No. 16
June 13, 1952

ENGINEERING NEWS

HOFFMAN SPECIALTY MFG. CORP.
INDIANAPOLIS 7, IND.

THERMOSTATIC TRAPS

Thermostatic steam traps are the most common of all types found in modern steam heating systems. Some of the reasons why this is true is due to the following facts: - (1) They are simple in construction; - (2) small in size and weight; - (3) have adequate capacity for pressure differentials found in the average steam heating system.

A thermostatic trap is one which opens to discharge air and condensate (water) in response to temperature changes, and closes against the passage of steam. Some of the early thermostatic traps functioned by the expansion and contraction of carbon posts and metal tubes. These were adjusted to open and close at a fixed temperature. Fig. 1 is a diagramatic sketch of such a trap.

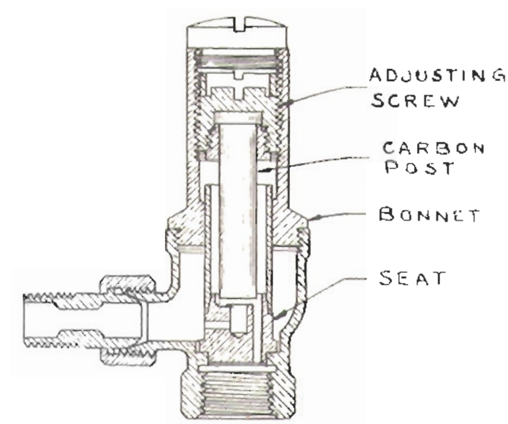


Fig. 1
Diagram of Carbon Post Trap

A modern thermostatic trap employs one of the following basic designs of thermal elements (temperature responsive member).

Type a. - Thermal element which responds to the vaporization of a liquid.

Type b. - Thermal element which responds to the expansion of a liquid.

Type c. - Thermal element which depends upon the deformation of a bi-metallic unit.

Thermal elements referred to in Types a. and b. are of two general constructions: - (Fig. 2) Bellows type, and (Fig. 3) Diaphragm type. There is a third type that uses a Bourdon tube which responds to vaporization of a volatile liquid. The material used in the construction of these elements is usually a non-corrosive alloy ranging from phospher bronze to those containing a high nickel content.

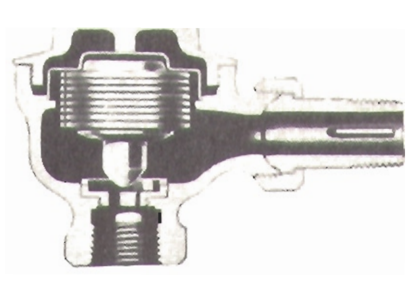


Fig. 2

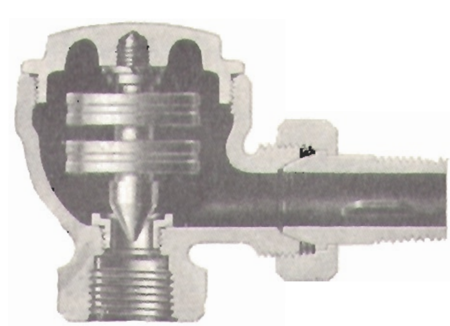


Fig. 3

DESIGN. Thermostatic steam traps with thermal elements whose performance depends upon the vaporization of a liquid are the most common or generally used types. For that reason, the design of this type will be discussed more completely in this Engineering News. Fig. 4 shows a conventional thermostatic radiator trap of the diaphragm type. It consists of the following parts:

A - Trap Body
B - Cover
C - Thermal Element
D - Valve Seat
E - Valve Pin (fastened to Thermal Element "C"
F - Connection Nipple
G - Coupling Nut

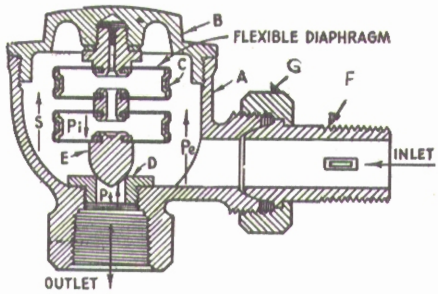


Fig. 4

The thermal element "C" is constructed of four (4) flexible diaphragms arranged to form two (2) cells or chambers intercommunicating with each other. The diaphragms are of such physical dimensions and shape to give known pressure-deflection characteristics to the thermal element. Also, within design pressure ranges, the required internal vapor pressure is developed for proper performance.

The thermal element is partially filled with the required quantity of a volatile liquid and sealed under vacuum. The expansion of the element is controlled so that the valve pin will open and close the valve seat when the thermal element is at the desired temperature, which is always below the temperature of saturated steam.

Referring to Fig. 4, the forces acting upon the thermal element for certain conditions are as follows:

S - The metal stress or springiness of the thermal element diaphragm. When all other things are equal, this force tends to collapse the thermal element and open the trap. This action is upward.

P_e - The pressure due to steam pressure. This force tends to collapse the thermal element and open the trap. This action is also upward.

P_t - The tail pipe pressure which when the valve pin is on its seat, also acts upward and tends to collapse the thermal element and open the trap.

P_i - The internal pressure caused by the vaporization of the volatile liquid. This force acts downward and tends to close the trap.

The forces are balanced when - $P_i = S + P_e + P_t$

The trap closes when - P_i is greater than $S + P_e + P_t$

The trap opens when - P_i is less than $S + P_e + P_t$

OPERATING PRINCIPLE. A thermostatic trap of the design discussed above operates on the principle of the expansion and contraction of the thermal element by the increase or decrease of its temperature. This change in temperature effects the internal pressure produced by the vaporization of the volatile liquid and is represented by the force P_i in Fig. 4. The thermal element is designed to contain a suitable volatile liquid which will cause the trap to open when the temperature surrounding the element is at a required number of degrees below that of saturated steam. This difference between saturated steam temperature and the opening temperature of the trap is called Temperature Drop.

The opening of the trap is caused by the temperature of air or condensate (water) present in the trap body. When the trap opens, the air and condensate is discharged and the entering steam temperature increases the temperature of the thermal element. This causes the volatile liquid to vaporize and build up the internal pressure sufficiently to close the trap.

Thermostatic traps operate both intermittently and with continuous discharge. Usually upon starting up cold equipment, they will discharge intermittently. This intermittent action is also common to high pressure thermostatic traps. For low pressure use, a thermostatic trap will discharge continuously when pressure and load conditions have stabilized.

EFFECT OF TEMPERATURE DROP. Thermostatic steam traps are designed to operate with Temperature Drop held within certain limits. This usually varies from about 5^{o} F. to 30^{o} F. and depends upon many factors. Usually Temperature Drop increases with increase in steam pressure. Because of these facts, it is well to understand the effect of Temperature Drop upon the operation of steam equipment. If a thermostatic steam trap is installed on equipment having a small internal volume, such as a unit heater, and the trap has a large Temperature Drop, the heat output from the equipment will be effected adversely because water will be held up by the trap remaining closed and the equipment will be flooded. This is the reason cooling legs are desirable and specified for many thermostatic trap applications. A cooling leg is nothing more than an adequate length of piping installed between the outlet of the equipment and the trap. This cooling leg permits the condensate to cool sufficiently to open the trap before the equipment becomes flooded.

Temperature drop can have adverse effects if it is too small. If the trap is used on equipment employing a vacuum pump, the return piping may become filled with steam due to re-evaporation to such an extent that the vacuum pump operation will be effected. Often it is necessary to cool the condensate before it reaches the pump. A common method employed to reduce the condensate temperature is to pass it through a heat exchanger to pre-heat domestic hot water.

CAPACITY. The capacity of a thermostatic steam trap for constant differential pressure conditions depends upon the diameter of the discharge port and the lift of the valve pin. The valve pin lift is, of course, governed by the expansion and contraction of the thermal element. This movement is dependent upon Temperature Drop and within certain limits of design, the capacity depends upon Temperature Drop.

The rapidity with which a thermostatic trap reaches maximum capacity depends to some extent upon the shape of the valve pin. A flat seat reaches maximum capacity opening with less travel than is required for a spherical or "V" shaped valve pin. The use of these different shapes is arbitrary, but usually there is a distinct advantage in using spherical or "V" shaped valve pins. They usually afford slower opening and better seating or sealing between the valve pin and the valve seat.

APPLICATION. Thermostatic steam traps are used to discharge air and drain the condensate from 2-pipe steam heating equipment such as radiators, convectors, and unit heaters. They are also used for dripping down-feed risers and runouts to equipment. They also find industrial uses for installation on water heaters, cooking kettles, steam tables, and process work in general.

The following diagrams suggest some of the more common uses for thermostatic traps.

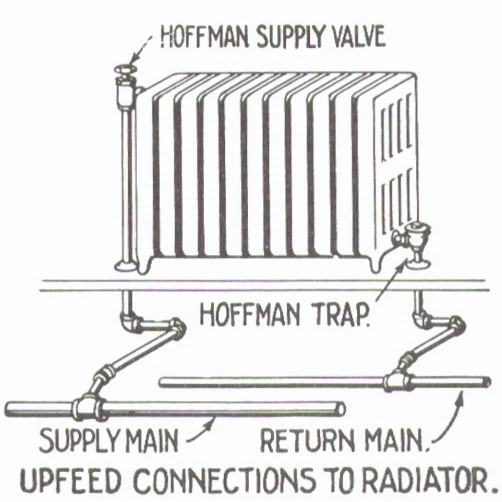


Fig. 5

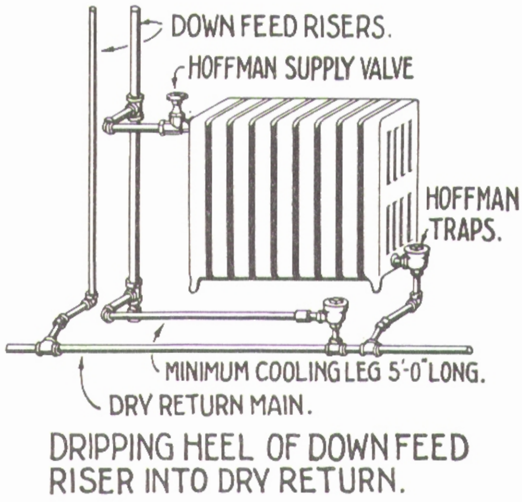


Fig. 6

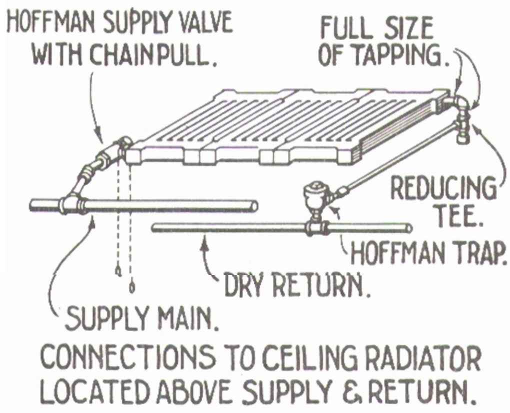
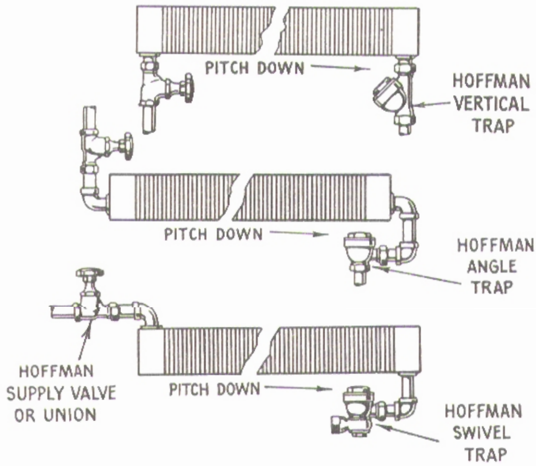


Fig. 7



Convectors and Fin Tube Wall Radiation

Fig. 8

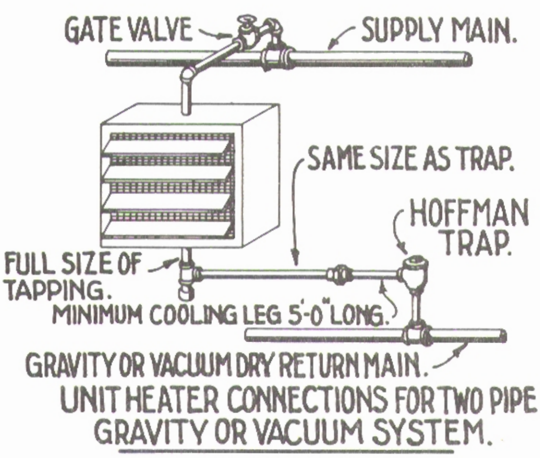


Fig. 9

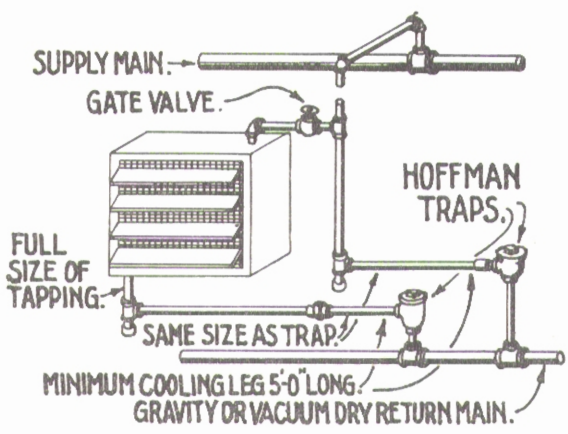


Fig. 10

The following diagrams suggest some of the more common uses for thermostatic traps.

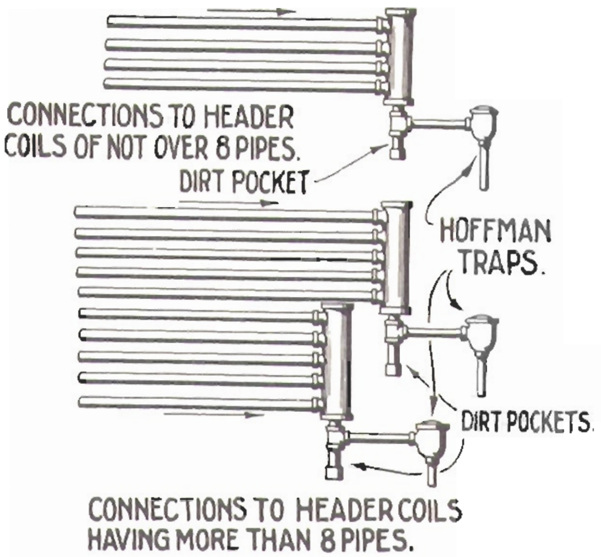


Fig. 11

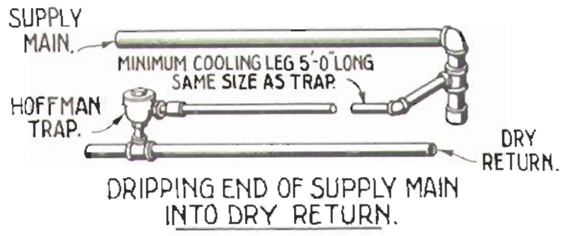


Fig. 12

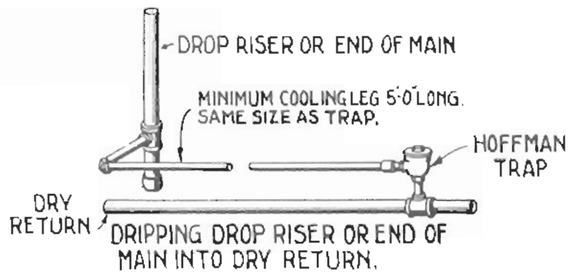
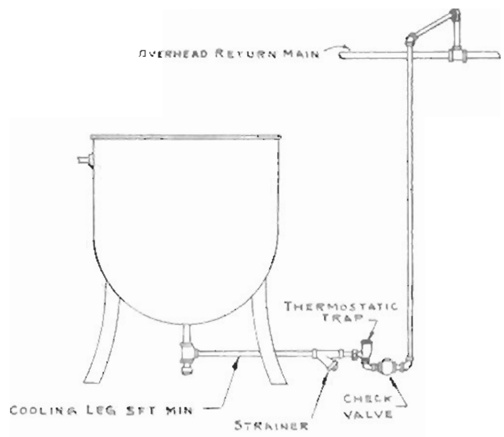


Fig. 13



Steam Kettle Showing Cooling Leg

Fig. 14

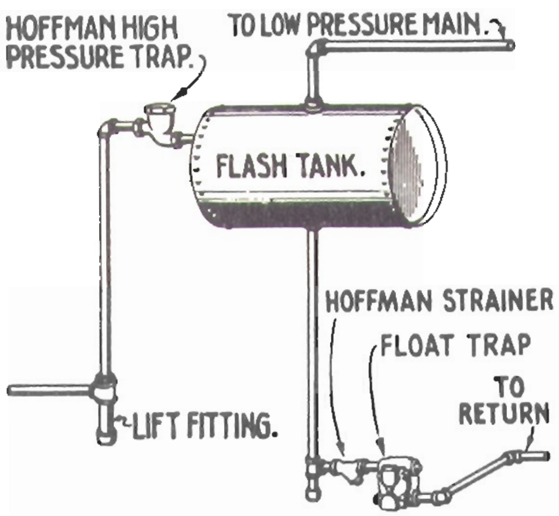
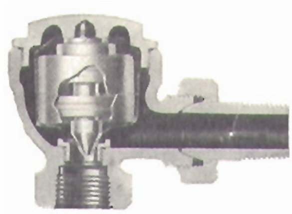


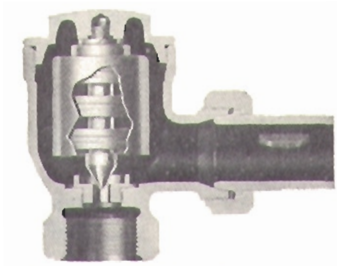
Fig. 15

RATING OF THERMOSTATIC TRAPS. For low pressure heating system use, small thermostatic traps are rated in square feet E. D. R. (Equivalent Direct Radiation). One square foot E. D. R. is equivalent to an output of 240 B. T. U. per hour or 0.25 lbs. of condensate (water) per hour. When the maximum operating pressure exceeds 25 P.S.I. the ratings are then given in lbs. of condensate per hour.

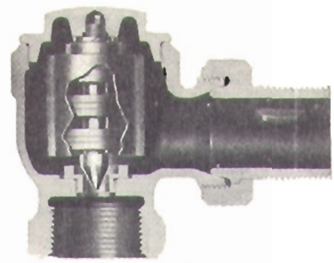
Ratings of Hoffman thermostatic traps:



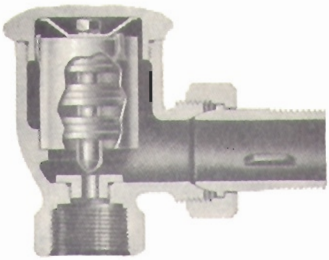
Capacity - 200 Sq. Ft. E.D.R.
Maximum Operating Pressure - 15 psi
Types - Angle, Swivel and Vertical



Capacity - 400 Sq. Ft. E.D.R.
Maximum Operating Pressure - 25 psi
Types - Angle & Straightway



Capacity - 700 Sq. Ft. E.D.R.
Maximum Operating Pressure - 25 psi
Types - Angle Only

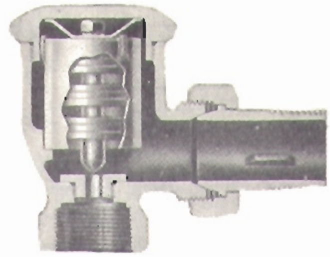


Maximum Operating Pressure - 50 psi
Types - Angle, Right Hand, Left Hand & Straightway

CAPACITY—LBS. CONDENSATE PER HOUR

No.	Size	Working Pressure—Lbs. Per Square Inch Gage			
		5	15	25	50
No. 8	3/8"	100	180	235	400
No. 8	1/2"	125	225	300	490

To convert lbs. of condensate or steam per hour, to sq. ft. E.D.R., multiply by 4.

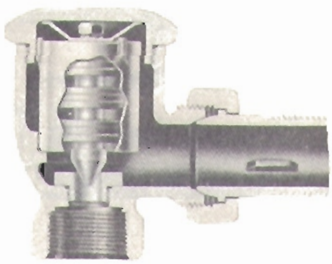


Maximum Operating Pressure - 50 psi
Types - Angle Only

CAPACITY—LBS. CONDENSATE PER HOUR

No.	Size	Working Pressure—Lbs. Per Square Inch Gage			
		5	15	25	50
No. 9	3/4"	225	350	450	650
No. 9	1"	325	500	625	850

To convert lbs. of condensate or steam per hour, to sq. ft. E.D.R., multiply by 4.

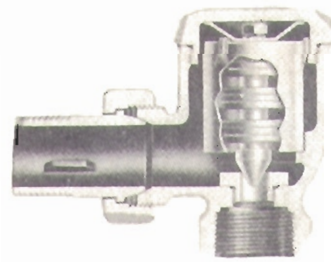


Maximum Operating Pressure - 125 psi
Types - Angle, Right Hand, Left Hand & Straightway

CAPACITY—LBS. CONDENSATE PER HOUR

No.	Size	Working Pressure—Lbs. Per Square Inch Gage			
		25	50	100	125
No. 8H	3/8"	235	400	550	590
No. 8H	1/2"	300	490	650	720

To convert lbs. of condensate or steam per hour, to sq. ft. E.D.R., multiply by 4.



Maximum Operating Pressure - 125 psi
Types - Angle Only

CAPACITY—LBS. CONDENSATE PER HOUR

No.	Size	Working Pressure—Lbs. Per Square Inch Gage			
		25	50	100	125
No. 9H	3/4"	450	650	875	950
No. 9H	1"	625	850	1125	1250

To convert lbs. of condensate or steam per hour, to sq. ft. E.D.R., multiply by 4.

QUIETNESS OF OPERATION. Thermostatic traps are noiseless in their operation. This long recognized fact makes them adaptable to any condition where noise would be objectionable.

WEAR OF VALVE PIN AND SEAT. Thermostatic traps often operate in a throttled position of continuous discharge. This can cause wire drawing of the valve pin and seat. These parts are the only ones subject to wear due to trap operation. If wear occurs at all, it usually effects both the valve pin and valve seat. The thermal element must be replaced if the valve pin becomes too badly worn and the valve seat should also be replaced at the same time. For this reason, a thermostatic trap should have a renewable seat rather than one made integral with the trap body.

RUST AND SCALE EFFECTS. Foreign matter such as rust, scale, dirt, and other abrasive particles entrained in the steam flow, often erodes the valve pin and seat of a thermostatic trap. In low pressure heating applications employing radiators and convectors, it has been the practice to install thermostatic traps directly on the units without the use of dirt strainers. For this type of service, the velocities are usually low and abrasive action is at a minimum.

It is considered good practice to use dirt strainers ahead of thermostatic traps on industrial equipment, high pressure dripping service, and other piping applications where velocities are sufficiently high to cause erosion. The proper use of dirt strainers often prevents the frequent replacement of thermal elements and seats.

EFFECT OF WATER HAMMER. Thermostatic steam trap thermal elements are more likely to be damaged by water hammer than other types of traps, such as Bucket or Float and Thermostatic. The principle reason for this is due to the very thin material used in the construction of the Bellows or diaphragm type of units.

The strength of these materials cannot withstand the very high shock pressures caused by the sudden halting or changing the flow direction of water (condensate) flowing at high velocity. These forces are often great enough to rupture much stronger equipment, such as pipe fittings and valves. It is important, therefore, to avoid use of a thermostatic trap at places where water hammer occurs unless the condition which causes the water hammer can be corrected.

Water hammer conditions can often be completely eliminated in the case of long pipe runs by correcting any sags or pockets in the piping between supports to give a continuous downward grade in direction with the steam flow. If the steam pipes are very long, water hammer can occur even with correctly pitched lines if the steam is turned into a cold line too quickly. Gradual warm up of the line will usually overcome this difficulty. Greenhouse systems with their long pipe coils, either above or below the growing beds, is an example of the type of system which can cause trap troubles from water hammer. Good installation and operation practices must be given every consideration to avoid these water hammer troubles.

MAINTENANCE OF THERMOSTATIC TRAPS. Thermostatic steam traps are simple in construction and wear can only occur at the valve pin and seat due to normal operation. Periodic inspection of these parts is good maintenance practice. If the valve pin shows wear from any cause, it is advisable to replace the thermal element. Usually this same type of wear is common to the valve seat and it should be replaced also. If the valve seat is integral with the trap body and cannot be replaced, even though it shows wear, it can often be factory reconditioned to give good results. To do such repairs in the field usually requires special tools.

Locating leaking traps is not always an easy task. Sometimes it is possible to detect leakage between the valve pin and seat of a thermostatic trap while it is still installed on the equipment. It is good practice to start at the pump and by a process of elimination, separate the very hot returns from the cooler ones. A portable pyrometer (Pyrocon) is very useful for this purpose. Often the trap which is leaking can be determined in relatively quiet surroundings by listening for a slight continuous hissing noise. If any doubt exists, test the trap on test fixture shown in Fig. 17. This inspection should also determine if thermal elements have been damaged by water hammer. Fig. 16 shows the difference between a thermal element having correct physicaldimension andone which has been damaged by water hammer. Usually at room temperature (below 100° F.) a thermostatic trap element valve pin is open or lifted from the seat less than 1/8 inch. This dimension is difficult to determine and must be measured. If the distance is greater, the thermal element is usually collapsed. If the trap is completely closed, the chances are that the thermal element has a leak.

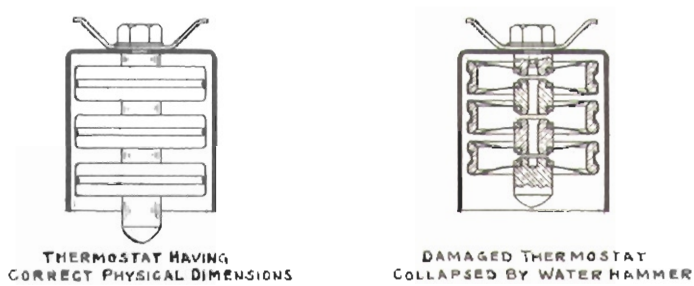


Fig. 16

Any leakage in the thermal element can cause the trap to perform improperly. The only safe way to determine this is to use steam and actually check its opening and closing. A simple fixture for performing this test is shown in Fig. 17. The test procedure for low pressure traps is as follows:

1. Open drip valve "C".
2. Place trap in test fixture.
3. (a) Turn on steam valve "A" and adjust steam to 1 to 1½ P.S.I
   (b) Observe trap discharge. If no leakage occurs, raise steam pressure to 5 to 10 P.S.I. This may momentarily open trap until pressure and temperature condition equalize.
   (c) If no leakage occurs, close steam valve "A" and drip valve "C" and open water valve "B" and adjust pressure to 5 to 10 P.S.I. If trap opens and discharges water, it can be accepted as o.k.

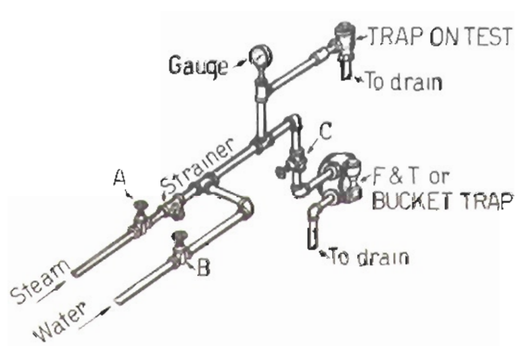


Fig. 17

4. If trap leaks during test 3(a), 3(b), or 3(c), observe if extent of leakage is caused by worn valve pin or seat. If both are worn, replace thermal element and the seat. If only one shows wear, then replace it and repeat tests.
5. **Caution** - Do not mistake flash steam for live steam. Flash steam is re-evaporated condensate and has a white, puffy appearance. Live steam is often called "blue steam" and usually it can be detected by its direction of movement when passing through leaking trap seats.

Austin O. Roche Jr

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