outlined
for both Float and Float and Thermostatic Traps.  The seat port opening varies
with the pressure differential with which the valve will operate and the selec-
tion tables reflect this.

60

It is always good practice to install a strainer ahead of traps. Some traps are provided with optional internal strainers which can be removed for cleaning. Another optional feature is a thermostatic element which holds the trap port open a bit after it discharges condensate and the bucket drops. This allows any air entering the trap to vent even though it is in its normally closed position. Should steam reach the thermal element, it will allow the valve port to close. The thermal element and strainer are shown in Figure 69.
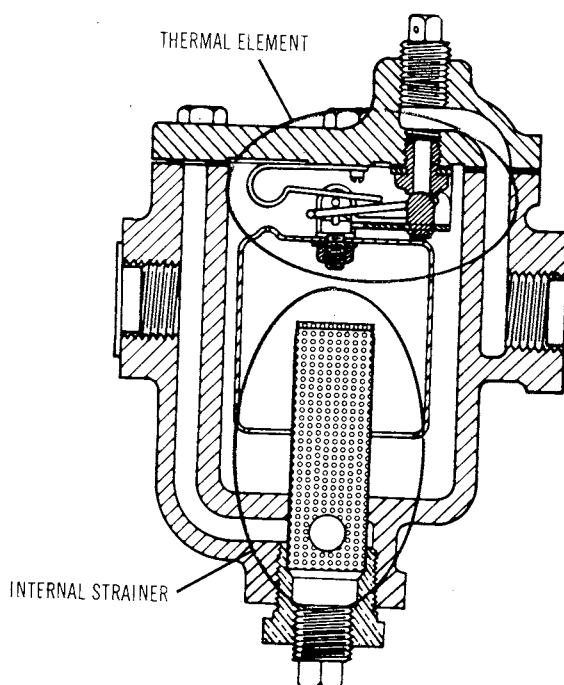


Inverted Bucket Trap with Internal Strainer

Figure 69.

A typical selection table for inverted bucket traps is shown in Figure 70. The catalog numbers designate the construction features of the valve.

A typical bucket trap application appears in Figure 65. Here the trap is used to rapidly discharge condensate coming off a unit heater. The vent valve furnishes additional air venting capacity for fast start-up. The vent valve is elevated to prevent condensate from closing off its float should it back up from the trap.

A safety factor should be applied to the calculated condensate load when selecting an inverted bucket trap. The condensate load should be carefully calculated, since a greatly oversized inverted bucket trap tends to lose its prime and will then continually blow steam. The safety factor usually applied is 2 to 3 times the normal condensate load, depending upon the application.

61

# CAPACITY TABLE

| TRAP | CONN. SIZE | PRESSURE DIFFERENTIALS — POUNDS PER SQUARE INCH | | | | | | | | | | | | | | | |
| | | 30 Lb. Seat | | | | 75 Lb. Seat | | | 125 Lb. Seat | | | 150 Lb. Seat | | 200 Lb. Seat | | 250 Lb. Seat | |
| | | 5 | 10 | 20 | 30 | 30 | 50 | 75 | 75 | 100 | 125 | 125 | 150 | 150 | 200 | 200 | 250 |
| | | CAPACITIES IN POUNDS WATER PER HOUR | | | | | | | | | | | | | | | |
| †601A | ½" and ¾" | 450 | 590 | 770 | 910 | 620 | 740 | 870 | 590 | 660 | 740 | 600 | 660 | 450 | 510 | 415 | 460 |
| †601AS | ½" and ¾" | 450 | 590 | 770 | 910 | 620 | 740 | 870 | 590 | 660 | 740 | 600 | 660 | 450 | 510 | 415 | 460 |
| †601AT | ½" and ¾" | 450 | 590 | 770 | 910 | 620 | 740 | 870 | 590 | 660 | 740 | 600 | 660 | 450 | 510 | 415 | 460 |
| †601AST | ½" and ¾" | 450 | 590 | 770 | 910 | 620 | 740 | 870 | 590 | 660 | 740 | 600 | 660 | 450 | 510 | 415 | 460 |
| †600B | ½" and ¾" | 720 | 900 | 1100 | 1260 | 760 | 940 | 1115 | 870 | 960 | 1050 | 740 | 800 | 800 | 880 | 760 | 840 |
| †600BS | ½" and ¾" | 720 | 900 | 1100 | 1260 | 760 | 940 | 1115 | 870 | 960 | 1050 | 740 | 800 | 800 | 880 | 760 | 840 |
| †600BT | ½" and ¾" | 720 | 900 | 1100 | 1260 | 760 | 940 | 1115 | 870 | 960 | 1050 | 740 | 800 | 800 | 880 | 760 | 840 |
| †600BST | ½" and ¾" | 720 | 900 | 1100 | 1260 | 760 | 940 | 1115 | 870 | 960 | 1050 | 740 | 800 | 800 | 880 | 760 | 840 |
| †602B | ½" and ¾" | 1085 | 1670 | 2225 | 2665 | 1550 | 1885 | 2245 | 1635 | 1795 | 2035 | 1740 | 1890 | 1375 | 1520 | 1170 | 1275 |
| †602BS | ½" and ¾" | 1085 | 1670 | 2225 | 2665 | 1550 | 1885 | 2245 | 1635 | 1795 | 2035 | 1740 | 1890 | 1375 | 1520 | 1170 | 1275 |
| †602BT | ½" and ¾" | 1085 | 1670 | 2225 | 2665 | 1550 | 1885 | 2245 | 1635 | 1795 | 2035 | 1740 | 1890 | 1375 | 1520 | 1170 | 1275 |
| †602BST | ½" and ¾" | 1085 | 1670 | 2225 | 2665 | 1550 | 1885 | 2245 | 1635 | 1795 | 2035 | 1740 | 1890 | 1375 | 1520 | 1170 | 1275 |
| †603B | ¾" and 1" | 2750 | 4600 | 6200 | 7150 | 3300 | 4320 | 5400 | 3055 | 3490 | 3845 | 3700 | 3950 | 2900 | 3225 | 2180 | 2380 |
| †603BT | ¾" and 1" | 2750 | 4600 | 6200 | 7150 | 3300 | 4320 | 5400 | 3055 | 3490 | 3845 | 3700 | 3950 | 2900 | 3225 | 2180 | 2380 |
| †604B | 1" and 1¼" | 4750 | 7600 | 9900 | 11500 | 5950 | 7525 | 8950 | 5880 | 6440 | 7180 | 6230 | 6750 | 5250 | 6040 | 4550 | 4970 |
| †604BT | 1" and 1¼" | 4750 | 7600 | 9900 | 11500 | 5950 | 7525 | 8950 | 5880 | 6440 | 7180 | 6230 | 6750 | 5250 | 6040 | 4550 | 4970 |
| *600 | ½" and ¾" | 980 | 1250 | 1600 | 1850 | 990 | 1180 | 1350 | 1000 | 1100 | 1200 | 1000 | 1050 | 880 | 975 | 680 | 740 |
| *600 | 1" | 2800 | 3550 | 4500 | 5200 | 3500 | 4150 | 4800 | 3100 | 3400 | 3700 | 3100 | 3300 | 2600 | 2900 | 2100 | 2300 |
| *600 | 1¼" and 1½" | 5200 | 6700 | 8600 | 10000 | 7400 | 9000 | 10500 | 7500 | 8300 | 9000 | 6100 | 6600 | 5400 | 6000 | 4900 | 5350 |

"T" Thermal Element in Trap    "S" Internal Strainer    †Stainless steel interiors    *Brass lever

Figure 70.

## Thermodynamic Traps

These traps find wide use in the medium to high pressure application range. They have a minimum operating pressure and a maximum operating back pressure. Since these parameters vary with the various types available, the specifications for the trap should be checked when applying it to a specific application.

It is possible for a thermodynamic trap to be closed due to "flashing" of the condensate passing through it. The trap specifications should be checked to determine the number of degrees below saturated steam temperature required for proper trap operation. Should the condensate temperature be too high, premature closing of the trap and flooding of the equipment on which the trap is installed can take place.

These traps may be installed in any position and when installed vertically, they are freeze-proof. As a rule, a safety factor of twice the estimated maximum load is applied.

## Condensate Handling Equipment

This product specification covers a broad variety of condensate pumping systems. In general, they may be classified as:

1. Condensate Pumps
2. Boiler Feed Pumps
3. Vacuum Pumps

All types have the function of accumulating condensate from the system and delivering it to the boiler or boiler feed unit. Both also are manufactured as single or duplex units. Single units have a single tank and one pump, while duplex units have a single tank and two pumps. Each pump is capable of handling the full rated capacity so as to provide standby capability.

## Condensate Pumps

Condensate pumps are used for any of several reasons. They are listed below:

1. Boiler pressure is too great to permit gravity return.

2. The return mains are below the boiler water line.

3. Large systems where the condensate must be returned at a controlled rate.

4. Condensate must be pumped over a high point.

Selecting a condensate pump requires that consideration be given not only to the condensate pumping rate required, but also to the system "time lag". The time lag is the time interval required for the condensate to begin returning to the boiler once steaming has started. If the boiler has sufficient storage capacity to furnish steam until the time lag has been satisfied, a condensate pump can be used to return condensate to it. The storage capacity of a boiler is the available volume between the high and low water levels.

The condensate receiver should be kept small so as to provide prompt return of water to the boiler. As a rule, a one minute storage capacity at the system condensing rate is required. The condensate pump should also be kept as small as practical in order to provide a more constant transfer of water.

At design condition, the condensing rate corresponding to 1,000 sq. ft. EDR is 0.5 GPM. At start-up the condensing rate will be greater than at design, but will always be somewhat less than 150% of design. Old cast iron boilers may be capable of handling 150% of rated load. Therefore, the old standard was to size pumps three times the condensing rate. This also allowed for loss of pump

capacity due to cavitation. Units with standard pumps are often rated at three times and new units are generally rated for two times.

Condensate pumps are furnished in the following basic types:

1.  Single Pump  -  One pump operating from float switch in the receiver.

2.  Duplex Pump  -  Two pumps, each sized for the total system pumping requirement and operating from float switches in the receiver. Should the lead pump allow the receiver level to drop to the float setting of the lag pump, the lag pump will cut in. Manual or automatic switching of the pumping sequence can be provided.

Figure 71 shows a two-pipe heating system with a condensate pump installed. The return main must be pitched at least 1/4" in 10 ft. to the receiver inlet. The pump discharge is connected to the boiler return header, never to a Hartford Loop. Such an arrangement results in very noisy operation. The receiver vent pipe is brought up to an elevation above the boiler water line to prevent discharge of condensate at this point during shut-down in the event of a leaking check valve at the pump discharge.



STRAINER

IN ONE PIPE INSTALLATION OR WHERE TRAPS ARE NOT USED ON RADIATORS OR DRIPS - INSTALL FLOAT & THERMOSTATIC TRAP AFTER LAST UNIT.

OPEN VENT ABOVE WATER LINE

MAIN RETURN FROM HEATING SYSTEM

STRAINER

WATER LINE OF BOILER

BY-PASS TO DRAIN & GATE V.

OPEN

BOILER

NOTE - ENTIRE MAIN RETURN MUST HAVE GRADUAL PITCH DOWN TOWARDS PUMP

CHECK V.

PRESSURE GAGE TAP

SQUARE HEAD STEAM COCK

Typical Condensate Pump Installation
Return Mains Above Condensate Receiver Inlet

Figure 71.

When the condensate pump must be located below the floor level to insure condensate drainage, the installation shown in Figure 72 may be used. This utilizes an underground type condensate pump, similar to the one shown in Figure 29.
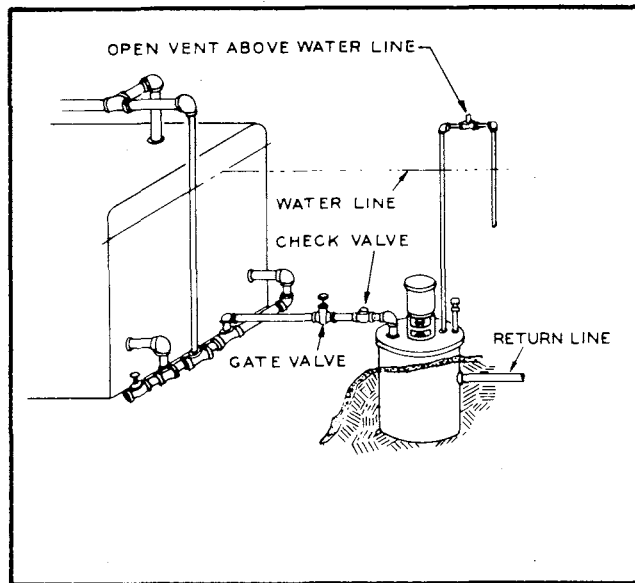


Underground Condensate Pump

Figure 72.

Systems with cast iron boilers up to 12,000 sq. ft. EDR can usually be fed with a condensate pump. However, larger systems or those with fire tube boilers require the use of a boiler feed pump to guard against a low water condition. Installations using more than one boiler require a boiler feed unit to balance the flow rate to each boiler.

## Boiler Feed Pumps

A boiler feed pump is operated by a level switch on the boiler, with a make-up water valve in the receiver. Being sensitive to the boiler water level, the level switch starts and stops the boiler feed pump as required.

Larger systems, or those with fire tube boilers, are usually installed with boiler feed pumps. Figure 73 shows an installation with a combination pump control and low water cut-off operating the pump. Reference to Figure 37 will show the appearance of this control. The low water cut-off in the receiver shuts down the feed water pump if the water level in the receiver drops to an unsafe level.
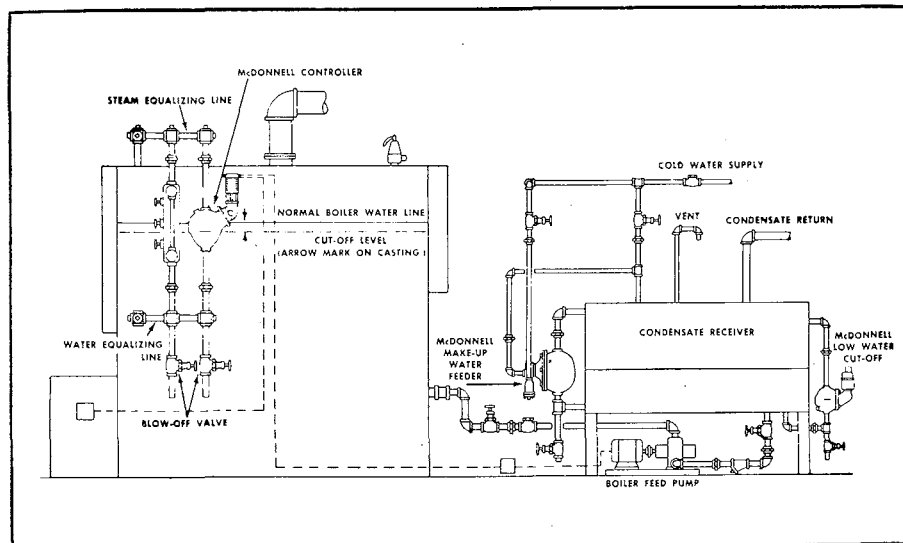
Typical Boiler Feed Pump Installation

Figure 73.

Where this installation is used, the make-up water control may be a float-operated mechanical type in smaller systems. Large systems often require more make-up water than this type can provide. In such cases, a diaphragm valve operated by water pressure from a water feeder may be used as shown in Figure 74. A liquid level controller may be used to operate an electric valve as an alternative. Figure 74 also shows this arrangement.
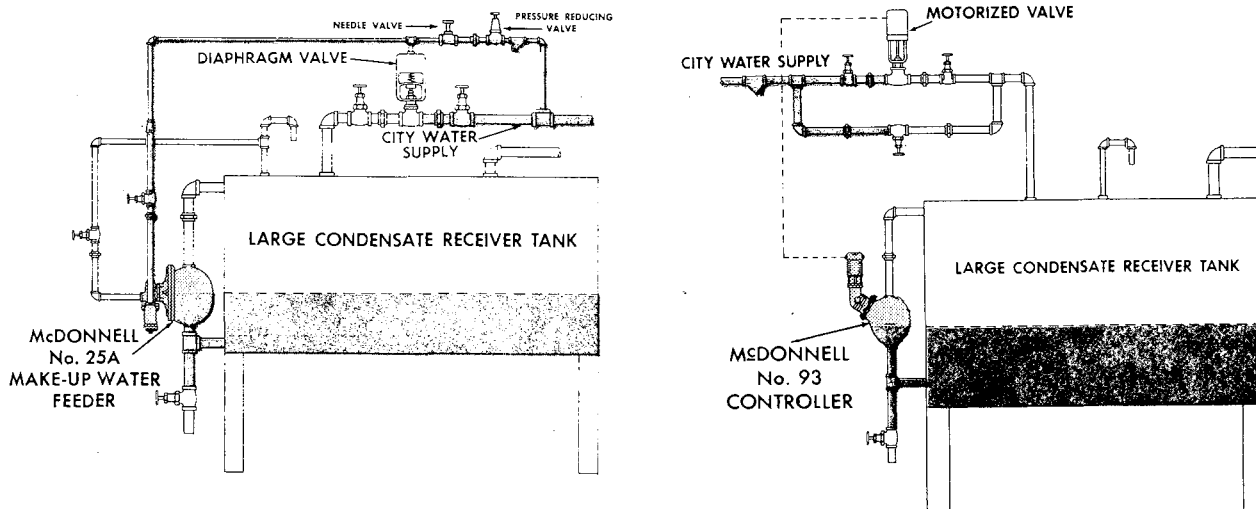


Large Condensate Receiver Tank Control

Figure 74.

The receiver in a boiler feed pump system is sized to hold the system time lag. The pump itself should be capable of delivering condensate as outlined in the section on Condensate Pumps.

There are job situations where the condensate return lines end up below the elevation of the boiler feed pump receiver inlet. In such cases, a condensate pump is used to pick up the low returns and pump them to the boiler feed pump receiver. The condensate pump receiver must be kept small so as to assure quick condensate return. A one minute storage capacity is generally recommended. As in the case with a straight boiler feed pump job, the boiler feed pump receiver should be sized to handle the condensate volume equal to the system time lag.

The system time lag can be determined by actual observation of the time required for condensate to begin returning once the boiler has begun steaming. The system time lag volume is the amount of condensate developed by the system during the timed period. A five minute storage capacity should be sufficient for systems up to 200 boiler H.P. or 6,900 lbs. per hour. Systems larger than this should have 10 minutes or more storage capacity.

The system time lag will be greater on a single story or multiple building complex than on a single multiple story building.

When the boiler feed receiver is undersized, the result will be overflowing of the condensate on system shut-down. The steam in the system will condense and return to the receiver at this time. It is best to retain this condensate as it contains heat and is virtually as pure as distilled water. The receiver should, therefore, be sized so as to contain the condensate without overflow. Oversizing of the receiver will cause no system problems but will result in excessive initial costs.

The temperature of the returning condensate has an important bearing on the type of condensate or boiler feed pump selected for the job. Where the condensate temperature approaches saturation pumps designed to operate at a low NPSH should be used. Such pumps are available which have a required NPSH of only 2' and which can handle $210^{\circ}$ F. condensate heightless receiver or $212^{\circ}$ with a receiver elevated only 2 ft. above the floor.

Vacuum Pumps

The vacuum pump has a dual role - it pumps condensate and keeps the system under the required vacuum. Therefore, when sizing a vacuum pump both the required water pumping rate and the air removal rate must be considered.

The condensate pumping capability would be selected as discussed in the section on Condensate Pumps.

Pumps for tight vacuum systems should have a capacity of 0.3 to 0.5 CFM of air removal for each 1,000 EDR served. The larger air capacity is suggested for systems up to 10,000 EDR. The pump selection basis should be 5-1/2" Hg at 160° F., which is representative of actual system conditions. These air removal rates are based on the vacuum range of 0" to 10" Hg with the air pumps usually operating between 3" and 8" Hg.

Some conditions require larger air removal rates. Systems with excessive air in - leakage are sometimes difficult to correct. It has been found that air removal rates of about 1 CFM/1,000 EDR have been adequate for most systems of this type operating in the standard 3" to 8" Hg range.

The following table offers suggested vacuum pump sizing data.

| SUGGESTED GUIDE FOR AIR REMOVAL REQUIREMENTS | | |
|---|---|---|
| | Vac. Range In Hg | cfm/1000 EDR |
| Tight systems thru 10,000 EDR | 0-10* | .5 |
| Tight systems in excess of 10,000 EDR | 0-10* | .3 |
| All systems, some air in-leakage | 0-10* | 1.0 |
| All systems | 10-15 | 1.5 |
| All systems | 15-20 | 2 |

*Air pumps are usually adjusted to operate between 3" and 8" Hg.

Vacuum pumps are available in a number of types and capacities. Some commonly used types are listed below:

1.  Single units with a common pump for pumping water and inducing vacuum (See Figure 32).

2.  Duplex units with two common water and vacuum pumps.

3.  Single units with separate water and vacuum pumps (Figure 33).

4.  Duplex units with two water pumps and two vacuum pumps.

5.  Semi-Duplex units with two water pumps and a single vacuum pump.

The purpose of the Semi-Duplex and Duplex pumps is to provide standby protection. Each water or vacuum pump is selected to take care of the full system requirements. Integral control systems provide for the operation of the lag pump should the lead pump fail or be unable to meet the system requirements.

An installation detail for Duplex vacuum pumps is shown in Figure 75. This piping is used where all of the radiation and the return mains are above the vacuum pump. Where a single vacuum pump is used, only one discharge line is piped to the boiler.
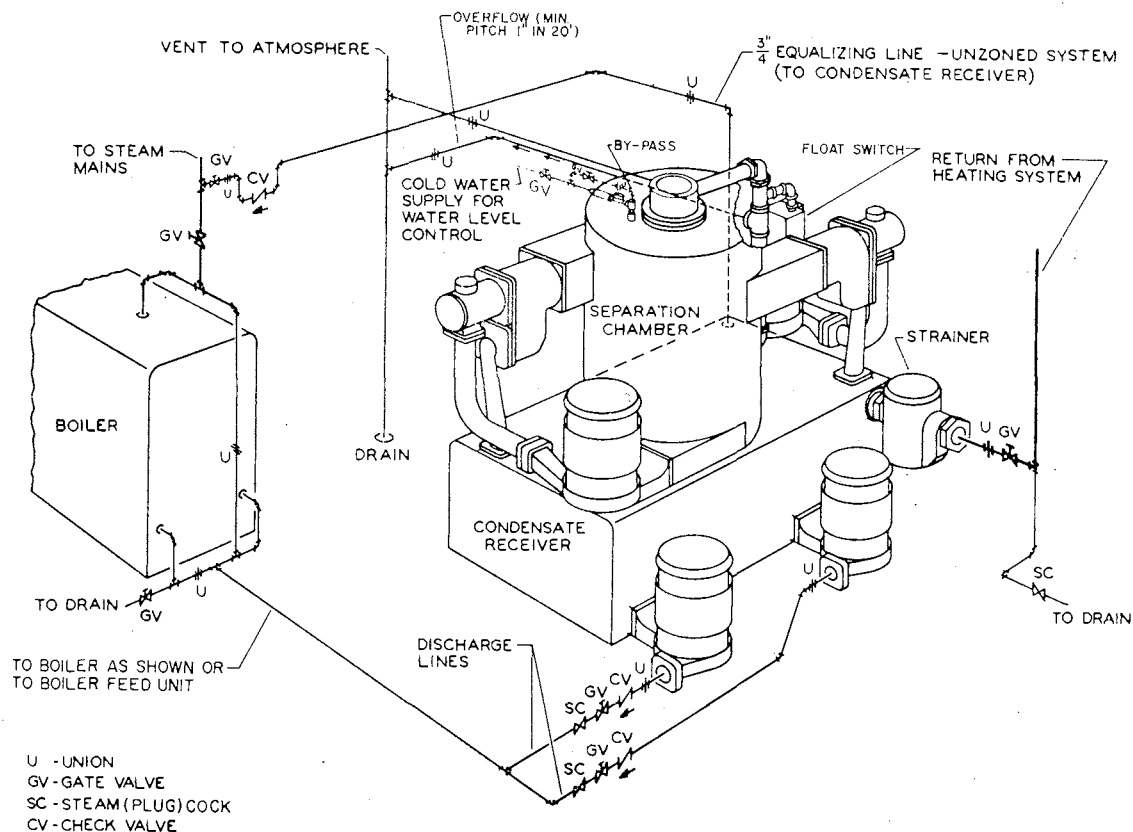


NOTE:
AVOID ELBOW OR TEE LOCATED CLOSER TO INLET STRAINER
THAN 10 TIMES INLET DIAMETER.

RECOMMENDED CONNECTIONS TO DUPLEX VACUUM PUMP WITH No. 100 OR 150 RECEIVERS WHERE HEATING UNITS AND RETURNS ARE ABOVE PUMP INLET. SINGLE UNITS; ELIMINATE ONE DISCHARGE LINE.

Duplex Vacuum Pump Installation Detail

Figure 75.

Where the return lines come back below the level of the vacuum pump, provision must be made for lifting the condensate to the vacuum pump receiver. A condensate pump may be used to collect the condensate and deliver it to the vacuum pump. An installation of this type is shown in Figure 76.

TRAP — SUPPLY VALVE

PRESSURE REDUCING VALVE STATION

MAIN VENT

BOILER WATER LINE

HIGH PRESSURE BOILER

VENT

VACUUM RETURN

VACUUM PUMP

SUPPLY VALVE

TRAP — F & T TRAP
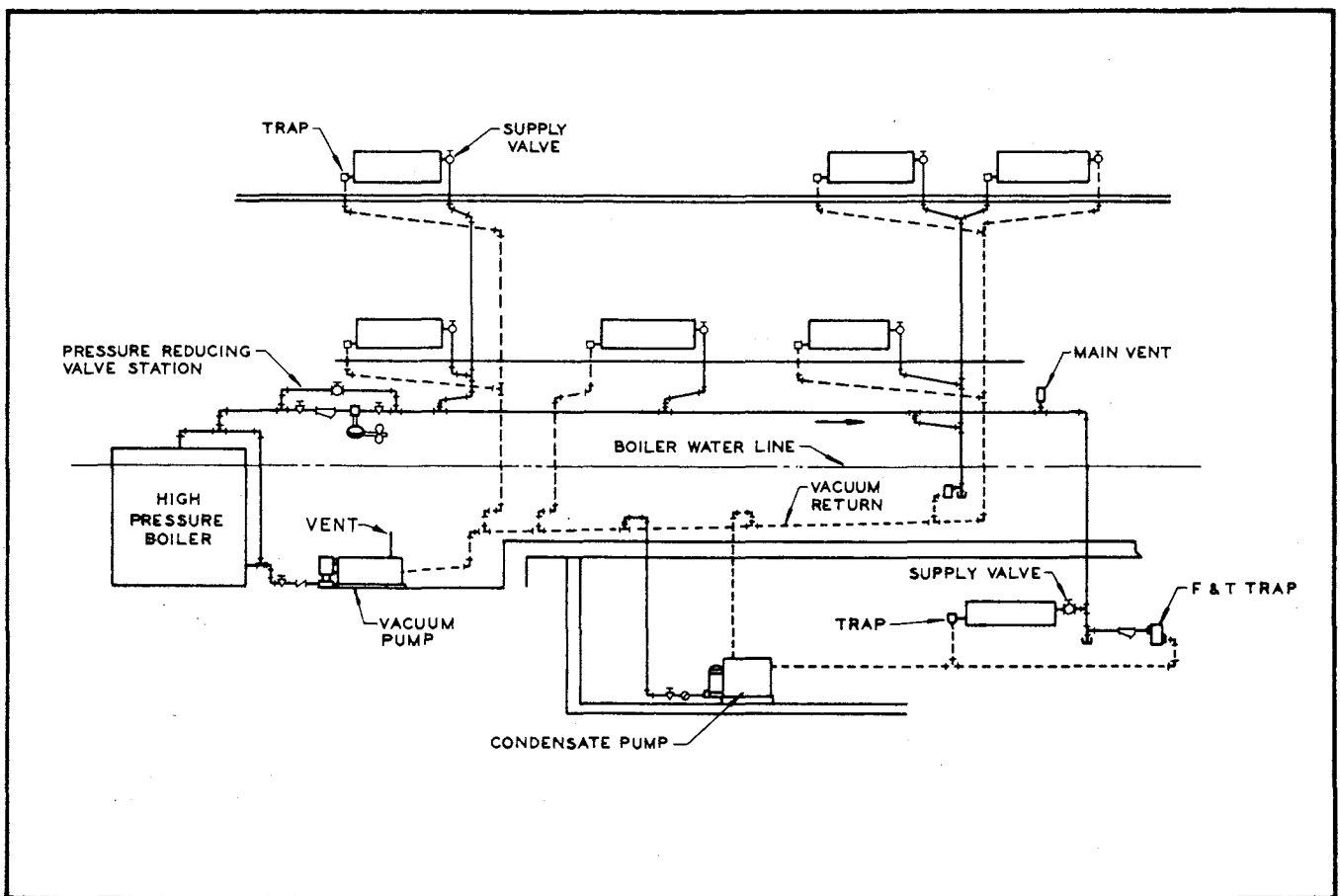
CONDENSATE PUMP

Condensate Pump Collects Low Returns For
Vacuum Pumps

Figure 76.

The vacuum return line drains the condensate from the radiation above the boiler water line. The low return for the radiation below the boiler water line drains to the condensate pump receiver. The condensate pump and receiver are sized for this radiation load. The condensate pump is kept under vacuum by a connection to the vacuum return as shown. The vacuum pump is sized for the total condensate load.

The required pumping head for each of the pumps is dictated by the job conditions. In the case of the pumps in Figure 75, two conditions prevail. The condensate pump head would be the static elevation between the pump discharge opening and the vacuum return line plus the pressure drop in the pipe and fittings of the discharge line. The vacuum pump head would be the pressure drop of the discharge line plus the boiler pressure against which the pump must operate.

## Lift Fittings

Lift fittings are sometimes used to elevate condensate from the low return vacuum systems to the vacuum pump. Commercial lift fittings may be used to make a series of "lifting steps" as shown in Figure 77. The total lift is divided into an equal number of steps, each of which is trapped by a lift fitting. Water and air are drawn up by the vacuum pump from the low return in a series of "slugs".
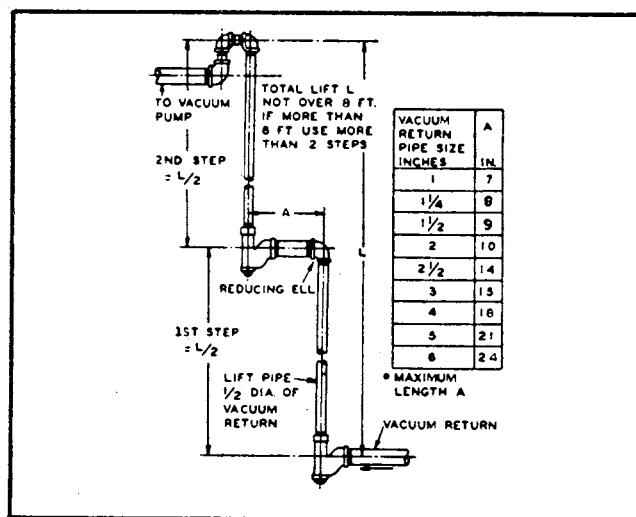


Typical Lift Fitting Construction

Figure 77.

Additional vacuum above the system requirements is needed to produce this lift. The additional required vacuum is 1" Hg for each foot of lift. The condensate temperature must be well below its saturation temperature at the system vacuum or "flashing" will take place and destroy the syphon action of the lift fitting.

It is necessary to operate the vacuum pump continuously for the successful operation of the lift fitting. The vacuum pump must, therefore, have separate water and air pumps. The air pump will operate continuously and the condensate pump will be cycled by its float switch as required.

## Accumulator Tanks

Accumulator tanks are also used where low returns exist on a vacuum system. The low returns drain into a steel or cast iron accumulator tank which must be vacuum-tight. Figure 78 shows typical installations using either above or below the floor type tanks.
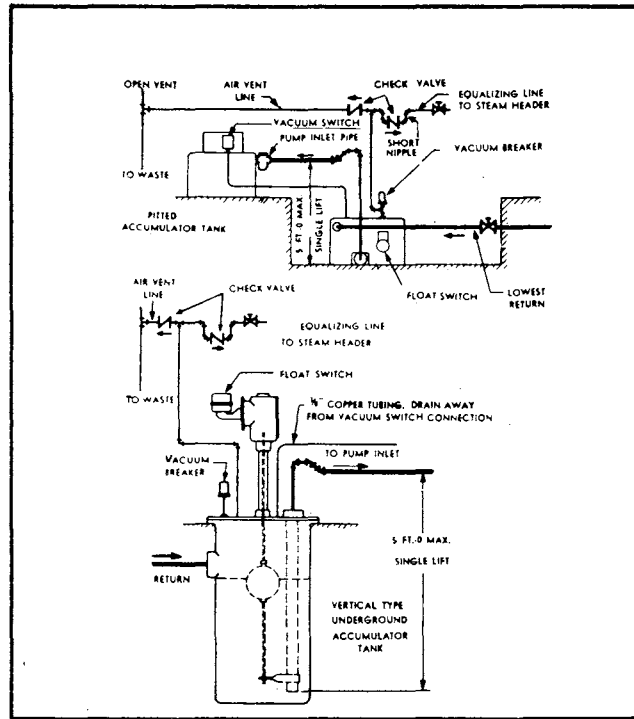


Piping to Vacuum Pump Where Return Main
is Below Pump Floor Level

Figure 78.

The float switch which operates the vacuum pump is installed in the accumulator tank. The vacuum switch which also operates the pump has its sensing line connected to the accumulator tank. The maximum single lift from the accumulator tank to the vacuum pump is five feet. Additional lifts with appropriate fittings must be used for higher elevations.

The principal advantage of the accumulator tank over a straight lift fitting is that it allows some cooling of the condensate to take place before it enters the pump inlet line. This reduces the possibility of flashing in the lift line. Also, the vacuum pump may be cycled instead of operating continuously.

## Boiler Accessories

The functions of various steam boiler controls as well as their installation principles have been covered in Chapter 3. Sizing of these controls is important in the particular case of water feeders. These must be capable of delivering the required make-up water at the pressure differential existing across the control inlet and outlet.

## Boiler Water Feeders

The feeding rate of a float operated mechanical water feeder varies with the float position. A typical capacity curve showing the feeding rate and system sizing information is shown in Figure 79.
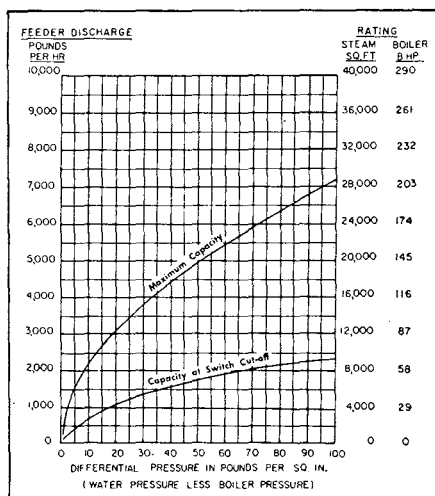


Water Feeder Capacity Curves
Feeder For Boilers Over 5,000 Sq. Ft.

Figure 79.

This particular water feeder is designed to handle the requirements of boilers over 5,000 sq. ft. in size. Smaller water feeders are available for systems of lesser requirements. Figure 80 shows the feeding capacity of a water feeder for systems up to 5,000 sq. ft. in size.

CAPACITY CURVES

FEEDER DISCHARGE
POUNDS
PER HR

3,000

2,000

1,000

0

Maximum Capacity

Capacity at Switch Cut-off

0    10    20    30    40    50    60    70    80    90    100
DIFFERENTIAL  PRESSURE  IN  POUNDS  PER  SQ  IN.
( WATER  PRESSURE  LESS  BOILER  PRESSURE )
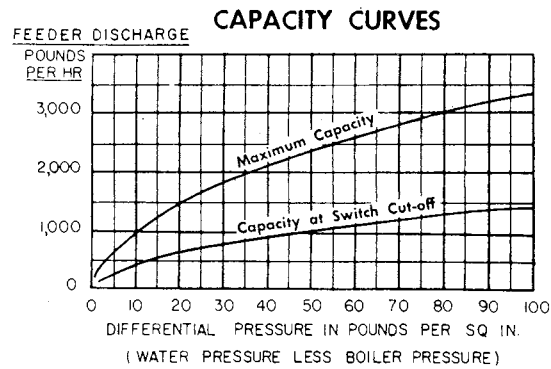
Water Feeder Delivery Curves
Feeder For Boilers up to 5,000 Sq. Ft.

Figure 80.

In addition to the feeding capacity, the maximum pressure of the supply water must be within the operating range of the control. Controls are also limited to the steam side pressure. For example, a job with available make-up water pressure of 100 psi and a steam pressure of 30 psi in the boiler requires that the water feeder selected be rated at working pressures equal to or in excess of these pressures.

The same limitations hold true for any boiler control such as low water cut-offs or pump switches. The control specifications must be checked to be sure it will meet the pressure requirements imposed by the job. The electric contact ratings and switching action should also be verified with the application requirements.

When installing float operated boiler controls, the manufacturer's installation instructions must be carefully followed. An example of a typical installation diagram for a combination boiler water feeder and low water cut-off is shown in Figure 81. The equalizing lines are run in 1" size, the full size of the control tappings. The steam equalizing line is taken off an available opening other than a steam flow line. Variations in pressures in steam flow lines can cause erratic float levels to take place.

Blow-offs are provided at both vertical columns for periodically blowing off dirt and sediment. These should be used at regular intervals to keep the gauge glass and control free of dirt.

The installation principles shown in Figure 81 apply to all float operated controls. The important thing to keep in mind is that they should be installed at the proper elevation with relationship to the boiler water level. These relationships were discussed in Chapter 3.

74

Installation on boiler with independent water column.
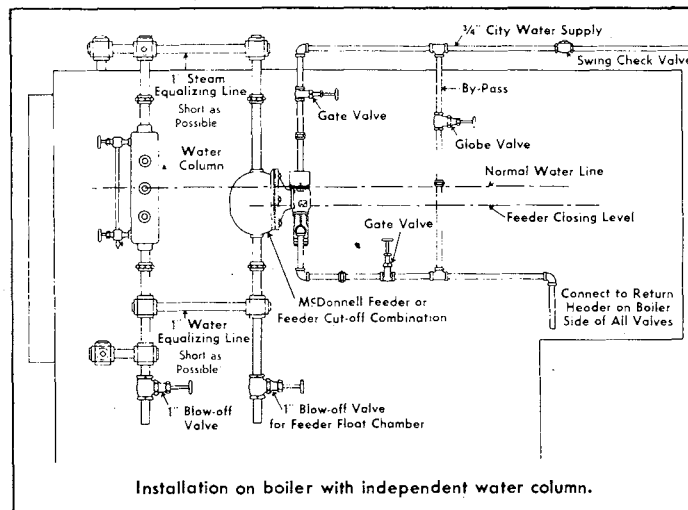
Boiler Water Feeder and Low Water Cut-off
Installation Detail

Figure 81.

## Pressure Regulating Valves

Pressure regulating valves are sized taking the following factors into consideration:

1.    Type of application.
2.    Controlled and inlet steam pressure.
3.    Amount of steam required.

Figure 76 shows a typical example of the application of a pressure reducing valve to a steam heating system. A high pressure boiler is being used to provide low pressure steam to a heating system.

When selecting the valve type, consideration must be given as to whether "dead-end" operation is needed. If this is the case, a single seated valve should be used.

Many heating system applications will condense enough steam to permit the small amount of leakage past the valve which occurs when a double seated valve is used. If this is the case, a double seated valve is the better selection, being less costly and simpler in construction.

The valve should be selected so as to deliver the proper number of pounds of steam per hour at the system design conditions. For example, assuming the boiler pressure to be 80 psi and the reduced pressure to be 3 psi, we would select a valve for these characteristics. Because of the close pressure regulation required, a weight and lever type would be a good selection Assuming dead-end operation as a system need, a single seated valve would be required.

If the system load requirement were 1,000 lbs. of steam per hour, what valve would be selected from the capacity table below?

| CAPACITIES IN POUNDS OF STEAM PER HOUR FOR MODEL 710 P.R.V. | | | | | |
|---|---|---|---|---|---|
| PRESSURE LBS/SQ. INCH GAGE | | VALVE SIZE IN INCHES | | | |
| INITIAL | REDUCED | ½ -¾ | 1 | 1¼ | 1½ |
| 70 | 3-35 | 231 | 616 | 924 | 1540 |
| | 50 | 173 | 460 | 690 | 1150 |
| | 60 | 123 | 328 | 492 | 820 |
| 80 | 3-41 | 258 | 688 | 1030 | 1720 |
| | 50 | 219 | 584 | 876 | 1460 |
| | 60 | 183 | 488 | 732 | 1220 |
| 90 | 3-41 | 287 | 764 | 1146 | 1910 |
| | 60 | 231 | 616 | 924 | 1540 |
| | 70 | 195 | 520 | 780 | 1300 |

A 1" valve, operating at 80 psi initial pressure and 3 - 41 psi reduced pressure, will furnish 1,030 lbs. of steam per hour. We would, therefore, select a weight and lever type 1" valve for the job.

The installation would be made in accordance with the diagram shown in Figure 82. A globe valve is placed in a bypass around the reducing valve for emergency use. A pressure gauge in the bypass permits observation of the reduced pressure. Gate valves on either side of the reducing valve permit serving it while operating the system on the throttled bypass.
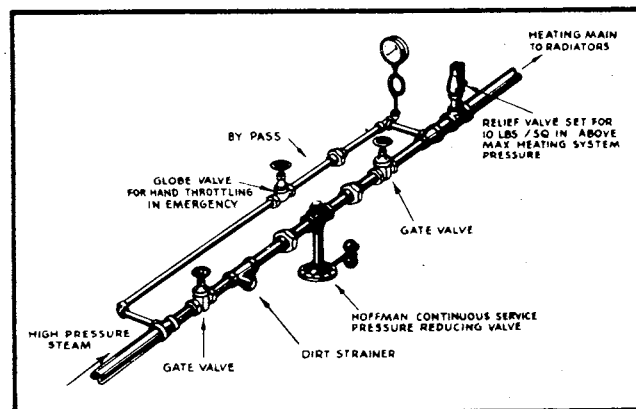


Typical Reducing Valve Installation

Figure 82.

Treatment of boiler water with various chemical agents is necessary to remove oxygen, prevent corrosion and break up sludges into a form that can be "blown down" from time to time.

The need for chemical water treatment is diminished when corrosion gases such as oxygen and carbon dioxide are removed from the feed water. Deaerating heaters and deaerators are used to accomplish this. These devices offer the additional advantage of heating the feed water, which reduces thermal shock and increases boiler efficiency.

The principle difference between a deaerator heater and a deaerator is the amount of oxygen removed. Deaerators are defined as units capable of removing from the water all dissolved oxygen in excess of .005 cc's/liter (7 parts per billion). A deaerating heater is a unit which reduces oxygen content down to .03 cc's/liter (44 parts per billion). The maximum safe figure for most boilers is about .005 cc's/liter or 7 parts per billion.

## Deaerating Heaters

A deaerating heater removes oxygen and other gases from the feed water by raising its temperature to saturation. Figure 83 shows a typical installation. Make-up water and feed water enter the spray manifold and the mixture falls into the tank as a mist. Steam is injected into the water at the lower level of the tank in order to heat it to saturation. A temperature sensing element in the tank water modulates a steam control valve to maintain the water temperature.

The combination of spraying and heating the water drives out the dissolved gases which are released through the vent. Controls in the unit include a float switch for low water cut-off service. A sacrificial anode in the tank helps prevent corrosion.

Units of this type require pumped returns with a minimum pressure of 10 psig for servicing the spray nozzles. Gravity returns are connected to a separate inlet at the top of the tank. A pump switch in the boiler operates the boiler feed pumps.

Deaerating heaters are often used with accumulators to provide more or less constant flow of the water entering the deaerator component. Most systems have condensate pumps which deliver 2 to 3 times the condensate flow rate when they operate. The resulting flow surges do not permit the most efficient use of the deaerating heater.

DETAIL OF STAINLESS STEEL SPRAY NOZZLE.

30" PRESS. GAUGE.

STEAM SUPPLY CONTROL VALVE.

STEAM SUPPLY LINE.

FLOAT & THERMOSTATIC TRAP.

TO DRAIN.

BLOW OFF VALVE.

TO DRAIN.

DISPLACER TYPE SWITCH FOR LOW LEVEL CUT OFF (OPT. HIGH & LOW LEVEL ALARM).

GRAVITY RETURNS AND LOW PRESSURE DRIPS.(OPT.)

30" PRESS. GAUGE.

LOW PRESSURE PUMPED RETURNS.

VENT.

SYPHON BREAKER.

GAUGE GLASS.

SPRAY NOZZLES.

BAFFLE.

DIAL TEMP. GAUGE.

MIXING TEE.

MAKE-UP WATER SUPPLY.

SPRAY MANIFOLD.

*ALLOW____INCHES CLEARANCE AT RIGHT HAND END FOR REMOVAL OF SPRAY MANIFOLD.

OVERFLOW LOOP.

ANODE.

TEMP. SENSING ELEMENT.

MECH. WATER MAKE-UP VALVE.

TO DRAIN.

S.S. STEAM INJECTION ELEMENTS.

HIGH PRESSURE RETURNS AND DRIPS.(OPT.)

LEGEND:

DRAIN VALVE.

DIAL TEMP. GAUGE.

ORIFICE TYPE UNION.

REMOVEABLE SUPPORT BASE.

TO DRAIN.

"Y" STRAINER
GATE VALVE
UNION
REDUCER
PLUG COCK
CHECK VALVE
NON SLAM CHECK VALVE
FLANGE
GLOBE VALVE

DOMESTIC TYPE B CENTRIFUGAL PUMP (MULTI-STAGE PUMP OPT. SEE DETAIL AA.)

SOLENOID, MOTORIZED OR PROPORTIONING ELECTRIC WATER MAKE-UP VALVE WITH 3-VALVE BY-PASS.

PUMP DISCHARGE.

PUMP SUCTION.

FLEXIBLE PUMP CONNECTOR

DETAIL OF PIPING WHEN ELECTRIC WATER MAKE-UP VALVE IS USED.

DETAIL AA.

DETAIL OF RECOMMENDED PIPING TO MULTI-STAGE HIGH PRESSURE PUMP

FOR CONNECTING PIPING TO BOILER(S) REFER TO DRAWING NO._ _ _ _ _ _ _ _

CAUTION:
DO NOT INJECT CHEMICAL WATER TREATMENT INTO RECEIVER.

NOTES:
1. SEE ORDER SPECIFICATION SHEET FOR DETAILS OF OPTIONAL EQUIPMENT & PUMP CAPACITIES.
2. OPTIONAL ITEMS FURNISHED AT EXTRA COST WHEN ORDERED.

## Recommended Connections to Type DH Deaerating Heaters Without Accumulator Compartment

Figure 83.

Accumulators may be either of the integral or separate types. A unit with built-in accumulator compartment is shown in Figure 84. The condensate returns from the system discharge into this compartment and the make-up water also enters here. A float switch in the deaerator tank operates the transfer pump, which delivers water from the accumulator tank through the spray nozzles.

An optional heat reclaimer may be installed in this circuit to pick up otherwise waste heat from the vent vapor. The vent is connected to the tube side of the heat exchanger, which drains back to the shell of the deaerator heater. This vapor gives up its heat to the transfer liquid in the shell of the heat exchanger, as shown in the alternate piping arrangement.

30# PRESS. GAUGE.

STEAM SUPPLY CONTROL VALVE.
FLOAT & THERMOSTATIC TRAP.
STEAM SUPPLY LINE.

TEMP. SENSING LINE.
VENT.
BLOW OFF VALVE.

OPT.
TO DRAIN.
TO DRAIN.
VENT.

DISPLACER TYPE SWITCH FOR LOW LEVEL PUMP CUT OFF (OPT. HIGH & LOW LEVEL ALARM).
SHELL & TUBE VAPOR CONDENSER (OPT.)
FLOAT SWITCH FOR TRANSFER PUMP(S).
DISPLACER TYPE SWITCH FOR LOW LEVEL PUMP CUT OFF (OPT. HIGH & LOW LEVEL ALARM).
INLET STRAINER.

PUMP DISCHARGE.
FLEXIBLE PUMP CONNECTOR.
PUMP SUCTION.

DETAIL OF STAINLESS STEEL SPRAY NOZZLE

DETAIL AA
DETAIL OF RECOMMENDED PIPING TO MULTI-STAGE HIGH PRESSURE PUMP.

GAUGE GLASS.
SPRAY NOZZLES.
SPRAY MANIFOLD.
BAFFLE.
RETURNS.
SYPHON BREAKER.
GAUGE GLASS.
OVERFLOW.
TO DRAIN.
MAKE-UP WATER SUPPLY.

LEGEND:
"Y" STRAINER
GATE VALVE
UNION
REDUCER
PLUG COCK
CHECK VALVE
NON SLAM CHECK VALVE
FLANGE
ELECTRIC VALVE
GLOBE VALVE.

DIAL TEMP. GAUGE.
ANODE.
ANODE.
ACCUMULATOR COMPARTMENT.
S.S. STEAM INJECTION ELEMENTS.
DIAL TEMP. GAUGE.
MECH. WATER MAKE-UP VALVE.

HIGH PRESS RETURNS.
DOMESTIC TYPE B CENTRIFUGAL PUMP (MULTI-STAGE PUMP OPT. SEE DETAIL AA)
TO DRAIN.
TRANSFER PUMPS.
ORIFICE TYPE UNION.
REMOVEABLE SUPPORT BASE.

SOLENOID, MOTORIZED OR PROPORTIONING ELECTRIC WATER MAKE-UP VALVE WITH 3-VALVE BY-PASS.

FOR CONNECTING PIPING TO BOILER(S) REFER TO DWG. NO._____
(OPT. USED ONLY WITH VAPOR CONDENSER).

DETAIL OF PIPING WHEN ELECTRIC WATER MAKE-UP VALVE IS USED.

*ALLOW____INCHES CLEARANCE AT LEFT HAND END FOR REMOVAL OF SPRAY MANIFOLD.

USED ONLY WHEN VAPOR CONDENSER IS NOT FURNISHED.

CAUTION:
DO NOT INJECT CHEMICAL WATER TREATMENT INTO RECEIVER.

NOTES:
1. SEE ORDER SPECIFICATION SHEET FOR DETAILS OF OPTIONAL EQUIPMENT & PUMP CAPACITIES.
2. OPTIONAL ITEMS FURNISHED AT EXTRA COST WHEN ORDERED.

Recommended Connections to Type DHA Deaerating Heaters
With Integral Accumulator Compartment, Showing Optional
Shell-and-tube Vapor Condenser

Figure 84.

Deaerating heaters of the type shown in Figure 84 but with a separate accumulator are also available. Figure 85 illustrates this type. The operation of the two is essentially the same, the only difference being in the arrangement of the accumulator.

A proportioning valve may be installed in the transfer piping from the accumulator to the heater tank. A slide wire controller in the heater tank controls the modulating valve to provide almost continuous water flow. This controller has an end switch for operating the transfer pump or pumps.

Recommended Connections to Type DHR Deaerating Heaters
With Separate Accumulator Tank, Showing Opertional
Shell-and-Tube Vapor Condenser

Figure 85.


## Application and Selection

Single compartment deaerating heaters of the type shown in Figure 83 are used:

1.     Where 80% or more of the water entering the unit is make-up water.

2.     Where an adequately sized condensate receiver exists which can be connected to an accumulator tank and transfer unit.

The size of the receiver shell of the deaerator heater depends upon the system time lag. The table below states the storage capacity recommended for various situations, based on the amount of condensate developed in the time period mentioned.

## SUGGESTED STORAGE CAPACITIES

| Type DH | Systems Requiring 80 to 100% Make-Up (Suggest Proportioning Make-Up Controls). | Systems with Time Lag of 10 Min. or Less | System with Exceptionally Long Time Lag (Campus Style Complex) |
|---|---|---|---|
| | | LESS THAN 80% MAKE-UP | |
| Controlled returns from system using accumulator tank— continuous transfer of condensate from accumulator (proportioning level control and valve) | 5 Min. | 5 Min. | 5 Min. |
| Uncontrolled pumped returns—i.e., from condensate or vacuum pumps | 5 Min. | 10 Min. | 15 Min. (suggest using accumulator with 15 min. storage and 5 min. in deaerator; refer to type DHA or DHR units) |

Two compartment units are recommended for systems with steaming rates up to 113,000 lbs. per hr., the maximum size for which integral accumulators are available. They are used where the condensate returns uncontrolled and where some gravity returns are present with pumped systems.

The storage capacities suggested for this unit type are listed below. The total storage capacity is apportioned between the deaerator compartment and accumulator as noted.

## SUGGESTED STORAGE CAPACITIES

| Type DHA—Systems Up to 113,000 #/Hr. | Systems Requiring 80 to 100% Make-Up | Systems with Time Lag of 10 Min. or Less | Systems with Exceptionally Long Time Lag (Campus Style Complex) |
|---|---|---|---|
| | | LESS THAN 80% MAKE-UP | |
| Continuous, controlled transfer of condensate between compartments (proportioning level control and valve) | Usually not required. Refer to type DH single compartment unit. | 15 min. total (5 min. in deaerator compartment and 10 min. in accumulator compartment). | 20 min. total (5 min. in deaerator compartment and 15 min. in accumulator compartment |
| Intermittent transfer of condensate between compartments. | | 20 min. total (10) min. in each compartment). | Use controlled transfer of condensate—See above. |

81

Separate accumulator tanks are used together with single compartment units where:

1. Systems larger than 113,000 lbs./hr. are involved (two compartment unit of this size is not available).

2. The condensate return rate is uncontrolled.

3. Some gravity returns are present with pumped returns.

4. Space restrictions require separating the accumulator and deaerating heater.

The suggested storage capacities for the separate accumulator tank are stated below:

## SUGGESTED STORAGE CAPACITIES

| Suggested Storage Periods of Accumulator Only, Type DHR | Systems Requiring 80% to 100% Make-Up | Systems with Time Lag of 10 Min. or Less. | Systems with Exceptionally Long Time Lag (Campus Style Complex) |
|---|---|---|---|
| | | LESS THAN 80% MAKE-UP | |
| Pumped or gravity returns | Accumulator normally not required | 10 Min. | 15 Min. (data on time lags longer than 15 min. on request). |

The boiler feed pumps furnished with the deaerating heater are sized on the basis of the boiler pressure and horsepower. When boiler feed pumps are discharging into a common header to feed multiple boilers, the pumps should be sized for the combined load of all boilers. When each pump feeds an individual boiler, it should be sized for the load of its respective boiler only. Suggested boiler feed pump capacities are shown below.

## SUGGESTED PUMP CAPACITIES BASED ON BOILER EVAPORATION RATE

| BOILER HP | EVAPORATION RATE | | PUMP GPM* | PUMP GPM** |
|---|---|---|---|---|
| | LBS./HR STEAM | GPM | | |
| 72 | 2500 | 5 | 7.5 | 10 |
| 144 | 5000 | 10 | 15 | 20 |
| 216 | 7500 | 15 | 22.5 | 30 |
| 290 | 10,000 | 20 | 30 | 40 |
| 434 | 15,000 | 30 | 45 | 60 |
| 580 | 20,000 | 40 | 60 | 80 |
| 720 | 25,000 | 50 | 75 | 100 |
| 868 | 30,000 | 60 | 90 | 120 |
| 1160 | 40,000 | 80 | 120 | 160 |
| 1440 | 50,000 | 100 | 150 | 200 |
| 2160 | 75,000 | 150 | 225 | 300 |
| 2900 | 100,000 | 200 | 300 | 400 |

*for continuously running pumps only.
**recommended capacity based on twice the evaporation rate.

82

The transfer pumps are also sized from this chart. Transfer pump capacities should equal boiler feed pump capacities if the boiler feed pumps are sized for the combined loads of all boilers. When multiple boiler feed pumps are sized to feed their repsective boilers, the transfer pump size should be based on the combined total of the active feed pumps not including the stand-by pumps when specified.

## Deaerators

Deaerators are more efficient in removing air from water than are deaerating heaters. They achieve this efficiency by first heating the water above its flash temperature and then breaking it down into minute particles to release its gases.

Like deaerating heaters, deaerators are furnished in three basic configurations. The single compartment unit is used where make-up water consists of 80% or more of the load or where an existing condensate receiver can be converted to an accumulator and transfer unit.
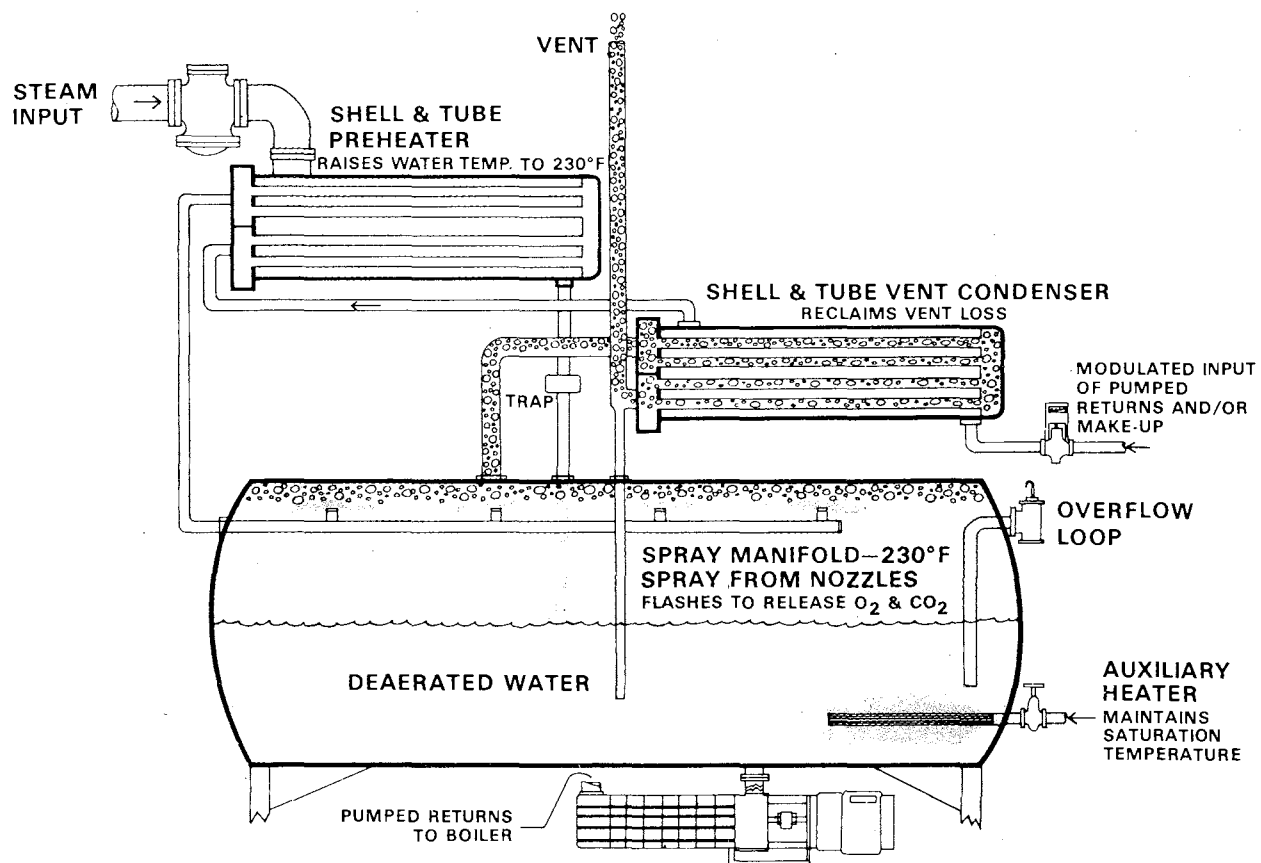
The operating principle of a deaerator is shown in Figure 86. Condensate and make-up water enters the shell side of the shell and tube vent condenser. The water picks up heat from the vent vapor in the tubes and goes on to the shell and tube preheater, which raises its temperature to $230^\circ$ F. A steam control valve with its sensing bulb at the outlet of this preheater controls the temperature of the water.

The $230^\circ$ water now enters the spray manifold and is released by the spray nozzles to the deaerator tank. Some of the water flashes to steam and air and carbon dioxide are released in the process. The vent vapor passes through the tubes of the vent condenser where it condenses and returns to the deaerator shell. The released gases are vented to the atmosphere.

The drawing in Figure 86 is a schematic and does not include the controls or the make-up water feeder which are a part of the unit. A profile view of the single compartment deaerator is shown in Figure 87.

The two compartment deaerator with self-contained accumulator appears in Figure 88. The transfer pumps which move the water from the accumulator through the heat exchangers and to the spray nozzles can be seen at the right hand side of the unit. These units are used where the system make-up water is less than 80%, where the condensate return rate is uncontrolled, or where some gravity returns are present with pumped returns.

Single compartment units with separate accumulators are used for systems where the condensate return rate is uncontrolled, where gravity returns are present with pumped returns, or where space or size considerations require separating the deaerator and the accumulator. Figure 89 shows the piping with this arrangement.

STEAM INPUT →

SHELL & TUBE PREHEATER
RAISES WATER TEMP. TO 230°F

VENT

SHELL & TUBE VENT CONDENSER
RECLAIMS VENT LOSS

TRAP

MODULATED INPUT OF PUMPED RETURNS AND/OR MAKE-UP

OVERFLOW LOOP

SPRAY MANIFOLD—230°F
SPRAY FROM NOZZLES
FLASHES TO RELEASE $O_2$ & $CO_2$

DEAERATED WATER

AUXILIARY HEATER
MAINTAINS SATURATION TEMPERATURE
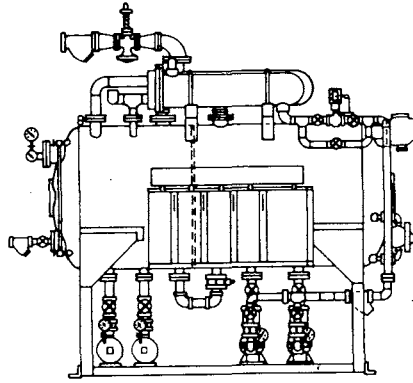
PUMPED RETURNS TO BOILER

Schematic Diagram of Deaerator Operation
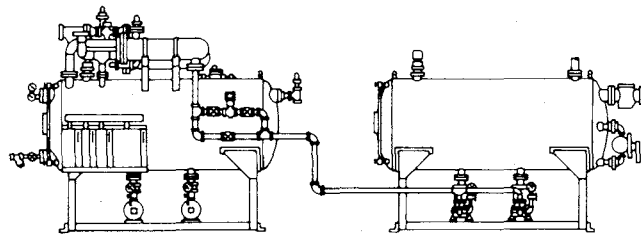
Figure 86.
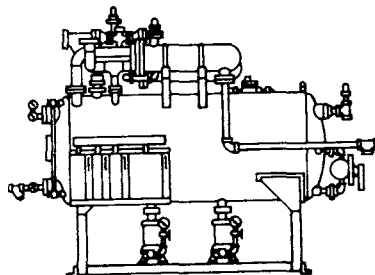
Single Compartment Deaerator

Figure 87.

Two Compartment Deaerator

Figure 88.



Deaerator with Separate Accumulator

Figure 89.

## Application and Selection

Single compartment deaerators are sized by their storage capacity. The table below states the required storage capacity for various system configurations in terms of condensate produced in the stated time interval.

**SUGGESTED STORAGE CAPACITIES—Style DA5M Deaerator**

| Nature of Returns | Water Make-Up Requirement | | |
| --- | --- | --- | --- |
| | 80 to 100% | Less than 80% | |
| | (Suggest proportioning make-up controls) | Systems with time lag of 10 minutes or less | Systems with exceptionally long time lag (Campus style complex) |
| Uncontrolled: Pumped returns— i.e., from condensate or vacuum pumps | 5 min. | 10 min. | 15 min. (Suggest using accumulator with 15 min. storage and 5 min. in deaerator; refer to Style DA5A or DA5R units) |
| Controlled: Returns from systems using accumulator tank—continuous transfer of condensate from accumulator (proportioning level control and valve) | 5 min. | 5 min. | 5 min. |

Where a two compartment deaerator is required, the required storage capacity is calculated in total, with this total being divided between the deaerator and accumulator compartments as shown in the following table.

**SUGGESTED STORAGE CAPACITIES—Style DA5A Deaerators**

| Nature of Returns | Water Make-Up Requirement | | |
| --- | --- | --- | --- |
| | 80 to 100% | Less than 80% | |
| | | Systems with time lag of 10 minutes or less | Systems with exceptionally long time lag (Campus style complex) |
| Continuous: Controlled transfer of condensate between compartments (proportioning level control and valve) | Usually not required. Refer to Style DA5M single compartment unit. | 15 minute total (5 min. in deaerator compartment and 10 min. in accumulator compartment) | 20 minute total (5 min. in deaerator compartment and 15 min. in accumulator compartment) |
| Intermittent: Transfer of condensate between compartments | | 20 minute total (10 min. in each compartment) | Use controlled transfer of condensate—See above |

86

Jobs requiring a deaerator with a separate accumulator tank require sizing the deaerator and accumulator tank separately. The deaerator is sized for controlled returns, which require a five minute storage capacity as shown in the first table of this section.

The accumulator is sized individually for the storage capacity indicated in the following table.

**SUGGESTED ACCUMULATOR TANK STORAGE CAPACITIES—**
**Style DA5R Deaerator**

| Nature of Returns | Water Make-Up Requirement | | |
| --- | --- | --- | --- |
| | 80 to 100% | Less than 80% | |
| | | Systems with time lag of 10 minutes | Systems with exceptionally long time lag (Campus style complex) |
| Pumped or gravity returns | Accumulator not normally required | 10 min. | 15 min. (data on time lags in excess of 15 minutes furnished on request) |

## Sizing the Boiler Feed Pumps

The boiler feed pumps are sized for the pressure required at the boiler and for the capacity indicated on the following table, according to boiler horsepower.

**SUGGESTED BOILER FEED & TRANSFER PUMP**
**CAPACITIES BASED ON SYSTEM LOAD**

| Boiler hp | System Load lbs./hr. Steam | GPM | Pump GPM* | Pump GPM** |
| --- | --- | --- | --- | --- |
| 72 | 2,500 | 5 | 7.5 | 10 |
| 144 | 5,000 | 10 | 15 | 20 |
| 216 | 7,500 | 15 | 22.5 | 30 |
| 290 | 10,000 | 20 | 30 | 40 |
| 434 | 15,000 | 30 | 45 | 60 |
| 580 | 20,000 | 40 | 60 | 80 |
| 720 | 25,000 | 50 | 75 | 100 |
| 868 | 30,000 | 60 | 90 | 120 |
| 1,160 | 40,000 | 80 | 120 | 160 |
| 1,440 | 50,000 | 100 | 150 | 200 |
| 2,160 | 75,000 | 150 | 225 | 300 |
| 2,900 | 100,000 | 200 | 300 | 400 |

*For continuously running pumps only.
**Recommended capacity based on twice the system load.

When boiler feed pumps are discharging into a common header to feed multiple boilers, the pumps should each be sized for the combined load of all boilers. When each pump feeds its individual boiler, it should be sized for the load of its respective boiler only.

## Sizing the Transfer Pumps

The transfer pumps are sized using the same table presented in the boiler feed pump discussion. Transfer pump capacities should equal boiler feed capacities if the boiler feed pumps are sized for the combined load of all boilers.

When multiple boiler feed pumps are sized to feed their respective boilers, the transfer pump size should be based on the combined total of the active feed pumps; not including standby pumps when specified.

The transfer pump capacity for units with shell and tube vent condenser should be increased by 1-1/2 times the base figure determined in the above procedure. When a direct contact vent condenser is used on two compartment units, the transfer capacity should be 2 times the system load to allow for recirculation through the direct contact vent condenser. These units all use standard 25 psig single stage transfer pumps.

Operational problems in steam heating systems which have been functioning properly for a period of time are usually due to the malfunction of a system component. The malfunction may be caused by mechanical failure or by dirt and sludge from the system which interferes with the operation of the component.

This section will not attempt to treat the subject of system trouble-shooting in depth. The more common problems encountered in day-to-day service work will be dealt with. The approach will be to begin at the boiler, going to the other portions of the system from this point.

## Boiler Controls

A complaint of flooding of the boiler or too low a water level in the boiler indicates that boiler water feeder may be at fault. Other factors may also cause this problem, making it necessary to make a test of the feeder to determine whether it is actually at fault.

## Boiler is Getting Too Much Water

Figure 90 shows the piping around a typical water feeder. To test the feeder, the water level in the boiler must be higher than the closing level of the feeder. Valve (2) in the diagram should be run closed and union (3) should be broken.
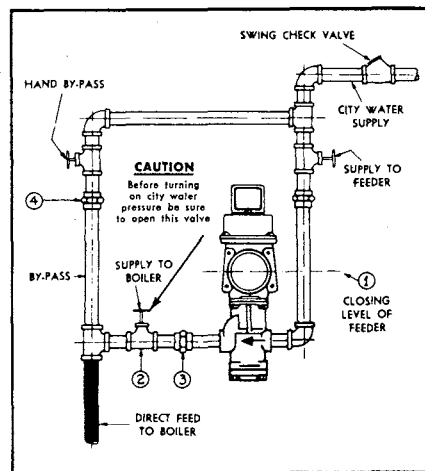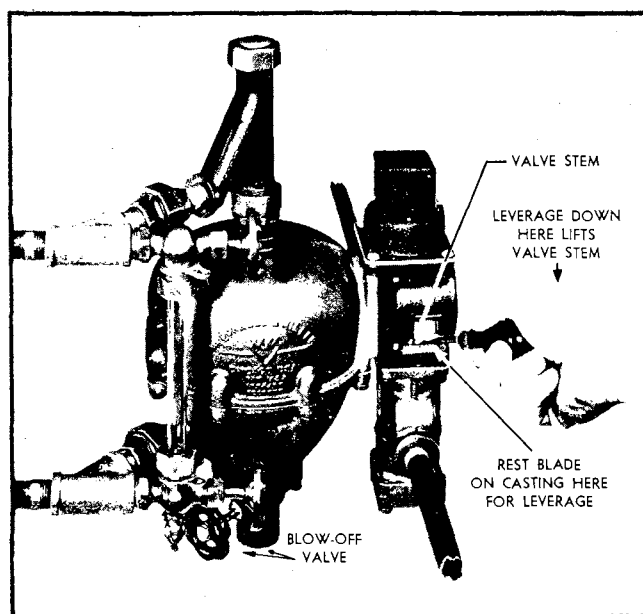


Make-up Water Feeder Installation

Figure 90.

If the feeder is closed off, no water should trickle out of the broken union.  A continuous trickle indicates a leaky valve in the feeder.  This is sometimes due to dirt on the valve seat.

It may be possible to flush the valve seat.  A screwdriver used as a pry under the float linkage lifts the stem.  Working the stem up and down in this manner often washes away the dirt from the seat.  Figure 91 shows how this is done.  If this doesn't stop the leakage, a replacement valve assembly should be installed.



VALVE STEM

LEVERAGE DOWN
HERE LIFTS
VALVE STEM

REST BLADE
ON CASTING HERE
FOR LEVERAGE

BLOW-OFF
VALVE

Testing Boiler Water Feeder

Figure 91.

If no water trickles from the broken union, the valve is okay and the cause lies elsewhere.  A common cause of overfeeding is shown in Figure 92.  If the line from the feeder to the boiler becomes partially plugged, a back-pressure builds up which holds the valve off its seat after it opens.  Opening valve (2) with the union (3) broken should show a full stream of water if the fill line is clean.  A mere trickle indicates a plugged line.  The supply line should be taken down and cleaned or better still, replaced when this condition is indicated.
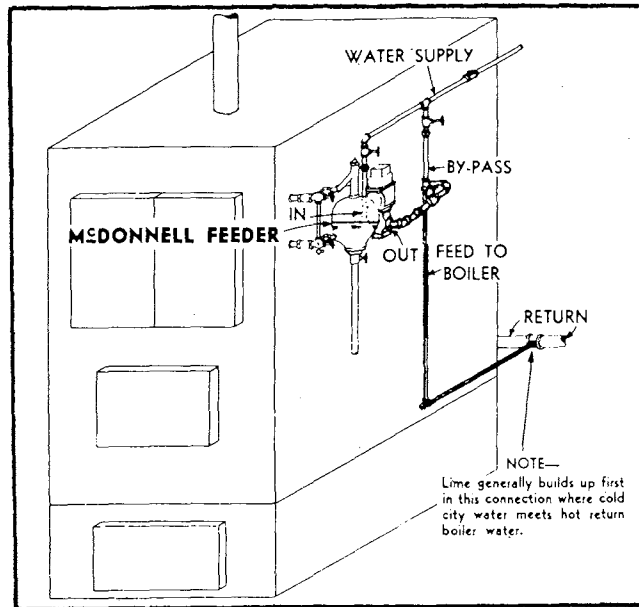
Plugged Water Feeder Supply Piping

Figure 92.

Other causes for boiler flooding are listed below:

1.    Leaky hot water coil in the boiler.

2.    City water supply pressure exceeds working press-
      ure of the feeder  -  valve cannot close tightly.

3.    Defective float in water feeder.

4.    Too much manual addition of water.

5.    Plugged equalizing pipe connection to boiler feeder.

6.    Leaky hand bypass valve.

## Boiler is Getting Too Little Water

The union (3) in Figure 90 should be broken.  Manual opening and
closing of the feeder valve as shown in Figure 91 should be easily accomplish-
ed.  Each time the valve lifts, a full stream of water should rush from the
broken union.  If this doesn't take place, the blow-off valve under the float
chamber should be opened.

If little or no water comes out the blow-off valve, the float chamber is loaded with sediment and preventing the float from dropping and opening the feeder valve. The float housing must be opened and cleaned, after which the operation of the water feeder may be checked again.

The broken union test may show the feeder to be okay, but with no water entering the boiler. The feed line to the boiler is likely to be fully plugged in this case. It should be taken down and cleaned or replaced.

If the valve operates easily when actuated manually but little or no water spills from the union, check the strainer. It is probably filled with dirt and requires cleaning.

Other common causes for low boiler water level are:

1.        Priming and foaming due to dirty boiler water.

2.        Faulty operation of boiler feed pumps.

3.        City water pressure lower than boiler steam pressure.

4.        Faulty swing check in return header allowing boiler water to be pushed out into return.
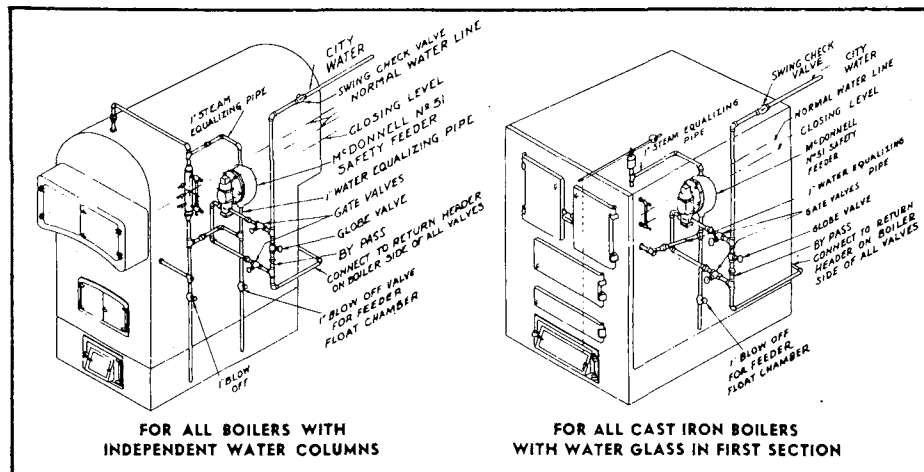
5.        Leaking return piping.

## Checking Float Operated Switches

If a defective low water cut-off or pump switch is suspected, it may be checked by opening the float chamber blow-down valve with the burner in operation. The pump should start first as the float drops, with the burner cutting out on a further drop. If this does not take place, the control switches require replacement.

A waterlogged float in a low water cut-off will hang down and hold its switch open. This will cause the burner to stay off. Replacement of the float is called for in this case.

## Improper Piping

Float operated controls cannot properly respond to changes in boiler water level unless they are correctly piped. Figure 93 shows recommended piping practice for both steel and cast iron boilers. Location of the control with respect to the boiler water level is extremely important. As a rule, the closing level of the water feeder should be set about 2" to 2-1/2" below the normal water line.

FOR ALL BOILERS WITH
INDEPENDENT WATER COLUMNS

FOR ALL CAST IRON BOILERS
WITH WATER GLASS IN FIRST SECTION

Typical Piping for Boiler Water Feeders

Figure 93.

Steam Vents

When a steam vent doesn't do its job, it must be replaced since it can't be dismantled for repair. When a radiator doesn't heat, it is probably due to a dirt plugged vent that won't allow air to escape.

Vents may continually discharge steam due to a collapsed float or a pinhole leak. In either case, the proper procedure is to remove the offending unit and replace it.

End of main vents will result in little or no heating in the entire main when they become plugged with dirt. A vent with a bad float will continually blow steam because it can't shut off. Proper repair procedure calls for replacement of the vent.

TRAPS

Thermostatic Traps

When the trap discharges continuously (trap hot, blowing steam), the bellows has gone bad or there is dirt on the seat. The trap should be cleaned or the bellows replaced, whichever inspection indicates is necessary.

A cold trap which doesn't discharge condensate could have a ruptured bellows which causes the trap to remain closed. The bellows should be replaced in this case.

The bellows in these traps is made of very thin material and can be damaged by water hammer. This is usually the problem when a bellows failure occurs.


## Float and Thermostatic Traps

Where problems are encountered with this trap type, the following check list will help in locating and remedying them.

### Trap Cold - No Discharge

1. Strainer screen clogged - clean or replace.
2. Obstruction downstream - locate and remove.
3. Trap clogged - clean out.

### Trap Hot - Blowing Steam

1. Thermostatic element not closing - replace.
2. Valve pin and seat worn - replace.

### Slow or Uneven Heating

1. Trap too small - replace with proper size.
2. Thermostatic element not eliminating the air - replace.

These traps are easily dismantled for cleaning or parts replacement by removing the cover. Have gaskets and replacement parts at hand before beginning the repair since the old cover gasket may be damaged when the cover is removed.


## Bucket Traps

Where operational problems are encountered with bucket traps, one of the following causes will probably be found. Suggested remedies are given.

### Continuous Discharge from Trap

1. Trap is too small - install larger trap or another in parallel.

2. High pressure trap may be installed on low pressure application - replace with proper trap.

### Trap Cold - No Discharge

1.  Pressure too high and trap will not open - replace with properly rated trap.

2.  No flow through trap due to obstruction in line - locate and remove obstruction.

3.  Trap clogged - clean out intervals.


### Trap Hot - Blowing Steam

1.  Trap may have lost its prime - prime trap.

2.  Worn valve mechanism - replacement valve parts.

3.  Valve stuck open by scale or dirt - clean valve.


### Slow or Uneven Heating

1.  Trap too small - replace with larger trap or another in parallel.

2.  Insufficient air handling capacity - installing auxiliary air vent.


## Condensate Pumps

Condensate pumps consist of a centrifugal pump attached to a receiver. The pumps are furnished as single and two stage, depending upon the available NPSH.

Figure 94 is a cross section of a single stage pump. The two stage is pictured in Figure 95. The principal difference is the extra impeller in the double stage pump, making possible low available NPSH operation.

The usual mechanical problem encountered with either pump type is leakage of the mechanical seal when worn. This calls for replacement of the seal assembly. The seals can be changed in the field. The service instructions for the pump should be obtained and followed when seal replacement becomes necessary.

Where condensate pumps are not operating properly, the following troubleshooting guide will help determine the cause and suggest a remedy.

40° C VERTICAL PUMP MOTOR

WATER SLINGER

MECHANICAL SEAL

AIR RELIEF

HEAD RING

HEAD GASKET

PUMP HEAD

PUMP CASE

WASHER

CASE RING

IMPELLER

LOCKING CAP NUT

MOTOR SHAFT KEYED OR THREADED
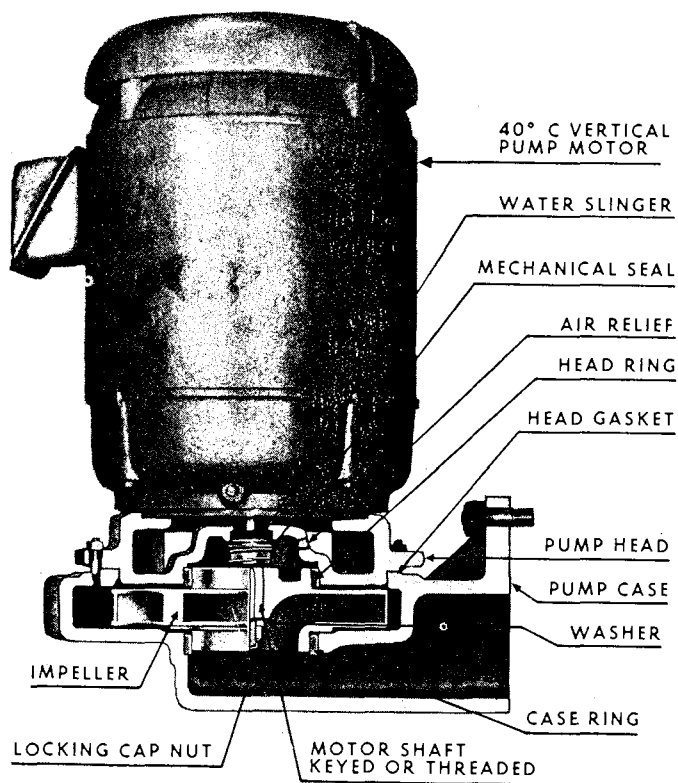
Single Stage Condensate Pump

Figure 94.



HEAVY DUTY BALL BEARING MOTOR
SAFETY SLINGER
PUMP HEAD
STAINLESS STEEL SHAFT
AIR RELIEF CONNECTION
PERFORMANCE TESTED MECHANICAL SEAL
PUMP CASE
IMPELLER
CAST BRONZE STRAIGHTENING VANES
STAINLESS STEEL AXIAL FLOW IMPELLER SHAFT
SUCTION HOUSING
CAST BRONZE AXIAL FLOW IMPELLER

DISCHARGE

SUCTION
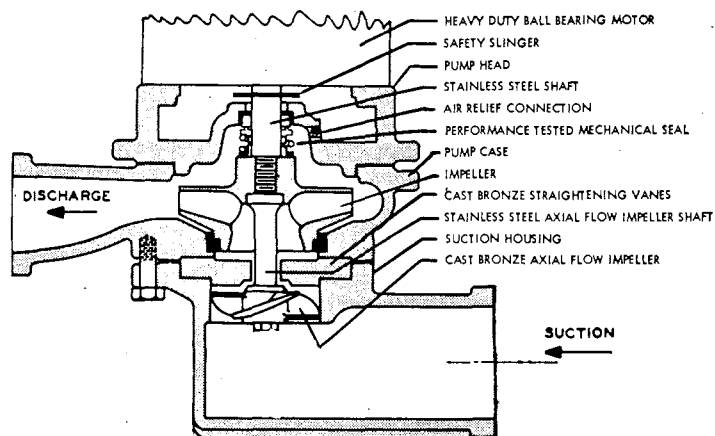
Two Stage Condensate Pump

Figure 95.

# TROUBLESHOOTING GUIDE

## Pump Will Not Start

1. The power supply has been interrupted, disconnect switch is open, or selector switch is improperly positioned.

2. Incorrect voltage for motor. Check voltage and wiring with motor characteristics.

3. Incorrect starter coil for power supply.

4. The overload relays and the starter have tripped out and must be reset. Ambient temperature may be too high.

5. Check pump controls or other controls for proper operation.

6. Wiring to control cabinet is incorrect or connections are loose.

7. The strainer is dirty thus retarding flow. Clean periodically.

## Pump Runs Continuously

1. Pump is running counter-clockwise looking down on motor. Rotation of three phase motors may be corrected by interchanging any two of the three wires.

2. Steam traps are blowing through causing condensate to return at excessive temperatures. This may reduce the capacity of pump below its rating, depending on the unit and type of pump furnished. Traps should be repaired or replaced.

3. The total pressure at the pump discharge is greater than the pressure for which the pump was designed. Check the total pressure which includes atmospheric pressure, the friction head and the static head.

4. A valve in the discharge line is closed or throttled too tightly. Check valve is installed backwards.

5. The impeller eye is clogged with trash. Refer to applicable pump manual.

6. Pump is too small for system.

## Condensate Pump is Noisy

1.  The pump is working against a lower pressure than designed for.  While pump is discharging, adjust plug cock in discharge line until pressure at pump approaches pump rated pressure.

2.  Excessive condensate temperature.  Correct system conditions.  However, this applies to certain units only; others are designed to handle boiling water.

3.  Magnetic hum or bearing noise in motor.  Consult motor manufacturer's authorized service station nearest unit location.

4.  Starter chatters.  Trouble is caused by low line voltage, poor connections, defective starter coil, or burned contacts.

5.  Pump is running backward.


## The System is Noisy

1.  Banging in the steam mains is usually caused by steam "imploding" in condensate lying in low points in lines.  These problems can be eliminated by dripping low points, properly supporting the pipe, or by increasing the pitch of the lines.

2.  Improper dripping of the steam mains and risers; where there is a rise in the steam main, or where it branches off into a riser, a drip trap must be installed in the drain line.

3.  The piping is too small to drain properly.

4.  A defective trap is holding condensate in steam supply line.


## Vacuum Pumps

The vacuum pump performs the functions of returning condensate to the boiler plus keeping the system returns under vacuum.  Troubleshooting, therefore, involves checking both functions.  The following troubleshooting guide will help isolate the cause of improper operation.

# TROUBLESHOOTING GUIDE

## Pump Will Not Start

1.      The power supply has been interrupted, disconnect switch is open or selector switches improperly positioned.

2.      Insufficient condensate has accumulated to actuate float switch.

3.      Vacuum is not low enough to actuate vacuum switch, or temperature limit switch is open.

4.      Incorrect voltage for motor. Check voltage and wiring with motor characteristics.

5.      Incorrect starter coil for power supply.

6.      The overload relays in the starter have tripped out and must be reset. Ambient temperature may be too high.

7.      Check float switch, vacuum switch or other control for proper operation.

8.      Wiring to control panel is incorrect or connections are loose.

## Pump Does Not Return All Condensate to Boiler (Pump Floods)

1.      Pump is running counter-clockwise looking down on motor. Rotation of three phase motors may be corrected by interchanging any two of the three wires.

2.      Steam traps are blowing through causing condensate to return at excessive temperatures. If 160° is exceeded the capacity of the pump may be reduced below its rating. Traps should be repaired or replaced.

3.      The total pressure at the pump discharge is greater than the pressure for which the pump was designed. Check the total pressure which includes the boiler pressure, the friction head and the static head.

4.      A valve in the discharge line between pump and boiler is closed or throttled too tightly. Check valve is installed backwards.

5.    Condensate is held up in system periodically by induced vacuum in boiler or radiation then released in a flood when pump starts. Install equalizer line.

6.    The strainer is dirty thus retarding flow. Refer to instructions for cleaning.

7.    The impeller eye is clogged with trash.

8.    The discharge valve fails to open. This may be caused by pilot valve remaining in a closed position or dirt becoming lodged in the pilot valve pressure release line.

9.    Systems with accumulator tanks should have equalizer line run from accumulator tank to steam header. NOT from accumulator tank to pump receiver NOR from pump receiver to steam header. Install vacuum breaker on accumulator tank, NOT on pump.

10.    Pump is too small for the system.

11.    Check valve in lift manifold leaks, causing pump to lose prime. Replace facing material or valve.

## Air Pump Runs Continuously or Fails to Produce Sufficient Vacuum

1.    Selector switch is set on "continuous" or "hand".

2.    The temperature of the condensate is too high. Normal operating condensate temperature should not exceed $160°$ F. for rated capacities. Correct the cause for high temperature condensate.

3.    There are excessive leaks in the system piping preventing the pump from producing sufficient vacuum to satisfy the vacuum switch setting. To confirm this, make sure pump is primed, close inlet valve, close equalizing line valve, plug other check valve on this line, replace vacuum breaker with plug and observe shut-off vacuum while pump is running.

4.    The vacuum or float switch electrical contacts remain in closed position. Adjust controls.

5.    The nozzle, strainer, or impeller passageways are clogged with foreign matter. Refer to instructions for cleaning.

6.    A vacuum breaker is set too low. It should not admit air at a vacuum within the range of the vacuum switch setting.

7.          The pump has losts its "hurling" water.  There should
never be less than about 1/4" in the water level gage
glass.  Loss of "hurling" water may be caused by any of
the following:

(1)   Discharge valve leaks due to dirt or worn seat.
(2)   Orifice in guide screw in discharge valve is closed.
(3)   Discharge valve bellows is ruptured.
(4)   Pilot valve remains in open position.
(5)   Check valve in lift manifold is leaking.

8.          Check valve in equalizer line or line from lower compart-
ment of receiver or from accumulator tank leaks, or is in-
stalled backwards.

9.          Pump is running backward.  Rotation must be clockwise
looking down on motor.

10.        Pump is too small for the system.

11.        Lower float switch does not turn off.  Float rests on receiv-
er bottom and should be raised.

12.        The upper compartment float switch does not cut-out be-
fore the pilot valve closes.  If pump continues to run after
discharging the condensate, with controls set for float
only, it will be necessary to readjust upper float switch.


## Pump Starts and Stops in Rapid Succession

1.          Strainer clogged with dirt. Clean strainer.

2.          A check valve in return line.  Remove.

3.          A partially closed inlet valve.  Valve should be a gate
valve rather than globe.

4.          A lift in return line at or near the pump.  Low return will
fill with condensate between pump operations. The inertia
of the collected water may be quite large, and before the
vacuum suddenly produced by starting of the pump can set
the water in motion, the vacuum at the pump may reach
the cut-off point of the vacuum switch, thus stopping the
pump.  The vacuum quickly recedes as the condensate
moves into the receiver and the pump "trips in" on vacuum
control again, thus repeating this "hunting action".

There are two ways to correct this difficulty:

(1)    If the vacuum sensing line can be drained away from the vacuum switch(es), connect this sensing line into the nearest "dry" point in the return main so that the operation of the unit may be governed by the vacuum in the system.

(2)    If the nearest "dry" point on the return main is more than 2 ft. above the vacuum switch, relocate and re-connect the switches to sense the vacuum at this point. If a separate selector switch is not already furnished with the control panel one must be provided for each vacuum switch. Contact manufacturer for details.

5.    Elbow in return line too close to unit inlet. Correct as described in item 3 above.

6.    Equalizer line is improperly connected.

7.    Either of the two check valves in equalizer line leaks or is installed backward.

Pump Makes Noise

1.    The pump is working against a lower pressure than designed for. While pump is discharging, adjust square headed steam cock in discharge line until pressure at pump approaches pump rated pressure. Secure adjustment of steam cock by tightening plug nut.

2.    Excessive condensate temperature. Correct system conditions.

3.    Magnetic hum or bearing noise in motor. Consult motor manufacturer's authorized service station nearest pump location.

4.    Starter chatters. Trouble is caused by low line voltage, poor connections, defective starter coil, or burned contacts.

5.    Pump is running backward.

6.    Water hammer when discharge valve closes:

(1)    Adjust steam cock to reduce discharge velocity or
(2)    Install surge chamber on boiler side discharge check valve or
(3)    Install additional check valve near boiler or
(4)    Install discharge piping 1 or 2 sizes larger.

## The System is Noisy

1.     Banging in the steam mains is usually caused by steam "imploding" in condensate lying in low points in lines. These pockets can be eliminated by "dripping" low points, properly supporting the pipe, or by increasing the pitch of the lines.

2.     Improper dripping of the steam mains and risers. Where there is a rise in the steam main, or where it branches off into a riser, a drip trap must be installed to the drain line.

3.     The piping is too small to drain properly.

4.     A defective trap is holding condensate in radiation.

5.     A priming boiler is permitting a carry-over of water with the steam. A priming boiler is caused by:

    (1)     Oil or other foreign matter. Clean boiler thoroughly.
    (2)     A reduction of the steam liberating area due to too high a water level in the boiler. Reduce water line.
    (3)     Overloading. Reduce firing rate.
    (4)     Undersized steam outlet area, resulting in velocities in excess of 15 to 25 ft. per second.

6.     Hartford return connection; repipe eliminating Hartford return. If Hartford connection is required, use Y fitting at connection to loop, directing condensate downward.

## Pressure Reducing Valves

Pressure reducing valves are furnished in two types as explained earlier. The troubleshooting procedure varies with the valve type involved. For this reason, each valve type will be discussed individually.

# REMOTE SENSING PRESSURE REDUCING VALVE

## TROUBLESHOOTING GUIDE

### Banging Valve - Sudden Open, Sudden Close

1.      Check feeler line - it must have a needle valve.

2.      Needle valve acts as orifice or restriction to allow slow change in downstream feedback.

3.      Close needle valve slowly until banging condition stops.

### Valve Will Not Close

1.      Stuffing gland nut too tight or dirt around the stem.

2.      Brown scale on stem is from teflon gland - build-up could restrict the travel.   (Clean stem with fine emery cloth.)

3.      Build-up of boiler compound or a blockage in the feeler line is preventing feedback of the downstream pressure to top of diaphragm case.

4.      Dirt under seat preventing tight closing of valve.

5.      Hole in diaphragm - control fluid will blow out around stem. If, when changing diaphragm, no hole is visible, then tighten diaphragm nut to create a better seal.

### Continuous Problem of Diaphragms Becoming Brittle and Leaking

1.      Water seal on diaphragm is either not forming or being siphoned off through feeler line. Diaphragm is being subjected to live steam or high temperatures. To eliminate, add a condensate chamber or mount the valve with the diaphragm case in the up position.

### Valve Constantly Hunts - Cannot Reduce Pressure or Required Setting

1.      Bypass line globe valve could be leaking and charging the downstream with full line pressure.   Make sure globe valve is tightly closed.

2.      Pressure reducing valve could be oversized.  To determine
        if valve is oversized, close the inlet gate valve and then
        open 1/2 to 2 turns.  If control pressure can be set and hunt-
        ing stops, valve is oversized.

## Valve Controls Reduced Pressure During Light Loads, But Pressure Falls Off During Peak Demand Loads

1.      Inlet or outlet gate valves could be partially closed restrict-
        ing the flow.  Make sure gate valves are fully open.

2.      Pressure reducing valve could be undersized.  To determine
        if valve is undersized, open bypass globe valve under peak
        demand conditions and check control.  If reduced pressure
        can be set with bypass valve partially open, then valve is
        undersized.

## INTERNAL SENSING PRESSURE REDUCING VALVE

## TROUBLESHOOTING GUIDE

## Valve Will Not Close

1.      Dirt under seat preventing tight closing.

2.      Internal feeler passage clogged or plugged with dirt.

3.      Diaphragm has torn and is leaking control fluid out of vent
        hole in upper diaphragm case or spring case.

## Valve Constantly Hunts - Cannot Reduce Pressure or Required Setting

1.      Bypass line globe valve could be leaking and charging the
        downstream with full line pressure.  Make sure globe
        valve is not leaking and is tightly closed.

2.      Pressure reducing valve could be oversized.  To determine
        if valve is oversized, close the inlet gate valve and open
        1/2 to 2 turns.  If control pressure can be set and hunting
        stops, valve is oversized.

## Outlet Pressure Falls Off During Heavy Load Demands

1.    Inlet gate valve could be partially closed restricting the flow.  Make sure the gate valve is fully open.

2.    Pressure reducing valve could be undersized.  To determine if valve is undersized, open bypass globe valve under peak demand conditions and check control.  If reduced pressure can be set with bypass valve partially open, then valve is undersized.

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1) The tissue in plants that brings water upward from the roots;
2) a leading global water technology company.

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Let's Solve Water

Xylem Inc.
8200 N. Austin Avenue
Morton Grove, Illinois 60053
Phone: (847) 966-3700
Fax: (847) 965-8379
www.bellgossett.com