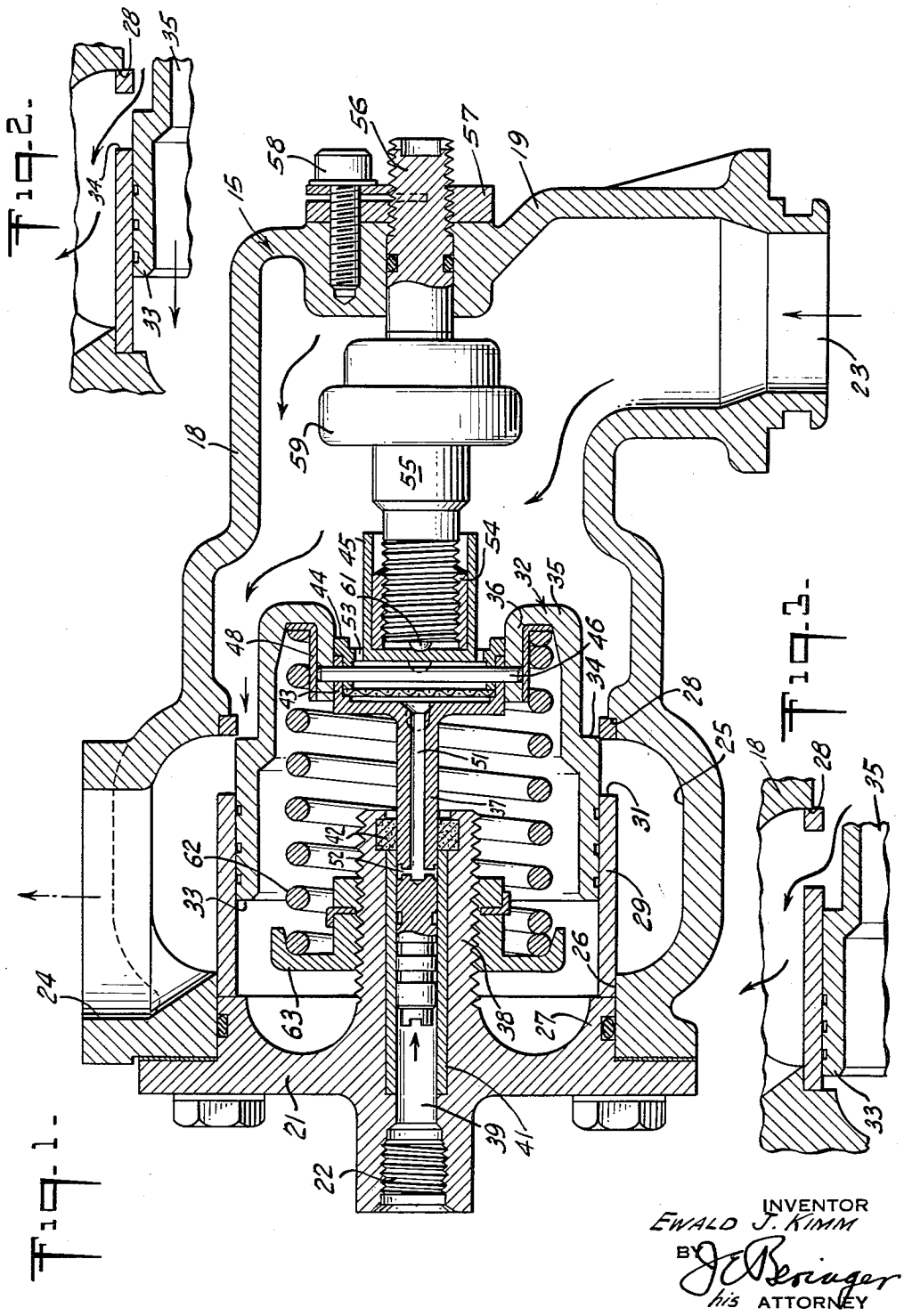
July 31, 1962 E. J. KIMM 3,047,055

FUEL HEATING APPARATUS

Filed May 6, 1958 2 Sheets-Sheet 1



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Fig. 4.

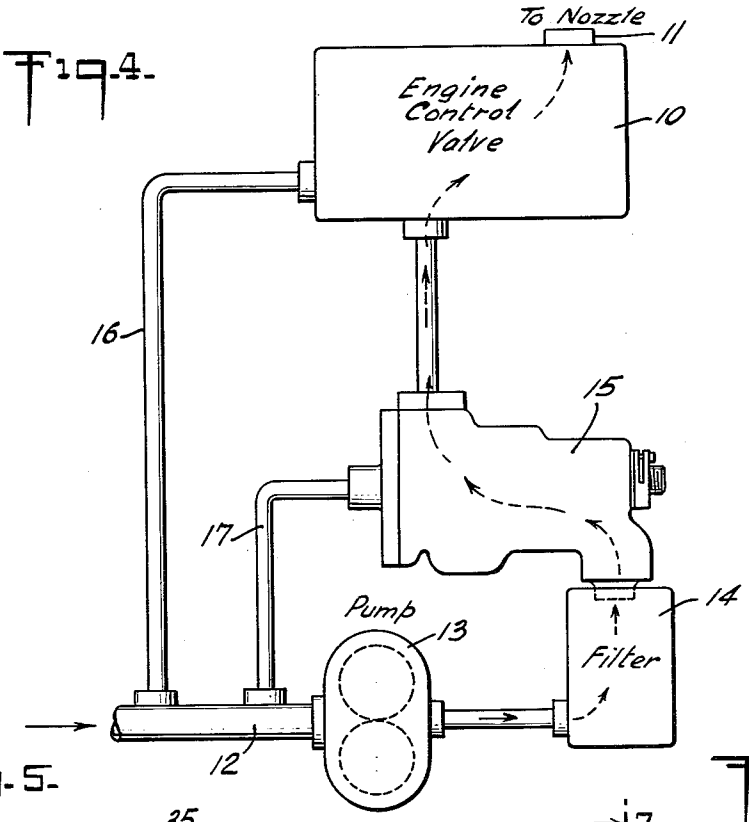


Fig. 5.

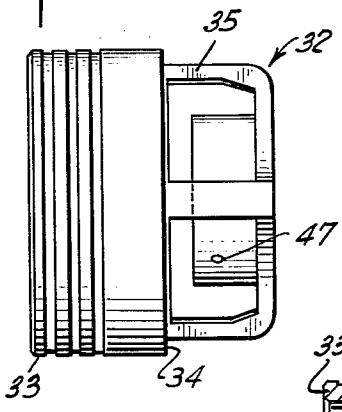


Fig. 6.

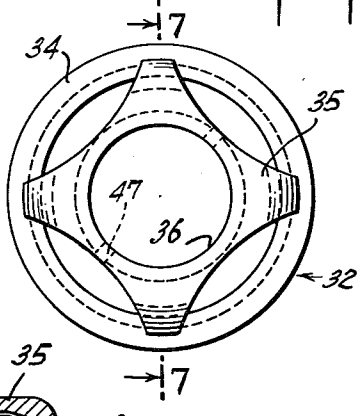
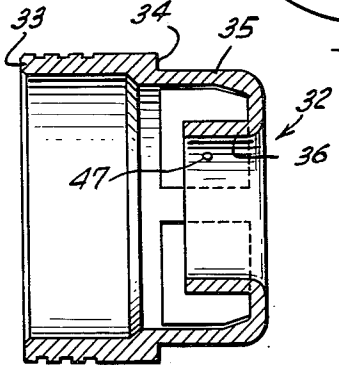


Fig. 7.



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FUEL HEATING APPARATUS

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5 Claims. (Cl. 158—36.3)

This invention relates to fuel burning systems utilizing a fuel which may be at a temperature sufficiently low to incorporate ice crystals therein. More particularly, the invention is concerned with systems as described, for example jet engines of aerial craft, equipped with means to heat the fuel for a dissolving of the ice crystals before the fuel reaches the burner.

The invention has in view the use of a new component in fuel supply and burning systems accomplishing its objective by a throttling of the fuel flow in such manner as to keep the fuel pumps operating at high differential pressures during cold weather operation to obtain through a dissipation of energy a warming of the discharged fuel.

Another object of the invention is to provide a generally new engine component in the form of a throttling valve responding to pressure differential and to fuel temperature to exert greater and lesser degrees of restriction upon fuel flow whereby to accomplish a heating thereof as needed.

Other objects and structural details of the invention will appear from the following description when read in connection with the accompanying drawings, wherein:

FIG. 1 is a view in longitudinal section of a valve in accordance with the illustrated embodiment of the invention, the valve being shown in maximum closed position;

FIG. 2 is a fragmentary detail taken from FIG. 1 and showing the valve in a partly open position;

FIG. 3 is a view like FIG. 2 showing the valve in fully open position;

FIG. 4 is a diagram of a fuel supply and burning system incorporating a throttling valve in accordance with the present invention;

FIG. 5 is a detail view in side elevation of a piston-like slide valve element embodied in the throttling valve assembly;

FIG. 6 is a front end view of the element of FIG. 5; and

FIG. 7 is a view in longitudinal section thereof.

Referring to the drawings, and first to FIG. 4, the invention is disclosed in connection with the fuel supply system of a jet engine which provides an engine control valve 10 operating selectively under pilot control or otherwise to admit fuel to burning nozzles by way of an outlet 11. The fuel is drawn from a suitable source of supply and directed to the valve 10 by way of a supply line in the form of a pipe or tube 12. Interposed in the supply line 12, between the source and valve 10, is an engine driven, positive displacement pump 13, a filter 14 and a throttling valve assembly 15. Fuel supplied to the valve 10 in excess of the demand therefor is returned to the inlet side of the pump by a line 16. The inlet side of the pump 13 also communicates, through a line 17, with one end of the throttling valve assembly 15 for a purpose which will hereinafter more clearly appear. In the operation of the system, the pump 13 places the supplied fuel under pressure, directing it through the filter 14 for a removal of entrained foreign particles and then compelling its passage through the throttling valve 15 to the engine control valve 10. As will be seen, the valve assembly 15 is temperature and pressure responsive in action to exert a variable degree of restriction upon the fuel flow therethrough to the end that the supplied fuel may be heated by the action of the pump 13 whenever

this appears necessary or desirable on account of the low fuel temperature.

Referring now to FIG. 1, the throttling valve assembly 15 comprises a generally cylindrical body 18. One end thereof is defined by a vertical wall 19. The other end is closed by a removable closure plate 21 having a threaded opening 22 to receive one end of the aforementioned pipe 17. The wall 19 terminates at its lower end in an inlet opening 23 receiving fuel from the filter 14. In substantially diametrically opposed relation to the inlet 23 is an outlet 24 by which the fuel leaves the throttling assembly and passes to the engine control valve 10. Thus, as indicated, fuel enters the throttling valve assembly at the right hand lower end thereof, progresses interiorly of the body 18 toward the opposite end thereof and leaves the body by way of outlet 24 in the upper left hand end thereof.

The outlet opening 24 communicates with an annular chamber 25 in the valve body. The latter is in effect in surrounding relation to a machined bearing surface 26 receiving a cylindrical interior projection 27 on the closure plate 21. Interposed between the cylindrical projection 27 and the bottom 28 of the surface 26 is a sleeve 29 which provides limited communication between the annular chamber 25 and the interior proper of the body 18 by way of radial slots 31 in the sleeve adjacent one end thereof. A piston like valve element 32 is formed with a cylindrical portion 33 having a sliding fit in the sleeve 29 and adapted to cover more or less of the area of the slots 31 whereby to restrict flow therethrough from the interior of the valve body to the chamber 25 and outlet 24. At its one end, the cylindrical portion 33 terminates in a sharp edged corner 34. From this location the valve element continues in the form of integral, relatively smaller diameter, spaced apart spokes joined together at their outer ends in a concentric ring portion 36 (see FIGS. 5 to 7). Surrounded by the valve element 32, and concentric therewith, is a relatively small diameter shaft 37. One end of the shaft 37 extends into a tubular boss 38 on the closure plate 21 within which is a through passage 39 communicating with the aforementioned opening 22. The piston 37 has a sliding fit in the passage 39 within a bushing 41 therein. An annular packing member 42 is seated in the inner end of the passage 39 in abutting relation to the adjacent end of the bushing 41 and in surrounding, wiping contact with the shaft 37.

The opposite end of the shaft 37 is flared to provide a relatively wider cylindrical portion 43 which is received within the ring portion 36 of the valve element 32. In interfitting engagement with the portion 43 is a flange-like rim 44 on the bottom or closed end of a cup shaped member 45. A pin 46 is mounted in openings 47 in the ring shaped portion 36 of the valve element and passes through the rim 44 of member 45 and through the cylindrical portion 43 of shaft 37 in a manner to hold these several elements in an assembled relation. A retainer 48 is slipped over the ring portion 36 and holds the pin 46 in place. By virtue of the described connection, the valve element 32, shaft 37 and cup shaped member 45 are in effect united for unison motion.

The rim 44 holds a filter screen 49 in place within the expanded end of the shaft 37 where it covers the end of a passage 51 in the shaft 37. The opposite end of the passage 51 terminates short of the end of the shaft and is open through radial passes 52 to the internal wall of the bushing 41 beyond packing 42. Fluid within the valve body 18 has access to the passage 51 by way of longitudinal openings 53 in the rim 44.

The cup shaped member 45 has its open end facing into the interior of the body 18 and slidingly receives a bush-

ing 54. Extending into the open end of the element 45 is one end of a thermostat unit 55 having threaded engagement with the bushing 54. Extending from the opposite end of the thermostat unit is a relatively stationary reactant portion 56 which is received in the wall 19 to project through and outside such wall. The projecting end thereof is threaded and has a lock nut 57 mounted thereon. The nut 57 is held to the body 18 by bolts 58 and as indicated the nut is split at one point for the application of tension to the interengaged threads to hold the nut tight against the effects of vibration. The thermostat unit 55 is in this manner securely mounted within the valve body but is accesible for adjustment purposes.

The thermostat unit provides a case 59 located within the valve body in the path of fluid flow from inlet 23 to outlet 24. The unit is generally conventional in nature, being constructed with a pellet of wax-like material contained in the case 59 and having the property of expansion under heat. The expansive force of the wax is sufficiently powerful to effect movement of the valve element 32 and associated parts, which it does through a relatively extensible plunger 61 which bears against the bottom of cup shaped member 45. The piston element 32 and associated parts are urged in a direction to maintain contact of the cup 45 with the plunger 61 through a compression spring 62 which is interposed between the spoked end of valve element 32 and a seat 63 adjustably mounted upon the exterior of box 38. Under the urging of the spring 62, the valve element and its parts tend to maintain contact with the plunger 61 and tend also to close the slots 31 in the sleeve 29, the force of the spring being exerted in a direction to cause the cylindrical portion 33 of element 32 to cover up or to close the slots 31. An expansion of the thermostat unit 55, under applied heat, serves to shift the valve element in a leftward or retracting direction to open the slots 31 for free flow of the fuel from the interior of the body 18 to the chamber 25 and outlet 24. Retracting movement of the valve element compresses the spring 62 providing therein a force for return of the valve assembly toward closed position as well as a force for re-compression of the wax-like thermostatic material in case 59 in response to a cooling of the fuel.

In the operation of the throttling valve assembly, motion of the valve element 32 to the right or in a direction to close off flow to outlet 24 is limited by engagement of the cup 45 with the bushing 54 on the thermostat unit 55. This stop point is adjusted and the spring load is set so that a maximum point of closure for the corner 34 with respect to the slots 31 is defined which still permits some flow through the slots, although the valve may be considered at this time to be in a position of maximum restriction. Fuel admitted to the valve body 18 is free to flow between the spokes on the front end thereof so that the pressure value of the fuel is applied to both front and back faces thereof. The valve is accordingly balanced except for the area defined by the diameter of shaft 37. The unbalance created by this diameter produces a resultant pressure applied in a direction opposed to the action of the spring 62 or in a direction to open the valve. A pressure differential is applied which makes use of the pressure at the inlet side of the pump 13 as a reference pressure since the passage 39 beyond the end of shaft 37 is connected as described to the supply pipe 12 ahead of pump 13.

The valve occupies its position of maximum closure only under conditions of low fuel temperatures and it will be understood that at a selected temperature value the thermostat unit 55 will begin to expand and to open the valve for a less restricted flow to the outlet 24. The initial cranking of the engine driven pump 13 produces a relatively low flow rate to the valve assembly 15, and, if the temperature is low, the fuel finds valve 32 in its maximum closed position. A throttling of flow results, with the fuel being heated in response thereto. As the engine starts and takes over the operation of the pump the pressure differential at opposite ends of the shaft 37 tends rapidly to rise, compelling a wider opening of valve 32. If the fuel temperature remains low, however, the spring loading of the valve continues to provide a force for closure thereof and the applied effort to throttle the fuel flow remains. Under a rising temperature, however, the thermostat 55 extends the plunger 61 whereby either to move the valve in a retracting direction or to interpose a relatively extended stop if the valve already is in a retracted position. In either case the effect is positively to prop the valve open and limit its range of movement under pressure differential.

The parts are shown in FIG. 1 in the position occupied when the system is cold and in effect unpressurized or with the applied pressure differential being only sufficient to balance the force of spring 62. FIG. 2 indicates the position of the parts when the thermostat 55 has expanded under a rising fuel temperature while FIG. 3 shows the valve fully open under maximum temperatures, there being at this time no restriction to flow.

The filter 49 serves, as before noted, to inhibit access of foreign particles to the passage 51 and thereby to inhibit their entry in the bearing space between the shaft 37 and bushing 42. The passage 51 serves to communicate the high pressure within the valve body to the rear of the inserted packing member 42 in order that the pressures on the opposite sides of this member may be balanced. The inserted packing member 42, which may be made of felt or the like, has a wiping contact with the exterior of shaft 37 and also inhibits entrance of foreign particles into the bearing bushing 41. The shaft 37 has exterior seals, beyond the passage 51, to prevent the high pressure fluid from such passage communicating with opening 22 and the low pressure side of the pump.

What is claimed is:

1. A thermostatic and pressure responsive throttling valve, including a valve body having an inlet and an outlet for a fluid flowing under pressure, a slide type valve in said body controlling flow therethrough from said inlet to said outlet, means to nearly balance fluid pressures applied to said valve in such manner as to provide a resultant pressure applied in a direction to open said valve, a spring urging said valve closed and adapted to be overcome by a resultant pressure of sufficient magnitude, and a thermostat in said body intermediate said inlet and said outlet in the path of flow of the fluid responding directly to rising fluid temperature to open said valve.

2. A thermostatic and pressure responsive throttling valve according to claim 1, characterized in that said slide valve comprises a cylindrical portion slidably mounted in said body and a shaft portion projecting from one side of the valve and separately received in said body, both sides of said valve being exposed to pressure fluid in said body and the cross sectional area of said shaft portion providing for an unbalance of such fluid pressures.

3. A thermostatic throttling valve, including a valve body having an inlet and an outlet for a fluid flowing under pressure, a valve controlling flow through said body, means to apply a fluid pressure to said valve in a direction for opening thereof, a spring urging said valve in a direction for closing thereof, and a thermostat in said body intermediate said inlet and said outlet in the path of flow of the fluid responsive directly to fluid temperature to limit closing of said valve by said spring and independently to open said valve.

4. In a fuel burning system, pump means to supply the fuel, a throttling valve assembly including a body having an inlet communicating with the discharge side of said pump and having an outlet, a throttling valve in said body controlling flow from said inlet to said outlet and adapted by its movement to exert a variably restrictive effect thereon, means applying a resultant fluid pressure to said throttling valve in a direction to decrease the restriction exerted thereby, said resultant pressure varying in

magnitude with variations in pressure of the fuel at said inlet, a spring opposing said resultant pressure, and means responding to the temperature of the fuel positively limiting movement of said throttling valve by said spring.

5. A system according to claim 4, characterized in that said thermostat is connected to said throttling valve for a positioning thereof independent of fuel pressure and spring force.

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