Nov. 22, 1955 J. F. McKEE 2,724,399

LEVER TYPE STEAM TRAP

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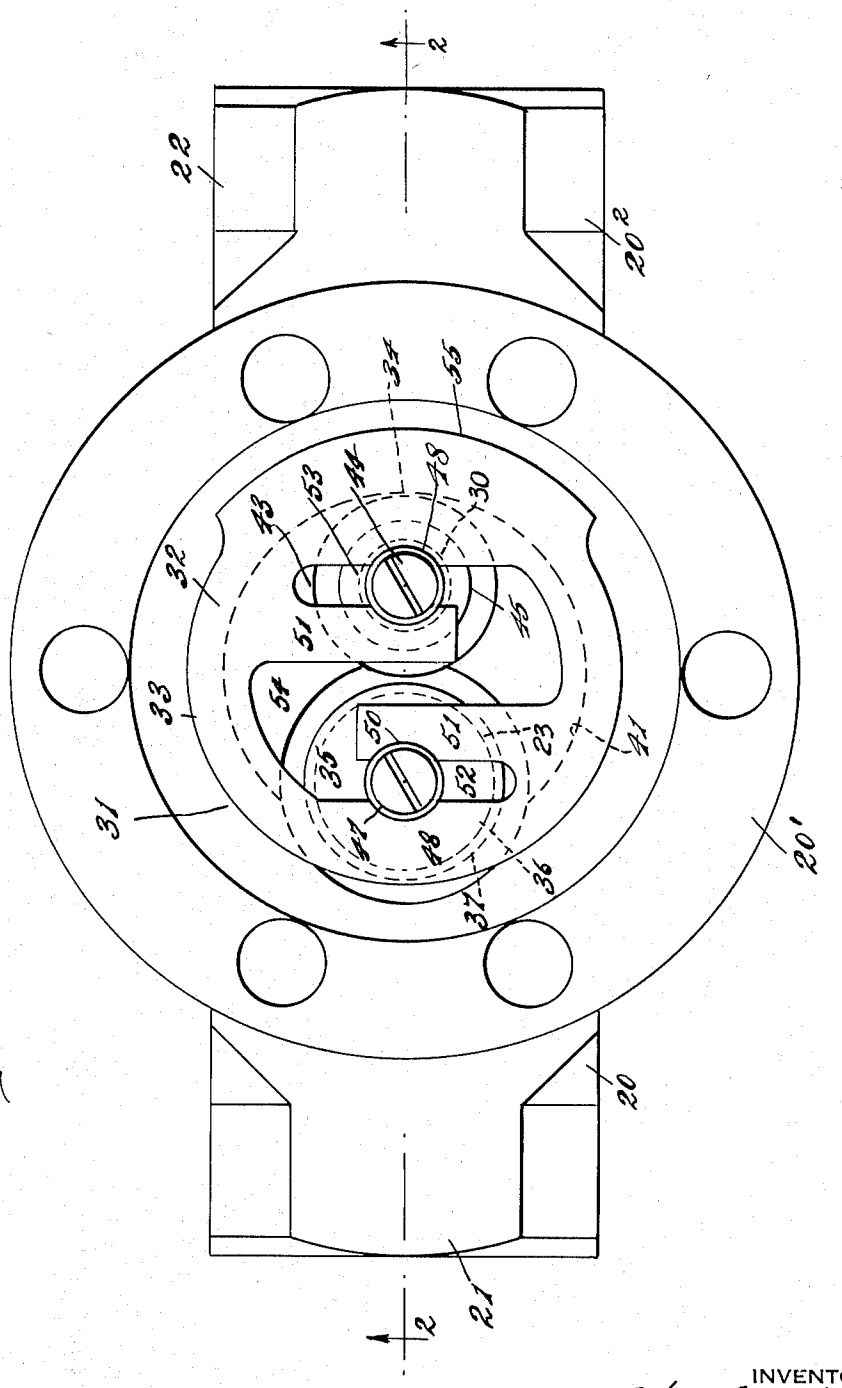


Fig. 1.

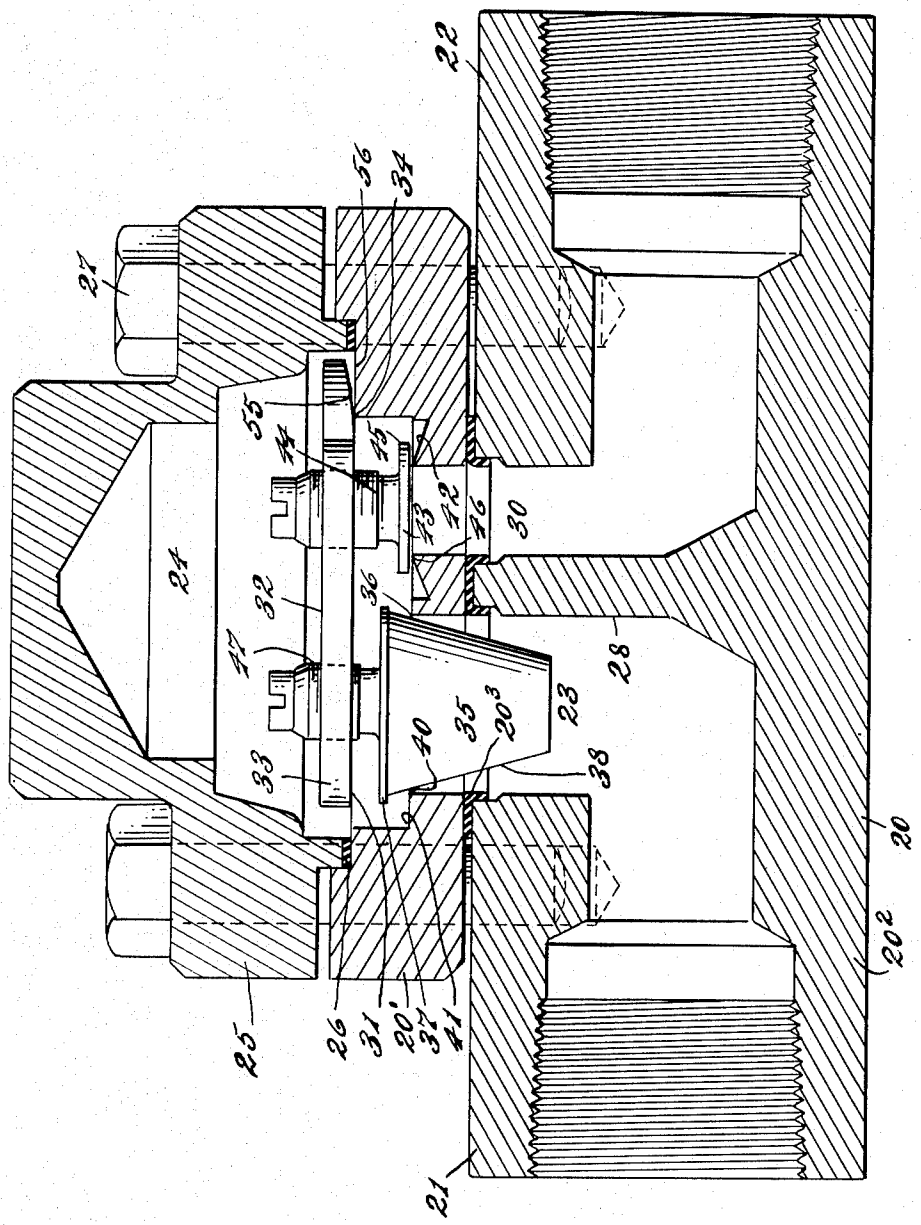
INVENTOR
John F. McKee
BY
ATTORNEYS.

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Fig. 2.



INVENTOR
John F. McKee
BY
ATTORNEYS.

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Fig. 3.

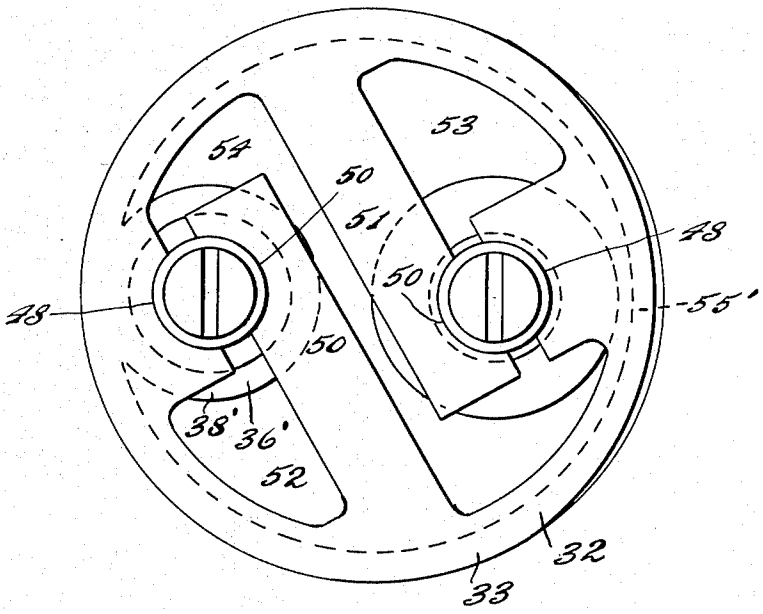
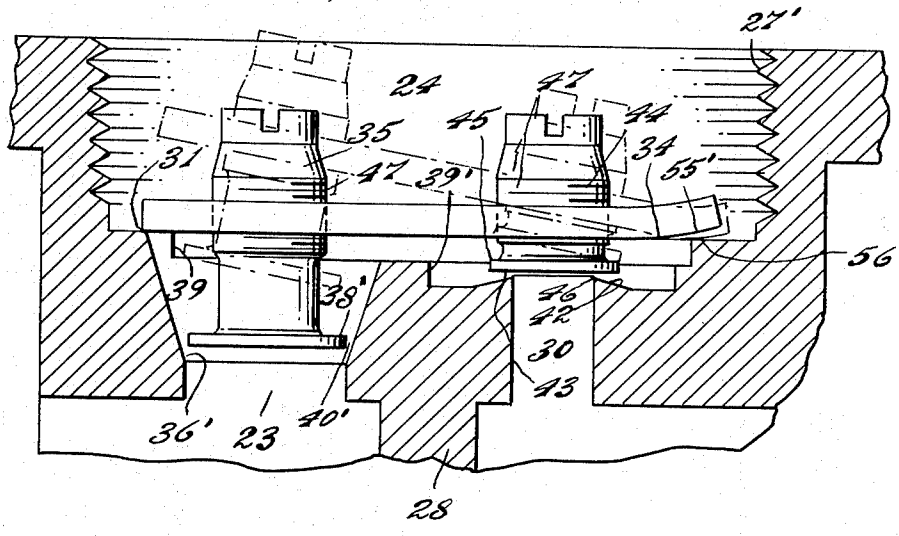


Fig. 4.



INVENTOR
John F. McKee
BY
ATTORNEYS.

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Fig. 5.

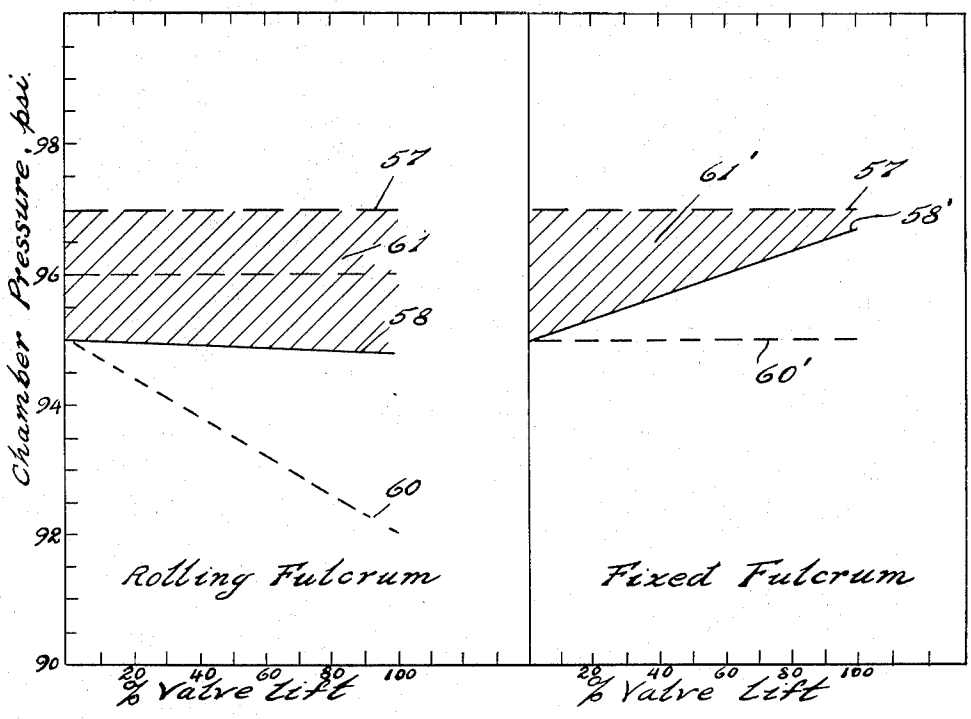
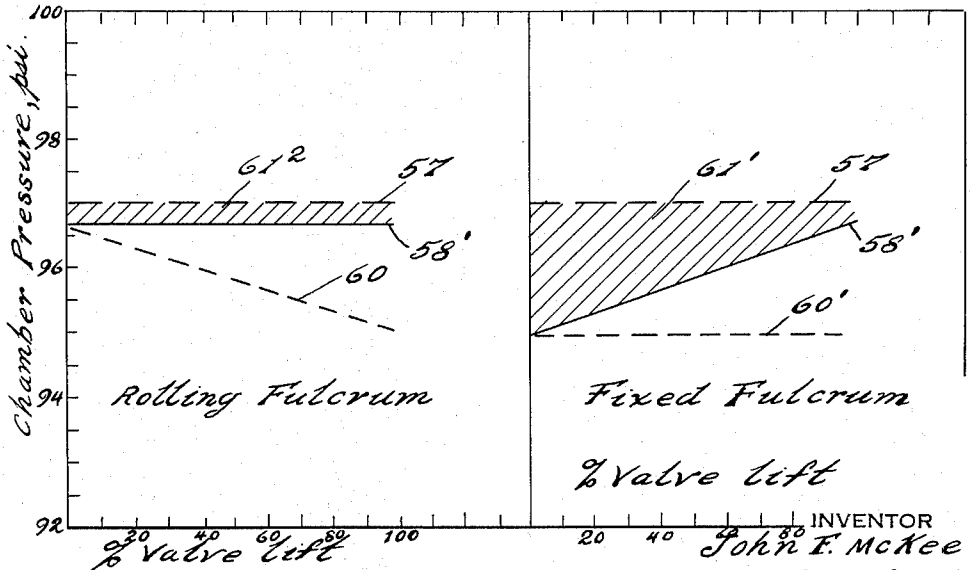


Fig. 6.



INVENTOR
John F. McKee
BY
ATTORNEYS.

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LEVER TYPE STEAM TRAP

John F. McKee, Ardmore, Pa., assignor to Yarnall-Waring Company, Philadelphia, Pa., a corporation of Pennsylvania

Application September 7, 1954, Serial No. 454,330

14 Claims. (Cl. 137—183)

The present invention relates to steam traps of the character in which the relative pressure and flow relationship with respect to a control chamber manipulate a lever element to open and close valves and thus open and close the trap.

A purpose of the invention is to assist reclosing of the valves by decreasing the control chamber pressure required for balance of the valves as the valves open.

A further purpose is to raise the discharge temperature of condensate from the steam trap nearer to the saturation temperature.

A further purpose is to shift the fulcrum of the valve lever relatively farther from the valves as the valves open.

A further purpose is to make rolling fulcrum engagement between the valve lever and the housing, and desirably to make the rolling fulcrum of a predetermined cam form which is most favorable to the operation of the device.

A further purpose is to obtain a faster opening of a steam trap to full open position.

A further purpose is to secure a higher closing pressure to a point near the closed position of the valves and thus obtain more positive action in closing.

A further purpose is to make it possible to obtain more economical and precise manufacture of a steam trap.

A further purpose is to compensate for the difference in pressure relations as the valve opens so as to make the valve close most advantageously.

A further purpose is to permit more compact construction of a lever type steam trap by reducing the angular lever lift required for full capacity.

A further purpose is to reduce the wear by spreading the fulcrum load over a larger wearing area, and by changing fulcrum contact in different positions.

A further purpose is to obtain greater stability and constancy of the valve relations by securing longer lateral contact of the rolling fulcrum.

A further purpose is to eliminate sliding friction and substitute rolling friction at the fulcrum.

A further purpose is to avoid close fits in the parts and thus reduce the danger of clogging by dirt or scale particles.

Further purposes appear in the specification and in the claims.

In the drawings I have chosen to illustrate one only of the numerous embodiments in which my invention may appear, selecting the form shown from the standpoints of convenience in illustration, satisfactory operation and clear demonstration of the principles involved.

Figure 1 is a top plan view of the preferred embodiment of the steam trap according to the invention, with the bonnet removed.

Figure 2 is a longitudinal section on the line 2—2 of Figure 1.

Figure 3 is an enlarged top plan view of a somewhat modified form of the lever and valves shown in Figures 1 and 2.

Figure 4 is an enlarged fragmentary axial section of

a modified form of the invention, employing the valve of Figure 3, illustrating the valves in closed positions, but showing the open position in dot-and-dash lines.

Figure 5 is a pair of comparative charts plotting chamber pressure in p. s. i. as ordinate against percentage valve opening as abscissa, showing the steam closing margin of a rolling fulcrum steam trap according to the invention and of a stationary fulcrum steam trap otherwise similar.

Figure 6 is a set of curves plotting chamber pressure in p. s. i. as the ordinate and percentage valve opening as the abscissa, showing the chamber pressure for valve balance permitted by the rolling fulcrum and by a fixed fulcrum steam trap which is otherwise the same.

Describing in illustration but not in limitation and referring to the drawings:

In the prior art, for example in my U. S. Patents Nos. 2,328,986 and 2,622,886, steam traps have been provided in which the inlet valve and the outlet valve are mounted on a lever operated by relative pressure and flow effects with respect to a control chamber. In such steam traps in the prior art, the lever has been pivoted on a fixed axis and the lever arms remain unchanged as the trap opens.

In the steam trap of the present invention, however, the lever arms for both the inlet valve and the outlet valve increase as the valves open, so that the ratio of the inlet valve lever arm to the outlet valve lever arm decreases as the trap opens.

It should be remembered that the pressure requirements between the inlet valve port and the outlet valve port for balance of the inlet and outlet valves will be different in the open and the closed positions. When the valves are closed, the pressure area is well defined and the pressure on the discharge side of the trap acting upon the lever side of the downstream valve (which in the present case is ordinarily the outlet valve) is essentially equivalent to the discharge pressure. The chamber pressure for balance under this condition is established by the design of the trap. The intermediate pressure or control chamber pressure with the valves in closed position for balance is in this case of the order of the discharge pressure plus 95 percent of the pressure difference between the initial pressure and the discharge pressure.

If the discharge pressure is at atmospheric pressure (0 p. s. i. g.), the intermediate pressure required for balance will be approximately 95 percent of the initial gage pressure. When on the other hand the valves are in open position, these relations are considerably changed. The pressure areas no longer have specific boundaries, and velocity effects are introduced while pressure variations of considerable size take place between the orifices, while the downstream pressure effective on the downstream valve area reaches higher values. This varies conditions established and a new average intermediate pressure value is created for balance of the valves in open position.

The change of the lever for the inlet and outlet valves by changing the fulcrum is a very satisfactory and controllable way of compensating for the thermodynamic conditions in the lever positions.

I preferably accomplish the compensation by introducing a rolling fulcrum of the lever as best seen in Figure 4.

The steam trap according to the invention in Figures 1 and 2 will suitably consist of a housing 20 having an inlet pipe connection at 21 and an outlet pipe connection at 22. These connections may be flanged, threaded or otherwise constructed as desired. The inlet connection communicates by an inlet port 23 to a control chamber 24 which is formed in the hollow interior of a bonnet 25 gasketed at 26 to the housing. The housing preferably comprises a top housing 20′ and a bottom housing 20^2 gasketed together at 20^3. The parts are bolted together

at 27. A wall 28 across the interior of the housing separates the inlet from the outlet.

An outlet valve port 30 communicates with the interior of the control chamber.

The housing has at the bottom of the control chamber an annular shoulder 31 which in closed position supports a suitable disc-like valve lever 32 having a circumferential rim 33 which engages around the shoulder.

The valve lever in closed position fulcrums at 34 on the bottom of the control chamber, and at the end more remote from the fulcrum the valve lever supports inlet valve 35 which in closed position extends generally longitudinally of an inlet seat 36 which is preferably an annular shoulder at the top of the cylindrical inlet port 23. The inlet valve suitably has at its upper end an annular flange 37, and below that a downwardly converging conical portion 38 which in closed position of the valve preferably does not fully close but leaves a leakage space 40 between the valve and the seat to permit a relatively small leakage flow. It will be evident that as the valve opens the spacing between the valve and the valve seat markedly increases, permitting greatly increased inlet flow. The degree of the taper can suitably be adjusted to increase the valve opening at the most desirable rate as the valve opens.

Located inwardly of the shoulder 31 the housing suitably has a counterbore 41 which extends completely around the interior of the housing, and facilitates main flow between the inlet and the outlet when the valve is open.

The outlet valve seat 42 is conical and diverging sharply from top to bottom. Outlet valve 44 has a straight transverse flanged end 43 which in relatively closed position protrudes at 45 beyond the inner edge of its seat. The seat edge desirably has a slight fillet. The form of the seat 42 is slightly different in Figures 2 and 4 to show variation.

The outlet valve is adjusted so that in closed position there is a constant leakage space 46 provided between the outlet valve and its seat to allow a small leakage flow even when the valve is closed as far as possible.

Each of the inlet and outlet valves is adjusted by forming a thread 47 on the outside and threading the valve through female thread sections 48 and 50 which are respectively positioned on the outside rim of the disc-like valve lever and on an internal spring prong 51 integral therewith and separated from the rim by openings 52 and 53 stamped out between the rim and the prong and an opening 54 stamped out between the two prongs. Thus there is ready access to the interior of the control chamber through these openings which extend across the lever. The prongs are distorted slightly laterally by the valves and thus grip and hold the valves in adjusted position.

As the valve lever opens, a cam or rocking fulcrum portion 55 at the back of the lever progressively engages the bottom of the control chamber at 56 to move the fulcrum further from the inlet valve and further from the outlet valve. Since the outlet valve is always closer to the fulcrum than the inlet valve, the ratio of the lever arm of the inlet valve to the lever arm of the outlet valve will decrease as the lever opens. This fulcrum portion is on an extension beyond the circle of the disc in Figures 1 and 2, but is within the circle of the disc at 55′ in Figures 3 and 4.

Figures 3 and 4 illustrate a modification of the form of Figures 1 and 2, which operates generally on the same principle. Whereas in Figures 1 and 2 the bonnet and housing are held together by bolts, in the form of Figures 3 and 4 provision is made by threading the housing at 27′ to use a threaded bonnet.

In the form of Figures 1 and 2 the disc-like valve is prevented from rotating in open position of the extension by its protruding inlet valve through the seat opening. In the form of Figures 3 and 4 the disc-like valve is prevented from rotating by the extension of the flanged flat end 38′ of the inlet valve into a downwardly converging conical seat 36′. Even in closed position there is preferably leakage provided at 40′ between the valve and the seat.

In this form, in addition to the counterbore 39, the outlet valve seat is depressed in a further counterbore 39′.

In the form of Figures 3 and 4 the rolling fulcrum portion 55′ is produced by bending or deforming a portion of the disc within the circular confines of the disc, whereas in the form of Figures 1 and 2 it is produced by machining.

There are several very beneficial effects from this increase in lever arm as the valve lever opens.

The control chamber pressure required for balance of the valve decreases with the lift of the valve lever, and this assists in reclosing the valve from open position. This increases the margin for positive closing and thus greatly improves the reliability of operation, or on the other hand permits the design relation to be shifted to raise the chamber pressure for balance of the valve a corresponding amount while retaining the original margin of closing pressure on steam.

Figure 5 shows this effect graphically, plotting chamber pressure in p. s. i. g. as ordinate against percent of valve lift (100 percent means full opening) as abscissa. Many design features will be apparent from the curves in view of my prior patents aforesaid. In the lefthand chart of the figure, for the rolling fulcrum device of the invention, line 57 shows the closing pressure on steam, line 58 shows the theoretical balance line for operation based on 40 percent back pressure at full discharge in steam and line 60 is the balance line for zero back pressure. The area 61 shows the closing pressure margin.

If we consider now a comparative case on steam operation of an exactly comparable steam trap having a stationary fulcrum with the same lever relations for the closed position of the valves, again line 57 shows the approximate closing pressure in steam, line 58′ shows the theoretical balance line based on 40 percent back pressure at full discharge on steam, and line 60′ shows the balance line for zero back pressure. Area 61′ shows the closing margin on steam, and it is evident that this area is much smaller in the case of the fixed fulcrum than in the case of the rolling fulcrum, and correspondingly the rolling fulcrum is much more reliable of operation in closing on steam.

The condition just described permits raising the discharge temperature on condensate nearer to the saturation temperature without sacrificing the closing margin. Figure 6 shows this effect, plotting as ordinate the control chamber pressure in p. s. i. g. against the percentage of valve lift as abscissa. The righthand portion of the figure is here the same as the corresponding portion in Figure 5, but the lefthand portion has been modified to redesign the trap to raise the theoretical balance pressure 58′ based on 40 percent back pressure at full discharge on steam. With the same margin of pressure for closing from full open position, we now have a correspondingly lesser and uniform margin for opening from the closed position of the valve. On condensate flow this insures more positive valve lift at near saturation steam temperature. See area 61^2.

Any desired compromise can be worked out between the condition of Figure 5 and the condition of Figure 6 to get the best combination of advantages.

A further important aspect of the increased lever arm effective on the outlet valve is that this increases the relative valve lift per unit angular lever movement and thereby reduces the angular lift necessary for full capacity opening. This simplies the design and reduces the size of the device.

The particular law which the cam surface 55 follows may vary with the results to be achieved within the object of the invention. In Figure 4 I illustrate a constant radius on the cam, but it will be understood that

the particular radius may vary to conform with the mathematical function being followed. The particular slope of the cam at any position will depend on the instantaneous pressure requirement at each position of the valve lever.

Although Figures 5 and 6 show the approximate chamber pressure on steam to remain constant with valve lift, this curve will of course be determined by the form of the inlet valve as well as the shape of the rolling fulcrum. It will, however, be evident that an adequate margin above the theoretical balance line is essential for reliable valve closure. It is likewise important that comparable flow relations on condensate produce chamber pressures below the chamber pressure required for balance to permit free and full discharge on condensate up to temperatures near steam temperature. The rolling fulcrum permits the establishment of the desired relationship to a precise degree since the design of the valves and the relative rate of valve opening with lever movement cooperate with the action of the rolling fulcrum. It will be evident that a large number of variations can be produced which will have advantages in particular cases. It will likewise be evident that as the inlet and outlet valves approach the same design form the compensating contribution of the rolling fulcrum will become more pronounced and where the individual inlet and outlet valve designs include compensations of their own, the rolling fulcrum will permit refinements while simplifying the forms of the valves.

In actual operation, the rolling fulcrum offers a number of advantages. With a rolling fulcrum immediate control of valve lift is obtained in response to the thermodynamic and flow properties of the fluid. The rolling fulcrum likewise permits refining the performance of the trap supplementary to the specialized design of the inlet and outlet valves.

The cost of the steam trap and particularly the cost of precise manufacture can be reduced due to the compensating effect of the rolling fulcrum. The rolling fulcrum thus provides continuous compensation in all positions of the valve lever.

By reducing the angular lever lift required for full capacity, the rolling fulcrum makes the design more compact.

The rolling fulcrum reduces wear in several ways. It provides a larger wearing area or surface as compared to the knife edges or pin pivots which have commonly been used. It furthermore provides a changing relation of contacting surfaces and thus distributes the wear over a larger area. It also substitutes rolling friction for sliding friction to a considerable extent.

The longer lateral contact of the rolling fulcrum gives greater stability and constancy of the valve relations. This provides for greater stability against unbalanced pressure conditions caused by unsymmetrical flow conditions. This likewise increases the resistance to wear and improves the service life.

The rolling cam engagement with the lever is simple and economical to produce as compared to the production of knife edges and pins.

Likewise the rolling engagement in one direction permits greater accuracy consistent with freedom from restraint.

Due to the rolling friction, the lever is more sensitive to response. There is also less danger of dirt or scale particles causing sticking, as sometimes is the case with pin bearings.

The fact that the valves are free to move slightly laterally permits simple self-adjustment for dirt particles and foreign matter and permits continuance of operation when a pin type fulcrum device is likely to jam or lock.

Although the particular form shown provides a curved rocking surface on the lower surface of the lever contacting a flat horizontal surface on the housing, it will be realized it is not important for the purposes of the present invention whether the curvature is entirely on one, entirely on the other or partly on one and partly on the other of the contacting surfaces that form the rolling fulcrum. It will be evident that in various designs any desired embodiment can distribute the cam effect between the contacting surfaces to meet the particular requirements.

It will likewise be evident that the rolling fulcrum will be placed on the side at which the reaction on the lever occurs, and this can be modified in different designs.

It will likewise be evident that while the form of the lever here shown is circular in plan, the question as to whether the lever is rectangular, square, triangular or circular is not important.

In the particular example shown in Figures 3 and 4, the lever multiplication ratio is 4.78 to 1 when the valves are closed and 2.965 to 1 when the valves are open. Consequently the chamber balance pressure varies from 95 p. s. i. g. when the valve is closed to 92.2 p. s. i. g. when the valves are open, with a line pressure at 100 p. s. i. g. and discharging to atmosphere. As the inlet valve opens the multiplication ratio thus decreases and the chamber pressure thus decreases.

In operation, when both valves are closed except for control flow clearance and condensate enters the control chamber, the flow between the inlet and outlet clearance creates a chamber pressure which is less than that necessary to hold the valves closed so they start to open and the leverage starts decreasing and this causes the fast opening to full open position above referred to.

The inlet and the outlet valves are in balance when the line pressure, chamber pressure and back pressure related to the areas and lever arms are such that the force up on the inlet valve equals the force down on the outlet valve. In opening or closing the lever arms are constantly changing, and therefore the pressure differences must change as the valve positions and the fulcrum change.

When the condensate is discharged on lower loads than maximum capacity, then live steam enters the control chamber and causes a higher pressure than the balance pressure and the valves close.

It will thus be evident that the shift in the fulcrum causes a higher closing pressure close to the closed position of the valve, thus making closing more rapid and positive.

It will further be evident that the rolling fulcrum comprises a compensating means adjusting the effective lever arm in accordance with difference in pressure conditions between the open and closed position of the valves for producing more uniform positive control of condensate discharge.

In view of my invention and disclosure variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain all or part of the benefits of my invention, without copying the structure shown, and I, therefore, claim all such insofar as they fall within the reasonable spirit and scope of my claims.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. In a lever steam trap of the type having walls forming a control chamber, an inlet valve port to the control chamber, an outlet valve port to the control chamber, a valve lever in the control chamber swingable on a fulcrum, an inlet valve cooperating with the inlet valve port and mounted on the lever and an outlet valve cooperating with the outlet valve port and mounted on the lever, the inlet valve being more remote from the fulcrum of the lever than the outlet valve, the invention which comprises a fulcrum shifting device having a fulcrum position for the lever which in closed position of the valves is relatively close to the inlet valve and the outlet valve, and which at open position of the valves is relatively more remote from the inlet valve and the outlet valve.

2. A steam trap according to claim 1, in which the

fulcrum shifting device includes a rolling element which progressively engages at points more remote from the inlet valve and the outlet valve as the lever moves to open position.

3. A steam trap according to claim 1, in which the outlet valve in relatively closed position provides a leakage path from the control chamber.

4. A steam trap according to claim 3, in which the inlet valve in relatively closed position provides a leakage path into the control chamber.

5. A steam trap according to claim 1, in combination with adjustment means between the inlet valve and the lever and between the outlet valve and the lever.

6. A steam trap according to claim 1, in which the lever includes opposed spring elements forming threaded gripping jaws, and one of the valves is adjustably threaded in the gripping jaws.

7. In a steam trap, walls forming a control chamber, lever means in the control chamber, an inlet valve port into the control chamber, an outlet valve port from the control chamber, an inlet valve on the lever means cooperating with the inlet valve port, an outlet valve on the lever means cooperating with the outlet valve port, the inlet valve being relatively farther from the fulcrum than the outlet valve, and in closed position there being at least leakage at the outlet valve through the outlet valve port, and cam means which varies the fulcrum position of the lever means as the lever means opens according to a law which decreases the chamber pressure required for balance of the valves with opening of the valves and thus assists reclosing of the valves from the open position.

8. A steam trap according to claim 7, in which the law for variation of the fulcrum position by the cam means raises the discharge temperature of the condensate nearer to saturated steam temperature in open position of the valves.

9. In a steam trap having walls forming a control chamber, an inlet valve port to the control chamber, an outlet valve port to the control chamber, and inlet valve cooperating with the inlet valve port and an outlet valve cooperating with the outlet valve port, the invention which comprises lever means in the control chamber swingable on a fulcrum and connected to the inlet valve and the outlet valve, the inlet valve being more remote from the fulcrum than the outlet valve, and compensating means adjusting the lever arm in accordance with difference in pressure conditions between the open and closed position of the valves for producing more uniform positive control of condensate discharge.

10. In a steam trap having walls forming a control chamber, an inlet valve port to the control chamber, an outlet valve port to the control chamber, the invention which comprises a disc valve member free in the control chamber, an inlet valve supported on the disc valve member and cooperating with the inlet valve port, an outlet valve supported on the disc valve member and cooperating with the outlet valve port and means relatively interlocking one of the valves with its valve port in all positions, whereby the interlocking relation prevents the disc valve member from turning.

11. A steam trap according to claim 10, in which the interlocking means extend between the inlet valve port and the inlet valve.

12. A steam trap according to claim 10, in which the inlet valve comprises a conical element which protrudes into the inlet valve port in both open and closed positions.

13. A steam trap according to claim 10, in which the inlet valve port is conical diverging toward the control chamber and the inlet valve extends into the inlet valve port in both open and closed positions of the valve.

14. A steam trap according to claim 10, in which the disc has at the position remote from the inlet valve a rolling fulcrum engagement between the disc valve port and the control chamber.

No references cited.