Nov. 17, 1953 L. C. E. FRAGER 2,659,383

SAFETY DEVICE FOR WATER SUPPLY NETWORKS

Filed Aug. 7, 1947 4 Sheets-Sheet 1

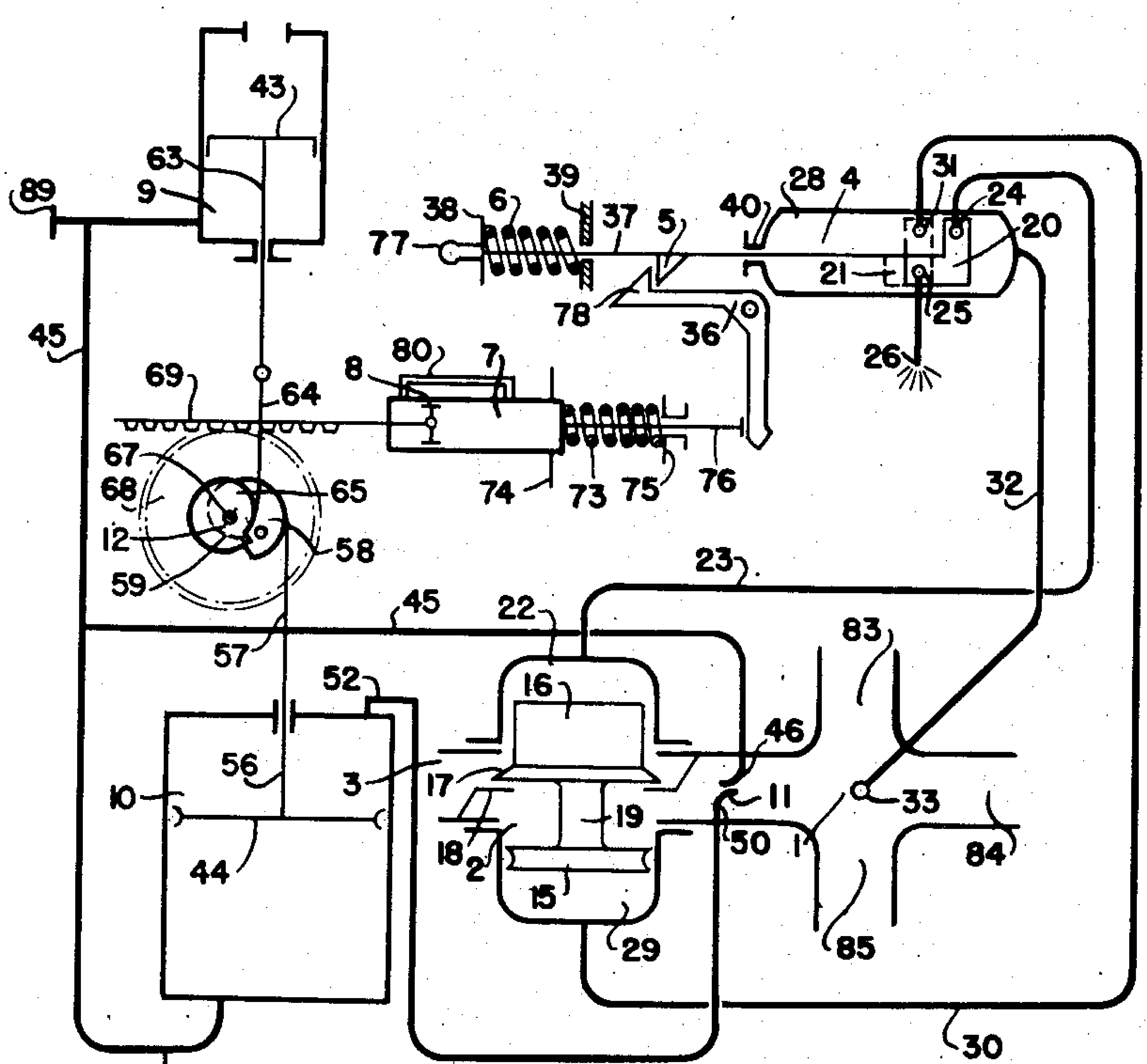

FIG. I.

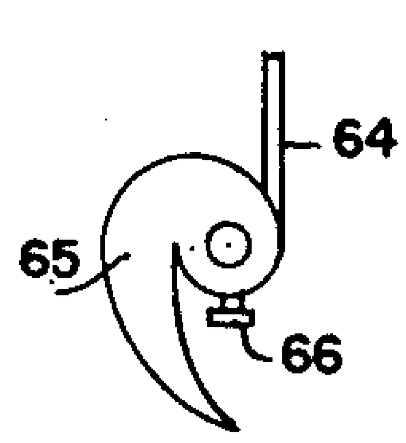

FIG. 3.

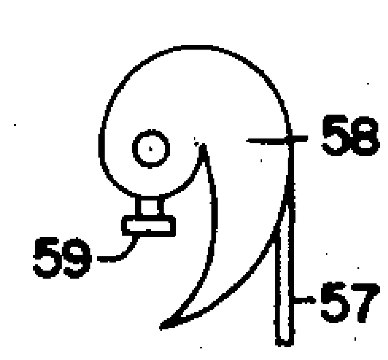

FIG. 4.

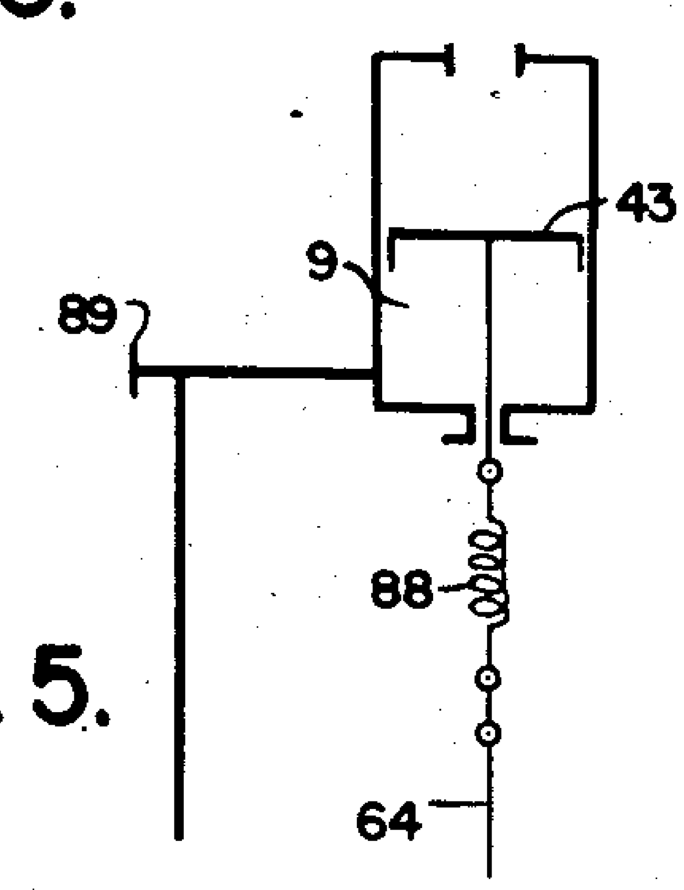

FIG. 5.

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SAFETY DEVICE FOR WATER SUPPLY NETWORKS

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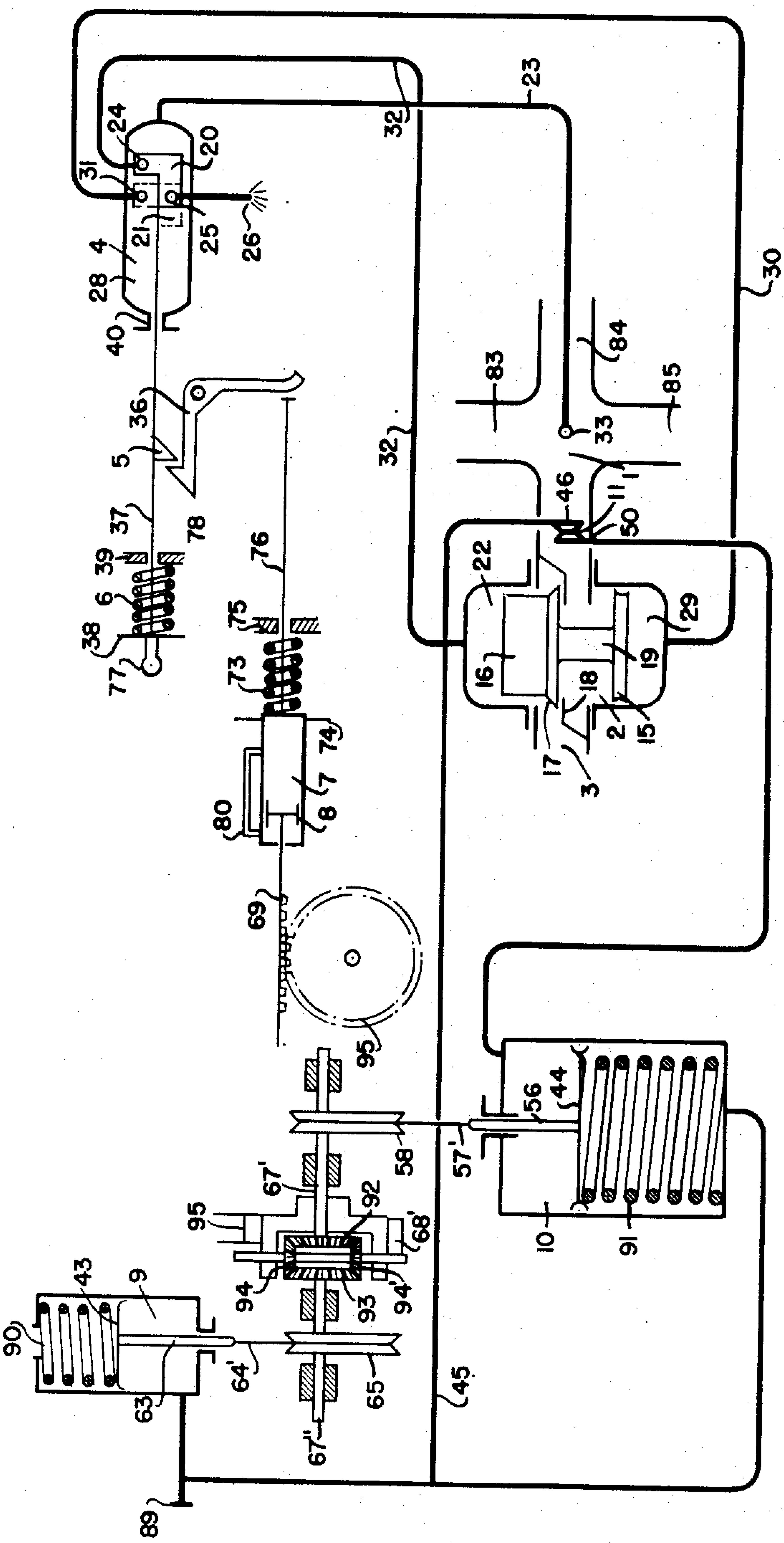

FIG. 2.

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SAFETY DEVICE FOR WATER SUPPLY NETWORKS

Filed Aug. 7, 1947 4 Sheets-Sheet 3

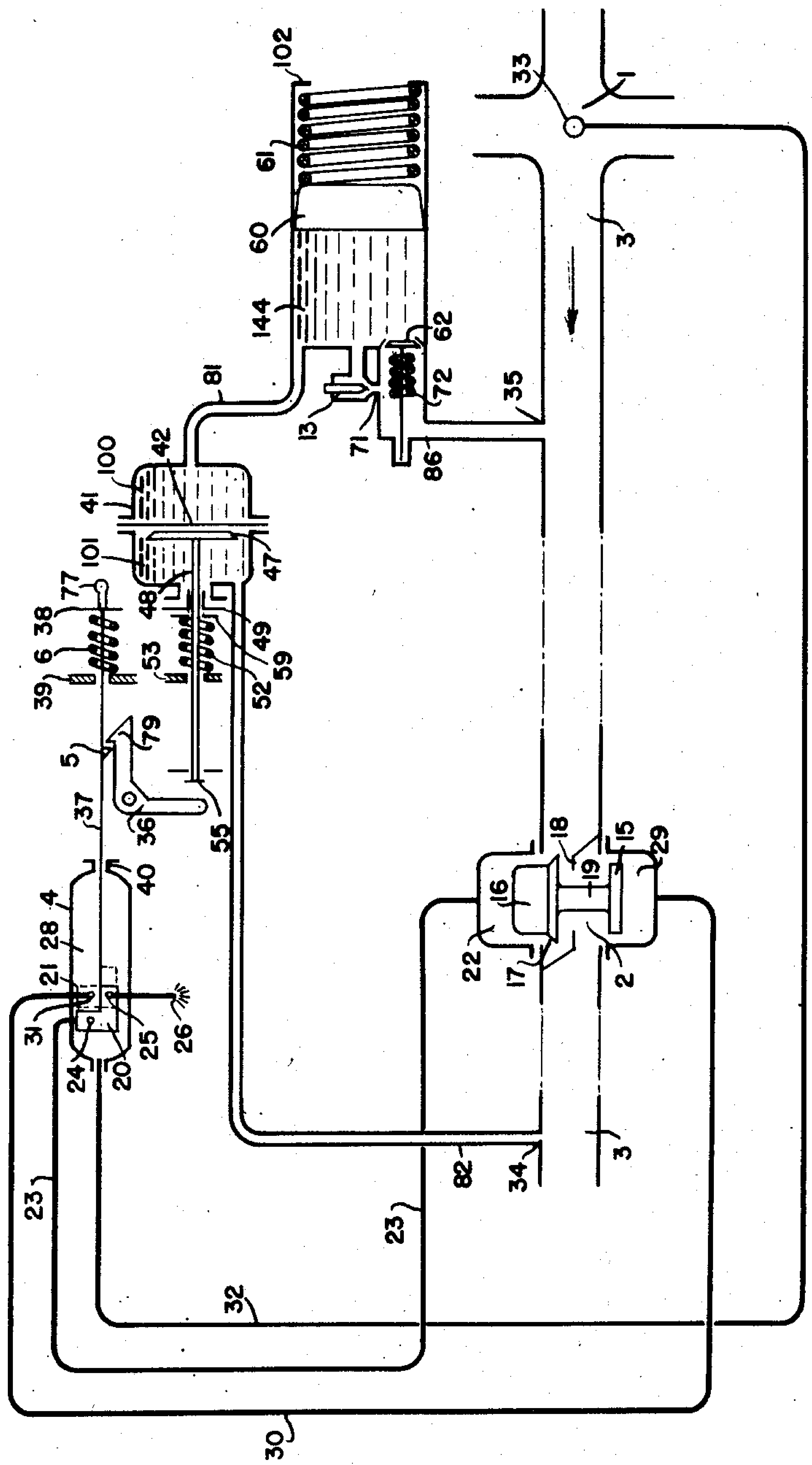

FIG. 6.

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SAFETY DEVICE FOR WATER SUPPLY NETWORKS

Filed Aug. 7, 1947 4 Sheets-Sheet 4

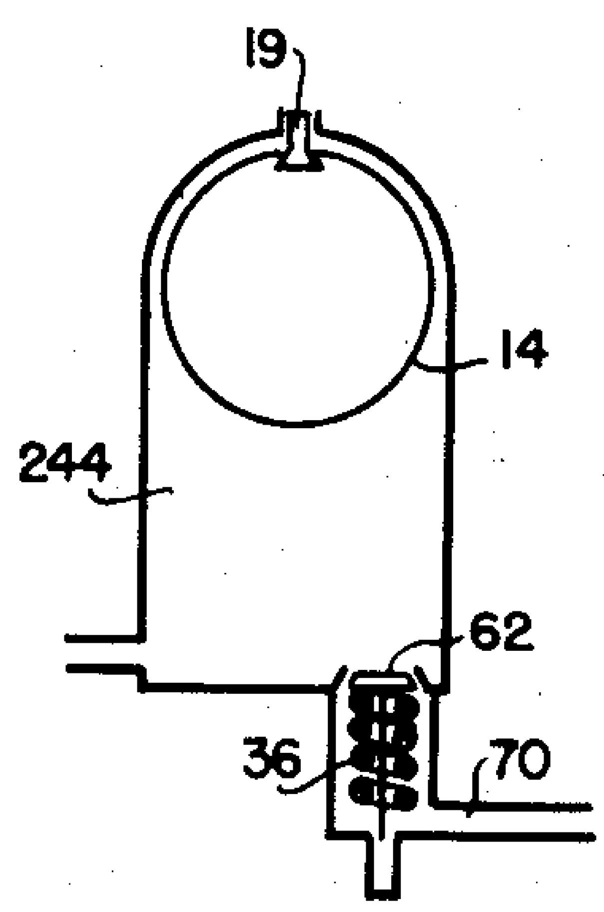

FIG. 7.

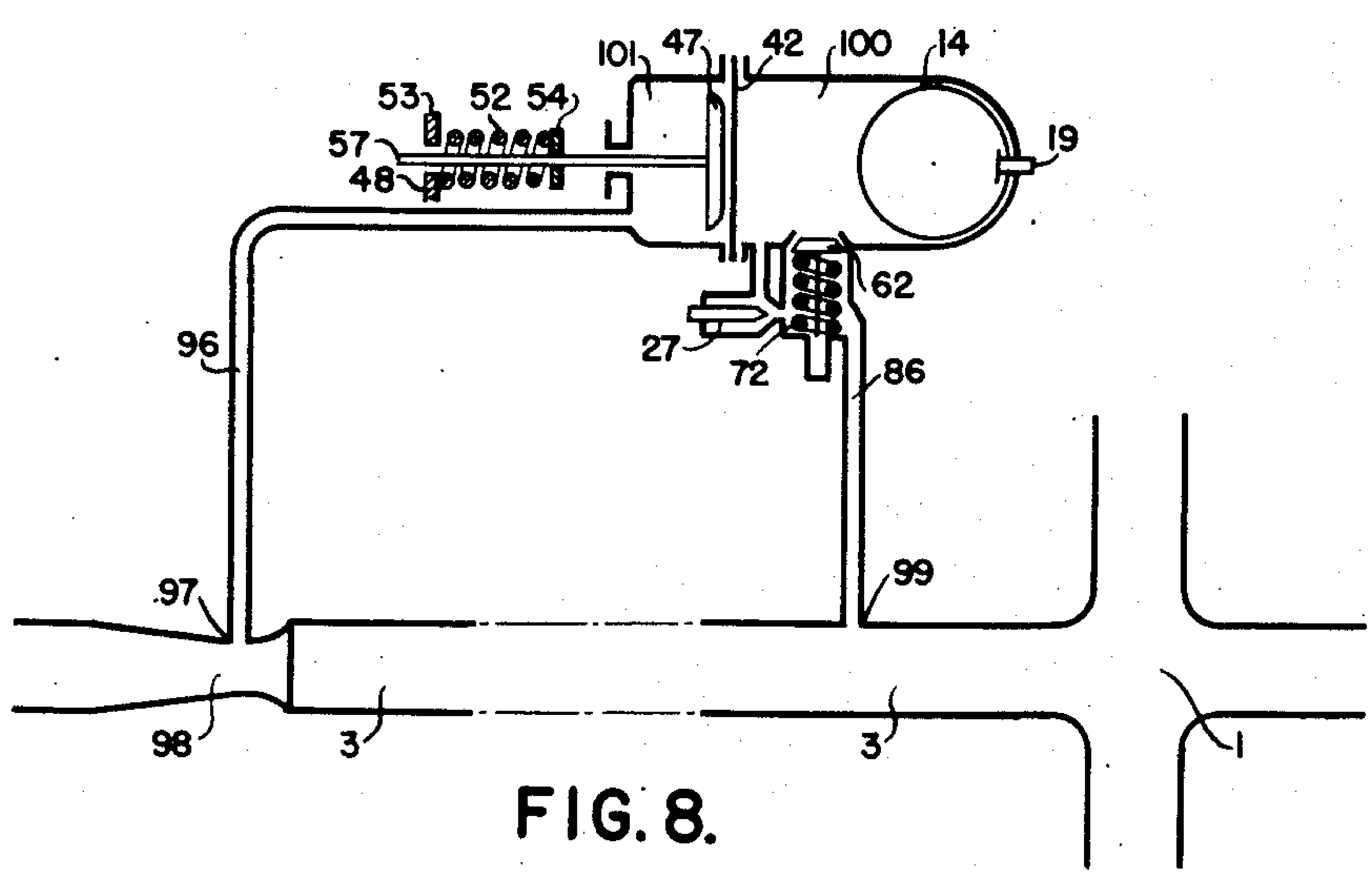

FIG. 8.

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2,659,383

SAFETY DEVICE FOR WATER SUPPLY NETWORKS

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Application August 7, 1947, Serial No. 767,273
In France July 6, 1944

Section 1, Public Law 690, August 8, 1946
Patent expires July 6, 1964

4 Claims. (Cl. 137—460)

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Water supply networks are generally composed of interconnected mains which are provided at their connected ends with safety valves allowing, in case of rupture, cutting off the flow of water in the damaged pipe.

These water-main valves may be operated through automatic control servomotors set in action through either excessive pressure drop or excessive waterflow.

These known systems are generally based on the principle of apparatus actuated in accordance with an appropriate physical quantity. The apparatus sets the controls of an automatic valve in closing position as soon as a predetermined value of the physical quantity has been reached.

When the physical quantity utilized is the rate of flow in the water main, an undesirable closing-off might occur because of a high rate of flow under normal service conditions since a high rate of flow might occur daily and also in different seasons or due to an increase in population in the water main's area. Furthermore if a break occurs, a great amount of water might run away before the predetermined value of rate of flow has been reached.

When the predetermined physical quantity is the pressure in the main, most of these same drawbacks are present and aggravated through variations of flow of water in the feeding reservoir and this is worse if the automatic valve is located in a high place and the upstream length of the main is greater. The frequency of inopportune closing-offs can be prohibitive under such conditions.

Furthermore, systems in which motion of the closing-controls of the automatic valve is obtained through swift pressure variations, might close off without necessity the automatic valves of uninjured mains and cause additional unnecessary inconvenience to customers as well as to water supply companies.

In a system where water mains are connected together in any number and one of these mains breaks, the pressure head decreases swiftly not only on the broken main but also on all the other mains and all the respective automatic valves will close at the same time.

The hereafter described system has as its object to avoid these drawbacks. It is essentially based on the use either of the time derivative of a function of the rate of flow or of the time derivative of a function of both the rate of flow and the pressure head, that is to say, on the derivatives of both these two functions and then two time derivatives as predetermined quantities for closing off.

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Such a system has the advantage of setting controls in closing position in such a manner that the broken main only is placed out of service and as soon as break occurs.

With the above and other objects in view as will become apparent from the detailed description below a preferred embodiment of the invention is shown in the drawings in which:

Fig. 1 is a diagrammatic view of one form of the invention;

Fig. 2 is a modified type of construction shown diagrammatically;

Fig. 3 is a plan view of a detail;

Fig. 4 is a plan view of another detail;

Fig. 5 is a diagrammatic view of some further details of the invention;

Fig. 6 is a diagrammatic view of a further modification particularly adapted for emergency use;

Fig. 7 is a diagrammatic view of a detail; and

Fig. 8 illustrates diagrammatically a further modification of the invention particularly designed for a system in which Venturi pipes are used.

Throughout the drawings similar reference characters are used for like parts.

In the present invention the arrangement for releasing the valves so that they move to closed position is subject to the action of a force which is a function of the quotient

$$\frac{p}{q^2}$$

wherein p indicates the pressure in the main and q^2 represents the square of the flow in such main. In accordance with the invention this force will only come into action to bring about the closing of the valves whenever there is a relatively rapid variation in the pressure or in the resistance to the flow of water in the main.

Therefore, the valves are controlled for the closing thereof only when the two following conditions are fulfilled simultaneously:

1. Whenever the ratio

$$\frac{p}{q^2}$$

indicates a relatively important decrease in p or increase in q^2.

2. Whenever there is a rapid variation in the resistance offered to the waterflow through the main considered.

Only when these two conditions are met will the safety valve close under abnormal conditions.

In accordance with the invention use is made of two pistons wherein one is set into action by the pressure p prevailing and the other by the square of the flow q^2 in the main. The movements of such pistons is coordinated so that the resulting action is a function of the ratio

$$\frac{p}{q^2}$$

The above two pistons are preferably coupled by a rotary device whose angular position varies when the ratio of the forces acting upon such pistons varies. The rotary coupling between the two pistons actuates preferably a toothed rack which in turn is connected to another piston which may reciprocate along its longitudinal axis in a movable cylinder which is submitted itself to the action of a spring actuating the said cylinder back to its rest position. If the motion of the toothed rack is rapid then the piston fixed thereto will displace its cylinder in spite of the spring action so as to release. However, if the motion of the toothed rack is relatively slow then the oil inside the cylinder, controlled by the toothed rack, may travel from one side to the other of the piston through a bypass having adjustable throttling means. In such case the water main valve control means are not released.

Furthermore, the invention contemplates a retarding device located on the piston which is actuated by the pressure prevailing in the water main. Such a device may be constructed as a throttle valve placed on the pipe connecting the active face of the above piston to the main and an elastic connection between the piston and the movable element that it operates or by a resilient mounting for the support of the cylinder containing the piston.

Referring to Fig. 1 there is shown a junction point 1 for two water mains. A watergate or valve 2 controls the branch 3.

A distributor 4 controls the valve 2 so as to move it either to its opened or closed position. The elements which release the distributor 4 comprise the tooth 5, the spring 6, the cylinder 7 and the piston 8. A cylinder 9 is under the pressure existing in the branch 3 upstream from the valve 2. A second cylinder 10 is subjected in its lower part to the same pressure and in its upper part to the pressure existing in a Pitot tube 50. The pistons 43 and 44 in the cylinders 9 and 10 are mechanically coupled by means of the rotary system 12. The pistons 43 and 44 act oppositely to one another.

The valve 2 is provided with two pistons 15 and 16 connected by a rod 19. At the bottom part of the piston 16 there is a circular valve member 17 designed to cooperate with the seat 18 and when in contact with such seat closes the branch 3.

The distributor 4 for operating the valve 2 comprises a slide valve 20 which is L-shaped. The position of slide valve 20 shown in Fig. 1 in full lines is the position it occupies when the valve 2 is in opened position. The dotted lines 21 show the position of the slide valve 20 when the valve 2 is moved to closing position. When the slide valve 20 is in the position shown in full lines the upper cylinder 22 of the watergate 2 is connected by the pipe 23, the aperture 24, and the aperture 25, through the exhaust pipe 26 to the atmosphere.

The lower cylinder 29 of the watergate 2 is connected by the pipe 30 and the aperture 31 to the chamber 28 of the distributor 4 and thence by the pipe 32 and aperture 33 to the water main junction 1. Therefore when the slide valve 20

is in the full line position the lower piston 15 is subjected to the pressure in the water main and is moved upwardly while the water in the cylinder 22 is exhausted through the pipe 23, aperture 24, aperture 25 and exhaust pipe 26. On the other hand, when the slide valve 20 is in the dotted line position, the piston 16 is subject to the pressure prevailing in the water mains through pipe 23, aperture 24, chamber 28, pipe 32 and aperture 33 and the cylinder 29 is exhausted through the pipe 30, aperture 31, aperture 25 and exhaust pipe 26.

The means for releasing the slide valve 20 so that it may move from the right to the left in Fig. 1 and bring about the closing of the circular valve member 17 upon its seat 18 comprises a tooth 5 carried by a control rod 37. The tooth 5 cooperates with the hook 78 provided upon a pivoted trigger 36. The control rod 37 passes through a stuffing box 40 and a fixed abutment 39. Encircling the control rod 37 on the side of the abutment 39 opposite to that where the distributor 4 is located is the spring 6 having one end bearing against the abutment 39. The other end of the spring bears against a disc 38 fixed upon the control rod 37 and a handle 77 is provided upon the end of the control rod 37 for manual control of rod 37 and of the slide valve 20.

Means for operating the releasing means comprises the following: Two pistons 43 and 44 reciprocate respectively in cylinders 9 and 10. The bottom of cylinder 9 is connected by a pipe 45 to the Pitot tube 46 located so as to be subject to the pressure in the branch 3. The upper portion of the cylinder 9 above the piston 43 communicates with the atmosphere. The lower portion of the cylinder 10 is connected by a pipe 51 to the down-stream Pitot tube 46.

It is to be understood that the expression "down-stream" and "up-stream" mean in general the Pitot tubes respectively subjected to the lowest and highest pressure when the flow comes from the water main junction 1. The pressure difference between the two Pitot tubes reverse when the flow reverses in branch 3.

The piston 44 in the cylinder 10 is operated by the pressure difference created by the Pitot tubes 46 and 50 submitted to the flow into branch 3. When the flow is from the water main junction 1 towards the branch 3 the piston 44 is subjected to a force which tends to move the piston 44 downwardly.

In such case the piston rod 56 exerts a pull upon the belt 57 which is wound on the pulley 58 and secured thereto at the point 59 (Fig. 1 and Fig. 4).

The piston rod 63 of the piston 43 also exerts a pull upon the belt 64 (Fig. 1 and Fig. 3) which is wound upon the pulley 65 and secured thereto at the point 66 (Fig. 3). The pulleys 58 and 65 are fixed to the same shaft 67 which is rotatably mounted. A gear 68 is also fixed on the shaft 67 which meshes with a toothed rack 69. The profiles of the pulleys 58 and 65 are preferably formed in accordance with a logarithmic law in order that the angular position of the gear 68 may be expressed in angles proportional to the logarithm of the ratio of the forces brought into play respectively on the pistons 43 and 44.

For example, if it is assumed that a force k_1p acts on the piston 43 and that a force of k_2q^2 acts on the piston 44 wherein p represents the pressure in the branch 3 and q the flow in such branch then the resultant angle assumed by the gear **68** will be:

$$k_3 \log \frac{p}{q^2}$$

in which k_1, k_2 and k_3 are constants.

The term

$$\log \frac{p}{q^2}$$

of liquid. The gear **68** as mentioned above represents the resistance of branch **3** to the flow meshes with the rack **69** and said rack is connected to the piston **8** reciprocating in the oil filled cylinder **7**.

The cylinder **7** has, fixed to one end thereof, an operating rod **76** designed to cooperate with the trigger **36** for tripping the hook **78** from the tooth **5**. The rod **76** is slidingly mounted on a fixed abutment **75** and on the side of the abutment **75** opposite to trigger **36**, the rod **76** is encircled by a spring **73** having one end bearing against the fixed abutment **75** and the other end bearing against a side wall of cylinder **7**. Cylinder **7** is also slidingly supported by the support **74**. A bypass **80** is provided in the cylinder **7**, opposite ends of the cylinder **7** communicating together through bypass **80**.

Whenever ratio

$$\frac{p}{q^2}$$

varies at a high rate (p diminishing or q increasing and this together or not) the new balanced position of the pulleys **58** and **65** corresponds to a clockwise rotation of the gear **68** thereby moving the rack **69** from left to right as shown in Fig. 1. Since it is a high rate variation, piston **8** will thus move up cylinder **7** which is filled with oil or liquid of appropriate viscosity overcoming the action of the spring **73** and the rod **76** will trip the trigger **36** thereby permitting the spring **6** to bring the slide valve **20** to the dotted line position whereby the valve **2** is closed. The releasing system may be reset by manually moving the rod **37** by the handle **77** against the action of the spring **6** and the hook **78** will then retain the tooth **5** holding the slide valve **20** in its right hand position of Fig. 1 and thereby again opening valve **2**.

On the other hand, if the motion of the rack **69** is relatively slow oil will pass through the bypass **80** and the cylinder **7** will not follow the movements of the rack **69**. In such case the trigger **36** is not tripped.

It is obvious that as the flow takes place from the branch **3** towards the water main junction point **1** the action of the pressure is not compensated by the action of such a flow because their effects are no more opposite one to another. On the contrary, if the flow reverses and as soon as such occurs the opposing action of the piston **44** will appear. This results in the advantage that the release of the distributor **4** cannot take place when the branch **3** discharges into the junction point **1** and this is a safety advantage because in the case of a breakage in the branch **3** it is advantageous to allow such branch to discharge into the junction point **1** as long as possible.

The device described above is suitable in the case of an isolated pipe wherein the pressure would not vary abruptly other than in the case of a rupture.

On the other hand, where there are adjacent mains such as **83**, **84** and **85** wherein ruptures might occur with an abrupt lowering of pressure at the junction point **1**, the square of the flow, q^2, into the branch **3** because of the inertia of the water will decrease less rapidly than the pressure so that the ratio

$$\frac{p}{q^2}$$

will sharply vary even though the branch **3** is intact and the rod **76** will actuate the trigger **36**.

In order to remedy any ill-timed releasing of that kind a cylinder **9**, such as shown in Fig. 5, may be used. Piston **43** reciprocates in the cylinder **9** and piston **43** acts upon a spring **88** connecting the piston rod to the belt **64**. Therefore, when the pressure p abruptly decreases due to a breakage in the adjacent mains **83**, **84** or **85** the piston **43** will not transmit pressure action quickly because of the retarding effect of the throttling faucet **89**.

This retarding action takes place in the following manner:

The spring **88** connecting the rod of the piston **43** to the belt **64** allows the independent displacement of the piston **43** with relation to the piston **44** in such a way that the valve **89** acting so as to slow the variations of the position of the piston **43** delays the action upon the pulleys due to the pressure p in the conduit.

In this way the time constant of piston **43** is set approximately equal to the time constant of the flow into the branch **3** and the torque exerted by the belt **64** will constantly balance the torque exerted by the belt **57** on the shaft **67**. Therefore, an ill-timed releasing is avoided since on account of the inertia of the water the term q^2 cannot vary as fast as p. The time constant of piston **43** may be adjusted so as to be a little greater than that one of the flow into branch **3** without any inconvenience since the restoration of the mains to normal use generally takes place slowly.

In Fig. 2 there is shown another modification of the invention wherein the piston **43** actuated by the pressure p in the branch **3** is balanced by means of a coil spring **90**. Also the piston **44** actuated by the Pitot tube **11** is balanced by a coil spring **91**. The rod **63** of the piston **43** has attached thereto a rope **64'** that is wound on the pulley **65**.

The pulley **65** is fixed to the rotatably mounted shaft **67''**. At the right hand end of the shaft **67''** is fixed a bevel gear **93**. The piston rod **56** of piston **44** has attached thereto a rope **57'** that is wound upon the pulley **58** which in turn is also fixed to the shaft **67'**. At the left hand end of shaft **67'** as shown in Fig. 2 a bevel gear **92** is fixed. The respective shafts **67'** and **67''** are located in alignment with one another. A pair of bevel wheels **94** and **94'** rotatably mounted upon a supporting member **68'** mesh simultaneously with the bevel gears **92** and **93**.

A planet gear **95** is cut in the circumference of the support **68'** and meshing with such planet gear is a rack **69**. The other elements such as the rack, piston **8** and cylinder **7** involved in this modification are the same as previously described with reference to the construction shown in Fig. 1.

The operation of this modification is as follows. The gear assembly **92**, **93**, **94** and **95** constitute a differential. Therefore, the movement of rack **69** is proportional to the sum of the rotations of pulleys **58** and **65** and since these movements of rotation are proportional to the respective logarithms of p, on one hand, and of q^2, on the other hand, with the same proportional factor on both sides, the difference in such movements will be proportional to the logarithm of

$$\frac{p}{q^2}$$

From this it results that the position of the rack 68 is dependent upon the ratio

$$\frac{p}{q^2}$$

With the device described a release is assured every time that

$$\frac{p}{q^2}$$

decreases abruptly. On the other hand if the pressure in 3 drops quickly following a rupture in one of the mains 83, 84 or 85 the movement of the piston 43, which is operated in accordance with variation of the pressure existing at the junction point 1, this being aggravated by the slow variation of rate of flow due to inertia, would be instantaneous. The ratio

$$\frac{p}{q^2}$$

would thereby be diminished considerably, and the rod 76 would react with the trigger 36 and bring about a shutting of the valve 2.

The faucet 89, therefore, will allow adjusting the time constant of the piston 43 so that it will be equal to the time constant of the square of the flow into branch 3 or slightly larger.

In this way, an unexpected closure caused by ruptures in the mains, 83, 84 or 85, is avoided. Such ruptures bring about a rapid decrease in pressure at the junction point 1 and an ill-timed closing of the automatic protecting valves on uninjured mains.

Instead of a cylinder movable along its axis use may be made of another trigger operating mechanism.

Referring to Fig. 6 the junction point of two water mains of a distribution network is shown at 1. The automatic watergate 2 permits cutting off branch 3. The distributor 4 controls the valve of the watergate and the releasing elements are disclosed at 5, 6 and 36 as described heretofore. The cylinder 144 is submitted to the pressure existing in branch 3 upstream from the watergate 2.

The automatic watergate 2 comprises two pistons 15 and 16 which are interconnected by a rod 19. At the bottom portion the upper piston is provided with a valve 17 which when seated upon the seat 18, cuts the flow through the branch 3.

The distributor 4 which operates the watergate 2 comprises a hollow L-shaped slide valve 20. The full lines in Fig. 6 show the slide valve in its position when valve 17 is kept in open position. The dotted lines showing in Fig. 6, shown at 21, indicate the position the slide valve holds when closing the valve 2.

When the slide valve is in the full line position of Fig. 6 the upper cylinder 22 of the watergate 2 communicates through the pipe 23, the aperture 24, the aperture 25 and thence through the exhaust pipe 26 to the atmosphere.

The lower cylinder 29 of the watergate 2 communicates through pipe 30, aperture 31, chamber 28 and pipe 32, aperture 33 with junction point 1. As a result of such connections the valve member 17 is maintained away from its seat 18.

On the other hand, however, when the slide valve 20 is in the dotted line position 21 the lower cylinder 29 will communicate through pipe 30, aperture 31, aperture 25 and pipe 26 to the atmosphere while the upper cylinder 22 will communicate through pipe 23, aperture 24, chamber 28, the pipe 32 and aperture 33 at the junction point 1. When the slide valve 20 is in dotted line position the valve member 17 is forced to closing position and maintained closed.

The releasing system comprises a tooth 5, engaged by a trigger 36, having a hook 78. The tooth is provided on the control rod 37 which rod is urged towards the right in Fig. 6 by a spring 6 which has one end in contact with a disc 38 mounted upon rod 37 and the other end bearing against a fixed abutment 39. The control rod 37 passes a stuffing box 40 and is fixed to the slide valve 20.

When the handle 77 is urged so as to tighten the spring 6, the releasing mechanism may be reset with the hook 78 engaging the tooth 5.

The system for actuating the trigger 36 comprises a differential manometer 41 and a pressure accumulator 144 which functions selectively. The manometer 41 comprises two chambers 100 and 101 and the membrane 42 separates the two chambers and rests against a disc 47. The disc 47 is provided with a rod 48 which extends through the stuffing box 49 and is encircled by a return spring 52 which bears at one end upon a fixed abutment 53 and at the other end on a disc 59 fixed to the rod 48.

When the pressure acting upon the respective faces of the membrane 42 results in a movement from right to left as seen in Fig. 6 the force of the spring 52 has been overcome and the end 58 of the rod 48 contacts the trigger 36 and frees the releasing system. When the hook 78 is released the tooth 5 is free and the spring 6 moves the rod 37 toward the right as seen in Fig. 6 whereby the valve member 17 is moved to its seat 18.

The pressure accumulator cylinder 144 is provided with a piston 60 whose right hand face as seen in Fig. 6 is open to the atmosphere and a return spring 61 bears at one end against the right hand face of the piston 60 and at the other end against the fixed abutment 102. The cylinder 144 is connected by a pipe 86 to the branch 3.

Whenever the pressure in the branch 3 falls water passes through the pipe 86 from the cylinder 144 due to the action of the piston 60, which is urged by spring 61, and such action continues until a new balanced position has been reached.

On the other hand, when the pressure increases in the branch 3 the water will enter the cylinder 144 slowly due to the throttling action at 71 which is adjustable by means of the pin screw 13. The clack valve 62 is closed at such time. The clack valve 62 is closed by action of the spring 72 which is of suitable softness. By the above described design any ill-timed releasing of the trigger 36 is avoided, such as:

1. When a flow is initiated in the branch 3 since at such time the pressure rises.

2. Whenever there is a rupture in an adjacent branch the automatic watergate therein having operated, the pressure then rises rapidly at junction point 1.

By the action of the cylinder 144 the operation of the valve member 17 is selective in that it will prevent any closing of the valve when the water acceleration corresponds with a rise in pressure at 1.

Also, a rise in pressure in the branch **3** will permit the upstream chamber of the manometer **41** to have a lower pressure than that existing at inlet **34** because of the time lag caused by adjustable throttling **71**.

The manometer **41** is connected on one hand by the pipe **81** to the cylinder **144** and on the other hand to the branch **3** by the pipe **82** connected at **34** so that the distance separating the junctions **34** and **35** of the pipes **82** and **86** with the branch **3** is sufficient to secure a good sensitivity to acceleration of the releasing system.

The cylinder **144** may be replaced by a simple closed chamber **244**, such as shown in Fig. 7, containing air; in order to avoid dissolution of air and elimination thereof, this air may be confined in a rubber bladder **14** provided with a flat valve **19** such as used in bicycles or automobile tires extending outside of chamber **244**.

In accordance with another modification of this invention a plate **47** has been mounted at the end of a rod **48**, this rod **48** being provided with a small disc **54** on which acts a restoring spring **52** the other end of which lies on the support **53**. A rubber foil **42** separates a casing into two compartments **100** and **101**. A hollow rubber ball **14** is located in compartment **100** and might be refilled with air at will through the valve **19** protruding outwardly. At **62** is a clack-valve submitted to the action of spring **72**; this clack-valve is by-passed through an adjustable throttling device needle valve **27**. The pipe **86** transmits the pressure of the main **3** in the right hand side on chamber **100**. The pipe **96** transmits the pressure taken at the neck **97** of the Venturi pipe **98** to the left hand side chamber **101**. In this manner, if there is any sudden equal drop of pressure on **99** and **97** the ball **14** increases in volume and the clack-valve releases water into the main **3** and conversely if pressure increases but water is stopped by clack-valve **62** there is an opposite action, the plate **47** being urged to right. Therefore when the main **3** again comes in action, the effect of acceleration of water which would otherwise push the plate **47** to the left will be overwhelmed by the faster flow of water, into the left hand side compartment **101** due to compression of air in the ball **14**.

Oppositely if there is a rupture in main **3** beyond point **97** an important drop of pressure between **97** and **99** will take place which will not be compensated, this drop being mainly due at the beginning to acceleration of water in main **3** and magnified by a sufficient distance between points **97** and **99**. This acceleration being transient, the throttling effect at **97** prevails later if such transient acceleration should not move the rod **57**.

Rod **48** acts on a trigger such as **36** (Fig. 1) releasing a tooth like **5** which as before explained operates the closure of the main valve such as **2''**.

This last modification provides the use of a differential manometer that will govern the releasing of the machanism to bring about the closing of an automatic watergate when the water acceleration goes above a certain value. The differential manometer is connected to two spaced points of the branch to be protected so that the difference in pressure owing to acceleration alone being able to bring about releasing.

Conjointly, to the differential manometer there can be made use of a selective device consisting in means for preventing the release of the closing mechanism, when the pressure to the nearby extremity of the main stump is increasing, those

means being characterized notably by the use of a rubber chamber in communication with the upstream pressure intake canalization of the differential manometer, this piping being fitted with a valve and a throttle bypass that permit the liquid to get out easily from this capacity, but not to enter as easily.

Finally as the pressure drop created concomitantly to the water's acceleration, might have only a transitory existance, one can furthermore connect the downstream intake of the release differential manometer on the downstream intake of a pressure drop generator such as venturi, tuyère or diaphragm so as to increase the safety in apparatus functioning.

The following are examples of operation of the invention in different cases:

In mains **3** (Fig. 1) in the vicinity of the automatic valve **2**, the quotient of the pressure p by the square q^2 of the rate of flow q measures the resistance of the main to the flow. If flow varies through normal service conditions, variations in rate of flow are slow. On the contrary a break in a main is followed by a rapid variation of resistance of the main and the controls of the automatic valve **2** are set up in closing position **4**, through action of instrument **78**, **5**, **36**, the latter being driven in accordance with the time derivation of the quotient P'/q^2.

When several mains are connected together (Fig. 6), it is desirable that when one of the mains breaks all the respective automatic valves do not close at the same time but that the uninjured mains continue to work. On this principle systems have been designed for delaying the effect of pressure variations. If a rapid decrease of pressure occurs in main **3**, the rate of flow, by virtue of the water's inertia decreases slower than the pressure and the throttle **89** (Fig. 2) avoids a rapid flow of water from chamber **9** to main **3** and prevents the closing of the automatic valves.

If one water main is fed by a reservoir in which the level of water is at 60 meters altitude and a break occurs on the main, at 10 meters altitude and the main length between break and reservoir is 5,000 meters; then at the spot of the break, pressure in the water main falls off to substantially zero. Water in the main is at once submitted to an acceleration which balances the pressure forces. Pressure drops in the upstream part of the main will be one centimeter water column per meter.

If the length of the main included between the two connection points **33** and **34** (Fig. 6) is 25 meters, a pressure drop of 25 centimeters water-column then surges on instrument **41**; a pressure drop of such importance is largely sufficient for setting automatic valve control in closing operation.

If after main **3** has been closed, it is again set to normal service conditions; flow in main **3** might increase too swiftly and the closing mechanism might enter in action.

This could happen also after a break occurs. Waterflow decreases in mains which are connected with the broken one, but as soon as the broken main is closed water rate of flow increases in the others. In order to prevent the closing mechanism **4**, **5**, **36** to enter in action, a chamber **144** slows down the pressure increase on the upstream side of the piston **47** and has an inhibitive action on the mechanism **4**, **5**, **36**.

Fig. 7 illustrates another example of a chamber which also will have such an inhibitive effect.

Fig. 8 illustrates an installation comprising a chamber analogous to chamber 244 of Fig. 7 and a pressure drop generation system such as a Venturi pipe. This design combines additively the drop of pressure effects both of the acceleration and of the rate of flow.

It is advantageous with respect to Fig. 8 operating in such a manner that the distance between the point in the neighborhood of the connecting junction constructed upon the conduit 3 and the point located at the neck of the venturi should be at least equal to 5 times the diameter of the conduit and preferably equal to 20 times such diameter.

What is claimed is:

1. In a valve located upon a liquid conduit, a water tight element whose application against an orifice and its recess assures respectively the opening and the closing of said valve, motor means for closing said water tight element, control means for said motor means, a chamber, a flexible membrane dividing said chamber into a first and a second compartment, a first pipe, one of the ends of said first pipe being tapped to a first point of said liquid conduit upstream while the other end is tapped to said first compartment of said chamber, a second pipe, one of the ends of said second pipe being tapped to the second compartment of said chamber and the other end being tapped to a second point of said conduit sufficiently spaced down stream from said first point in order to cause suddenly a difference in pressure between the two tapped points upon said conduit as a function of the second time derivative of the liquid volume which traverses a local cross-sectional area of said conduit, said difference in pressure tending to bring about a deformation of said flexible membrane, means for opposing the deformation of said flexible membrane when said second time derivative does not exceed a predetermined value and for deforming said membrane when said predetermined value is exceeded, means operated by the displacement of said membrane to bring about the action of said control means, said motor means and said water tight element to close said valve when said flexible membrane is deformed simultaneously with a rupture in said conduit and means for preventing the closing action of said valve when the pressure in said conduit increases.

2. In a valve located upon a liquid conduit, a water tight element whose application against an orifice and its recess assures respectively the opening and the closing of said valve, motor means for closing said water tight element, control means for said motor means, a chamber, a flexible membrane dividing said chamber into a first and a second compartment, a movable plate bearing against said flexible membrane, a first pipe, one of the ends of said first pipe being tapped to a first point of said liquid conduit upstream while the other end is tapped to said first compartment of said chamber, a second pipe, one of the ends of said second pipe being tapped to the second compartment of said chamber and the other end being tapped to a second point of said conduit sufficiently spaced down stream from said first point in order to cause suddenly a difference in pressure between the two tapped points upon said conduit as a function of the second time derivative of the liquid volume which traverses a local cross-sectional area of said conduit, said difference in pressure tending to bring about a deformation of said flexible membrane, a spring

cooperating with said plate for opposing the deformation of said flexible membrane when said second time derivative does not exceed a predetermined value and for deforming said membrane when said predetermined value is exceeded, means operated by the displacement of said membrane to bring about the action of said control means, said motor means and said water tight element to close said valve when said flexible membrane is deformed simultaneously with a rupture in said conduit and means for preventing the closing action of said valve when the pressure in said conduit increases.

3. In a valve located upon a liquid conduit, a water tight element whose application against an orifice and its recess assures respectively the opening and the closing of said valve, motor means for closing said water tight element, control means for said motor means, a chamber, a flexible membrane dividing said chamber into a first and a second compartment, a movable plate bearing against said flexible membrane, a first pipe, one of the ends of said first pipe being tapped to a first point of said liquid conduit upstream while the other end is tapped to said first compartment of said chamber, a second pipe, one of the ends of said second pipe being tapped to the second compartment of said chamber and the other end being tapped to a second point of said conduit sufficiently spaced down stream from said first point in order to cause suddenly a difference in pressure between the two tapped points upon said conduit as a function of the second time derivative of the liquid volume which traverses a local cross-sectional area of said conduit, said difference in pressure tending to bring about a deformation of said flexible membrane, a spring cooperating with said plate for opposing the deformation of said flexible membrane when said second time derivative does not exceed a predetermined value and for deforming said membrane when said predetermined value is exceeded, means operated by the displacement of said membrane to bring about the action of said control means, said motor means and said water tight element to close said valve when said flexible membrane is deformed simultaneously with a rupture in said conduit, means for preventing the closing action of said valve when the pressure in said conduit increases, a trigger normally locking said control means of said motor means and a rod having one of its ends connected to said plate and the other end cooperating with said trigger to release said control means when said flexible membrane is deformed to bring about the action of said control means simultaneously with a rupture in said conduit.

4. In a valve located upon a liquid conduit, a water tight element whose application against an orifice and its recess assures respectively the opening and the closing of said valve, motor means for closing said water tight element, control means for said motor means, a chamber, a flexible membrane dividing said chamber into a first and a second compartment, a first pipe, one of the ends of said first pipe being tapped to a first point of said liquid conduit upstream while the other end is tapped to said first compartment of said chamber, a second pipe, one of the ends of said second pipe being tapped to the second compartment of said chamber and the other end being tapped to a second point of said conduit sufficiently spaced down stream from said first point in order to cause

suddenly a difference in pressure between the two tapped points upon said conduit as a function of the second time derivative of the liquid volume which traverses a local cross-sectional area of said conduit, said difference in pressure tending to bring about a deformation of said flexible membrance, means for opposing the deformation of said flexible membrane when said second time derivative does not exceed a predetermined value and for deforming said membrane when said predetermined value is exceeded, means operated by the displacement of said membrane to bring about the action of said control means, said motor means and said water tight element to close said valve when said flexible membrane is deformed simultaneously with a rupture in said conduit, means for retarding the increase of pressure in said first compartment, said means comprising a retarding chamber having a volume variable with the pressure of the liquid in said first pipe, two branches connecting said last named chamber to said conduit, a neck provided in one of said branches, a valve provided in the other branch to retard the transmission of the pressure from the sampling point upstream to said first compartment of said first named chamber to prevent the deformation of said flexible membrane and its closing action when the pressure in said conduit increases.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,309,808	Pfau	July 15, 1919
1,514,839	Edwards	Nov. 11, 1924
2,072,314	Rhodes	Mar. 2, 1937
2,081,542	Kidney	May 25, 1937
2,137,874	Goldberg	Nov. 22, 1938
2,302,370	Hedene	Nov. 17, 1942
2,381,447	Hedene	Aug. 7, 1945