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TEMPERATURE-RESPONSIVE THROTTLING VALVE

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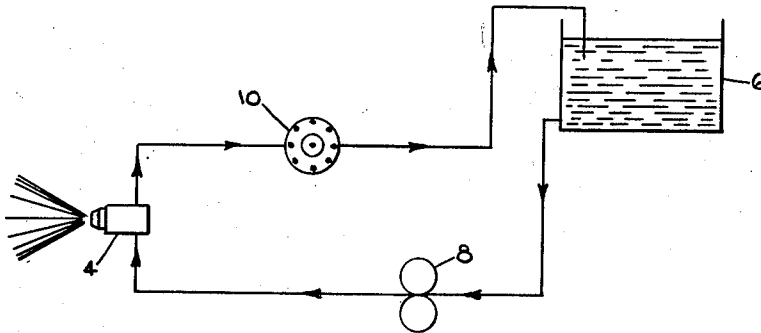


Fig. 1.

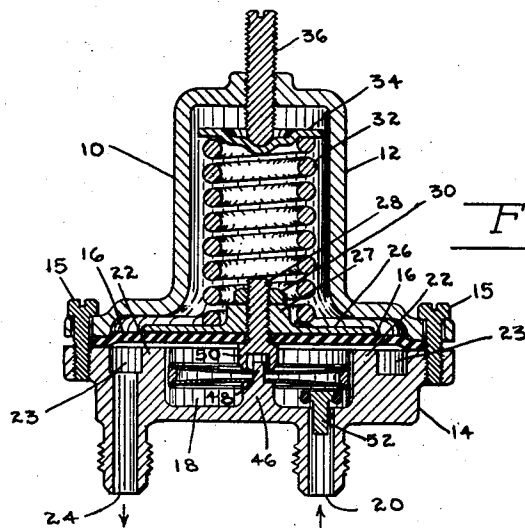


Fig. 2.

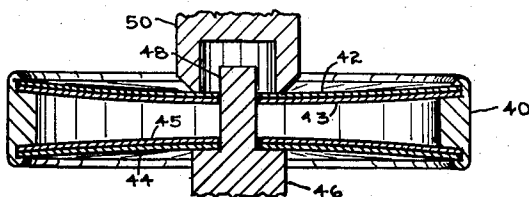


Fig. 3.

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TEMPERATURE-RESPONSIVE THROTTLING VALVE

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6 Claims. (Cl. 236—92)

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This invention relates to a temperature-responsive throttling valve which is particularly, but not exclusively, useful in connection with liquid fuel control systems employing mechanical atomizers or spray nozzles of the return-flow type, for example, a liquid fuel control system designed to supply a liquid fuel such as fuel oil, gasoline, kerosene, alcohol, etc. at a low rate, for example, at the rate of $\frac{1}{4}$ to 2 gallons per hour which is sufficient for heating purposes in most house-heating and certain other systems. The term "fuel oil" as hereinafter used is intended to include any liquid fuel.

This application is a division of our co-pending application Ser. No. 70,773, filed January 13, 1949.

Mechanical atomizers or spray nozzles of the return-flow type are characterized by a central whirling chamber to which the fuel-oil is supplied, at substantially constant pressure, through tangential passages, thereby imparting whirling motion to the oil in said chamber some of which is discharged in a spray through a small orifice and some of which leaves the whirling chamber through an orifice or orifices communicating with a pipe through which the oil returns to the supply source. The quantity of fuel-oil emitted from an atomizer of that type in the form of a spray may be controlled by regulating the flow of oil through the return pipe by providing therein a valve which is manually or otherwise operated. These return-flow type atomizers are particularly useful at low-fuel-oil delivery rates, because their larger total fuel-oil flow requires greater internal dimensions and gives a cooling and scouring action, all of which greatly reduces the tendency to plug-up with dirt or fuel-oil residue.

So long as the temperature of the fuel-oil in the atomizer remains substantially constant, the viscosity of the oil in the atomizer is substantially constant, and the quantity of oil supplied from the atomizer in the form of a spray for combustion purposes will not vary substantially if the pressure in the return pipe is held constant. However, in many heating systems of the type mentioned, the temperature and viscosity of the fuel-oil in the nozzle will vary considerably during the operation of the heating unit. Such variations may be due to variations in the temperature of the fuel-oil in the supply tank, particularly when the tank is located out-of-doors; but, in many cases, the variations in the temperature and viscosity of the fuel-oil in the nozzle are largely due to variations in

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the temperature of the nozzle itself due to the fact that it is alternately heated up and cooled off. Such variations in the temperature and viscosity of the fuel-oil in the atomizing nozzle may cause considerable variation in the quantity of oil supplied by the atomizer as a spray for combustion purposes. It is incorrect, however, to assume that the quantity of fuel-oil emitted by an atomizer of the type mentioned is greater when the oil in the atomizer has a high temperature and low viscosity, than when it has a low temperature and high viscosity. In fact, the contrary is true; and it is our belief that this is due to the fact that, when the temperature of the oil in the atomizer is high and its viscosity is low, more rapid whirling of the oil within the atomizer and decreased resistance in the return passage, which is larger than the spray orifice, result in a decrease of the total amount of oil which flows out of the spray orifice.

The principal object of the present invention is to provide a temperature-responsive throttling valve, adapted for use in the return pipe from an atomizer of the return-flow type, to so control the flow of fuel oil through the return pipe that the quantity of oil emitted as a spray by the atomizer, under variations of the temperature and viscosity of the oil in the nozzle, will be substantially constant.

Another object of the invention is to provide a throttling valve which will prevent "bleeding" of the oil from the return pipe back into the atomizer and out of the spray opening therein, when the system is shut down by cutting off the supply of oil to the atomizer. These objects are attained by the novel throttling valve hereinafter described, which automatically responds to variations in the temperature of the oil passing through said device, and exerts on the oil flowing therethrough a throttling effect which is greater at high temperatures of the oil than at low temperatures thereof and which, upon shutting off the oil supply, prevents any back flow of fuel to the atomizer.

The invention will be understood from the following description taken in connection with the accompanying drawing in which Fig. 1 is a diagrammatic representation of a fuel-oil control system in which the novel throttling valve of the invention may be employed; Fig. 2 is a sectional elevation of the novel throttling valve; and Fig. 3 is a sectional elevation, on an enlarged scale, showing the construction of the temperature responsive element of the throttling valve.

Referring to Fig. 1 of the drawing, a mechanical fuel-oil atomizer 4 of the return-flow type is shown as supplied with fuel-oil from an oil tank 6 at a substantially constant pressure by an oil pump 8; and the return-flow outlet of the atomizer 4 is connected through a throttling valve 10 (illustrated in Fig. 2 and hereinafter described) to the oil tank 6. As will hereafter appear, the throttling valve 10, through which flows the oil returning from the atomizer 4, is characterized by the fact that it contains an element responding to the temperature of the oil and functioning to increase and decrease the throttling effect of the valve on the oil flowing through it, with the rise and fall of the temperature of the oil. That is, after the throttling valve 10 has been set so as to exert a throttling effect on the returning oil such that the atomizer will spray fuel-oil at a desired rate, the throttling valve 10 will continue to function, in response to varying temperatures of the oil, so that the throttling effect of the valve will maintain substantially constant the quantity of oil sprayed by the atomizer.

Referring now to Fig. 2, in which the construction of the novel throttling valve 10 is illustrated, it will be evident that it has a casing consisting of the upper part 12 and the lower part 14 which parts have cooperating flanges which are bolted together by the bolts 15. A flexible circular diaphragm 16, of neoprene or any other suitable material, the edge of which is clamped between the flanges of the casing parts 12 and 14, is thus mounted within the casing and serves as a movable valve member. The lower casing part 14 is provided with a chamber 18 having a fuel-oil inlet opening 20 and surrounded by a circular lip 22 which cooperates with the diaphragm 16 and serves as a valve seat. The casing part 14 is also provided with a circular trough 23 located outside of and concentric with said lip 22 and this trough is provided with an oil outlet opening 24. Cooperating with the diaphragm 16 is a backing member consisting of a circular plate 26 having a hub 27 provided with a central hole through which is threaded a bolt 28 having a nut 30 cooperating therewith and with the hub 27 of the plate 26. It will be obvious from the drawing that the plate 26 forming part of the backing member cooperates with the upper side of the diaphragm 16 and that said plate 26 extends outwardly to the vicinity of the lip 22 and preferably to approximately the outer edge of said lip. Thus the plate 26 confines the upward flexing of the diaphragm 16 to that portion of the latter which is between the outer edge of the plate 26 and the casing flanges between which the edge of the diaphragm 16 is clamped. In Fig. 2, the space shown between the diaphragm 16 and the lip 22, and the flexing of the diaphragm 16 are both exaggerated, in order to aid in understanding that in the functioning of the throttling valve the oil flows from the chamber 18 over the lip 22 into the trough 23. Since diaphragm 16 is fastened to plate 26 only at the center, nothing holds the diaphragm off its seat 22 except the pressure of the oil flowing between the seat and the adjacent portion of the diaphragm, and when there is no pressure or the slightest negative pressure the diaphragm immediately seals against its seat. Since there is only a thin film of oil separating them, practically no oil is displaced when such sealing occurs.

Located within the upper casing section 12 is a coiled spring 32 which at its lower end coop-

erates with the plate 26 of the backing member and at its upper end with a disc 34 engaged by a screw 36 threaded through a hole in the top of the casing member 12. It will be understood that the screw 36 may be adjusted to vary the pressure exerted by the spring 32 upon the backing member which cooperates with the diaphragm 16.

Located within the chamber 18 in the lower casing member 14, is a temperature responsive means which is illustrated on an enlarged scale in Fig. 3. This temperature responsive means consists of two bi-metal discs spaced apart and secured to one another at their edges by a ring 40. As is best shown in Fig. 3, each of the discs of the temperature responsive device is composed of two layers 42-43 and 44-45 of metal welded together, said layers having different thermal coefficients of expansion. The layers 42 and 44 having the lower coefficients of expansion are located on the outside, and the layers 43 and 45 having higher coefficients of expansion are located on the inside of the temperature responsive means. Said discs (which are flat at room temperature with no compression but which are shown in Figs. 2 and 3 under initial compression from the force of the spring 32) buckle toward one another at higher temperatures and away from one another at lower temperatures. As shown in Fig. 2, the casing member 14 is provided in the bottom of the chamber 18 with an abutment 46 having an upwardly extending central portion 48; and the discs of the temperature responsive means just described are provided at their centers with openings adapted to receive the upwardly extending portion 48 of the abutment 46. In this way, the temperature responsive means is centered in the chamber 18. The bolt 28 is provided at its lower end with a cup-shaped head 50 the edges of which are adapted to cooperate with the temperature responsive means. The abutment and bolt head 50 limit the compression of the temperature responsive means under the force of the spring 32 so that the discs will not be overstressed by reason of the fact that the cup in head 50 is made of such depth that the top of portion 48 strikes the bottom of the cup and limits the compression. The inlet opening 20 in the casing member 14 may be provided with a check valve 52, as shown in Fig. 2, but this check valve may be omitted if desired.

The mode of operation of the throttling valve will be understood with the aid of Fig. 2. The fuel oil, returning from the atomizer 4 through the opening 20, fills the chamber 18 and flows over the lip 22 into the trough 23 and from that trough flows out through the opening 24 and on to the fuel-oil tank 6 or instead to the intake side of the pump if desired. As long as the oil remains at the same temperature, cooperation of the diaphragm 16 with the lip 22 will exert on the oil a constant throttling effect. Upon a rise in the temperature of the oil flowing through the chamber 18, and bathing the temperature responsive element, the discs in the temperature responsive element will flex toward one another, thereby increasing the net effective pressure exerted by the spring 32 upon the backing member and the diaphragm 16, and thus increasing the throttling effect on the oil flowing between the diaphragm 16 and the lip 22. The action of the thermal responsive element is not actually to raise or lower the diaphragm from its seat but to counterbalance the spring pressure on the diaphragm, to a greater or less extent, which opposes the pressure of the fuel in the return flow pipe. If, however, the temperature of the oil decreases, the

discs of the temperature responsive element will flex away from one another, thus decreasing the net effective pressure exerted on the backing member by the spring 32 and decreasing the throttling effect on the oil flowing between the diaphragm 16 and the lip 22. In this way, the pressure of the oil in the return passage of the atomizer 4 is automatically increased and decreased with the rising and falling of the temperature of the oil, that is, with the decreasing and increasing of the viscosity of the oil, with the result that the atomizer will spray oil at substantially a constant rate, even though the viscosity of the oil passing through the atomizer varies considerably. As has been stated, Fig. 2 represents in exaggerated form the space between the diaphragm 16 and the lip 22 and this space is in fact very small at all times. Virtually, the oil squeezes through between the seat 22 and the diaphragm 16 in a film of almost unmeasurable thinness against the net effective pressure of the spring.

When a fuel-oil control system of the kind illustrated in Fig. 1 is shut down by cutting off the supply of oil to the spray nozzle 4, it is important that no oil be allowed to "bleed" back into the atomizer 4 from the return pipe. The throttling valve shown in Fig. 2 prevents such back-flow into the oil atomizer, due to the fact that when the supply of oil to the atomizer is cut off the pressure of the oil in the return-flow pipe drops, and the outer portion of the diaphragm 16 instantly flexes into contact with the lip 22, thereby preventing back-flow toward the atomizer of the fuel-oil trapped in the return pipe and in the throttling valve. Because the flexing of the diaphragm 16 displaces only a minute quantity of oil from between the diaphragm 16 and the lip 22, the result is that substantially no back-flow of oil to the atomizer occurs. The check valve 52 assists in preventing such back-flow of oil but, as has been mentioned, this check valve is unnecessary under most conditions of operation because the diaphragm, in the absence of a defect, forms a complete seal by itself.

It will be understood that, when used with different oils having varying viscosities and with different types of return-flow nozzles having varying pressure-flow characteristics, the temperature responsive means will have to be changed accordingly. This is best done by varying the thickness of the bi-metallic discs which is normally about .025 to .030 of an inch. Also, if less temperature compensation is required, the thickness of the discs should be less and vice versa. In this disclosure two bi-metallic elements have been used in order to reduce the spring rate, that is, the rate of change of force exerted by the bi-metallic elements as they are further compressed. This is desirable in order to reduce sensitivity to dimensional tolerances. It should be understood that this effect can be accomplished in other ways or may not be necessary, and that a single bi-metallic element with corresponding changes in cooperating parts can be used.

What is claimed is:

1. A temperature-responsive throttling valve for liquid fuel subject to variations in temperature and adapted to increase the throttling effect with increase in temperature comprising, a casing having a chamber, a valve seat surrounding said chamber, a flexible diaphragm overlying said seat and forming a wall of said chamber, said casing having a fuel inlet communicating with said chamber and a fuel outlet communicating with

the space outside said valve seat, resilient means positioned on the opposite side of the diaphragm from said chamber urging said diaphragm toward said seat, and a thermally responsive pressure element in said chamber bathed by the fuel passing therethrough and acting in opposition to said resilient means to increase and decrease the closing pressure on said diaphragm according, respectively, to an increase or decrease in temperature of the fuel in said chamber.

2. A temperature-responsive throttling valve for liquid fuel subject to variations in temperature and adapted to increase the throttling effect with increase in temperature comprising, a casing having a chamber, a valve seat surrounding said chamber, a flexible diaphragm overlying said seat and forming a wall of said chamber, said casing having a fuel inlet communicating with said chamber and a fuel outlet communicating with the space outside said valve seat, a backing member positioned on the opposite side of the diaphragm from said chamber, a spring acting on said member and urging said diaphragm toward said seat, and a thermally responsive pressure element in said chamber bathed by the fuel passing therethrough and acting in opposition to said spring to increase and decrease the closing pressure on said diaphragm according, respectively, to an increase or decrease in temperature of the fuel in said chamber.

3. A temperature-responsive throttling valve for liquid fuel subject to variations in temperature and adapted to increase the throttling effect with increase in temperature comprising, a casing having a chamber, a valve seat surrounding said chamber, a flexible diaphragm of rubberlike material overlying said seat and forming a wall of said chamber, said casing having a fuel inlet communicating with said chamber and a fuel outlet communicating with the space outside said valve seat, a backing member positioned on the opposite side of the diaphragm from said chamber and overlying said seat, a spring acting on said backing member and urging said diaphragm toward said seat, and a thermally responsive pressure element in said chamber bathed by the fuel passing therethrough and acting in opposition to said spring to increase and decrease the closing pressure on said diaphragm according, respectively, to an increase or decrease in temperature of the fuel in said chamber.

4. A temperature-responsive throttling valve for liquid fuel subject to variations in temperature and adapted to increase the throttling effect with increase in temperature comprising, a casing having a chamber, a valve seat surrounding said chamber, a flexible diaphragm overlying said seat and forming a wall of said chamber, said casing having a fuel inlet communicating with said chamber and a fuel outlet communicating with the space outside said valve seat, resilient means positioned on the opposite side of the diaphragm from said chamber urging said diaphragm toward said seat, and a thermally responsive bi-metal pressure element in said chamber bathed by the fuel passing therethrough adapted to expand with a decrease in temperature and acting in opposition to said resilient means to increase and decrease the closing pressure on said diaphragm according, respectively, to an increase or decrease in temperature of the fuel in said chamber.

5. A temperature-responsive throttling valve for liquid fuel flowing under pressure at a low rate and subject to variations in temperature adapted to vary the throttling effect on said fuel

with variations in temperature of the fuel, comprising, a casing having a chamber, a circular up-standing valve seat surrounding said chamber, a flexible rubberlike diaphragm overlying said seat and forming a wall of said chamber, said casing having a fuel inlet communicating with said chamber and a fuel outlet communicating with the space surrounding said valve seat, a spring positioned on the opposite side of the diaphragm from said chamber and urging said diaphragm toward said seat, and a thermally responsive pressure element in said chamber comprising a pair of bi-metal discs secured together at their edges and bathed by the fuel passing there-through and arranged to oppose said spring to increase and decrease the pressure of said diaphragm against said seat according, respectively, to an increase or decrease in temperature of the fuel in said chamber.

6. In a temperature-responsive throttling valve having a casing, a flexible diaphragm, a rigid backing member therefor, a spring acting thereon to urge the diaphragm in one direction, and temperature-responsive means opposing the action of said spring; said means comprising a pair

of centrally perforated bi-metal discs secured together at their edges, said casing having a chamber in which is a centrally located abutment having a reduced portion positioned in the perforations in said discs and a cup-shaped member surrounding said reduced portion with its edge engaging one of said discs and held in contact therewith by said spring and having a stem extending through said backing member, whereby engagement of the end of said reduced portion of the abutment with the bottom of the cup in said cup-shaped member limits the compression of said temperature-responsive means by said spring.

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