Power Generation Department
Operator Trainee Training Program

Section 11
STEAM TRAPS

OBJECTIVES:

1. Discuss the basic functions of a steam trap
2. Discuss the construction and operating principles of the three general classes of heavy duty industrial stem traps.

Power Generation Department
Operator Trainee Training Program

Section 11
STEAM TRAPS

Traps, along with piping and valves, compose the arteries that interconnect the various pieces of equipment in a generating station. Steam traps are installed in steam lines to remove condensate without the loss of steam. They prevent water being carried into the turbine and damaging blading. In heating systems, they remove condensate and air without the loss of steam. They improve efficiency by causing steam to condense before it is removed, increasing the rate of heat transfer. They prevent water hammer from endangering the piping and fittings.

The steam trap must serve three major functions:

1. Let out condensate but hold back steam.
2. Eliminate air and gas quickly.
3. Remove condensate, air, and gas by responding promptly to changing conditions in the line.

In general, a steam trap consists of a valve and some device or arrangement which will cause the valve to open or close, when necessary, to drain the condensate from the line without allowing the escape of steam.

The steam trap does this by either (1) responding quickly to temperature changes in the line (identifying the difference between hot steam and slightly cooler condensate); or (2) being able to tell the difference between liquid (water) and vapor (steam). In the first instance, the trap opens and closes due to temperature changes ahead of it. In the second case, it operates due to change of state of the fluid, from water to vapor.

There are many different types of steam traps, but this section will deal only with heavy duty industrial types. They are divided into three general classes:

1. **Mechanical.** These operate on change of state of the fluid coming to the trap. They open to water or condensate, but close on steam.
2. **Thermostatic.** These are actuated by the temperature of the liquid flowing to the trap. They open on cool condensate and close near steam temperature.
3. **Thermodynamic.** These operate by utilization of the differences in thermodynamic energy available from steam and hot condensate.

MECHANICAL TRAPS

Although there are several basic types of traps in this class, they all have one principle in common; all are operated by response to the difference in density between steam and water or condensate.

The Float Trap is one of the earliest types of steam traps (Figure 11.1). It consists of a closed housing containing a ball float. In the simplest form of this trap, the float is attached to the end of a rod or lever . The opposite end of the lever is attached to a discharge valve. When condensate fills the body or housing of the trap the float rises, gradually opening the discharge valve. Increasing condensate flow raises the float and opens the valve wider adjusting it to

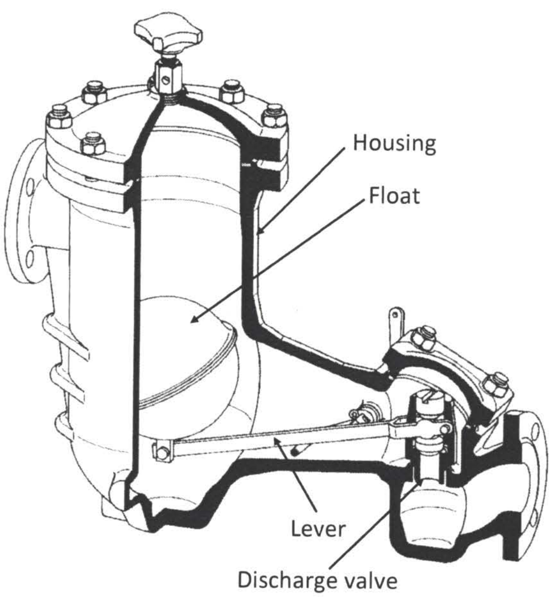


Figure 11.1—Float Trap

suit the condensate load and maintaining the proper condensate level within the trap body.

Another early type of trap is the Open Bucket Trap (Figure 11.2). This consists of a bucket or float, open at the top, operating within a housing. The bucket pivots around a fulcrum. Attached to the bucket is a valve

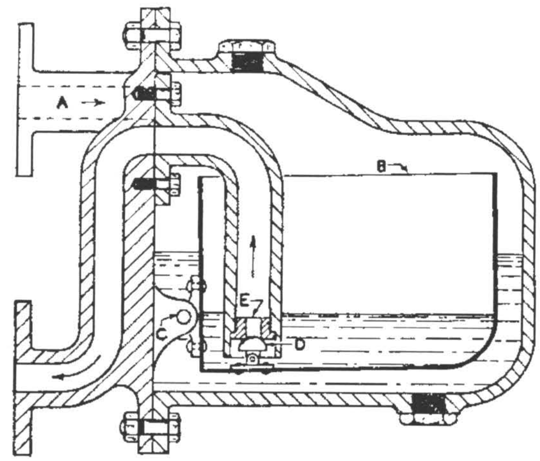


Figure 11.2—Open Bucket Trap

rod extending upward through a discharge tube. At the top of the valve rod is a discharge valve which seats in the orifice.

In some designs the bucket surrounds the discharge tube and slides up and down

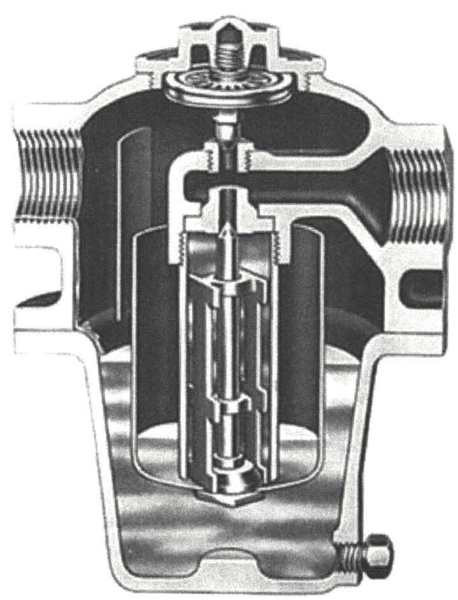


Figure 11.3—Open Bucket Trap

along the tube as shown in Figure 11.3, rather than being hinged to a pivot, but the operation is essentially the same.

When condensate reaches this trap, it gradually fills up the body and floats the bucket. This causes the bucket to rise and close the valve. Finally condensate spills over the top of the bucket and the bucket sinks. This opens the valve and the pressure inside the trap body forces the water up through the discharge tube and out the orifice. As soon as the bucket is emptied sufficiently, it floats again, closing the valve, and the cycle is repeated.

In earlier models of the float and open bucket traps, the accumulation of air in the body of the trap often became a problem. Later models were equipped with a thermostatic element, usually of the bellows type, which automatically vents the air from the trap body. As the air is cooler than the steam, the thermostatic element opens to let out the air, but closes on the steam.

A more recent and more commonly used type of bucket trap is the Inverted Bucket Trap (Figure 11.4). It is somewhat similar to the Open Bucket Trap, but in this case the bucket (A) is inverted and is open at the bottom. Attached to the top of the bucket is a valve (B) linkage mechanism which permits the air (C) discharge valve to open and close as the bucket falls and rises. When the bucket is at rest, it hangs downward with the valve open. Condensate enters the trap either from the side, flowing down the passage in the side of the trap and then

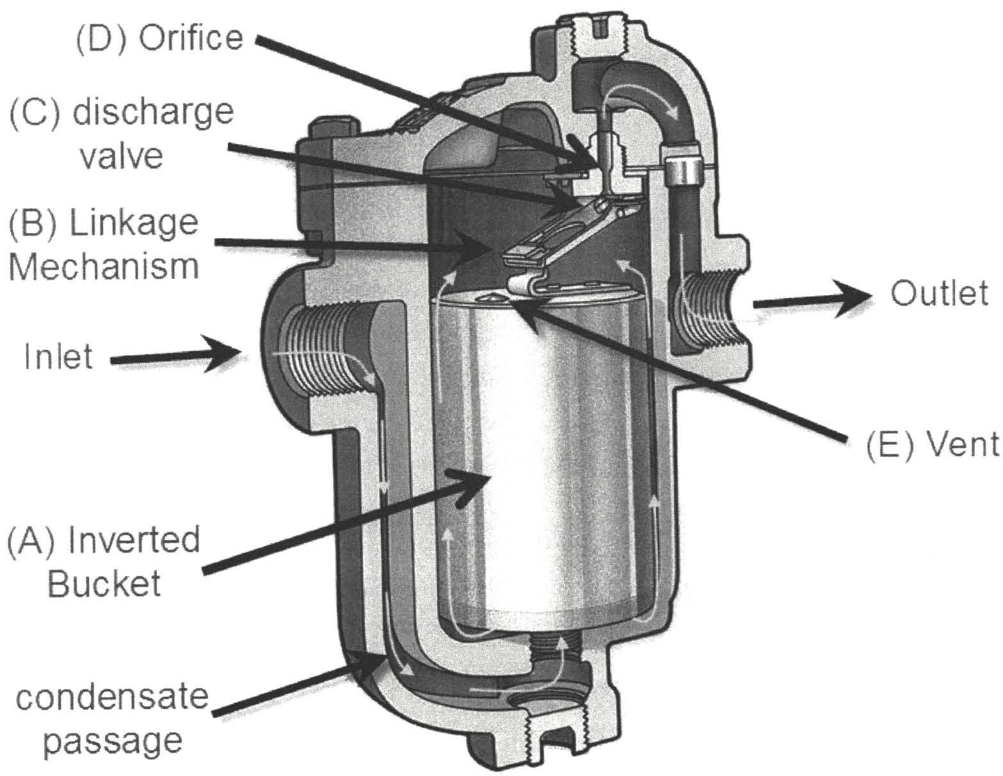


Figure 11.4—Inverted Bucket Trap

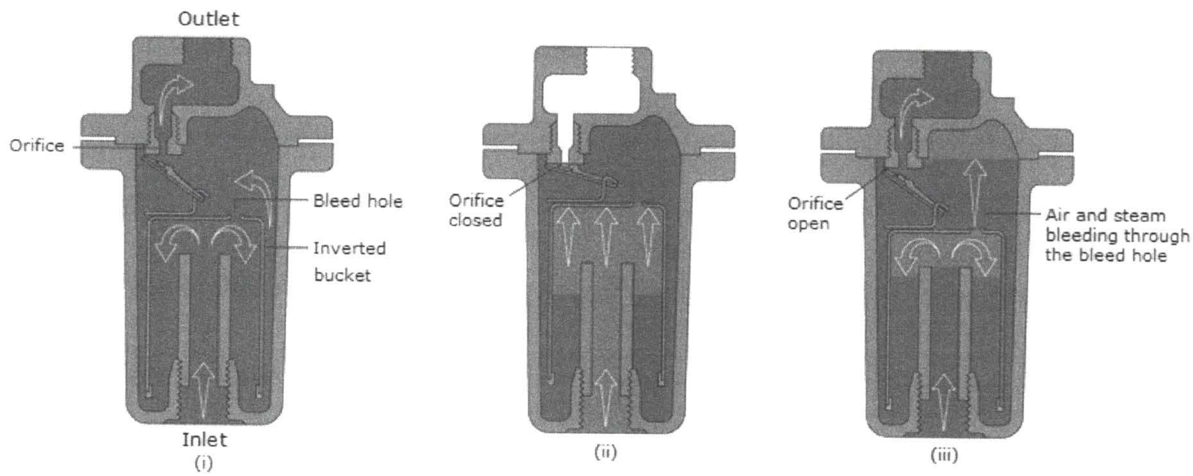


Figure 11.5—Inverted Bucket Trap with bottom inlet.

upward under the open end of the bucket, or, if the trap has a bottom inlet (Figure 11.5), the condensate will enter directly under the bottom of the bucket.

In operation, as long as condensate is flowing to the trap, the bucket stays down and flow continues out the orifice and passage (D). When steam reaches the trap, it fills the bucket, the bucket floats and rises to close the valve. The steam in the bucket slowly condenses and also bleeds off through the small vent (E) in the top of the bucket. Thus the bucket loses its buoyancy and finally sinks, opening the valve again to discharge more condensate.

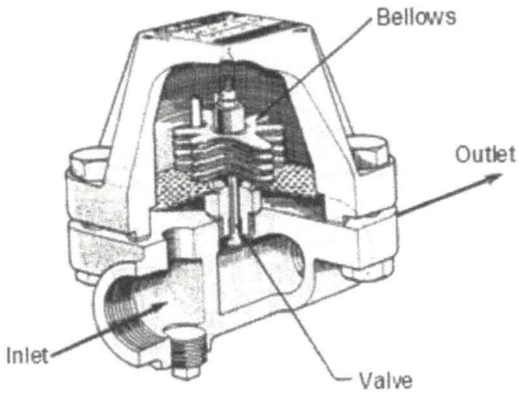
While the vent (E) (about 1/16" in diameter in a 1/2" trap) allows some of the steam in the bucket to bubble up into the body of the trap and condense, another important purpose of the vent is to permit passage of the air and non-condensable gases. If it were not for this vent the bucket would soon become filled with air and keep the valve closed all the time, rendering the trap air-bound and inoperative.

Flow of air through the vent is limited as it is due only to the buoyancy of the air in the water. The elimination of large amounts of air is handled by a bucket with a second or auxiliary vent. This auxiliary vent is much larger than the regular vent and is provided with a disc valve controlled by a thermostatic bimetallic strip. When the trap is cold the bimetallic strip bends downward opening the auxiliary vent valve. This provides quicker air elimination during the start-up period. As warmer condensate and air enter the bucket, the bimetallic strip gradually bends toward the closed position. As long as any air is present, the auxiliary vent will be at least partly open. When all air is eliminated and steam fills the bucket, the auxiliary vent closes completely leaving only the fixed vent open.

THERMOSTATIC TRAPS

All thermostatic traps work on the same basic principle. They respond to temperature changes in the line, opening to cool condensate and closing on steam.

The most commonly used is the bellows



THERMOSTATIC STEAM TRAP

Figure 11.6

type (Figure 11.6). The operating element consists of a corrugated bellows mounted within a housing. At the bottom of the bellows a valve is mounted which closes the orifice when the bellows expands. Usually the bellows is filled with a liquid, such as alcohol and water, which has a boiling point below that of water. When condensate approaching steam temperature comes to the trap, the liquid inside the bellows vaporizes, building up pressure inside that causes the bellows to expand and close the valve. The valve remains closed until radiation of heat from the body of the trap (and cooling of the condensate coming to the trap) allows the vapor within the bellows to slowly condense. The bellows then contracts, opening the valve wide again. As the valve is wide open when the trap is cool this type of trap provides quick start-up of equipment and excellent air handling ability.

Time required to condense the vapor within the bellows is dependent on a number of factors: size and material of trap body, length of pipe between trap and apparatus it is draining, and temperature of air surrounding the trap.

The bellows trap has several limitations. A sensitivity to water hammer requires that dips in the line ahead of the trap be avoided, as well as any sudden pressure changes that might allow slugs of water to strike and damage the bellows. The upper limit of pressure on which this type of trap may be used is approximately 300 psi.

A bimetallic strip is used to operate some types of thermostatic traps. As condensate cooler than the steam comes to the trap, this bimetal element bends one way, opening the valve. When hot steam comes along, the element bends the opposite way, closing the valve. (Figure 11.7).

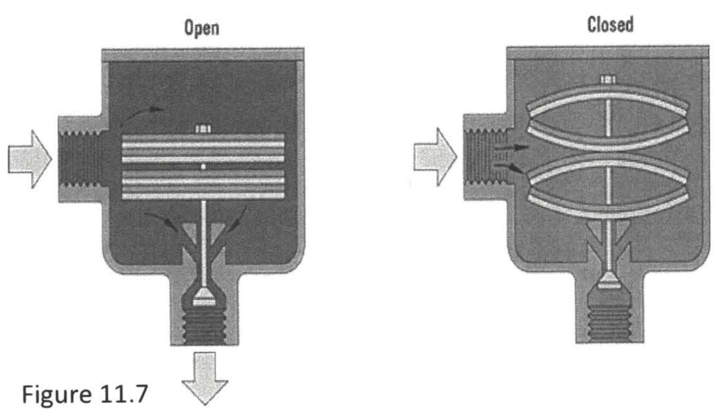
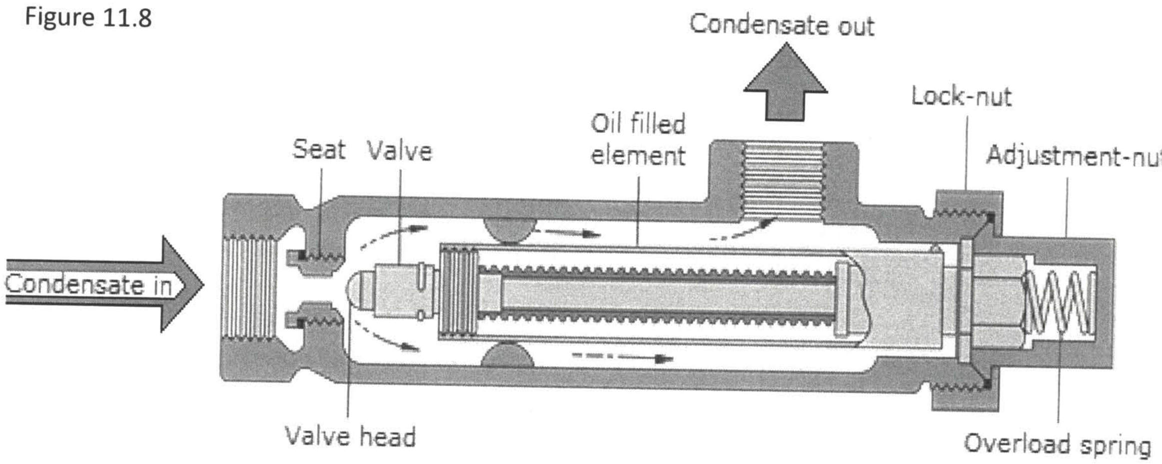


Figure 11.7

Another type of thermostatic trap is operated by the expansion of a liquid in a long enclosed tube which causes the tube to open and close a valve in the end of the trap housing. A similar type employs the expansion and contraction of a metal rod to

Figure 11.8



open and close the valve. (Figure 11.8).

FLOAT AND THERMOSTATIC TRAPS

This trap combines the float mechanism with a thermostatic element (Figure 11.9). The latter is usually of the bellows type although bimetallic elements are also used in some makes. The addition of the thermostatic element provides greater air handling ability, particularly at start-up, than the float mechanism alone, and the float trap portion provides variable flow according to the condensate load. All thermostatic traps have this in common, however, they are operated and controlled by the temperature in the line ahead of the trap and time must be allowed for the operating elements to either absorb heat to cause closure of the valve or dissipate heat to cause it to open.

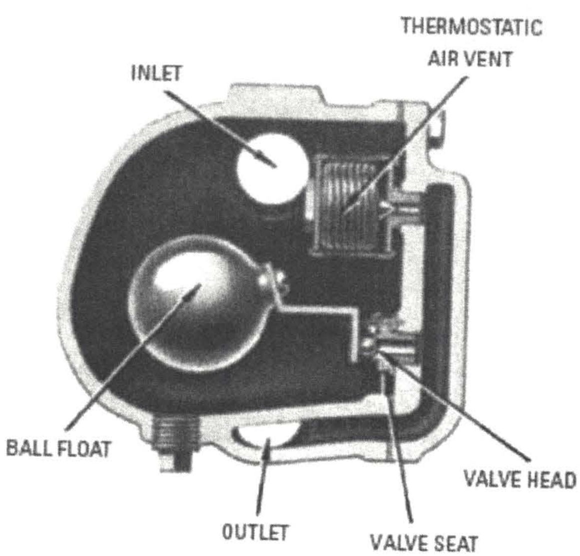


Figure 11.9 Float and thermostatic steam trap

FLASH STEAM (OR FLASH VAPOR)

Flash steam has an important bearing on the operation of Thermodynamic Traps, the third general class of steam traps. Flash steam or flash vapor is the vapor that forms when hot water at steam temperature is discharged to the atmosphere (or from a higher pressure to a lower pressure). A simple illustration of this is the cloud of vapor that rises when boiling water from a kettle is poured into the kitchen sink. If the hot water were placed in a closed vessel such as a pressure cooker and heated up, the pressure in the cooker would rise and each pound of water would then contain more heat than it held when it was boiling in the kettle at atmospheric pressure or 0 psig. As the pressure increases, the boiling temperature increases. If the safety valve from the top of the pressure cooker were removed, the contents of the cooker would be released to atmospheric pressure or 0 psig and a tremendous cloud of steam would burst out of the cooker. This is flash steam or steam at 0 psig. This flash steam expands to many times the volume it had when it was water. If the water in the cooker was at a pressure of 15 psig and the pressure is reduced to 0 psig, the portion of the water that turns to flash steam would have nearly 1600 times the volume it had before it turned to flash steam. This flashing is caused by the suddenly increased boiling of the water in the vessel as the pressure is reduced, because the water contains more heat than it can hold at atmospheric pressure. Flash steam is always formed when hot water (or condensate) is released from a higher pressure to a lower pressure.

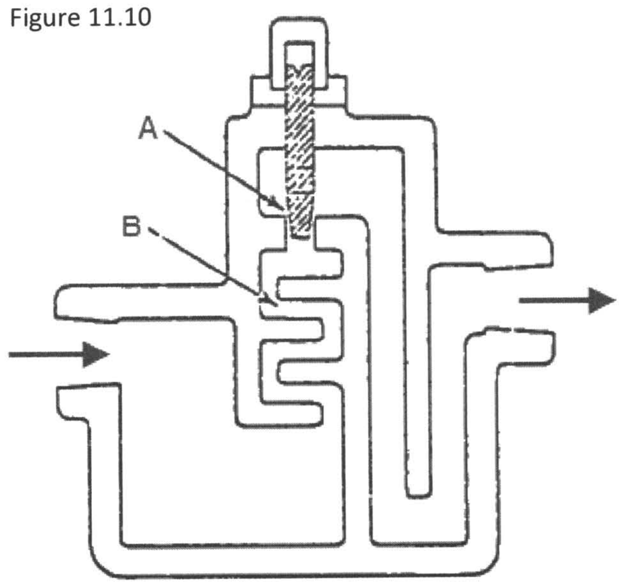
If a steam trap is discharging to the atmosphere and the trap is draining apparatus supplied with steam at 100 psig, the condensate is being discharged from a higher pressure (100 psig) to a lower pressure (0 psig). Therefore, some of the discharged condensate will reboil or turn to flash steam when it emerges from the trap. When steam first gives up its heat and turns to condensate, the condensate is at steam temperature. The closer to steam temperature a trap can discharge, the more quickly it can discharge the condensate after it forms.

THERMODYNAMIC TRAPS

This class of steam traps utilizes the heat energy in hot condensate and steam to control the opening and closing of the trap.

Orifice (Labyrinth) (Figure 11.10) was one of the earliest types of thermodynamic traps. In one form it combines an adjustable orifice (A) with labyrinth passages (B) to control the flow of condensate. Due to pressure drop through the labyrinth passages and the adjustable orifice, some condensate turns to flash steam as condensate approaches steam temperature. This provides a

Figure 11.10



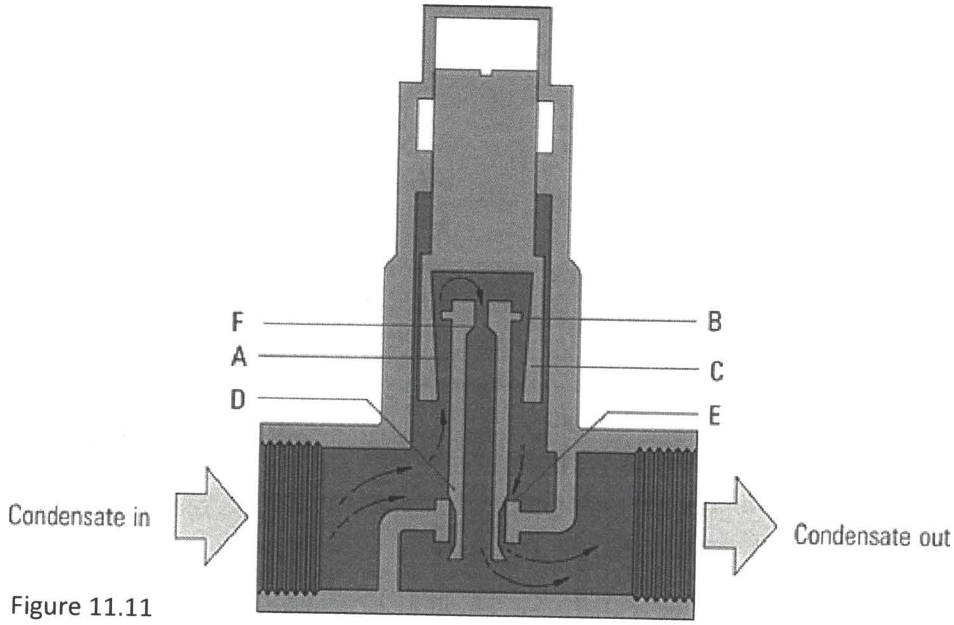


Figure 11.11

measure of automatic flow control. The nearer the condensate approaches steam temperature, the greater the flashing and the greater the choking effect of the flash steam. If the condensate load does not fluctuate to any great degree, this trap is quite satisfactory. However, if load or pressure vary considerably, it is likely to either back-up condensate or blow live steam.

The Impulse Trap is a more modern type of thermodynamic trap (Figure 11.11). Its best known form consists essentially of a piston type valve operating within a cylinder. The impulse trap has a hallow piston (A) with a piston disc (B) working inside of a tapered piston (C) which acts as a guide. At "start up" the main valve (D) rests on the seat (E) leaving a passage of flow through the clearance between piston and cylinder and hole (F) at the top of the piston. Increasing flow of air and condensate will act on the piston disc and lift the main valve off its seat to give increased flow. Some condensate will also flow through the gap between the piston and disc, through (E) and away to the trap outlet.

As the condensate approaches steam temperature some of it flashes to steam as it passes through the gap. Although this is bled away through the hole (F) it does create an intermediate pressure over the piston, which effectively positions the main valve to meet the load. The trap can be adjusted by moving the position of piston (B) relative to the seat, but the trap is affected by significant backpressure. It has a substantial capacity, bearing in mind its small size. Conversely, the trap is unable to give complete shut-off and will pass steam on very light loads. The main problem however is the fine clearance between the piston and cylinder. This is readily affected by the dirt normally found in a steam system.

The Integral Strainer Impulse Trap is for high pressure service and is made with a built- in

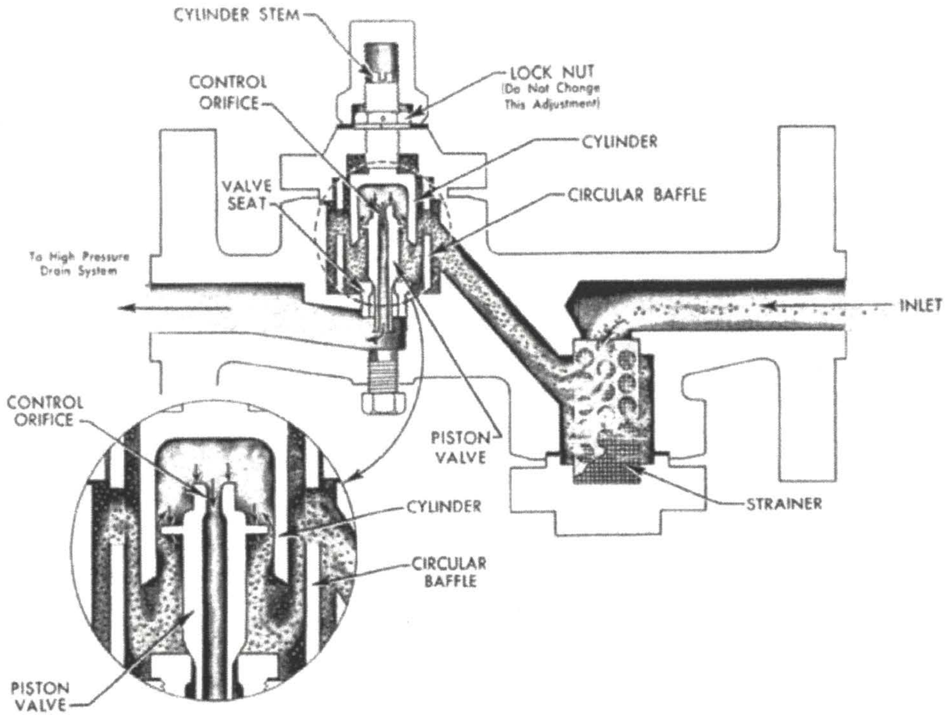


Figure 11.12 Integral Impulse Trap

or integral strainer that provides a compact and sturdy construction for such types of applications (Figure 11.12) . The Lever Valve Impulse Trap is a newer version of the Impulse Trap and is designed for extra heavy condensate loads (Figure 11.13). It operates on the same basic principle as the original type but with a lever action rather than a piston action. This trap consists of a valve disc attached to an inlet valve. The valve disc acts as an outlet valve, opening and closing the outlet orifice as the valve disc tilts up and down around the fulcrum point. A control orifice is provided in the valve disc over the center of the discharge or outlet orifice. When the valve disc is at rest there is a control flow between the inlet valve and its seat. This control flow then goes

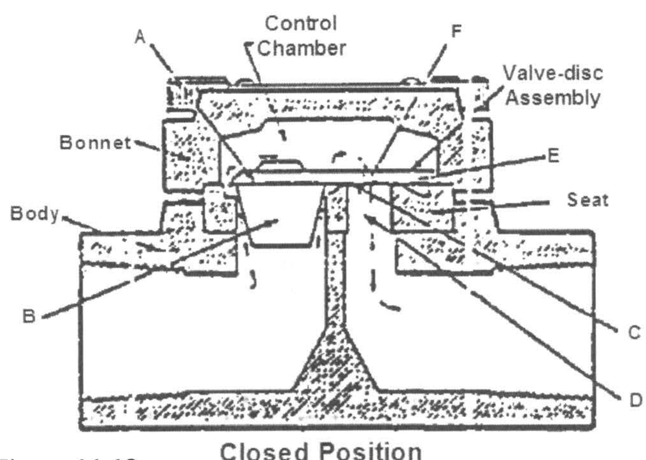


Figure 11.13

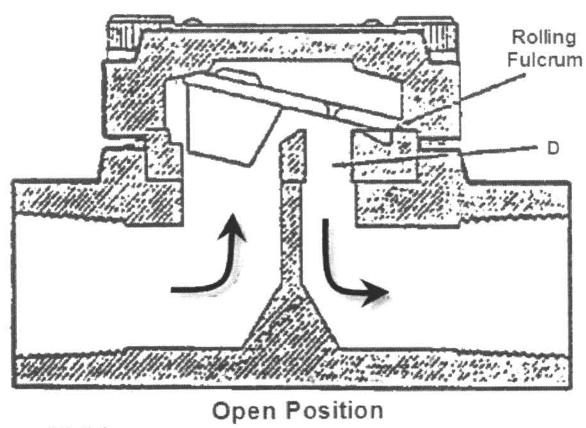


Figure 11.14

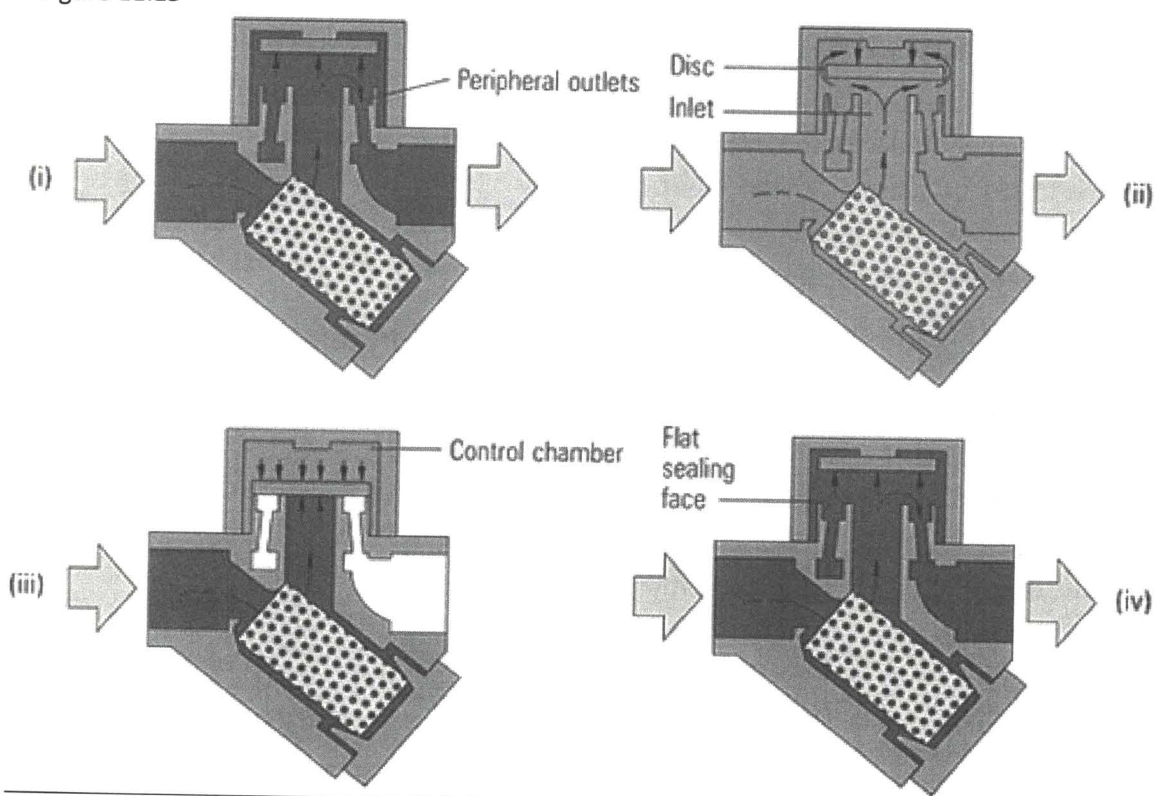
on out the control orifice. Incoming condensate and air push the disc upward with a tilting action and full flow goes out the discharge orifice (Figure 11.14).

On startup, air is handled through the control orifice. Only cool condensate or a mixture of condensate and air, will open the valve lever. As steam temperature condensate reaches the trap, flashing begins in the outlet orifice, building up pressure in the chamber above the lever. The lever closes as the chamber pressure increases. A small "control flow" permits quick response to inlet conditions. A slight drop in condensate temperature, for instance, reduces the chamber pressure, quickly opening the lever. Lever traps are designed for applications having large condensate loads and where rapid discharge of condensate is a requirement.

Operation is similar to that of the original Impulse Trap except the control flow combines with the main flow when the valve opens instead of following a separate flow path as in the earlier type. Flashing of the hot condensate controls the closing of the valve disc just as in the original Impulse type and action is governed by the same basic principle of control flow.

One of the most recently developed types of thermodynamic traps is the Disc Trap (Figure 11.15). It consists of a round flat Disc positioned over a center inlet orifice and an annular discharge leading off through a discharge port. All are enclosed within a bonnet mounted on the body of the trap. When operation starts, pressure in the inlet orifice pushes the disc up vertically off the two concentric seating surfaces surrounding the inlet and outlet pons. This allows

Figure 11.15



discharge to flow out through the peripheral outlets. Now when very hot condensate and steam come to the trap the high velocity flow outward past the rim of the disc up into the chamber tends to reduce the pressure on the under side of the disc causing some of the condensate to turn to flash steam (ii). At the same time the flashing condensate flowing outward at high velocity strikes the side wall of the chamber causing a build up of pressure in the chamber snapping the disc shut (iii). The disc remains in the closed position until the pressure in the bonnet falls due to the condensing of the steam in the bonnet. When pressure in the bonnet falls sufficiently the disc rises, condensate flows out and the cycle is repeated (iv).

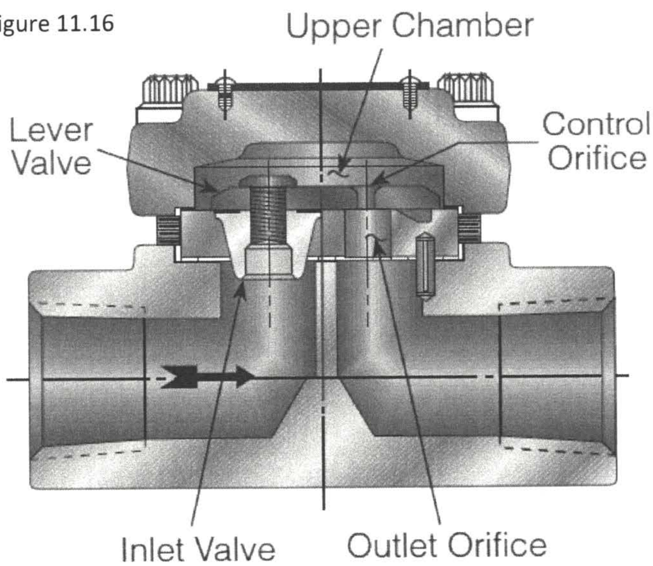
This type of trap is essentially a time cycle device. Under normal operating conditions, each time the disc closes on steam at a given pressure and temperature, it will stay closed for approximately the same length of time. This means that if condensate comes to the trap in the middle of a cycle, it will have to wait till pressure in the bonnet falls sufficiently to permit the disc to open.

The Lever Disc Impulse Trap operates in somewhat the same manner as the Disc Trap, except that the valve disc is arranged so that it opens and closes the valve with a tilting action rather than moving straight up and down. (Figure 11.16) It is designed primarily for the lighter condensate loads. When condensate enters this trap it pushes the disc upward with a tilting action because the inlet valve is off center. Discharge then goes out through the outlet orifice. When steam and steam temperature condensate come to the trap, flashing begins in the outlet orifice, the upper chamber fills with steam and the increased pressure closes the disc in a similar manner to that described for the disc trap above. The tilting or lever action of the valve in the lever disc trap insures a minimum of wear on the parts and also aids in reducing the noise from the trap discharge.

A small control flow through the control orifice allows quick response to inlet conditions.

This trap also operates on a time cycle; the time between opening and closing being relatively constant for a given set of load and pressure conditions. When the lever disc trap is closed by live steam and flash steam entering the upper chamber, it stays closed until the steam in the upper chamber condenses and also bleeds off slowly through the control orifice.

Figure 11.16



NOTES:

Section 11

STEAM TRAPS

Study Questions

1. List the three major functions that steam traps must serve.

   a.

   b.

   c.

2. Steam traps are installed in ______________________________________.

3. All basic types of______________________________traps have one principle in common; they operate on change of state of the fluid coming to the trap.

   a. Thermostatic

   b. Mechanical

   c. Thermodynamic

4. The *bellows* is one type of <u>mechanical</u> trap. True \ False

5. All thermostatic traps open on cool condensate and close near steam temperature. True \ False

6. What is one limitation of the *bellows trap*? ________________________________

7. The bimetallic element is instrumental in opening and closing a valve in some thermostatic traps. True \ False

8. Which of the following plays an important part in the operation of *Thermodynamic traps*?

   a. Bimetallic element

   b. Flash steam

   c. Valve rod

   d. None of the above

9. The thermodynamic trap utilizes the heat energy in hot condensate and steam to control the opening and closing of the trap. True \ False

10. The Disc trap and the Impulse trap are both essentially time cycle devices. True \ False