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[54] **DISPOSAL OF LIQUID SPILLAGE AND THE LIKE**

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[52] **U.S. Cl.** **417/80**, 417/89, 417/182.5
[51] **Int. Cl.** **F04b 23/08**, F04f 5/48
[58] **Field of Search** .... 417/79, 80, 81, 87, 89, 417/182.5; 60/39.09 F; 239/124, 127

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[57] **ABSTRACT**

The fuel dumped into a drain tank of an aircraft on shut-down of a gas turbine engine is re-introduced into the fuel system after re-starting of the engine by means of a jet pump fed by fuel from the delivery side of the backing pump via a non-return valve, which, during shut-down of the engine, prevents flow of fuel from the jet pump into the drain tank under backing-pump inlet pressure; aspiration of air after emptying of the drain tank is prevented by a float valve.

9 Claims, 3 Drawing Figures

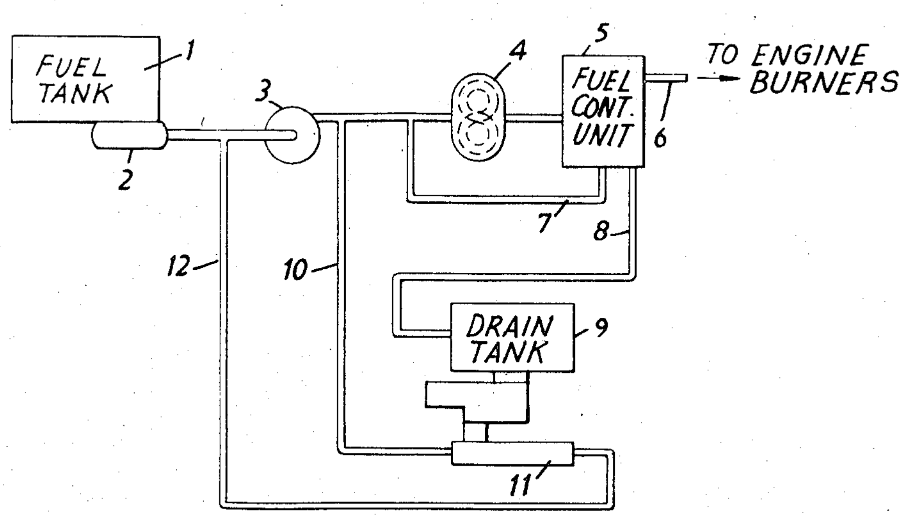
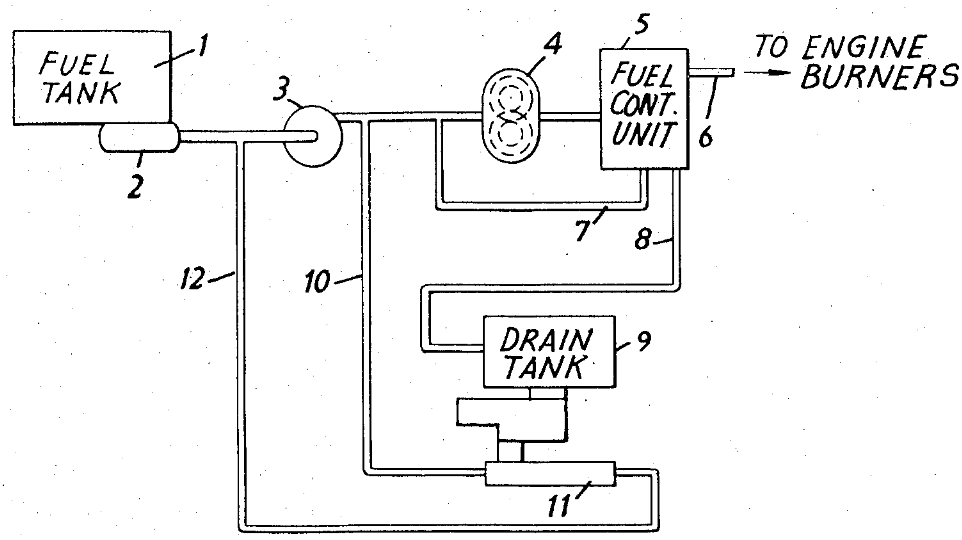


FIG. 1.


FUEL TANK
1
2
3
4
5
FUEL CONT. UNIT
TO ENGINE BURNERS
6
7
8
12
10
DRAIN TANK
9
11

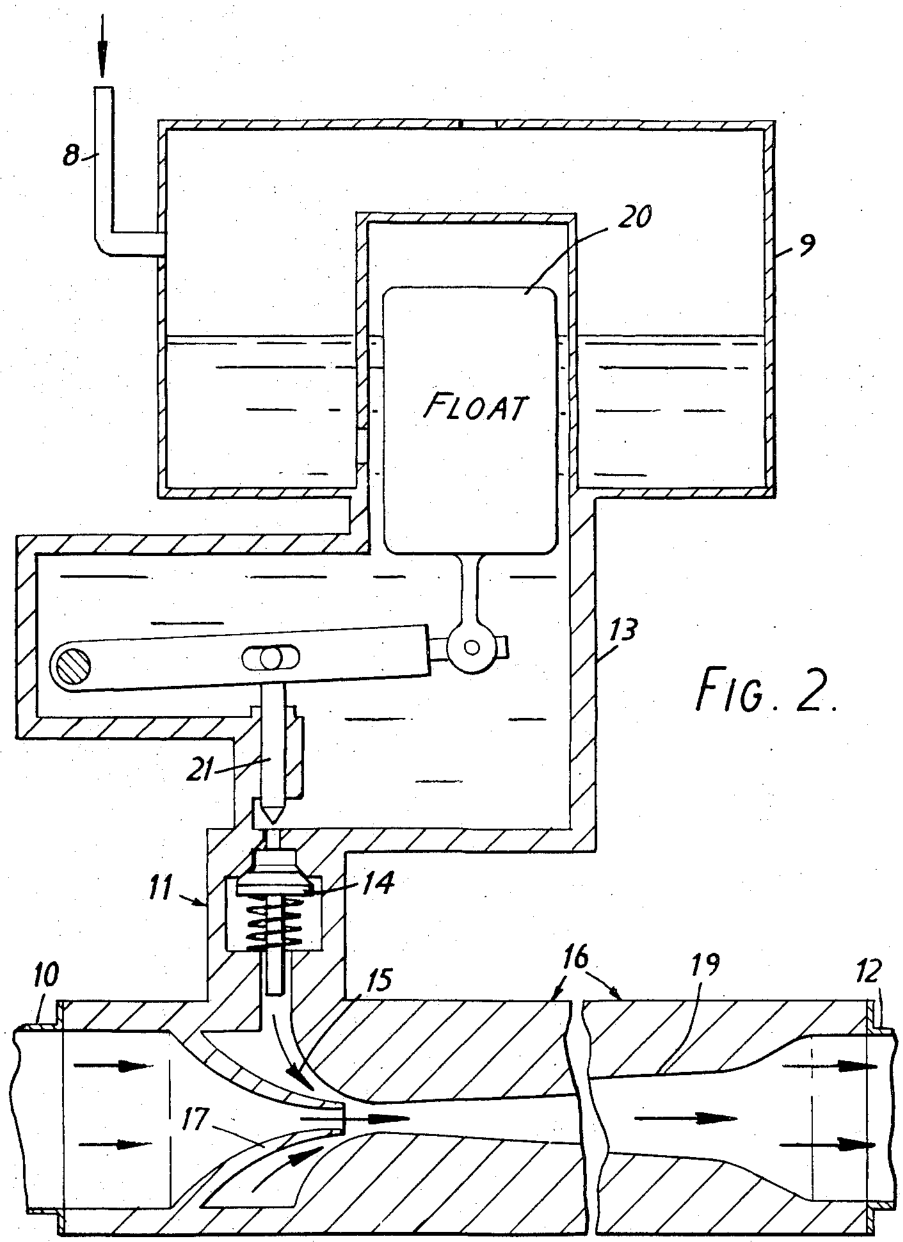
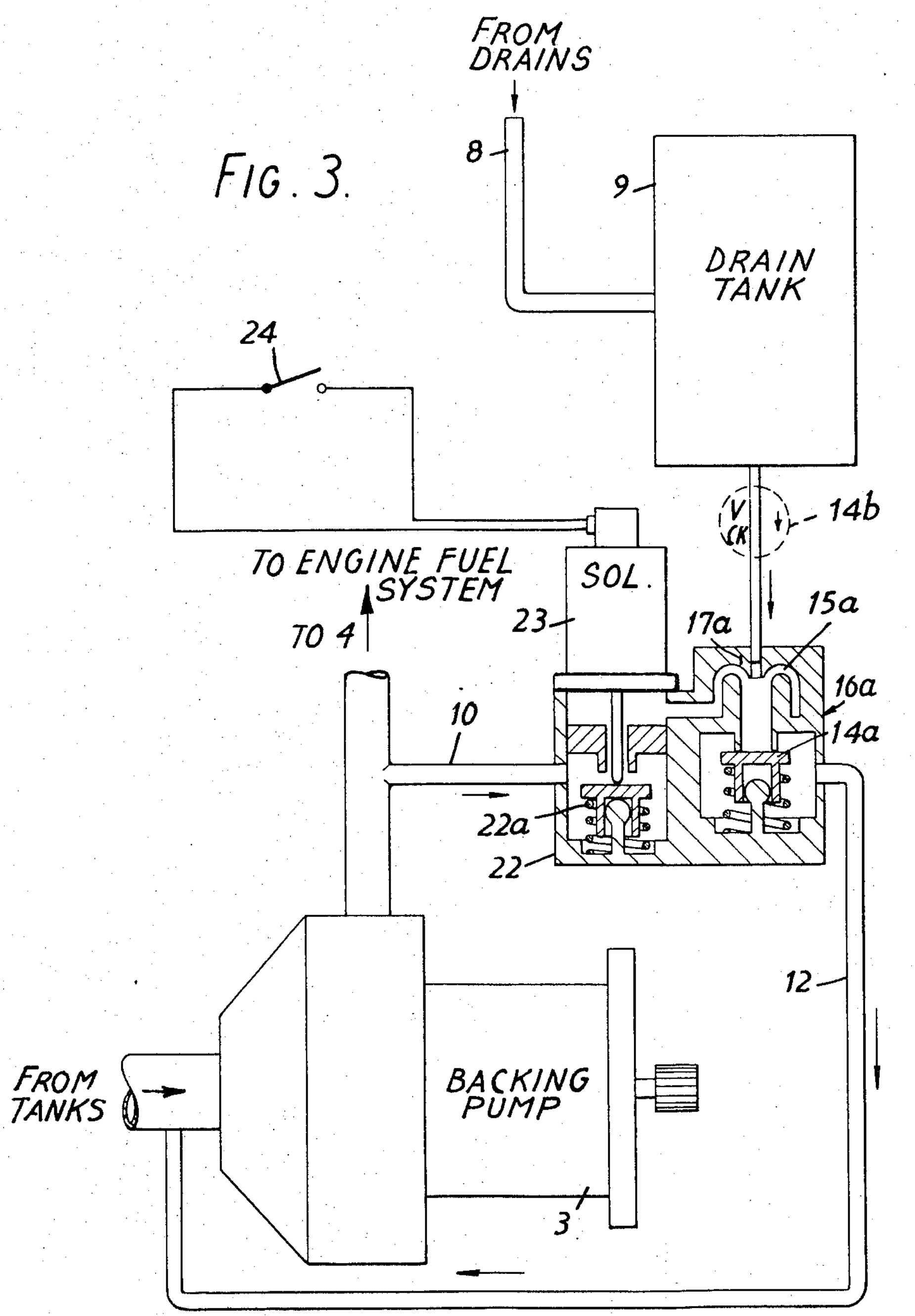


FIG. 2.

FIG. 3.


FROM DRAINS
8
9
DRAIN TANK
24
V CK
14b
TO ENGINE FUEL SYSTEM
TO 4
SOL.
23
17a
15a
16a
10
14a
22a
22
12
FROM TANKS
BACKING PUMP
3

DISPOSAL OF LIQUID SPILLAGE AND THE LIKE

This invention relates to the disposal of liquid spillage from a fluid-pressure system and has been developed with a special view to disposal of the contents of the so-called drain tank in connection with gas-turbine engines, more particularly for aircraft. In fluid-pressure systems in which fluids are raised from a lower pressure to a higher pressure by means of a pump, the problem frequently arises of the disposal of liquid, hereinafter called spill liquid, which has escaped or been released from the system and is under a pressure which is lower than the intake pressure of the pump or pumps of the system. This low pressure makes it difficult to return the spill liquid into the system, and the present invention has for a general object to provide convenient means which permit the return of such liquid into the system while the system is in operation. Thus according to the invention in a broad aspect, liquid supplied at a suitable pressure by a pump of the system is conducted, in a flow branched off the system at the delivery side of the said pump, to form the operation fluid of a jet pump arranged to draw-in the spill liquid and return it, together with the said operating liquid, to the inlet side of the said pump of the system.

In the more specific case of a gas-turbine engine, more particularly a gas-turbine engine of an aircraft, it is customary to fit the engine with a so-called drain tank into which, when the engine is to be shut down, all fuel supplied to the engine is dumped while the engine is running down. It has hitherto been customary in aircraft to retain this fuel in the drain tank while the aircraft is on the ground and to dump the content of the drain tank overboard into the atmosphere when, after take-off, the aircraft has attained a predetermined speed, leaving the tank then empty until the engine is shut down the next time.

Apart from the fact that this practice involves the loss of a quantity of fuel for each shut-down of the engine, dumping of the fuel from the drain tank is also highly undesirable because of the resultant contamination of the atmosphere and the risk of precipitation on people and it is one of the objects of the invention applied to such a system to avoid both the loss of fuel and particularly the contamination of the atmosphere and the risk of precipitation, and it will also be appreciated that more particularly in systems of this or a similar kind the use of a jet pump as the spill-return pump offers considerable advantages as regards weight and bulk while its relatively low efficiency is unimportant because its use is limited to a single short period at the beginning of each run of the gas turbine.

In order that the invention may be more readily understood, one embodiment and a modification of a detail thereof will now be descibed in more detail with reference to the accompanying drawings, in which

FIG. 1 is a diagram of the fuel system of a gas-turbine engine, more particularly the gas-turbine engine of an aircraft, which incorporates a drain tank and a recovery system according to the present invention,

FIG. 2 is a somewhat diagrammatic sectional elevation of a drain tank and the elements of one form of the recovery system associated therewith, and

FIG. 3 is a diagrammatic sectional elevation of a modified recovery system together with a fuel backing pump.

Referring now first to FIG. 1, the fuel system for an aircraft gas-turbine engine includes a fuel tank 1 equipped with a booster pump 2. This booster pump feeds fuel from the tank 1 to a backing pump 3, which serves to supply the fuel to a high-pressure main fuel pump which generally is a metering pump, repesented as a gear pump 4 and arranged to supply a metered quantity of fuel per revolution of the engine to a fuel-control unit 5. During operation of the engine, this fuel-control unit allocates an appropriate flow of fuel to a line 6 feeding the engine burners and returns the excess fuel via a line 7 to the inlet of the metering pump 4. When the engine is being shut down, fuel is drained from the engine-burner feed line 6, and since rapid and effective draining is required, the pressure is so low that it cannot be used for forcing the drained fuel to flow back into the system, and for this reason and drained fuel is dumped via a dump line 8 into a so-called drain tank 9..

To keep the dimensions of the drain tank small, regular emptying of the drain tank is necessary, normally after each engine shut-down, and this was hitherto done by dumping the fuel contents of the drain tank overboard. To avoid the need for such dumping, the illustrated arrangement is equipped with a branch line 10 which, when the fuel system is operative again after re-starting of the engine, directs a small portion of the delivery of the backing pump 3 through a unit 11 hereinafter referred-to as drain scavenge unit, from which the fuel flow from branch line 10, together with aspired fuel from the drain tank 9, is returned to the inlet of the backing pump 3 through a feed-back line 12, and two forms of such drain-scavenge units are respectively illustrated in more detail in FIGS. 2 and 3.

Referring now to FIG. 2, which illustrates a preferred form of drain scavenge unit 11, the drain tank 9 is formed with a well 13 which, via a non-return valve 14 leads to the throat tapping 15 of a jet pump 16, to whose jet nozzle 17 the branch line 10 is attached to supply a flow of fuel from the delivery side of the backing pump 3. This flow together with admixed liquid drawn from the drain tank 9 which has been introduced through the throat tapping 15, then passes through a diffusor portion 19 of the jet pump, where its static pressure increases. The mixture, whose pressure has thus been increased, then passes through the feedback line 12, by which it is returned to the inlet side of the backing pump 3. The non-return valve 14 has been provided in order to prevent when the engine has been shut down, and when accordingly backing-pump inlet pressure prevails throughout the jet pump 16, fuel under this pressure from flooding the drain tank 9 by way of the throat tapping 15 of the jet pump 16. Since fuel is only fed to the drain tank 9 for a short period each time when the engine is shut down, it will be appreciated that withdrawal of fuel from the drain tank 9 by means of the jet pump 16 should only take place for a short period after re-starting of the engine in order to avoid the risk of aspiration of air by the jet pump when all the fuel hás been withdrawn from the drain tank. In order to avoid this risk, the drain tank 9 is preferably equipped with a float 20, which is arranged to operate a float valve 21 at the bottom of the well 13 so as to prevent, when the level of fuel in the drain tank 9 has fallen to a predetermined limit, the jet pump 16 from withdrawing any further fuel from the tank 9 and well 13, and it will be readily appreciated that if desired, movement of the float may additionally or alternatively by arranged to cut-off the supply of liquid to the jet nozzle **17** through the line **10**, thereby limiting the use of energy for the provision of a branch flow through line **12** to the period necessary to empty the drain tank. Such limitation may alternatively be effected by other means, for example by the use of a solenoid valve, and one construction employing this alternative has been illustrated in FIG. **3**.

Referring now to FIG. **3**, the drain tank **9** is connected to the throat inlet **15***a* of a jet pump **16***a* without the interposition of a float valve, but a stop valve **22**, operable by solenoid **23** against a spring **22***a* urging the valve to the closed position, is interposed between the branch line **10** from the delivery side of the fuel-backing pump **3** and the jet inlet **17***a* of the jet pump **16***a*. The solenoid may be controlled by a pilot-operated switch symbolically indicated at **24** in FIG. **3** or, if desired, by a switch operated by a float similar to the float **20** of FIG. **2**. When the solenoid is energised, the valve **22** assumes the closed position shown in FIG. **3**, in which flow is admitted from line **10** to the jet pump **16***a*. When the fuel level in the tank **9** has fallen to a desired level, the switch **24** opens to de-energise the solenoid **23** so that the latter cuts-off the supply of liquid to the jet inlet **17***a*. It will be noticed that in the embodiment of FIG. **3** the non-return valve has been interposed at **14***a* between the pump **16***a* proper and its connection to the feedback line **12** but if desired, the non-return valve may alternatively be arranged in the connection between the tank **9** and the throat inlet **17***a* of the jet pump, as indicated in broken lines at **14***b*.

The embodimetns illustrated may be modified in vairous other respects without exceeding the scope of the invention. Thus the jet pump may, if desired, be fed by fuel from the delivery side of the main fuel pump **4**, from which, more particularly when the latter is not of the metering type, the flow feeding the jet pump may be branched off between the main fuel pump and the control unit **5** or, more particularly when the main fuel pump is used for metering purposes, the spill flow in the return line **8** may be utilised to operate the jet pump. Furthermore, the invention may, for example, be employed to return liqnid which has escaped through a shaft seal of a pump to the inlet side of the pump, even if the pressure at this inlet side is higher than that of the escaped liquid, by re-introducing the liquid with the help of a jet pump which is operated by a branch flow from the delivery side of the pump in question and whose diffusor is connected to the inlet side of the same pump.

What we claim is:

1. A fuel-supply system for a gas-turbine engine of an aircraft, which includes: a source of liquid fuel; an en-

gine-fuel line for supplying fuel to the engine; a fuel pump which has an inlet connected to said source and an outlet leading to said engine-fuel line and which is operable to deliver fuel under pressure to said line; a drain tank at a pressure lower than the pressure at said inlet; control means operable to cut-off delivery to the engine-fuel line from said pump and establish low-resistance communication between said line and the drain tank for facilitating rapid shut-down of the engine; a jet pump having a jet nozzle, an outlet connected to the inlet of said fuel pump, a jet-fuel inlet connected to said engine-fuel line downstream of said fuel pump and leading to said jet nozzle, and an induced-flow inlet; and a drain-fuel return line connecting said drain tank to said induced-flow inlet, said jet pump being operable, after the engine has been restarted subsequently to a shut-down, to withdraw fuel from the drain tank and pressurise the thus withdrawn fuel, causing such fuel to re-enter the system at a point upstream of the said fuel pump.

2. A fuel-supply system as claimed in claim **1**, further including a pressurising pump interposed between said fuel pump and said engine-fuel line, said fuel pump being arranged to operate as a backing pump for said pressurising pump.

3. A fuel-supply system as claimed in claim **1**, further including a non-return valve preventing flow to the drain tank from the said fuel pump through the jet pump and drain-fuel return line.

4. A fuel-supply system as claimed in claim **1**, which further includes cut-off means operable to render said jet pump inoperative after completion of a drain-fuel return operation following a shut-down of the engine.

5. A fuel-supply system as claimed in claim **4**, which includes a float arranged to rise and fall according to the level of fuel in the drain tank and to operate said cut-off means when that level is below a predetermined minimum.

6. A system as claimed in claim **5**, wherein said cut-off means include a valve operatively connected to said float so as co cut-off flow through said drained-fuel return line when said level is below a predetermined minimum.

7. A system as claimed in claim **4** wherein said cut-off means include means cutting-off the supply of the fuel to the jet nozzle of the jet pump.

8. A system as claimed in claim **4**, wherein said cut-off means include a solenoid valve.

9. A system as claimed in claim **4**, when installed in an aircraft having an engine forming part of the thrust-producing power system thereof, the system being arranged to supply fuel to said engine.

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