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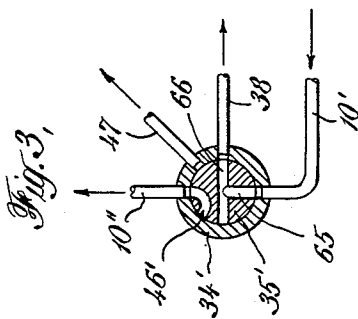
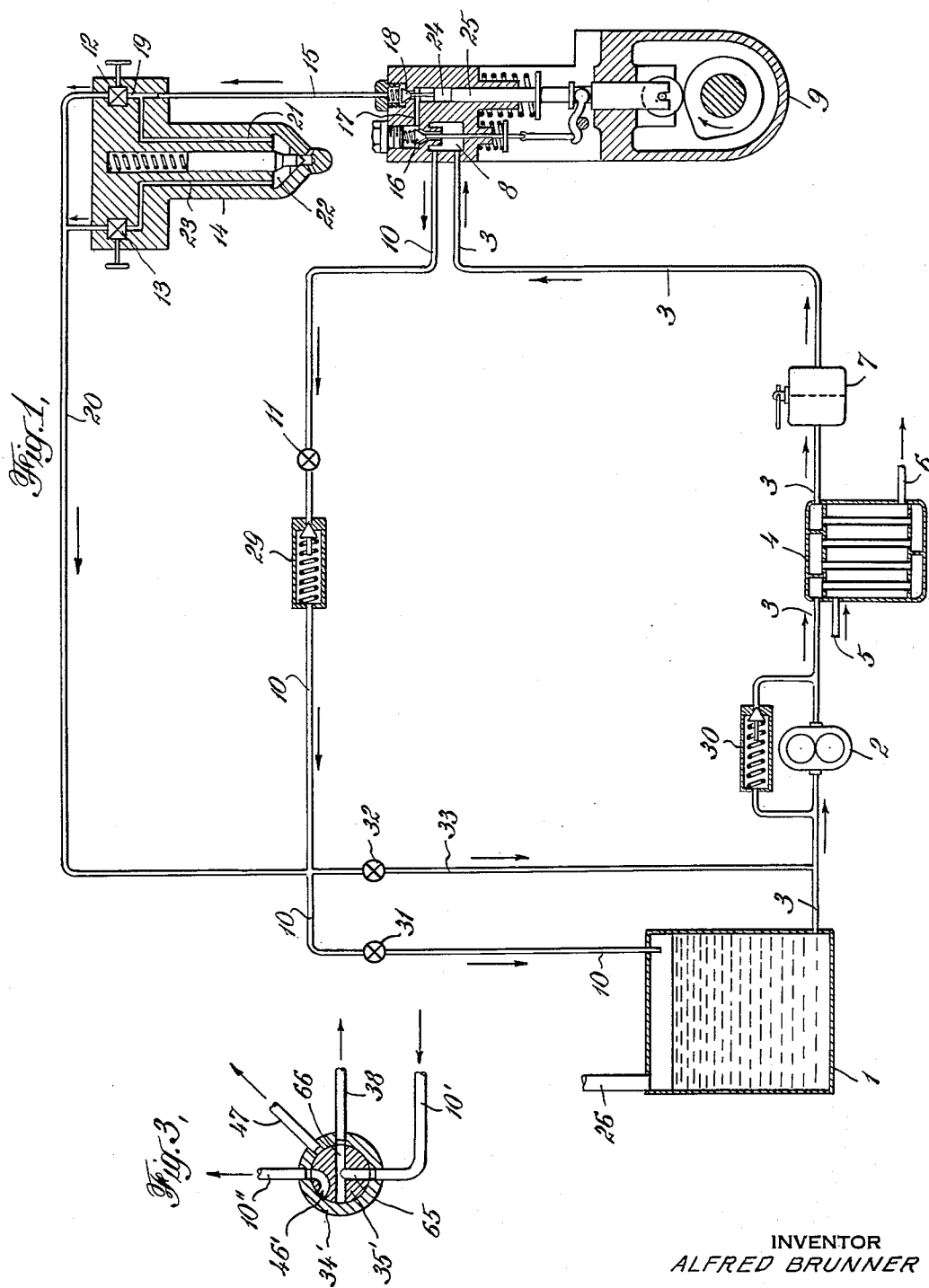
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FUEL SUPPLY SYSTEM FOR INTERNAL COMBUSTION ENGINES

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2 Sheets-Sheet 1



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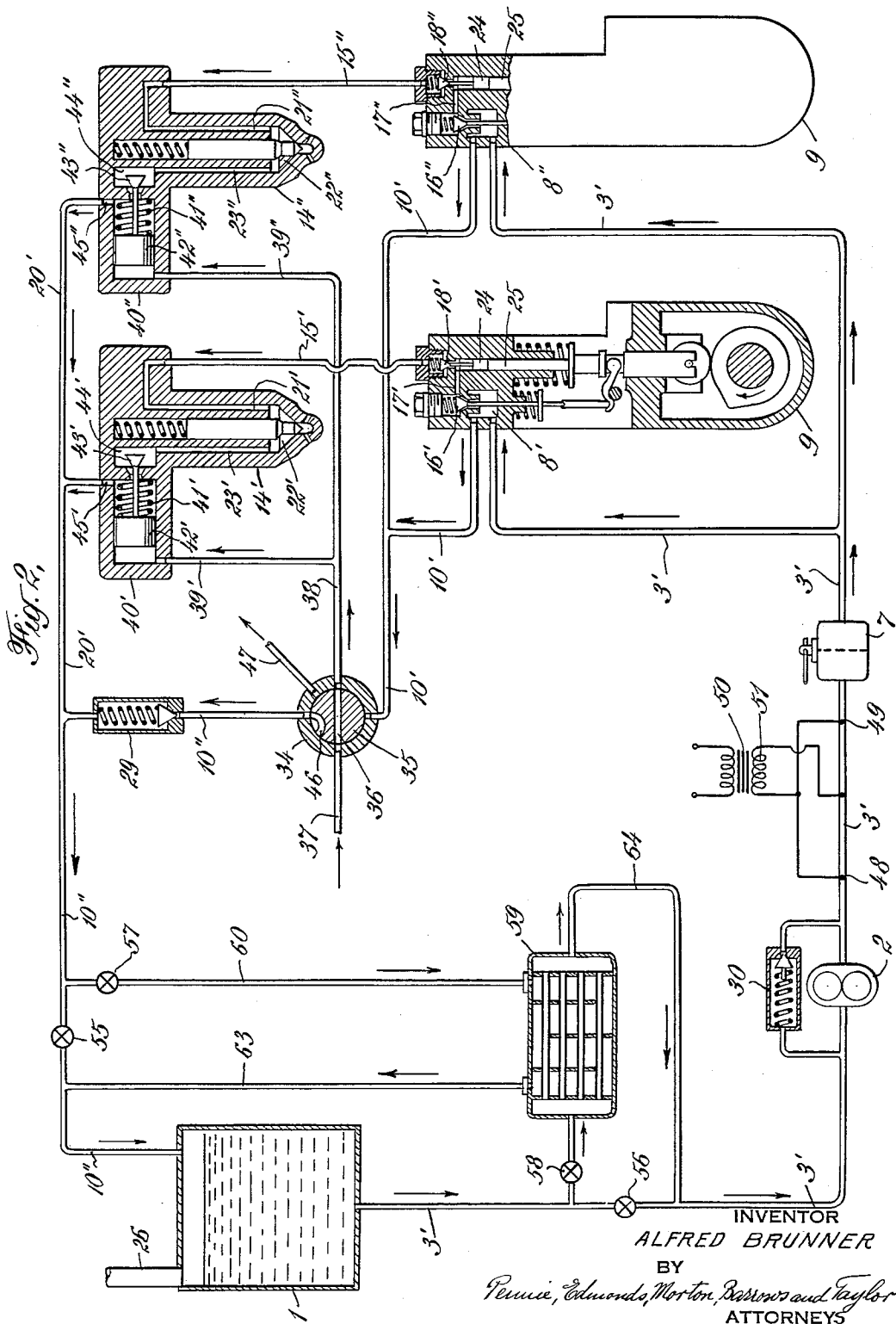
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FUEL SUPPLY SYSTEM FOR INTERNAL COMBUSTION ENGINES

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4 Claims. (Cl. 123—32)

This invention relates to a fuel supply system for internal combustion engines and, more particularly to a fuel supply system for internal combustion engines of the compression ignition type which utilize a pressurized fuel injection system to introduce metered quantities of finely divided fuel oil into cylinders of the engine. In an engine of the type referred to above, the fuel oil is injected into the cylinder under high pressure through a nozzle having a tiny orifice. The diameter of the orifice designed to cooperate with a particular engine serves as a limiting factor on the viscosity of the fuel oil which may satisfactorily be used with that engine. It is not unusual that the less expensive grades of fuel oil are too "heavy" or have a viscosity at normal temperatures which is too high to permit their use. However, as is well known, the viscosity of liquids and, in particular, of fuel oils decreases as the temperature of the oils is increased. This characteristic of fuel oils is utilized in the present invention which provides a fuel supply and heating system that raises the temperature of the fuel oil and hence decreases its viscosity to a value which will permit the oil to be satisfactorily passed through the tiny aperture of the conventional fuel injection nozzle.

A feature of the present invention is that it makes possible the use of the less expensive "heavy," of high viscosity, fuel oils in an otherwise conventional compression ignition engine.

Another feature of the present invention is that it provides a fuel heating and circulating system which utilizes the fuel oil itself as a heat transfer medium to raise the temperature of the vital components of the engine to operating temperature before the engine is started. This feature insures that the engine will operate at full efficiency immediately after it is placed in operation and eliminates to a large extent the customary delay encountered while the engine is being brought to its normal operating temperature before full power may be obtained.

Yet another feature of the fuel heating and circulating system of the invention is that in delivering hot fuel to the injection nozzle an appreciable ease in starting the engine is realized.

The invention will be readily understood from the following description of a particular embodiment and with reference to the accompanying drawings. In these drawings:

Fig. 1 represents a fuel supply system for a compression ignition engine according to the invention;

Fig. 2 represents a variation of the fuel supply system of Fig. 1; and

Fig. 3 represents a selective valve to be used in conjunction with the fuel supply system of Fig. 2 as an alternative to the selective valve shown there.

With reference to Fig. 1, the fuel supply system according to the invention, has a fuel tank 1, a fuel circulating pressure pump, such as a gear pump 2, a heat exchanger 4, a fuel injection pump 9, and a fuel injection valve 14 as its principal components. The fuel

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tank 1 is filled with "heavy" or high viscosity fuel oil. In order to decrease the viscosity in accordance with the requirements of a particular compression ignition engine, such as a diesel engine (not shown), the fuel oil is supplied from the tank 1 by means of the circulating pressure pump 2 through a supply pipe 3 to heat exchanger 4. In the heat exchanger 4 the fuel oil is heated by steam which is supplied from any convenient source through the pipe 5 into the heat exchanger 4 and leaves the latter through pipe 6 as condensate. The heated fuel from the heater exchanger is then conducted through a filter 7 to remove extraneous foreign matter which might foul or clog the minute apertures in the fuel injection pump and valve. From the filter 7 the heated fuel oil is piped into the fuel injection pump 9 of the diesel engine. This injection pump includes a suction chamber 8 having a fuel supply inlet and a recirculation outlet.

Before starting to operate the engine, the fuel flowing through the supply pipe is circulated in the suction chamber 8 and conducted back into the fuel tank 1 by way of a first recirculating circuit which includes the return flow pipe 10, the valve 11, pressure operated valve 29, and valve 31. This circulation of the fuel oil is continued until the whole volume of oil in the system and the elements of the system through which the oil has been circulated have reached the desired operating temperature. Following this, the heated oil is diverted into the second recirculating circuit of the selective circulating system which includes the suction chamber 8, the control valve 16, the channel 17 connecting the suction chamber 8 to the pressure chamber 24, the discharge valve 18, a pressure pipe 15 which connects the fuel injection pump to the inlet channel 21 of the fuel injection valve 22, and alternative paths through the fuel injection valve. One of these paths comprises channel 19 and valve 12; the other path includes the inlet channel 21, the fuel chamber 22, the outlet channel 23, and valve 13. Both paths make common connection with return flow pipe 20 which has a junction with return flow pipe 10. For this purpose the valve 11 is closed and the valve 12 opened so that the fuel passing under pressure into the suction chamber 8 opens the suction valve 16 and passes through the channel 17, the non-return valve 18, the pipe 15, the channel 19, and the pipe 20 into the return flow pipe 10 by which it is returned to the fuel tank 1. Following this operation, the valve 12 is closed and valve 13 is opened so that the circulating hot fuel now flows through the inlet channel 21, the fuel chamber 22, and the outlet channel 23 of the injection valve 14. The hot fuel is allowed to flow through this course until the fuel injection pump and the fuel injection valve are raised to any desired temperature.

After the fuel injection system has been heated by means of the circulating fuel and the fuel itself has obtained a sufficiently low viscosity, the normal operating course of the fuel is established by closing the valves 12 and 13 and opening the valve 11. This permits the circulating fuel to flow from the suction chamber 8 directly into the flow pipe 10 which returns it to the fuel tank 1. With this circulated flow established, the engine can now be set in operation. While the engine is running, the quantity of fuel necessary to the functioning of the engine is diverted from the suction chamber 8 through the channel 17 into the pressure chamber 24 where it is compressed by the piston 25 and discharged through the one-way valve 18 into the pipe 15 which conducts the fuel to the inlet channel of the fuel injection valve. The remaining substantially larger portion of fuel not necessary to the operation of the engine is discharged from the suction chamber 8 through the return flow pipe 10 and into fuel tank 1. Due to the continuous circulation of an excess of hot fuel through the suction chamber 8

and the fuel pump 9, the entire system is maintained at a substantially uniform operating temperature, even when the engine is operating at no load and consuming the least amount of fuel; therefore, the fuel remains at a sufficiently low and uniform viscosity at all times. In addition undissolved gases, such as air, which could cause interruptions in the operation of the engine are carried along by the stream of fuel scavenging the suction chamber 8 and discharged into the open air through the ventilation and filler pipe 26 of the fuel tank 1.

The system shown in Fig. 1 includes several precautionary devices. A pressure holding valve 29 is serially connected in the flowpipe 10 and maintains a sufficiently high pressure in the circulating system to prevent vaporization of the hot fuel. In the event that all valves become closed simultaneously, excessive fuel pressure is prevented by the by-pass valve 30. In effect, this valve produces a short circuit between the high pressure and low pressure outlets of the pump 2 if the fuel pressure attains a predetermined value sufficient to compress the valve spring and open the valve 30. In addition, a conduit is provided which connects the outlet channel 13 of the fuel injection valve and the low pressure side of the pump 2. This circuit for the fuel may be utilized by opening valve 32 and closing valve 31 in the event that the temperature of the oil in the system is increased to the point where its return to the fuel tank 1 would increase the contents of the fuel tank to the point where spontaneous combustion would be eminent. In this case only the amount of fuel necessary for the operation of the engine would flow out of the circulating system and into the pressure chamber 24. By intermediate adjustment of the valves 31 and 32, it is possible to divert only a part of the circulating fuel through the by-pass pipe 33 and the remainder of the fuel may be directed into the fuel tank 1. In this manner, the temperature of the contents of the fuel tank may be regulated.

In the fuel supply device shown in Fig. 2, the flow path of the circulating fuel may be selectively changed by means of a selective valve 34 which is centrally located with respect to the engine. This selective valve 34 has a reversible tap 35 which is shown in the position it assumes before the engine is started, here deemed the "warming" position, and in this position prevents, on the one hand, the direct outflow of the fuel conveyed by the circulating pump 2 from the suction chamber 8' and 8'' through the return flow pipe 10' and 10'' into the fuel tank 1 and, on the other hand, allows compressed air from an external source (not shown) to flow by way of the channel 36 through the pipes 37, 38, 39' and 39'' into the servo-motors 40' and 40'' of the injection valves 14' and 14'', respectively. The compressed air overcomes the resisting forces of the springs 41' and 41'' and opens the valves 43' and 43'' by moving the pistons 42' and 42''. Then the total output of the circulating pump 2 is divided between the parallel paths which include the suction space 8' and 8'', the suction valve 16' and 16'', the channel 17' and 17'', the non-return valves 18' and 18'', the pressure pipe 15' and 15'' and the injection valve 14' and 14'', where it flows through the channels 21' and 21'', the fuel chambers 22' and 22'', the channels 23' and 23'', the space 44' and 44'', the now open valve 43 and 43'', and the channels 45' and 45''. From the injection valve the fuel passes back into the tank 1 through the pipe 20' and 10''.

Immediately before starting the engine, the reversible tap 35 is brought into the "running" position by being turned 90° clockwise. The supply of compressed air from the pipe 37 is thus blocked and the compressed air still present in the servo-motors 40' and 40'' is exhausted through the pipes 39 and 38, the channels 46, and the pipe 47 into the open air so that the valve 43' and 43'' closes under the action of the springs 41' and 41''. At the same time the channel 36 of the reversible tap 35 establishes a connection between the pipe 10' and 10'' so that

the circulating fuel flows from the suction chambers 8' and 8'' through the one-way valve 29 into the fuel tank and only the portion of the fuel destined for injection into the cylinders of the engine passes from the suction chambers 8' and 8'' through the pipe 15' and 15'' into the injection valve 14' and 14''. It is readily apparent that a similar circulating system according to the invention may be constructed to cooperate with an engine having more than the two cylinders contemplated for the system of Fig. 2.

In the embodiment of Fig. 2, the fuel is heated electrically. An alternating current from a source (not shown) is supplied at a suitable voltage through the transformer 50 to the section of the electrically conductive pump discharge pipe 3' between the points 48 and 49 which serves as a resistance heating element. One terminal of the secondary winding 51 of the transformer 50 is connected to the center tap of the heating element. The other terminal of the secondary winding 51 is connected to the points 48 and 49 of the heating element. This arrangement of the heating circuit insures that the points 48 and 49 of the fuel pipe 3' have the same potential so that it is not necessary to insulate this section of of piping from the other parts of fuel pipe 3'.

To prevent spontaneous combustion of the contents of the fuel tank 1 through excessive heating by the circulating fuel passing from the return flow pipe 10' of the fuel tank 1, the valves 55 and 56 can be closed and the valves 57 and 58 can be opened so that fuel circulating through the pipe 10' to the fuel tank and fuel flowing out of the tank to the pipe 3' can be conducted through a heat exchanger 59. The hot fuel from the pipe 10' then passes through the pipe 60 into the heat exchanger 59. Fuel from pipe 10' there gives off a part of its heat to the fuel conducted from the fuel tank 1 to the heat exchanger 59 and passes in cool state through the pipe 63 and 10' into the fuel tank 1. The fuel preheated in the heat exchanger 59 flows out of the fuel tank 1 through the pipe 64 and 3' to the circulating pump 2.

Fig. 3 shows a variation of the selective valve 34 of Fig. 2. Instead of utilizing compressed air to displace pistons 41' and 41'', a portion of the fuel from pump 2 is diverted in the selective valve 34' of Fig. 3 from the suction chambers 8' and 8'' into the chambers 40' and 40'' of the servomotors 14' and 14''. This selective valve 34' has a three-way reversible tap 35' which is situated in the illustrated position of Fig. 3 before starting up the engine so that a part of the fuel passes through the pipe 10', the channels 65 and 66 and the pipes 38, 39' and 39'' (Fig. 2) of the servomotors into the chambers 40' and 40'' of the servo-motors and opens valves 43' and 43'' by displacing the pistons 42' and 42''. The circulating fuel can then flow out of the suction chamber 8' and 8'' through the pressure pipes 15' and 15'', the injection valve 14' and 14'', and the pipe 20 and 10'' into the fuel tank 1.

By turning the three-way tap 35' 90° clockwise, it is brought into "running" position, whereby the channel 46' connects pipe 38 to exhaust pipe 47 which allows discharge of the fuel from the servo-motor chambers 40' and 40'' into a tank (not shown) so that the valves 43' and 43'' close. At the same time, the connection is made between the pipe 10' and 10'' so that the circulating fuel can flow off from the suction chambers 8' and 8'' directly through these pipes into the fuel tank 1.

These centralized selective valves of Figs. 2 and 3 are especially suitable for use in fuel circulating systems on large diesel engines in which the numerous individual valves in the selective system of Fig. 1 might be disposed at widely separated points about the engine. The single centralized selective valve simplifies operation of the system and greatly reduces the possibility of connecting errors by the operator. The circulating fuel may be heated by means other than those disclosed in detail herein without going outside the scope and spirit of the invention. For example, coils which circulate hot water

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or hot exhaust gases around the supply pipe 3 or 3' might be used, or a wound wire electric heating element surrounding the supply pipe 3 or 3' would be equally as effective. Under some circumstances the pipes 15' and 15'', especially when they are relatively long, may also be heated by any of these means.

It is to be understood that the foregoing description and the accompanying drawings are merely illustrative of my invention and the scope of my invention is not to be limited by them, but is to be measured solely by the scope and terms of the subjoined claims. What I desire to secure by Letters Patent is:

1. A fluid fuel supply circulating system for internal combustion engines comprising a fuel supply tank having a supply outlet and a recirculation return inlet, a fuel injection valve having an injection nozzle, a fuel chamber internally adjacent the injection nozzle of the valve, an inlet channel to said fuel chamber, and an outlet channel from said fuel chamber; a fuel injection pump, the discharge of said fuel injection pump being connected to the inlet channel of the fuel injection valve; a suction chamber in said fuel injection pump; a pressure chamber in said fuel injection pump; a conduit inter-connecting said suction and pressure chambers; a supply inlet to said suction chamber; a recirculation outlet from said suction chamber; a fuel circulating pressure pump connected to the supply outlet of said fuel tank; a heat exchanger serially connected between the discharge of said pressure pump and said supply inlet of said suction chamber; a first valved connection between said recirculation outlet from said suction chamber and said recirculation return inlet of said fuel supply tank; and a second valved connection between said outlet channel from said fuel chamber and said recirculation return inlet of said fuel supply tank, whereby fuel circulated through and heated by the heat exchanger may be selectively circulated either through the suction chamber of the fuel injection pump or serially through both the suction and pressure chambers of the injection pump and the channels and chamber of the injection valve.

2. A fluid fuel supply circulating system for internal combustion engines comprising a fuel supply tank having a supply outlet and a recirculation return inlet; a fuel injection valve having an injection nozzle, a fuel chamber internally adjacent the injection nozzle, a servo-operated valve, an inlet channel to said fuel chamber, an outlet channel connecting said fuel chamber and the intake of said servo-operated valve, a discharge port for said servo-operated valve connected to said recirculation return inlet of said fuel supply tank, and a pressure supply port for the servo-operated valve; a fuel injection pump, the discharge of said fuel injection pump being connected to the inlet channel of the fuel injection valve; a suction chamber in said fuel injection pump; a pressure chamber in said fuel injection pump; a conduit interconnecting said suction and pressure chambers; a supply inlet to said suction chamber; a recirculation outlet from said suction chamber; a fuel circulating pressure pump having its intake connected to the supply outlet of said fuel tank; a heat exchanger serially connected between the discharge of said pressure pump and said supply inlet of said suction chamber; a selective valve having a first inlet port connected to the recirculation outlet of said suction chamber, a first outlet port paired to said first inlet port and connected to said recirculation return inlet of said fuel supply tank; a second inlet port connected to a source of pneumatic pressure, a second outlet port paired to said second inlet port and connected to the pressure supply port for the servo-operated valve, and a discharge vent; a tap in said selective valve having a through channel and a discharge channel whereby fuel oil delivered under pressure from the circulating pump is heated in the heat exchanger and selectively circulated either serially through the suction and pressure chambers of the injection pump, the inlet channel, the fuel chamber, the outlet channel

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the servo-operated valve, the discharge port of the servo-operated valve, and the recirculating return inlet of the fuel tank when the through channel of the tap of the selective valve interconnects the paired second inlet and outlet ports of the selective valve thereby opening the servo-operated valve, or through the suction chamber of the fuel injection pump and the recirculation return inlet of the fuel tank when the through channel of the selective valve tap interconnects the paired first inlet and outlet ports of the selective valve and the discharge channel of the tap of the selective valve interconnects the second outlet port and the discharge vent of the selective valve thereby closing the servo-operated valve.

3. A fluid fuel supply circulating system for internal combustion engines comprising a fuel supply tank having a supply outlet and a recirculation return inlet; a fuel injection valve having an injection nozzle, a fuel chamber internally adjacent the injection nozzle, a servo-operated valve, an inlet channel to said fuel chamber, an outlet channel connecting said fuel chamber and the intake of said servo-operated valve, a discharge port for said servo-operated valve connected to said recirculation return inlet of said fuel supply tank, and a pressure supply port for the servo-operated valve; a fuel injection pump, the discharge of said fuel injection pump being connected to the inlet channel of the fuel injection valve; a suction chamber in said fuel injection pump; a pressure chamber in said fuel injection pump; a conduit interconnecting said suction and pressure chambers; a supply inlet to said suction chamber; a recirculation outlet from said suction chamber; a fuel circulating pressure pump having its intake connected to the supply outlet of said fuel tank; a heat exchanger serially connected between the discharge of said pressure pump and said supply inlet of said suction chamber; a selective valve having an inlet port connected to the recirculation outlet of said suction chamber, a first outlet port connected to the recirculation return inlet of said fuel tank, a second outlet port connected to said pressure supply port for the servo-operated valve, and a discharge vent; a tap in said selective valve having a branched through channel and a discharge channel whereby fuel oil delivered under pressure from the circulating pump is heated in the heat exchanger and selectively circulated either serially through the suction and pressure chambers of the injection pump, the inlet channel, the fuel chamber, the outlet channel, the servo-operated valve, and the discharge port of the servo-operated valve, and the recirculating return inlet of the fuel tank when the branched through channel of the selective valve tap interconnects the inlet port and the second outlet port thereby delivering the fuel under pressure to the servo-operated valve to open said servo-operated valve, or through the suction chamber of the injection pump and the recirculating return inlet of said fuel tank when the branched channel of the selective valve tap interconnects the first inlet and first outlet ports and the discharge channel of the selective valve tap interconnects the second outlet port and the discharge vent thereby releasing the pressure on the servo-operated valve and closing said servo-operated valve.

4. In internal combustion engine fuel supply apparatus of the type including a fuel injection pump having a suction chamber, a fuel injection valve, a pressure conduit for conducting fuel from said pump to said valve, a heater for the fuel supplied said suction chamber, and a circulating system for the heated fuel by-passing said pressure conduit and including independent pump means, the improvement characterized in that the suction chamber of the injection pump is arranged in the flow path of the circulating system and selective control means are provided for diverting the flow of heated fuel leaving said suction chamber away from said circulating system to said pressure conduit with the engine at rest.

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