July 8, 1952 G. W. ALLEN ET AL 2,602,468

FLOW RESTRICTOR

Filed May 4, 1946 2 SHEETS—SHEET 1

Fig. 1.

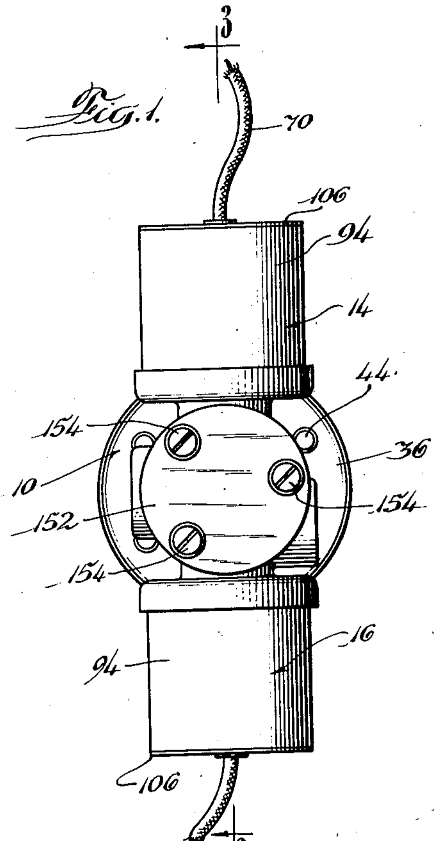


Fig. 2.

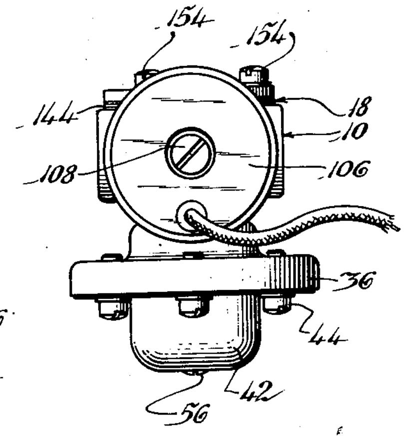


Fig. 4.

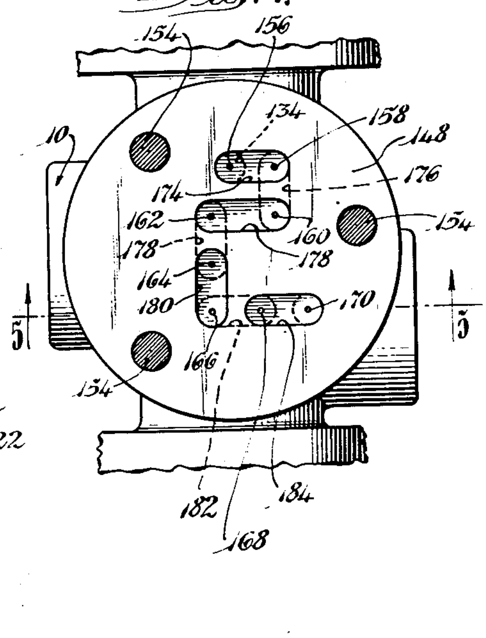
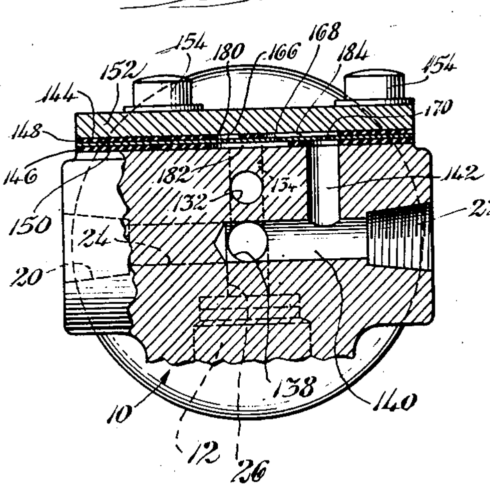


Fig. 5.



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Filed May 4, 1946 2 SHEETS—SHEET 2

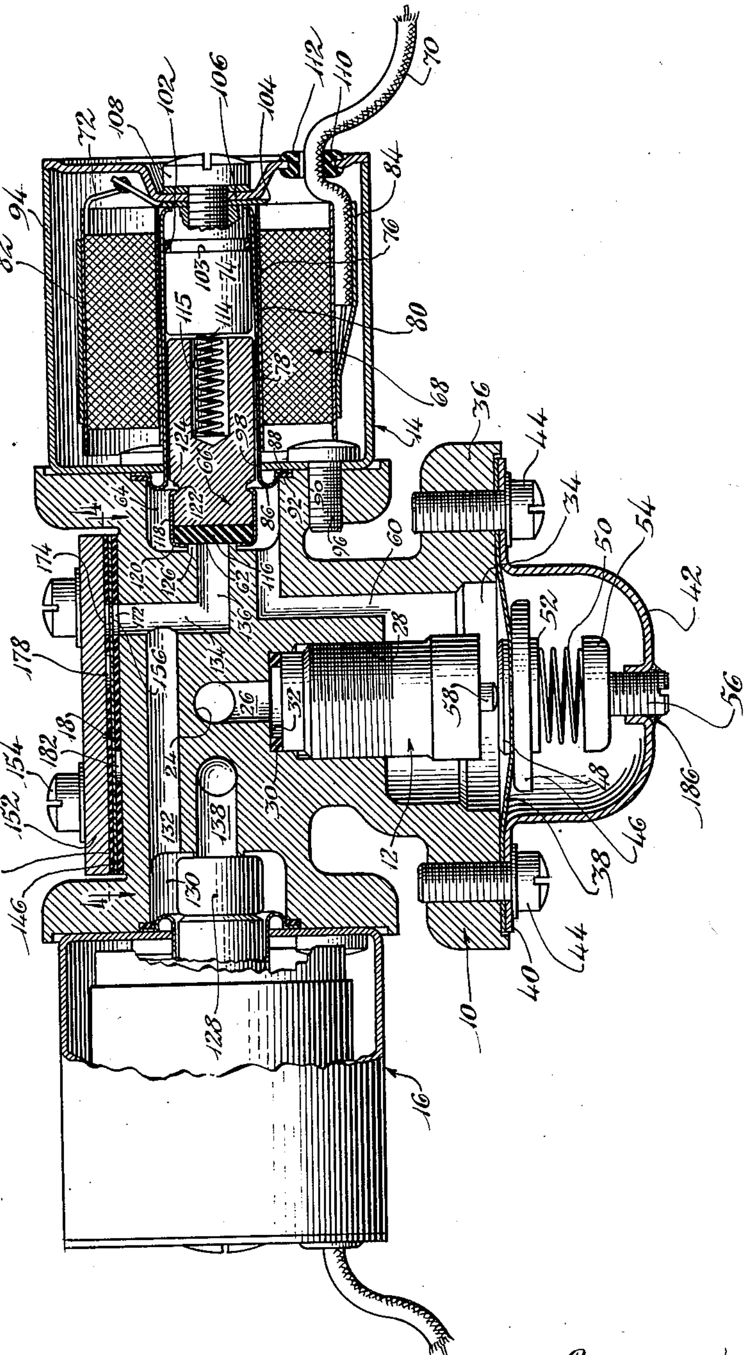

Fig. 3.

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UNITED STATES PATENT OFFICE

2,602,468

FLOW RESTRICTOR

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3 Claims. (Cl. 138—42)

1

The present invention relates to a control valve and in particular to a control valve for use in a fuel control system for combustion heaters. A typical system of this type is described in the copending application of Vernon N. Tramontini, Serial No. 633,733, filed December 8, 1945, for an invention entitled "Heater Controls," now Patent No. 2,481,630.

The principal object of the present invention is to provide a novel control valve having a plurality of valve elements therein, operable in response to temperature conditions in the heating system including an internal combustion type heater to obtain high heat, low heat, and no heat output.

Another object is to provide a novel unitary control valve which will supply fuel to an internal combustion heater at a rate designed to give the desired optimum heat output from the heater, in response to conditions existing in the heater and heating system.

Another object is to provide a novel control valve in a single unit which will supply liquid fuel to a heater of the internal combustion type at a predetermined pressure regardless of the pressure at the inlet to the control valve.

Another object is to provide a new and improved control valve which incorporates one or more electromagnetically operated valve members.

A further object is to provide a novel control valve incorporating a unique means for reducing pressure and restricting fuel flow without stopping the flow completely.

Still another object is to provide a new and improved control valve having the aforementioned advantages and which is comparatively simple in construction, rugged, and easily adjusted.

Other objects and advantages will become apparent from the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a top plan view of the novel control valve forming the subject matter of the present invention;

Fig. 2 is an end elevational view of the control valve;

Fig. 3 is a sectional view on an enlarged scale taken substantially along the lines 3—3 of Fig. 1 but showing some of the elements in elevation;

Fig. 4 is a cross sectional view taken substantially along the lines 4—4 of Fig. 3; and

Fig. 5 is a cross sectional view taken substantially along the lines 5—5 of Fig. 4.

The novel control valve of the present invention comprises a main casting 10 forming a valve body which mounts or houses an automatic pressure regulator 12, an on-off solenoid operated valve 14, a second on-off solenoid valve 16, and a flow-restricting means 18. The valve body 10 should be aluminum or some other non-magnetic metal and is formed with an inlet 20 and an outlet 22, both of which may be provided with standard pipe threads for connection into the fuel supply system of an internal combustion heater. The on-off valves 14 and 16 and the flow-restricting, pressure reducing means 18 are positioned in the passageway, hereinafter described, connecting the inlet 20 and the outlet 22. The inlet 20 is adapted to be connected to a fuel pump or other suitable source for supplying fuel under pressure, while the outlet 22 may be connected directly to the inlet to an internal combustion heater.

2

The inlet 20 is connected to passageway 24 formed in approximately the center of the valve body 10, passageway 24 leading to a cross passageway 26 at right angles thereto. Passageway 26 is connected to an enlarged cylindrical threaded bore 28 into which the automatic pressure regulator 12 of well known construction is threaded. Leakage past the pressure regulator 12 is prevented by a sealing gasket 30 which is held against a shoulder 32 at the upper end of the bore 28 by the upper end of the pressure regulator 12. The outlet of the pressure regulator 12 opens into an enlarged cylindrical chamber 34 formed in a depending portion 36 of the valve body.

The chamber 34 is closed by a flexible diaphragm 38 which is held at its outer edge between a circumferential flange 40 formed on a dome-like housing 42 and the depending portion 36. The flange 40 and diaphragm 38 are secured to the casting 10 by suitable machine screws 44, and the diaphragm 38 thus forms a fluid and pressure tight seal for the chamber 34 against the atmosphere.

At its center, the diaphragm 38 is retained between a large cup-like washer 46 and the head of a rivet 48. The washer 46 has a rounded peripheral edge lying against the diaphragm 38 to prevent cutting the diaphragm when it is flexed upwardly, as seen in Fig. 3. The diaphragm 38 is urged upwardly against the pressure in the chamber 34 by a spring 50 which is held between a pair of cups 52 and 54, the cup 52 being a part of the washer and the rivet structure and the cup 54 being fixedly mounted on the end of an adjustment screw 56 which is threaded into the dome of the housing 42.

The head of the rivet 48 bears against the lower end of a valve stem 58 of the automatic pressure regulator 12; when the pressure in the chamber 34 drops below a predetermined desired value, the spring 50 flexes the center of the diaphragm and moves the valve stem 58 upwardly thereby further opening the valve in the automatic pressure regulator 12 to increase the fuel flow and the pressure in the chamber 34.

A passageway 60 leads away from the chamber 34 toward the solenoid controlled valve 14, which controls the flow of liquid fuel through valve port 62. The valve port 62 and the passageway 60 communicate with a valve chamber 64 in which reciprocates a valve body 66 formed as a movable iron core armature of the solenoid.

The solenoid comprises winding 68 having a conductor 70 and a ground terminal 72, the movable armature 66, and a fixed iron core 74. The solenoid winding is wound around an insulating sleeve 76. The sleeve 76 has a friction-fit engagement with a second sleeve 78 formed of a non-magnetic metal such as brass which is tapered at 80 to insure proper centering relative to the iron core 74 and so that the sleeve 76 is easily started during assembly. The solenoid winding 68 is covered with a wrapping 82 of an impregnated insulating material and is covered by a second sheet of a similar material 84, which is wrapped around the conductor 70 to insulate it from contact with the metal parts of the control valve.

The sleeve 78 is rolled back at 86 and is provided with a flange 88 which is positioned in a recess 90 in the casting 10 and which with a gasket 92 forms a pressure and fluid tight seal for the valve chamber 64 against the atmosphere. The flange 88 and the gasket 92 are retained in the recess 90 by the bottom wall of a housing 94 made of iron or some similar magnetic flux conducting material. The housing 94 is secured to the casting valve body 10 by suitable bolts 96 and has an opening 98 to accommodate the sleeve 78. At its opposite end, the sleeve 78 is rolled inwardly at 100 against the outer end of the fixed iron core 74 so that the core fixes the end of the sleeve, as will appear presently. As the inside of the sleeve 78 is open to the valve chamber 64, it is insulated against pressure and fluid leakage by a gasket 102 secured in a circumferential groove 103 in the iron core 74. The solenoid winding 68 is positioned in the housing 94 and is connected at one end to a terminal washer 104 secured between the end of the sleeve 78 and a housing cover 106 by means of a machine screw 108 threaded into the iron core 74. The circuit through the solenoid winding may be traced through the conductor 70, solenoid winding 68, terminal lead 72, washer 104, and to ground. The cover 106 for the housing is provided with an opening 110 for the conductor 70 in which is secured a synthetic rubber grommet 112.

The valve armature 66 reciprocates within the sleeve 78 and is biased toward closed position by a coil spring 114 which is confined in a recess 115 in the armature 66 and against the inner face of the iron core 74. At its opposite end the valve armature 66 is provided with a seating pad 116 of soft synthetic rubber which is secured thereto by a metal ring 118 which has a retaining lip 120 pressed against the face of the synthetic rubber pad 116. The opposite edge 122 of the ring 118 is rolled into a groove 124 in the armature 66.

When in closed position, the synthetic rubber pad 116 seats against a circumferential valve face 126 surrounding the port 62 and seals the port 62 against communication with the chamber 64. When the solenoid is energized by its controlling circuit, a magnetic field is set up which bridges the air gap between the movable armature 66 and the iron core 74 thereby moving the armature 66 to the right to open the port 62 to establish communication between the chamber 64, passageway 60, and chamber 34 on the one hand and passageway 136 leading from port 62 on the other hand. The magnetic circuit is set up through the housing 94, housing cover 106, iron core 74, and movable armature 66, and the field so set up closes the air gap existing between the core 74 and the armature 66 to open the on-off valve 14. Thus the magnetic field has a substantially closed path through materials of high permeability. It is to be noted that the armature 66 slides freely in the sleeve 78, and that this sleeve is ordinarily filled with liquid fuel since it is in constant communication with the chamber 64, but leakage of the fuel from the sleeve 78 is prevented by the gasket 102.

Solenoid valve 16 has a construction identical with that of solenoid valve 14 and, consequently, need not be described in detail. It includes a movable armature 128 which reciprocates in a chamber 130. The chamber 130 is connected to the port 62 through passageways 132, 134, and 136, which are drilled or cored in the casting 10 (Fig. 3) and communicates with the outlet 22 through passageways 138 and 140 (Fig. 5).

When the solenoid valve 16 is closed and the solenoid valve 14 is open, fuel is fed to the outlet 22 through the flow of restricting means 18 which has its inlet connected to the passageway 134 and which is connected to the passageway 140 through a cross passageway 142. The flow restricting means 18 is formed generally by placing a plurality of very tiny orifices in series in a passageway which connects the passageway 134 with the passageway 142. The orifices are formed in a thin sheet metal plate 144 which is retained between a pair of gaskets 146 and 148. The gasket 146 is placed against a smooth, machined surface 150 on the valve body 10 and the upper surface of gasket 148 is engaged by the under surface of a circular retaining plate 152. The assembly of the orificed plate 144, gaskets 146 and 148, and plate 152 is mounted in sandwich form on the valve body 10 by machine screws 154.

The arrangement of the orifices in the plate 144 is most clearly shown in Fig. 4. The fuel flows through the orifices in the following order: 156, 158, 160, 162, 164, 166, 168, and 170. Orifice 156 is in communication with passageway 134 through a circular opening 172 in the gasket 146 (Fig. 3). Orifice 156 is in communication with orifice 158 through a slot 174 formed in gasket 148. In turn, orifice 158 communicates with orifice 160 through a similar opening 176 formed in gasket 146. A similarly shaped opening 178 is formed in gasket 148 to connect the orifice 160 with orifice 162 which, in turn, communicates with orifice 164 by means of a slot 178 formed in gasket 146. Slot 180, formed in gasket 148, connects orifice 164 with orifice 166, which is placed in communication with orifice 168 through an opening 182 in gasket 146, and orifice 168 communicates with outlet orifice 170 through an opening 184 formed in the gasket 148. The slots which have been described as being formed in the gaskets 146 and 148 form these passageways connecting adjacent orifices in the plate 144 by being confined between the casting 10 and the orificed plate 144, and between plate 144 and the retaining plate 152, respectively. This construction is clearly shown in Figs. 3 and 5. When the shut-off valve 14 is open and the valve 16 is closed, the fuel will be metered through these minute orifices which are arranged in series between the passage 134 and the passageway 142 leading to the outlet.

From the foregoing description, it will be seen that this control valve is relatively simple in construction and is pressure and fluid leakproof. It is likewise relatively easy to assemble as each of the elements of the automatic pressure regulator 12, the solenoid control valves 14 and 16, and the flow restricting means 18, are separately and individually mounted on the casting 10 on an outwardly facing surface.

In assembling the control valve, the automatic pressure regulator 12 is screwed into the threaded opening 28 after the gasket 30 has been placed against the shoulder 32. The diaphragm 38 is placed over the end of the automatic pressure regulator so that the rivet 48 engages the valve stem 58. The coil spring 50 is confined between the cups 52 and 54 as the dome-like housing 42 is mounted on the casting 10 by the machine screws 44. If, for example, it is desired that the pressure of the fuel in the chamber 34 be 1 p. s. i. gauge, the action of the diaphragm is adjusted to drop the pressure at the inlet 20 which may be 3 or 4 p. s. i. gauge, to 1 p. s. i. in the chamber 34. In order accurately to obtain this regulation, the compression on the spring 50 is carefully adjusted by means of the screw 56. When this adjustment has been made, the screw may be secured in position by placing a ring of solder 186 around the screw 56 where it contacts the dome-like housing 42.

The flow restricting means 18 may then be mounted on the casting 10. Gasket 146 is placed against the machined surface 150 on the casting 10. Orificed plate 144 and gasket 148 are, in turn, laid on the top of gasket 146, and then the retaining plate 152 is put in position, the whole being secured to the casting 10 by means of the machine screws 154. The gaskets are compressed slightly so as to provide a pressure and fluid tight seal in the passageways formed by the retaining plate 152, gaskets 146 and 148, plate 144, and casting 10. Care must be taken to insure the proper sequential relationship between the orifices formed in the plate 144 and the slots formed in each of the gaskets 146 and 148. In order that this might be facilitated, the mounting holes in the plate 144, gaskets 146 and 148, plate 152 and casting 10 are offset relative to a symmetrical or equi-angular spacing so that they may assume only one position relative to each other with the mounting holes coinciding.

The solenoid control valves 14 and 16 may then be readily assembled on the casting 10. The sub-assembly of the sleeve 78, iron core 74, and armature 66 is assembled before mounting the casting 10. This sub-assembly is mounted with the flange 88 in the recess 90 in such position as to hold the gasket 92 against its seat and to position the rolled edge 86 slightly within the valve chamber 64. The housing 94 is then slipped over the sleeve 78 and against the flange 88 to hold the sleeve 78 and associated parts in place, and the machine screws 96 are threaded into their

respective holes to secure the sleeve and movable elements of the valve to the casting 10. The solenoid winding 68, which has previously been wound on the sleeve 76, may then be slid onto the sleeve 78 with which the sleeve 76 is in friction engagement. The solenoid winding carries the washer 104 which is held securely against the housing cover 106 by the screw 108. The other solenoid controlled valve 16 is assembled in a similar manner.

The control valve forming the subject matter of this invention is particularly well adapted for supplying liquid fuel to an internal combustion heater at the rate required to maintain the output of the heater sufficient to maintain the temperature of the space being heated at a desired and controllable level. For example, in starting the heater, it might be required that it deliver a maximum output of 20,000 B. t. u. per hour. The control valve, which has been described, and with the pressure examples which have been given in the description, which are at between 3 and 4 p. s. i. gauge pressure at the inlet 20 and 1 p. s. i. gauge pressure in the chamber 34, will be in fully open position. In this position, the solenoid controlled valves 14 and 16 are both open, that is, the solenoids are energized so as to move the valve armatures 66 and 128 to the right and to the left, respectively (Fig. 3). When the space to be heated has warmed to a predetermined temperature, and it is desired merely to maintain that temperature, the solenoid controlled valve 16 will be de-energized and the spring biased armature valve body 128 will move to the right, shutting off the flow of fuel between the valve chamber 130 and the passageway 138. This shuts off the flow of fuel from the chamber 64 through the chamber 130 to the outlet 22 via the passageways 134, 132, and 138.

However, the chamber 64 is in communication with the passageway 134 through the open port 62, and the passageway 134 is in communication with the outlet 22 and passageway 142 leading thereto through the flow restricting means 18 which comprises the tortuous passageway formed by the casting 10, gasket 146, plate 144, gasket 148, and retaining plate 152. This tortuous passageway is provided with the plurality of interconnected orifices 156, 158, 160, 162, 164, 168, and 170, which reduce the flow rate so that the heater output will be approximately 5,000 B. t. u. per hour. If the temperature of the space to be heated then drops below a satisfactory level, the valve 16 is reopened to establish high heat operation.

If the temperature in the space to be heated still rises above the desired maximum, or if the heater tends to overheat, even though valve 16 is closed, it may be desirable to interrupt heater operation, in which case the solenoid valve 14 closes through the deenergization of its circuit.

When the fuel feeding system to the heater is in operation, the chamber 34, the valve chambers 64 and 130, and all of the passageways in the valve body 10 will be completely filled with fuel. Thus there will be no air pockets present and the flow of fuel from the outlet 22 will be instantaneous upon opening the valve, and at a rate determined by the positions of the solenoid valves 14 and 16.

The examples for thermal output of the heating system and the fuel pressures which have been given in the foregoing description of this invention are merely illustrative, and it is to be understood that they may vary according to the particular installation. Should the required pressure drop between the chamber 34 and the outlet 22 through the restricting means 18 be greater than that which can be obtained with the number of orifices illustrated herein, more orifices may be used in the series. Conversely, fewer or larger orifices may be used when less restricting effect is desired.

While there has been described but a single embodiment of the invention, it is appreciated that changes and modifications may be made therein without departing from the sphere and scope of the invention, therefore, what is desired to be claimed as new and secured by United States Letters Patent is:

1. A liquid flow restrictor comprising a thin plate having a plurality of tiny orifices formed therethrough from face to face, said orifices being of such size and number that the pressure drop through a series connection of said orifices produces the desired restricting effect, and passage forming means having substantially no restricting effect disposed on both sides of said plate for connecting said orifices in series so as to cause liquid to flow alternately from one side of said plate to the other by way of said orifices.

2. A liquid flow restrictor comprising a body portion having a flat face, said body portion being formed to provide liquid inlet and outlet connections and passages leading from said connections respectively to liquid inlet and outlet ports formed in said flat face, a cover having a flat surface adapted to cover said ports, means for securing said cover to said body portion, a thin flat plate disposed between said body portion and said cover, said plate having a plurality of small orifices formed therethrough from face to face, a body gasket disposed between said body and said plate, a cover gasket disposed between said cover and said plate, said body gasket having a plurality of apertures formed therein which form individual spaces when said body gasket is confined between said body and said plate, one of said spaces intersecting said inlet port and another of said spaces intersecting said outlet port, said cover gasket having a plurality of apertures formed therein which form individual spaces when said cover gasket is confined between said cover and said plate with the apertures in said cover gasket disposed so as to intersect and interconnect the apertures in said body gasket, the orifices in said plate being located with one at each of said intersections so that the liquid is required to flow back and forth between the two faces of said plate by way of said orifices as the liquid passes from said inlet port to said outlet port, and said orifices being

so small as compared with said spaces that substantially all of the restricting effect on said liquid is due to the series arrangement of said small orifices.

3. A liquid flow restrictor comprising a pair of members having flat faces, a thin plate clamped between said faces, said plate having a plurality of small orifices therethrough from face to face, a pair of gaskets disposed with one between said plate and one of said members and the other between said plate and the other of said members, one of said gaskets having a plurality of apertures therein with each of said apertures overlapping separate pairs of said orifices so that said orifices are connected into individual sets of two each by the passages formed by said apertures when said one gasket is confined between said plate and its member, the other of said gaskets having a plurality of apertures therein with each of the last said apertures overlapping other separate pairs of said orifices so that said orifices are connected into individual sets of two each by the passages formed by the apertures in said other gasket when said other gasket is confined between said plate and its member such that said orifices are connected in series by the passages formed on alternate sides of said plate, means for establishing liquid inlet and outlet connections at opposite ends of said series, and said orifices being so small as compared with said passages that substantially all of the restricting effect on said liquid is due to said orifices in series.

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