Sept. 7, 1943. J. F. McKEE 2,328,986

STEAM TRAP

Filed Nov. 22, 1940 3 Sheets-Sheet 1

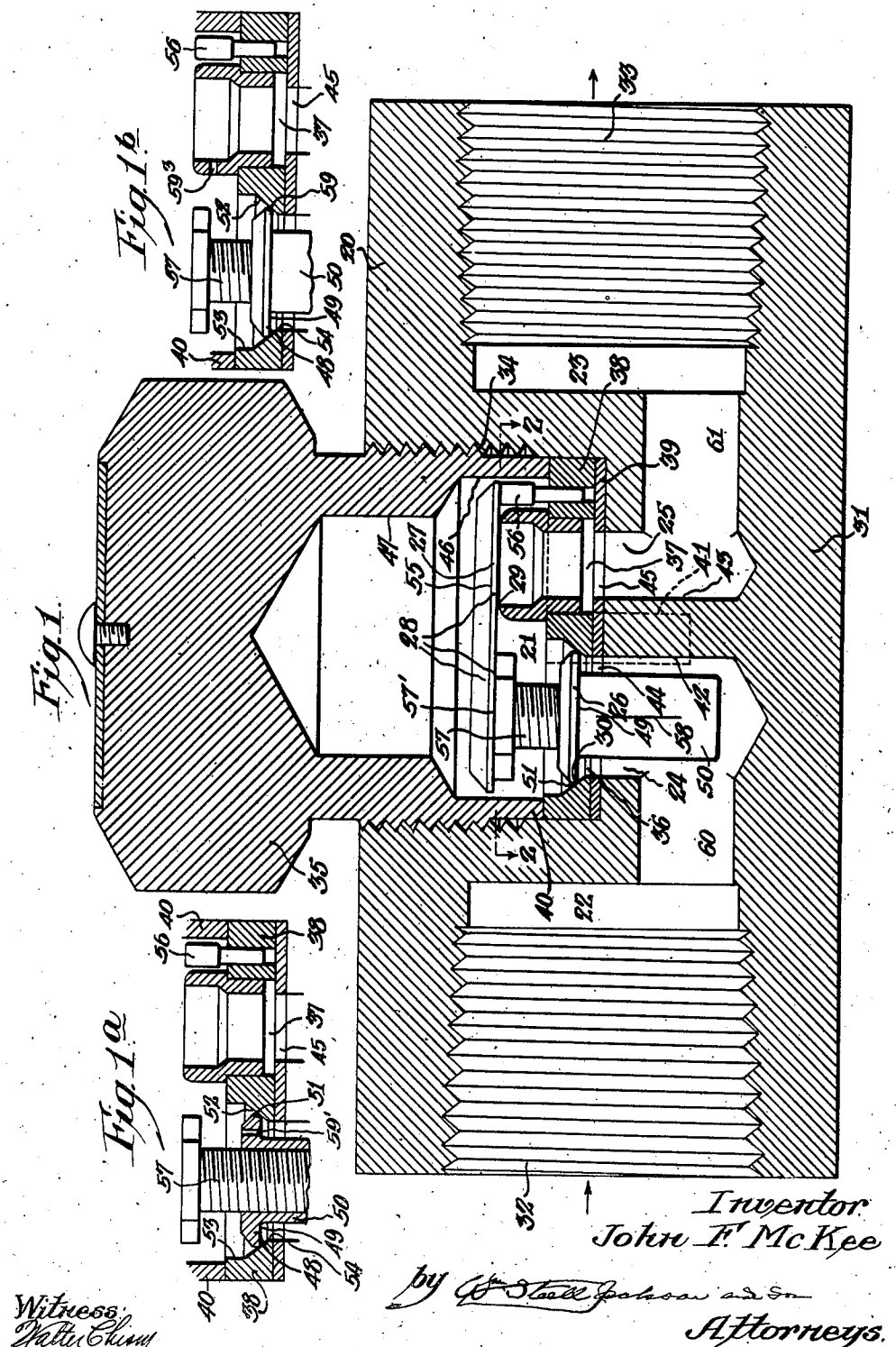


Fig. 1

Fig. 1a

Fig. 1b

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Filed Nov. 22, 1940 3 Sheets-Sheet 2

Fig. 2.

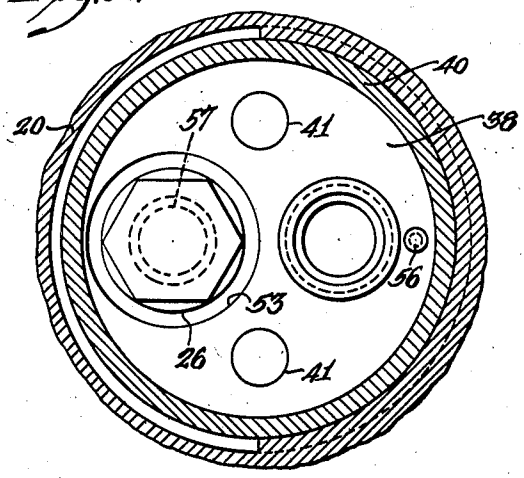


Fig. 3.

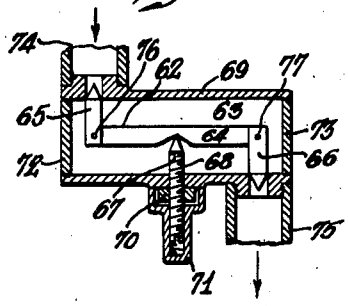


Fig. 5.

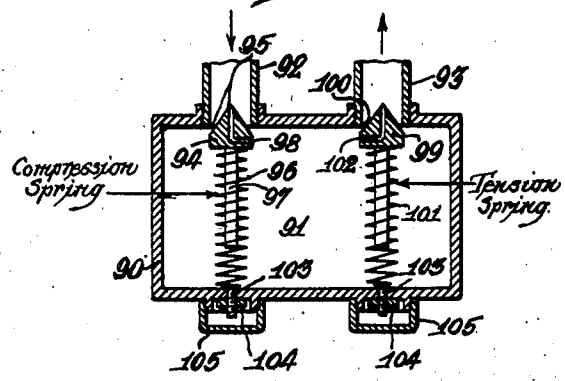


Fig. 4.

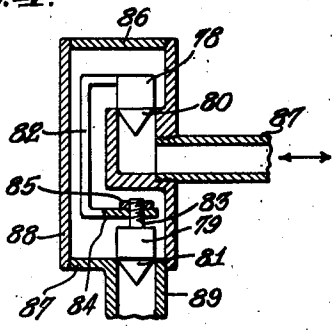


Fig. 1c.

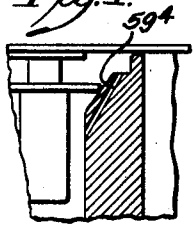
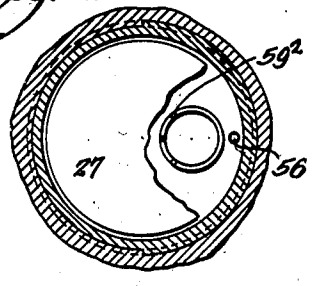


Fig. 2a.



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Filed Nov. 22, 1940 3 Sheets-Sheet 3

Fig. 6.

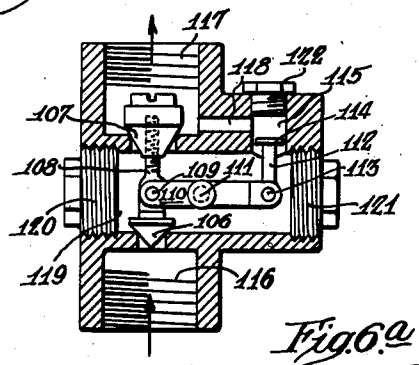


Fig. 6a.

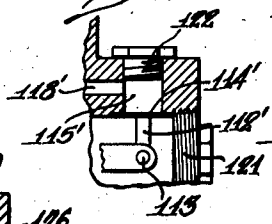


Fig. 7.

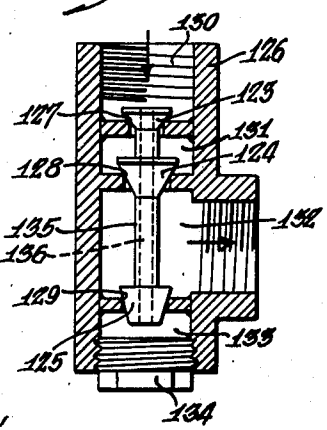


Fig. 8.

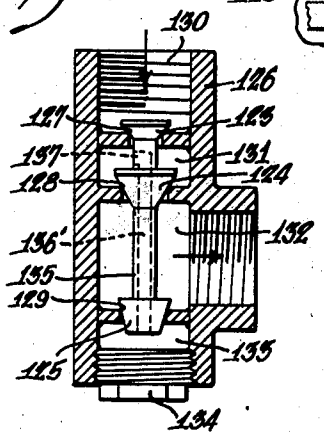


Fig. 9.

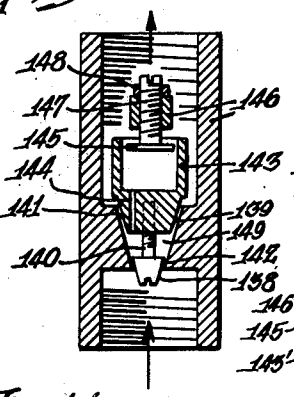


Fig. 9a.

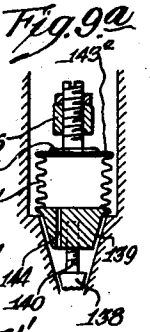


Fig. 10.

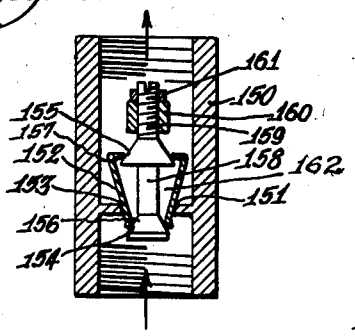
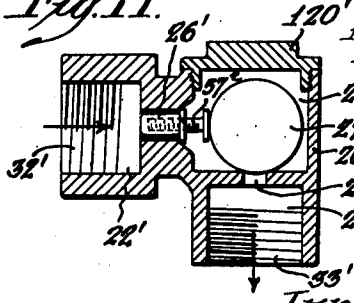


Fig. 11.



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Patented Sept. 7, 1943 2,328,986

UNITED STATES PATENT OFFICE

2,328,986

STEAM TRAP

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

Application November 22, 1940, Serial No. 366,540

22 Claims. (Cl. 137—103)

My present invention relates to a trap, that operates upon a liquid under pressure which by reason of liberation of gas or vapor, with pressure drop increases liquid flow or, on the other hand, reduces liquid flow according as the pressure and temperature of the liquid fall or rise.

As in the case of the structure of my two patents, Nos. 2,051,732 and 2,127,649, the present trap is actuated by the change in pressure between two or more orifices in series as affected by change of phase or change of state of the flow medium, either prior to reaching the orifices or during passage through the orifices or as back pressure, such changes being altered by changes of heat content, pressure or temperature of a single flow medium, by difference in phase or state of two or more flow mediums or by variant back pressure.

The present differs from the older type in that the control and discharge orifices are combined into one flow path which consists essentially of two or more controllable orifices in series. The relative intermediate pressure as before controls the discharge, but instead of controlling flow through a separate parallel flow path, it controls the flow passing through the intermediate chamber along the control flow path itself. This is done without materially affecting the intermediate chamber pressure for a given flow condition by proportionate restriction or enlargement of the effective opening of both orifices simultaneously. Thus with a given back pressure the requirements of the control element which depend on the maintenance of proportional flow relationship of the orifices to each other are preserved, although the actual flow is caused to vary over a wide range in response to pressure fluctuation in the intermediate chamber with change in condition of the flow medium.

One purpose of the invention is to secure a light, inexpensive and highly efficient trap.

My invention is suited to control of discharge and separation of fluid parts having different characteristics (such as hot condensate and vapor) or different fluids (a liquid and gas for example) under many conditions, but finds its widest application in withdrawing hot condensate from steam.

A further purpose is to combine leakage control and hot condensate discharge passages into a single flow path through two or more controllable orifices in series.

A further purpose is to provide continuous leakage of hot condensate through a control compartment and through operation of the control to pass the main discharge of condensate through the same compartment.

A further purpose is to provide leakage controlled valved trap openings in series with an intermediate control chamber and interconnection between the valves, the leakage providing and the interconnection proportioning like movements of both valves together.

A further purpose of the invention is to use progressive change in phase in the hot condensate to change and limit the effective inlet and outlet areas to and from a single trap compartment operating as a control compartment and also as a passage for the main liquid discharge flow.

A further purpose is to provide a control chamber with throttled inlet and throttled outlet which cause reduction in pressures at each of the throttlings and to use the variation in pressure within this chamber as a basis for enlarging or reducing a main discharge of condensate through the same chamber.

A further purpose is continuously to draw off condensate at the same rate or lower than that at which condensate forms and pass it through a control chamber, and to discharge accumulated excess from the system periodically through the same chamber and at the same or higher rate than that at which it forms.

A further purpose is to provide inlet and outlet valve openings closed by interconnections to the extent that opening of the inlet opens the outlet and to use the interconnection between the valves to proportion the extents of opening for inlet and outlet, respectively, for flow.

A further purpose is simultaneously to increase and simultaneously diminish the effective areas of inlet and of outlet of a trap compartment by balancing related valve mechanism operative upon both inlet and outlet areas between pressure drops, an opening pressure-drop across the inlet against a closing pressure-drop across the outlet, whereby mechanism controlled by these pressure-drops is moved to diminish both areas when the vapor phase content increases beyond a predetermined limit and, on the other hand, increases both areas under corresponding decrease of the vapor phase content.

A further purpose is to use a valve-operating disc loosely fitting the compartment interior and tilting or turning to close and open an outlet, the disc being directly or indirectly operated upon by pressure drop at the inlet and the outlet.

A further purpose is to have the inlet to outlet area ratio of effective openings at the inlet and

outlet at the combined control and flow chamber increase with compound valve lift in order to offset the effect of back pressure increase with increased flow.

A further purpose is to operate a ball trap outlet valve by an inlet valve and to control the operation by variant pressure in a passage between the valves.

A further purpose is to couple an inlet trap closure with an outlet closure so that they will act together, both to open at the same time and likewise both to close together, whether the valves be actually joined or connected or not, and whether they physically move in the same general direction or at the same actual speed or not.

The invention applies to the methods of operation as well as to the structure for carrying out the methods.

I have elected to illustrate a few only out of many possible forms of my invention, selecting forms that are practical and efficient in operation and which well illustrate the principles involved.

In the drawings:

Figure 1 is a longitudinal section of a desirable embodiment of the invention.

Figures 1*a*, 1*b* and 1*c* are modified fragments of Figure 1.

Figure 2 is a broken detail section of Figure 1 taken upon the line **2—2** thereof.

Figure 2*a* is a modified fragment of Figure 2.

Figures 3 to 11 are longitudinal sections illustrating different embodiments of the invention.

Figures 6*a* and 9*a* are fragmentary views corresponding generally to Figures 6 and 9, respectively, but showing modifications.

In the drawings like numerals refer to like parts in all figures, the numerals being differently primed in some figures, where parts function the same in different illustrated embodiments of the invention.

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

In all of the illustrated forms the trap body, **20** in Figures 1 and 2, includes an intermediate trap compartment which acts as a control chamber, indicated at **21** in Figure 1, and inlet and outlet compartments **22** and **23** with adequate inlet and outlet valve openings **24** and **25** and closure valves **26** and **27** therefor.

The closures are related, that for the inlet to that for the outlet of the same trap so that they move together, both opening at the same time and both closing at the same time. The combined structures performing the valve functions may be viewed as compound valves **28**. The related or compound valves are located within the intermediate compartment and close or open adjacent inlet and outlet areas A_1 and A_2 through the valve openings, from the inlet compartment and to the outlet compartment, respectively. The extents of valve openings progressively vary the actual openings exposed, i. e., the effective inlet and outlet flow areas a_1 and a_2.

The letter references above set forth are not upon the drawings but are used for purposes of theoretical discussion or explanation.

a_1 and a_2 correspond to the effective inlet and outlet areas respectively of opening to and from the trap compartment from and to the inlet and outlet compartments, that is, the actual opening provded by the movements of the valve elements. a_1 and a_2 are varied in the same direction, i. e., both opening concurrently and closing concurrently, by movement of the compound valve which carries the related valve elements. The ratio between the a_1 and a_2 areas, the pressure relations of the condensate before reaching the trap and of the outlet into which discharge takes place and the condition of the condensate with respect to temperature as it reaches the trap, cooperatively determine the pressure within the trap compartment and I use the pressure-drops upon the closure areas A_1 and A_2 automatically to control the operation of the valve.

From a condition of balance, the compound valve shifts or not, assuming it free to shift in both directions, according to the direction of change of vapor content in the condensate, and the condition of balance may be expressed algebraically by the relation

$$(P_1-P_2)A_1=C(P_2-P_3)A_2$$

where C is a constant determined by characteristics of the compound valve, P_1, P_2, and P_3 are pressures respectively within the inlet, intermediate or control and outlet compartments and A_1 and A_2 are the effective areas presented by the compound valve to the inlet and outlet pressure-drops (P_1-P_2) and (P_2-P_3) respectively.

The ratio of the effective areas A_1 and A_2 and the design constant C determine the ratio of P_2 to P_1 for balance of the compound valve member in the case of normal operation where $P_3=0$.

The constant C may be predetermined at will in Figures 1 and 3 and will be unity in Figures 4 to 10.

While the function of the compound valve is automatically to vary the magnitudes of the inlet and outlet areas a_1 and a_2 in order correspondingly to vary the discharge through the trap by the condition of the condensate with respect to temperature, the compound valve also must control the a_2/a_1 ratio in that this ratio indirectly controls the operation of the valve, whether the valve be open, closed, or in an intermediate position.

Preferably the a_2/a_1 ratio is made greater when the valve is closed than when the valve is open, because of an effect of back pressure, present when the valve is open and usually absent when the valve is closed. This assumes that the back pressure is determined by the discharge through the valve.

The a_2/a_1 ratio and the back pressure are both factors in determining the pressure P_2 within the intermediate compartment.

I provide an a_2 outlet leakage opening, in Figure 1, **29** large enough so that when the valve is closed this leakage prevents the intermediate pressure with incipient opening of the valve from mounting too high for opening operation of the valve when the condensate temperature falls to the point at which the valve is intended to open. Either an inlet leakage opening **30** is provided, open whether the inlet valve be open or not or partial opening of the inlet valve is used to provide inlet leakage. The leakage may be between the valve and its seat as in most of the figures, through the valve as in Figure 1*a*, or through a fixed member as in Figure 1*b* or all of these.

The opening between the intermediate and the outlet compartments when the compound valve is in its closed position is intended to comprise any suitable small leakage opening between these compartments. For example, this outlet leakage may take place between the outlet valve seat and the valve closure as in Figures 1, 3 and 4 (which may be extended to other forms), through stationary wall structure of the body as in Figure 1*b*,

1c and 2a, or through the valve structure as in Figures 1a and 5.

If d_1 and d_2 be the leverages upon which the valve areas A_1 and A_2 operate and the back pressure be considered as zero, the pressure P_2 in the intermediate chamber for balance at—say—100 pounds pressure per square inch can be found by the formula

$$P_2=\frac{100\times A_1\times d_1}{(A_1\times d_1)+(A_2\times d_2)}$$

I prefer at present to have this equal 87 lbs. approximately.

It has also been found advantageous to use relations of openings for A_1 and A_2 having perimeters in the ratio of approximately 1½ to 1 for inlet and outlet openings respectively.

Openings need not be round but may be rectangular or any other conceivable shape or section.

The compound valve structure **28** may be integral or rigid or movable, one part with respect to another. It may be composite and of any of many different forms. In every case, however, the compound valve is adapted to balance between a pressure-drop at the inlet to the intermediate (control) compartment, exerted upon one area of the valve, and a pressure-drop at the outlet of the intermediate compartment upon a different area of the valve.

In every case the pressure-drop between the inlet and intermediate compartment tends to open the compound valve and the pressure-drop between the intermediate compartment and the outlet tends to close the compound valve, so that when the valve is closed this latter pressure drop pressing upon the outlet valve effective area must be operating to hold the valve in its closed position against an oppositely acting pressure-drop between the inlet and intermediate compartment, pressing upon the outlet valve effective area.

In all of the forms the direction of condensate flow is shown by arrows.

In general, the form of Figures 1 and 2 follow the illustrations of the two patents above in that the stock **21** is longitudinally bored and threaded at **32** and **33** to provide for pipe connections and also for the inlet and outlet compartments and is laterally recessed and internally threaded at **34** for a threaded cap **35**.

For convenience the inlet and outlet valve passages **36** and **37** adjacent their seats are formed in a disc **38** which is held within the recess and is sealed against a desirably metal gasket **39**, permissibly copper, by axial pressure of a skirt **40** formed upon the inner end of the cap. The disc is set in its angular positions by pins **41** within openings in the disc and body. The body is bored at **42** and **43** in line with the inlet and outlet valve openings. The gasket is apertured, correspondingly at **44** and **45**.

The cap is bored at **46** leaving the skirt **40**, and is counterbored at **47**, the space within the bore and counterbore together comprising the intermediate or control chamber **21**. All parts of this chamber are sufficiently in free communication, one part with another, for the space to constitute an effective single intermediate chamber through which both leakage and main condensate discharge flows take place. The discharge rate is controlled by the variant conditions within this chamber or compartment.

The composite or compound valve combines the inlet valve **26** and the outlet valve **27**. Here the two parts are separate, with an adjustment between them. They are interrelated in that the outlet valve—here a pivot plate—is lifted (opened) by the inlet valve and cannot approach closure except as the inlet valve closes to permit this.

Neither inlet nor outlet valve wholly closes in the sense that flow cannot take place. Leakage is provided in one way or another, as discussed elsewhere.

The inlet valve **26** is flanged at **48** to present a shoulder **49** to the flowing condensate. It carries an appendage **50**. The upper face of the inlet valve seat **51** is so shaped as to increase the opening progressively as the valve flange is lifted. In the best shape which I have found for the seat it comprises a sloping valve-engaging face **52**. The "slope" though desirably uniform need not be uniform; i. e. the section need not be straight. It need not be a taper as distinguished, for example, from a cupped or crowned cross section. As a matter of practical construction it is bordered by cylindrical connecting walls **53** and **54**.

The outlet lever valve **27** is in the form of a plate **55** which tilts upon any suitable fulcrum, illustrated as pin **56** supported by the disc **38**. The plate rests (that is, as it is held down by the pressure within the control chamber) at its end opposite the fulcrum upon the upper surface of an adjusting screw **57** which is threaded into the body of the inlet valve appendage. It must be tight enough so as not to work loose. One form of securing this is to squeeze the sides of the appendage (as a nut) in along several opposite lines **58**.

Where the top of the screw **57** is plane—as shown—the inlet valve cants slightly as it opens, thus maintaining the plane top **57'** of the screw in contact with the plane under surface of the plate **27**.

The outlet valve seat is formed as a sleeve supported in disc **38** but lifted above it.

The outlet path must be open at all times to prevent undue accumulation of pressure in the control chamber.

The two valves together are intended to permit constant leakage through the intermediate or control chamber and the adjustment available by screw **57** is set so that the outlet valve plate **55** is slightly tilted (open) or there is otherwise slight outlet leakage even when the inlet valve member is closed, making it impossible for the outlet valve to close at any time. The inlet valve is opened by pressure.

The leakage for inlet or outlet may be provided in various ways, by lifting of the valves, in Figures 1, 2, 3 and 4. The outlet leakage point resulting from lifting of the inlet valve is shown at **29**. There are also shown inlet leakage through the valve at **59'** in Figure 1a, outlet leakage through one of the valve parts at 59^2 in Figure 2a and outlet leakage through the body at 59^3 in Figure 1b and at 59^4 in Figure 1c.

The outlet valve plate is made enough smaller than the cylindrical wall counterbore within which the valve tilts so as to maintain the space above the disc or plate, and the space below this plate effectively as one flow compartment at the same pressure, and to maintain control of the valve operation by the pressure within the same (control) compartment **21** through which leakage and main discharge flow of condensate take place.

Longitudinal bores **60** and **61** connect the in-

let and outlet valve openings with the inlet compartments, respectively, and form parts of the latter.

The form of Figures 1 and 2 is particularly fortunate in that by it a desirable proportion between the inlet and discharge openings easily may be maintained as the coupling valves lift.

But for some type of throttling inlet control the inlet opening would be greatly excessive compared with the outlet opening, since the valve tilts about the pin (beyond the edge of the outlet valve) as a fulcrum and the vertical lift of the plate would be much greater for the inlet than that for the outlet. This would result correspondingly in excessive pressure in the control chamber and would also much reduce the capacity of the trap.

In the valve in Figures 1 and 2 the extent of the slope or cupping of the valve seat can be chosen to give just the right amount of actual inlet valve opening for the intended lift at that position, with the result that the proportion desired between inlet and outlet openings can be maintained and the adjustment between the inlet valve and the disc permit nice adjustment of the outlet opening as compared with the inlet opening, either initially or at any subsequent part of the valve operation.

Continuous leakage of condensate can be accommodated by partial lifting of the inlet valve where leakage grooves or apertures are objectionable.

The conditions determining flow of condensate through the chamber to discharge—as distinguished from mere leakage through—are that pressure upon the inlet valve from below tending to lift the inlet valve and acting for that purpose upon a leverage fulcruming at the pin **56**, plus back pressure upon the under side of the valve plate, overcome control chamber pressure upon the inlet valve fulcruming at the pin plus control chamber pressure upon the outlet valve again fulcruming at the pin. As soon as this condition is reached the inlet valve is lifted, opening the outlet valve also for flow of condensate through chamber **21** and this flow is continued until increasing temperature and vapor pressure of the condensate cause the forces acting upon the individual valves from within the control chamber to overcome the inlet and back pressure upon the valves so as to force the compound valve toward effective closed position.

Flow—as distinguished from leakage—will take place in many instances over long periods of time, the flow fluctuating, increasing during the time of delivery of larger quantities of condensate from the steam system and reducing during times when there is but little condensate accumulation.

As distinguished from the situation in my previous patents, there are here definite valves upon which the inlet pressure and back pressure act, one at the inlet and the other at the outlet to tend to open both valves. Moreover the definite valves are coupled together in most of the forms so that the inlet and back pressure are combined so that pressure on each tends to open both valves; and the control chamber pressure at the two valves resists the opening pressure of each and, because they are coupled, tends to close both valves. With changing control chamber pressure the valves move to open farther when the inlet and back pressure overcome the control pressure, and move toward closure when the control chamber pressure overcomes the inlet and back pressure.

The function of the dished, sloped or tapered valve seat is to maintain the desired proportionality of opening of the two orifices, inlet and outlet. Consequently the extent of dishing, cupping, sloping or tapering, both in the thickness of the seat and the lateral extent of flare may be used to affect the proportionality of the opening of the two orifices. The lift of the inlet valve also, of course, lifts the outlet valve in all of the forms except in that of Figure 5.

The pressure in the control chamber can be maintained as nearly constant but the back pressure varies over a wide range due to widely variant conditions of flow.

It is desirable to maintain substantially the same control temperature and pressure notwithstanding wide differences in opening of inlet and outlet valves and to accommodate widely divergent rates of condensate flow.

Assuming normal control chamber pressure and that momentarily the inlet valve has closed as far as it is intended to close, the outlet valve will still be slightly open in order to avoid danger that inlet flow will lift the control chamber pressure so high as to prevent opening of the outlet valve.

Let us assume that condensate has backed up on the inlet side, that is at the left in Figure 1, and that the connecting pipe is full of condensate for a considerable distance. During normal use this condensate will be very hot close to the trap, and at the trap will closely approach steam temperature. It will be under steam pressure.

Constant leakage of hot condensate through the intermediate control chamber **21** and out the outlet maintain the temperature—and pressure—within the control chamber **21**, both above and below the valve plate at nearly steam temperature and pressure and as soon as these (temperature and pressure) lower much from the predetermined operating temperature and pressure for this chamber the reduction of pressure upon the inlet and outlet valves will result in both opening or opening further, with discharge of condensate until the pressure in this control chamber (due to the higher temperature of the hotter condensate now flowing) causes both valves to close or partially close. There is no substantial difference in pressure above and below the valve plate.

As flow starts or increases through the flow chamber the inlet pressure remains substantially unchanged and the chamber pressure alters but little but the back pressure due to discharge from the outlet rises considerably and may rise as much as 20 to 30% of line pressure. It has been found that with a construction such as that of Figures 1 and 2, with back pressure zero at the start, the chamber pressure will be approximately 87% of the inlet pressure, for balance but that with condensate flow and a back pressure built up by that flow the closing differential pressure at the outlet is reduced by the higher back pressure; with the result that the chamber pressure necessary for balance is increased.

To put this in another way, this means that the valves then will not close until discharge through the chamber has brought into the chamber high temperature condensate in quantity sufficient to raise the pressure in the control chamber.

As in the case of the traps of my two patents it is necessary to discharge at as nearly steam temperature as possible. With opening of the combined valve the pressure in the control chamber increases progressively, as the temperature of the inlet increases, reaching equilibrium before steam reaches the valve.

The forms of Figures 3 to 9 are diagrammatic and are intended to illustrate the wide range of application of the invention.

In Figure 3, the compound or composite valve 62 is shown within intermediate (control) compartment 63. The lever 64 carries inlet and outlet valve elements 65 and 66 at opposite ends of the lever. It pivots about a supporting pin 67 which is vertically adjustable by screwing the thread 68 of the pin into the casing 69 and is held by lock nut 70. The cover 71 is threaded on the pin 67. The casing 69 is closed by threaded plugs 72, 73 and connections are made by pipes 74 and 75.

In this case for opening movement one valve moves down and the other up, considered as directions on the drawing, but both open concurrently. Likewise both move toward closure concurrently. Neither will wholly close unless there be other means of leakage than through the valve.

As will be seen lifting the lever will relatively increase the control leakage and lowering the lever will relatively decrease the control leakage.

In the form shown in Figure 4 the valves 78 and 79 fit against seats 80 and 81 and are carried rigidly by a yoke 82. They move in straight line direction. The extent of movement again is very small. Adjustment of the valves so that they will seat substantially together, but so that outlet flow cannot be stopped is provided by threaded stem 83 screwed into arm 84 of the yoke and locked in position by nut 85. Plugs 86 and 87 close the ends of a casing 88 and the inlet is provided by pipe 89.

In all of the forms previously described there has been some mechanical interlinkage between inlet and outlet valves. In Figure 1 it is the forced opening of the outlet valve by the opening of the inlet valve and the necessity for the inlet valve to move toward closure before the outlet valve can so move. In Figure 3 it is the common lever support moving the valves in opposite directions. In Figure 4 it is the yoke support moving the valves in the same direction.

In Figure 5 however the valve parts are mechanically independent the coaction between them being due to dependence upon the pressure within the control chamber.

The casing 90 bounds the control chamber within which is intermediate compartment 91. Inlet takes place through pipe 92 and outlet passes through pipe 93. The inlet valve 94 is pressed toward its seat 95 by a compression spring 96 held against collapse by a stem 97. Leakage takes place normally through this valve by passage 98.

Outlet valve 99 is pressed against its seat 100 by the pressure in the control compartment. The tension spring 101 constantly pulls against this pressure and tends to pull the valve away from its seat. Leakage takes place through a passage 102 in this valve. Both springs are anchored at the rear to the casing by screws 103 threaded into the casing and locked by nuts 104. The covers 105 protect against leakage.

In Figure 6 rigidly connected small inlet and large discharge conical valves 106 and 107 connected adjustably by a stem 108 threaded into one of the valves are pivoted at 109 to a lever 110 which turns about a pin 111. At the opposite end of the lever a piston rod 112 is pivoted at 113 and carries at its opposite end a piston 114. Between the piston and the walls of a cylinder 115 leakage is provided. Trap inlet is through threaded passage 116 with outlet through threaded discharge 117. The cylinder is freely connected at 118 with the discharge.

The construction is diagrammatic but is shown as built up through a fitting having a transverse bore at 119 to provide the control chamber and a piston bore. The bores are closed by plugs 120, 121 and 122.

Cold condensate will flow freely through both valves. Particularly is this true because the discharge area of the outlet valve is larger than the inlet area of the inlet valve. There is also leakage from the control chamber past the piston.

This condition of free discharge of condensate through the valves will continue until such time as the rising temperature of condensate reaching the trap causes the hot condensate or steam to flash as it enters the control chamber, bringing pressure on the piston 114 in the cylinder at that end of the lever opposite to the valve. The piston will then draw the valves toward closure. They will stay in partly closed position most of the time.

Leakage is provided past the piston. It is desirable to have leakage past both valves in order that they may be never wholly closed. It will be noted that in this view, as also in Figures 9 and 10 there will be double leakage. For this reason these constructions are suited to uses where there is a considerable quantity of average condensate flow and are suited best to use where a substantially continuous leakage discharge is to be handled having a volume in excess of the amount of leakage past the piston.

In Figure 6a the construction corresponds generally with that in Figure 6 except that the second leakage is stopped by using a diaphragm 114' on rod 112' instead of the piston 114. The port 118' is thus rendered substantially without utility but may be used. The diaphragm will lie in a plane if the inner surface of the trap adjacent the bore 115' be faced to accommodate it. The diaphragm is retained by any suitable means, not shown and its resilience against transverse distortion assists in return to initial position.

In the form of Figure 7 three tapered valves 123, 124 and 125 are shown within a casing 126. The valves move toward or against seats 127, 128, 129 in fixed partitions in the casing.

In addition to the inlet 130 intermediate control compartment 131 and discharge compartment 132 there is a supplemental counter-balancing compartment 133 which, however, is in no sense a leakage compartment. The supplemental compartment is closed by a plug 134.

The valves 123 and 124 need never close. In one way or another passage is supplied to permit continued leakage through to the discharge compartment. The stem 135 rigidly connecting the several valves is hollow forming a through passage 136 so as to ensure pressure in the counterbalancing compartment 133 equal to inlet pressure.

In order to avoid awkwardness of expressioon and make it possible to cover in the same claims and in simple language valves which never close

wholly and allow leakage to take place between the valves and what would be their seats if they fully closed, and also valves which fully close against seats and provide no leakage between valve and seat but provide leakage through grooves in the seats or valves, or by separate openings in the walls (as in Figures 1*b* and 1*c*) or through the body of the valve itself (as in Figures 1*a* and 5), I have referred to "providing flow through the intermediate compartment, whether the valves be in open or closed position" and other language regarding the closing of the valve.

It is intended to cover in the claims cases such as in Figure 1 where the valve has a seat toward which it approaches but which it never reaches, considering the closed position of the valves as that position where it shuts off fluid flow to the fullest intended extent. In other words, the closure of the valve is the movement of the valve as far as it is intended to move for constriction of flow even if it does not close entirely. The valve may or may not rely upon other leakage provision than its own opening for the constant flow through the intermediate compartment.

In starting cold condensate will flow through the tubular stem to the chamber or compartment **133** at the lower end of the trap and will bring pressure upon the projected cross-sectional area of the lower valve, opening the inlet and outlet valves for free discharge flow because of the low chamber pressure between the two upper valves. This discharge is facilitated by the fact that the outlet valve is larger than the inlet valve and will allow discharge of cold water through it freely. When the condensate discharge becomes sufficiently hot, flashing of the hot condensate takes place past the inlet valve. This builds up the pressure in the chamber or compartment **131** and causes the valve to move toward closure, the same as in the other forms of trap. The bottom valve operates to make the chamber **133** a counterbalancing chamber.

It will be noted that no second leakage is here provided, the leakage through the casing or valve or at the valve being sufficient.

In Figure 8 the condition is much the same as in Figure 7 except that the pressure available in the balancing or counterbalancing chamber against the lowest valve is not the inlet pressure of say 100 lbs., as in Figure 7, but is the pressure (say 87 lbs.) of the control chamber **131**, because the passage **136'** does not pass entirely through the stem in Figure 8 but starts at an opening **137** within the control compartment **131** and not from the end of the stem where it would receive the inlet pressure.

Figure 9 represents a reversal in part of the structure of Figure 6, but lacks a lever connection. In it the small inlet and larger outlet valves **138** and **139** are rigidly connected by an adjustable stem **140** and close, as nearly as they are intended to close, at different points toward or against taper seats at **141** and **142**. The outlet valve carries a cylinder **143** into which leakage takes place through a continuously open passage **144**. A fixed piston **145** is rigidly positioned within the casing **146** but is capable of adjustment in it by threaded stem **147** locked in adjusted position by nut **148**.

The control chamber **149** lies between the seats **141** and **142** in the space located longitudinally betwen inlet and outlet valves.

Leakage takes place continuously along two paths from inlet to outlet. There is also free discharge flow—as distinguished from leakage—through the two valves until the temperature of condensate—for example—gets high enough for flashing to take place.

The cylinder and piston act as a dash pot tending to offset rapid movement of the valve, and, as the pressure rises in cylinder **143**, the cylinder is pushed away from the piston **145**, tending to close the valves.

In Figure 9*a* the cylinder is displaced by a bellows **143'** of resilient material, one end of which is secured to the outlet valve. Both ends are closed except as passage **144** opens into the bellows.

The end **143²** pushes against a stop **145'** which occupies the position of piston **145**.

The diaphragm of Figure 6*a* and the bellows of Figure 9*a* are therefore for this purpose alternatives for the piston and cylinder of Figures 6 and 9.

Flashing not only increases pressure between the valves but increases pressure within the cylinder **143**.

In Figure 10 the casing **150** contains a valve seat at **151** against which rests the outside (valve) surface of a truncated cone shell **152** forming a valve between the outside of the shell and the inside of the valve seat **151** at **153**. The shell forms inlet valve seat **154** and outlet valve seat **155** for fixed valve elements **156** and **157**. The fixed valves are carried by a stem **158** which is threaded at **159** into a bar **160**. The stem is locked by nut **161**. The bar **160** is rigid with the casing **150**. The shell therefore has three valve contacts, an outside valve contact at **151**, and inside valve contacts at **154** and **155**. As in the other forms there is intended to be leakage through the casing at all times and this may take place past the outside of the shell and through the control chamber **162** whether between the valves and their seats or through the shell or valve body, a illustrated in other forms.

In operation leakage takes place also between the outside valve and its truncated cone seat. Condensate, for example, passes through freely when cold and until it gets very hot. As the temperature of the condensate gets sufficiently hot so that vaporization takes place within the control chamber the capacity of the outlet larger valve to discharge as fast as the inlet valve admits is reduced progressively. Acting on the projected area inside the truncated cone the resulting pressure within chamber **162** presses the cone toward closure of all three valve openings. As in the other forms the trap normally operates with the valves slightly open, allowing condensate to pass through at nearly steam temperature and fluctuating in rate of discharge as condensate approaches the trap in larger volume, and thus at slightly lower temperature, or in less volume at nearly steam temperature.

In Figure 11 a form is shown bearing considerable resemblance to the form of Figures 1 and 2. The fluid—let us assume that it is condensate—comes into the compartment **22'** through a trap connection **32'** and passes through an inlet opening controlled by valve **26'** into control compartment **21'**. This compartment is closed by a plug **120'**.

As the valve **26'** moves, the outlet ball valve **27'** is shifted by the head of an adjusting screw **57²** so as to permit passage of discharge flow through outlet valve **25'** into outlet compartment **23'**, whence it passes to discharge through the threaded connection **33'**.

Inlet and outlet leakages are provided in this

form—as in the forms seen in Figures 3, 4 and 6–10, in any suitable way, such as one of the ways already described.

In the form of Figure 9 the valve has an appendage just as in the Figure 1 main form. The valve flange is of the same character and the seat against which the flange fits may be convex or concave as desired to properly proportion the increasing inlet flow to the outlet flow. The ball rolling to expose the outlet is equivalent to an angular plate which tilts on a pin fulcrum. The fulcrum here is the edge of the outlet.

The operation of the Figure 11 form is substantially the same as with that of Figures 1 and 2. Leakage through the trap takes place all the time and cold or cooler condensate will flow through freely, the outlet leakage providing for a faster rate for discharge than is permitted by the inlet leakage. Likewise, the outlet flow provided when discharge in quantity is taking place through the leakage and control chamber 21', is larger than the inlet provided under like conditions. When the temperature of the condensate causes flashing in the chamber 21' the vaporization due to the flashing progressively slows down the discharge rate. The temperature and pressure in the control compartment both increase, the temperature approaching steam temperature as the temperature of the condensate at the inlet valve approaches steam temperature.

It will be evident that the two orifices in series contemplated in this application include any aperture opening, hole, tube, etc., having an inlet and an outlet and an intermediate portion having pressure between that at the inlet and that at the outlet, the inlet corresponding to the first orifice and the outlet corresponding to the second orifice.

It will be evident that the varying pressures at points between the inlet and outlet may be utilized accordingly to open and close inlet and outlet valves by any of a variety of possible means, varying from the rigid coupling of Figures 4, 7 and 8 through movable directly connected coupling, as in Figure 3, and cooperative control, one over the other by position, as in Figures 1, 2 and 10, to wholly separate and distinct valves related in their opening and closing movements through the pressure at the intermediate point as in Figure 5.

In each of the forms when the inlet and outlet closures are in closed positions there is flow nevertheless through the control chamber, whether that flow takes place through deliberate failure to close the valves tightly, through grooves in the valve faces or in the valve seats, through passages independent of the valves and their seats such as in Figures 1a, 1b and 1c at $59'$, 59^3 and 59^4 or otherwise, and language referring to closing of the valves or of the closures of the orifices is therefore to mean completing the closing movement and not to negative leakages remaining as where a valve does not fully reach a seat even if capable of shutting off flow completely against such a seat. Because of the obvious desirability of covering all the forms in which such leakage is provided in one expression I have referred to it in some of the claims by reference to the condition of leakage notwithstanding "closure" of the valves, meaning leakage notwithstanding such closure as is intended, to shut off what might be considered the "flow" as distinguished from the quantity which is provided as "leakage."

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 in so far as they fall within the reasonable spirit and scope of my invention.

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

1. A trap having spaced inlet and outlet orifices and an intermediate control chamber located between the orifices and through which main discharge takes place, pressure operated closures for both orifices, both opening inwardly into the intermediate control chamber and against its pressure and continuous leakage means for permitting continuous flow into the chamber and out from it even when the closures are otherwise closed.

2. A trap having spaced inlet and outlet orifices and an intermediate control chamber located between the orifices and through which main discharge takes place, pressure operated closures for nearly closing both orifices, both opening inwardly into the intermediate chamber against its pressure and the outlet being always open, and a connection between the closures whereby the closures move in opening direction together and in closing direction together.

3. In a trap, a body having inlet and outlet compartments, an intermediate control compartment, valve openings between the respective inlet and outlet compartments and the intermediate compartment and valves in the openings opening into the intermediate compartment in which the valves are coupled to open together and to close together and the valves are opened by the combined inlet pressure upon the inlet valve and back pressure upon the outlet valve and are closed by the preponderance over these of the pressure within the intermediate compartment upon both valves and means for providing flow through the intermediate compartment whether the valves be in open or closed position.

4. In a steam trap, a trap having a body and openings in series therein for inlet and outlet flow to an intermediate control compartment to and through which the main discharge flow passes, a pressure operated valve for each of the openings, and connections between the inlet valve and the outlet valve whereby the lifting of the inlet valve proportionately lifts the outlet valve, and means for providing continuous flow through the control compartment even when the valves are in closed position.

5. A steam trap having spaced inlet and outlet orifices and an intermediate control chamber through which condensate is adapted to pass from a steam system at steam pressure through the intermediate chamber where it is at lower pressure and to discharge, and separate means for substantially closing the orifices, the opening of the orifices being opposed by the pressure in the intermediate chamber, both means being responsive to pressure in the intermediate chamber and means for providing flow through the control chamber even when the closures of the orifices are in closed position, whereby fluctuations in pressure in the intermediate chamber become effective for movement of both closure means toward opening when the intermediate pressure

lowers and toward closure when the intermediate pressure rises.

6. A control element for the discharge of condensate from steam providing a plurality of separate orifices in series and an intermediate pressure control chamber through which the entire flow passes, means for effectively closing the orifices and means for providing flow through the control chamber whether the closures be in closed position, or not, the flow being controlled by the pressure within the intermediate chamber and its relation to the inlet and discharge back pressures to open both closures or to close both closures.

7. A trap having two spaced orifices and an intermediate pressure control chamber through which entire discharge takes place and valves closing the two orifices, the valves being connected, both to open together for inlet flow into the chamber and both to close together, the valves being controlled in their movement by varying the pressure in the chamber, and means for providing continuous flow through the control chamber even when the closures are in closed position.

8. A steam trap having spaced orifices and an intermediate pressure control chamber for main discharge and interconnected closures for the orifices, both opening into the intermediate chamber and both controlled in movement by the pressure in the intermediate chamber and its relation to inlet and discharge back pressure, whereby the pressure of the intermediate chamber controls opening of both closures when the pressure is reduced and closing of both when the pressure is increased, and means for providing flow through the control chamber even when the closures are in closed position.

9. A steam trap having spaced inlet and outlet orifices and an intermediate control compartment and pressure operated closures for the inlet and outlet orifices mechanically interconnected to provide movement together and both opening together and closing together and means for providing leakage into and out from the control compartment even when the closures are in closed position.

10. In a steam trap, a body having a control chamber and inlet and outlet valved openings, pressure operated movable valve means for opening and substantially closing the two openings, and connected to open together and close together and means for providing leakage of inlet fluid to and outlet fluid from the control chamber to determine the pressure in the control chamber, the variation of pressure in the chamber being effective to permit the valves to be opened or substantially to close the connected valves.

11. In a steam trap, a trap body having openings through it to provide inlet and outlet flow through an intermediate control compartment, there being leakage between the inlet and outlet compartments to and from which the flow passes, a pressure operated valve for each of the openings, a mechanical connection between the inlet valve and the outlet valve, coupling them for opening movement greater for the inlet valve than for the outlet valve, whereby the lifting of the inlet valve proportionately opens the outlet valve, and an adjustment in the connection between the inlet valve and the outlet valve, whereby the extent of opening of the outlet valve with a given movement of the inlet valve may be varied.

12. The method of continuously draining the liquid phase from fluid having a gaseous phase also, which consists in leaking the liquid and gas continuously through throttling spaced orifices and a single intervening control chamber and discharging the liquid through the same chamber and both orifices at a rate determined by the pressure in said chamber.

13. The method of operating a fluid trap having a single control chamber, an inlet opening thereto from a condensate supply and an outlet opening therefrom to permit discharge against back pressure, and pressure operated inlet and outlet valves for the openings, each valve moving about an axis and both subject to closing pressure within the chamber, which consists in coupling the valves together to cause them to move concurrently in the same direction about said axis, both opening or both closing, in leaking condensate continuously through the control chamber along the path of flow between the inlet and the outlet, and in opposing reduced pressure exerted against the inlet valve plus back pressure against the outlet valve on the one hand, against the control chamber pressure upon the two valves on the other hand, to open both valves or substantially to close both valves according to which of the forces predominates.

14. A steam trap comprising a body having inlet and outlet passages and a bore between the passages, a disc within the bore carrying inlet and outlet valve seats, a cupped closure threaded into the bore having a skirt engaging the disc and holding it in position, the bore providing a control compartment through which condensate passes from the inlet to the outlet, a valve for the outlet passage resting within the bore, a valve for the inlet adapted to lift the outlet valve with lifting of the inlet valve and means for providing leakage to and from the compartment to provide for normal leakage of condensate through the control compartment.

15. A steam trap comprising a body having inlet and outlet passages and a lateral threaded bore between the passages, a disc within the bore carrying inlet and outlet valve seats, a cupped closure threaded into the bore having a skirt engaging the disc and holding it in position, the bore providing a compartment through which fluid passes from the inlet to the outlet, a valve for the outlet passage resting within the bore, a valve for the inlet adapted to cooperate with the outlet valve and means for providing leakage to and from the compartment.

16. In a steam trap, a trap body having inlet and outlet openings and a transverse bore connected respectively therewith, a disc in the bore carrying inlet and outlet valve seats at the outer face of the disc, a loose outlet valve adapted to turn about and pivot with respect to the outlet valve seat to open the outlet valve, an inlet valve, adjustable connections between the inlet valve and the opposite end of the disc from the end at which the loose valve pivots and leakage means for passing condensate through the outlet valve whether the inlet valve be closed or open.

17. In a steam trap, a trap body having inlet and outlet openings and a bore connected respectively therewith, a disc in the bore carrying inlet and outlet valve seats at the face of the disc, an inlet valve, a loose outlet valve adapted to turn about and pivot with respect to the outlet valve seat to open the outlet opening and resting upon the inlet valve, adjustable connections between the inlet valve and the opposite end of the out-

let valve from the end at which the loose valve pivots and leakage means for passing condensate through the passage when the inlet is otherwise closed.

18. In a steam trap, a trap body having openings through it for inlet and outlet and an intermediate control compartment to and from which flow passes, a valve for each of the openings, connections between the inlet valve and the outlet valve whereby the lifting of the inlet valve proportionately lifts the outlet valve, and an adjustment between the inlet valve and the outlet valve, whereby the extent of opening of the outlet valve with given movement of the inlet valve may be varied and the outlet valve may be held open when the inlet valve is closed.

19. In a steam trap, a trap body having a cylindrical bore between inlet and outlet ends of the body, the bore connecting with the inlet through an inlet passage and with the outlet through an outlet passage, a disc within the bore alined with the inlet and outlet passages and having inlet and outlet valve seats connecting with these passages, a cupped cover threaded into the bore, bored and counterbored and adapted to engage the disc and hold it in position, an inlet valve engaging the inlet valve seat, a liftable outlet disc valve within the cup of the cover, a shoulder between the bore and counterbore of the cover, engaged by the disc and an adjustable connection between the inlet valve and the outlet valve whereby the extent of lifting of the outlet valve with respect to the inlet valve may be adjusted.

20. A drainage device to operate between relatively high and low pressure systems for delivering drainage from the high pressure system to the low pressure system, the device having an inlet from the high pressure system and an outlet to the low pressure system and valve means operative in reverse directions by the pressure drops at the inlet and outlet to constrict the inlet and outlet at one vapor-phase content of the flowing medium and to enlarge the inlet and outlet at another and lower vapor-phase content of the flowing medium, and in which the said means includes a lever having an intermediate pivot and inlet and outlet valve elements on opposite ends of the lever.

21. A drainage device to operate between relatively high and low pressure systems for delivering drainage from the high pressure system to the low pressure system, the device having an inlet from the high pressure system and an outlet to the low pressure system and means operative in reverse directions by the pressure drops at the inlet and outlet to constrict the inlet and outlet at one vapor-phase content of the flowing medium and to enlarge the inlet and outlet at another and lower vapor phase content of the flowing medium, and in which the said means includes a lever having a pivot at an intermediate portion of the lever, an adjustment for the pivot and valves at opposite ends of the lever adapted to be presented respectively to the inlet and outlet.

22. A drainage device to operate between relatively high and low pressure systems for delivering drainage from the high pressure system to the low pressure system, the device having an inlet from the high pressure system and an outlet to the low pressure system and means operative in reverse direction by the pressure drops at the inlet and outlet to constrict the inlet and outlet at one vapor-phase content of the flowing medium and to enlarge the inlet and outlet at another and lower vapor phase content of the flowing meduim, in which the inlet and outlet includes axially spaced ports and the said means includes a valve element at each port and a yoke connection between the elements whereby movement of the means in one direction opens both ports and movement thereof in the other direction closes both ports.

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