OIL BURNER WITH SPILL RETURN DUCT
CONTROLLABLE BY FLOW REVERSAL

Filed July 18, 1952

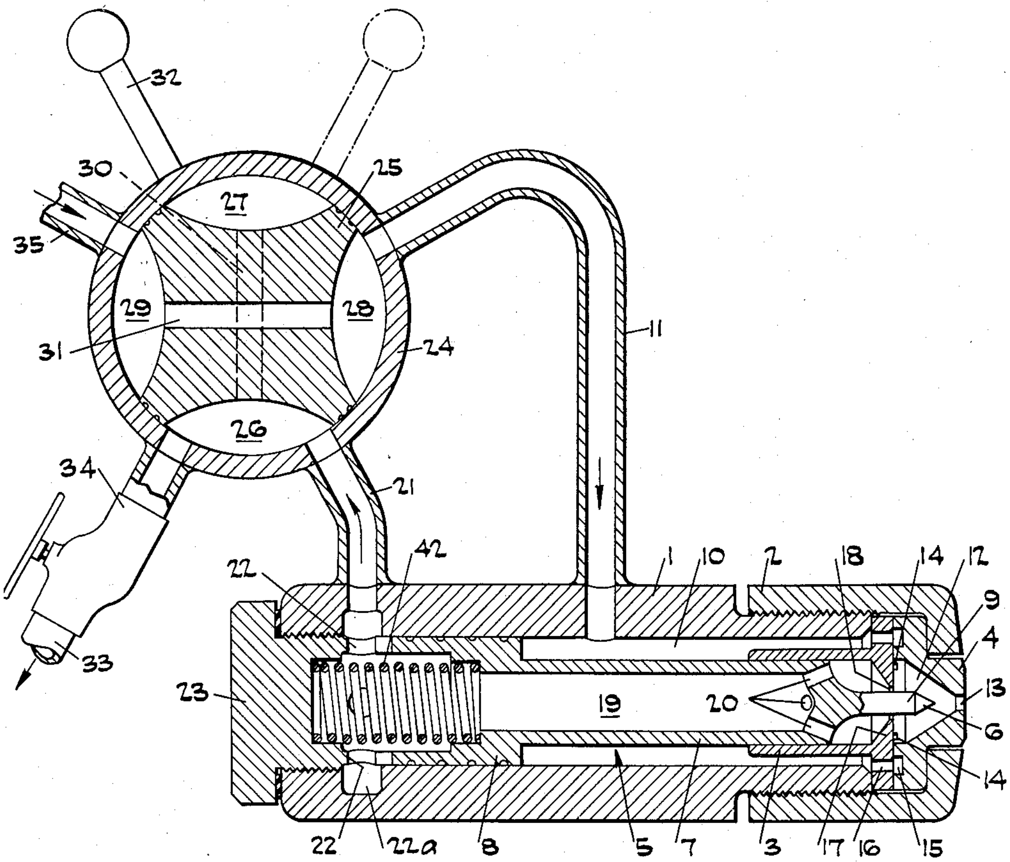

FIG. 1

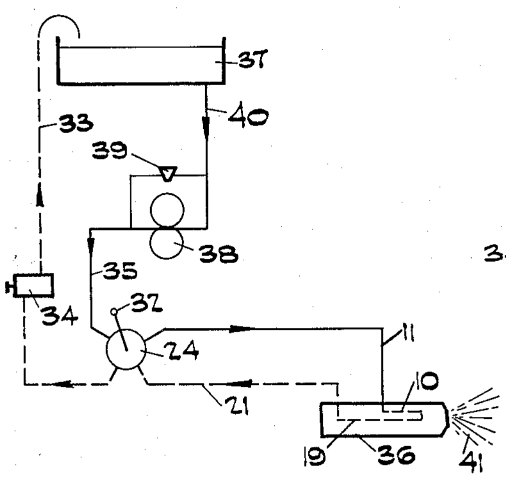

FIG. 2

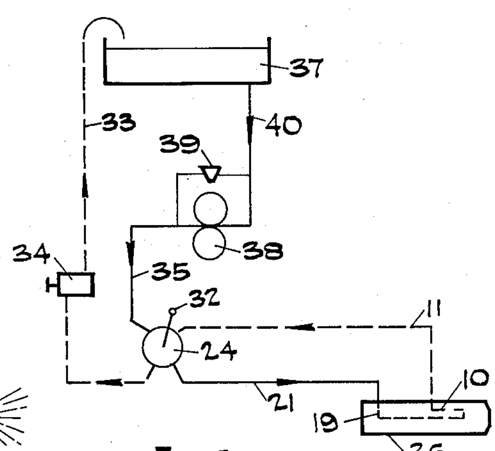

FIG. 3

Inventor: Alan W. Wilson
By Oswald H. Milmore
His Attorney

United States Patent Office

2,743,137
Patented Apr. 24, 1956

2,743,137

OIL BURNER WITH SPILL RETURN DUCT CONTROLLABLE BY FLOW REVERSAL

Alan William Wilson, London, England, assignor to Shell Development Company, Emeryville, Calif., a corporation of Delaware

Application July 18, 1952, Serial No. 299,611
Claims priority, application Great Britain August 2, 1951
11 Claims. (Cl. 299—118)

This invention relates to apparatus for burning liquid fuel of the type comprising a reservoir for liquid fuel such as oil and a pump for supplying fuel from this reservoir under pressure to one or more liquid fuel-atomizing burners of the kind which comprises a pre-chamber, such as a vortex chamber, communicating with a fuel supply duct through one or more ports, such as tangential ports, and with a spill return duct for returning a variable amount of excess fuel from the vortex chamber to the reservoir, the vortex chamber having a final outlet orifice through which the fuel emerges as a spray. Apparatus of this type is hereinafter referred to as "apparatus of the type specified." The invention relates further to an improved liquid fuel-atomizing burner proper, suitable for use in the apparatus of the type specified.

It is frequently necessary or desirable to circulate the liquid fuel through the body of the burner to a point adjacent to the burner tip when the burner is not in operation, i. e., before the tip or orifice valve thereof is opened up, in order, for example, when heavy or highly viscous fuel is used, to displace viscous cold fuel which is left in the vortex chamber and associated parts from a previous operation and to replace it by heated fuel which has a lower viscosity and is adapted to be discharged through the orifice as a well-formed spray. It may also be desirable to circulate fuel through the burner immediately after it has been shut down, in order to protect it from the heat radiated by the combustion chamber wall. Again, where a combustion chamber is provided with a plurality of atomizing burners, some of which may be shut down under conditions of light load while others are in operation, it is advantageous to circulate fuel through the burners that are shut down in order to cool them and thereby avoid damage to them from the intense radiation of the flames from the other burners or of the refractory in the combustion chamber.

In order to enable the fuel to be circulated through the atomizing burner when the latter is not in operation, it has heretofore been proposed to provide the burner with a tip or orifice valve which can be operated manually to close the final orifice, thus allowing fuel to be circulated through the fuel supply duct, vortex chamber and spill return duct in sequence without issuing from the final orifice. Manual operation of the tip valve, however, involves structural complication, especially where the rear end of the burner is enclosed, for example, in the air supply duct of a gas turbine combustion chamber. It has also been proposed to utilize the differential pressure between the fuel supply duct and the spill return duct to open the tip valve against the pressure of a spring tending to close it. The rating or stiffness of the spring must be such that the maximum differential pressure at which the fuel can be circulated when the tip valve is closed is less than the minimum pressure differential when the burner is in operation. Since the latter differential is quite low when the burner is operating at maximum load, with the spill return duct closed or nearly closed, the circulation of the fuel with the tip valve closed must be carried out at a differential pressure which may

be insufficient to produce an adequate flow, especially with viscous fuels. Moreover, if the stiffness of the spring is such as to afford a narrow margin between the pressure differential at which the tip valve closes and the minimum operating differential pressure of the burner, capricious operation may result, with the tip valve tending to close at maximum burner loads. Again, a drop in the stiffness of the spring due to a change in the ambient temperature of the space wherein it operates may lead to the opening of the tip valve when fuel is circulating under non-operating conditions, with undesirable and even dangerous results.

The main object of the present invention is to provide an improved construction for controlling the tip valve in a manner which avoids the above-mentioned disadvantages of the previous proposals.

A specific object is to provide an improved liquid fuel-atomizing burner having a tip valve the position of which can be controlled by controlling the direction of flow of fuel through the burner. Another specific object is to provide an improved apparatus of the type specified wherein provision is made for reversing the direction of flow of fuel from the pump through the atomizing burner and back to the reservoir.

The foregoing objects are attained in accordance with the invention by providing each liquid fuel-atomizing burner of the apparatus of the type specified with a tip valve adapted to close the final outlet orifice of the vortex or pre-chamber and operatively connected to a differential pressure responsive device, such as an operating piston which may be integral with the valve or a diaphragm, having movable surfaces disposed to act in opposition to each other of which one face is exposed to a fluid, e. g., the fuel itself, substantially at the pressure prevailing in the fuel supply duct and the other to fluid at substantially the pressure in the spill return duct, the vortex chamber being connected to the fuel supply duct and to the spill return duct by the passageways which inherently create a pressure differential whereby the downstream pressure is lower than the upstream pressure.

The composite apparatus, which may include one or a plurality of liquid fuel-atomizing burners as described in the foregoing paragraph, has a flow-diverting valve for each burner connected to the outlet of the fuel pump to permit the fuel under pressure to be directed at will either to the fuel supply duct or to the spill return duct of the respective burners; further, valve means (which may be a part of the aforesaid valve or an additional valve connected for synchronous operation therewith) are provided for each burner to selectively connect either the spill return duct or the fuel supply duct (whichever is not receiving fuel from the pump) of the respective burner to an oil reservoir so as to maintain a complete circuit. A simple four-way valve may serve both of the foregoing purposes. The valve thus permits the flow of fuel through the burner to be reversed. When the flow is in the normal direction, that is from the fuel supply duct through the vortex chamber to the spill return duct, even a slight differential pressure serves to open the tip valve. When the flow is reversed, differential pressure acts in the opposite direction and closes the valve. Hence, the pressure at which the fuel is circulated when the tip valve closes can be as high as desired without incurring any risk of opening the valve.

In order to hold the tip valve closed and prevent dribble from the burner orifice when the pump is not operating, the tip valve may be advantageously provided with a light spring which is capable of holding the valve closed in these conditions. Such a spring will, of course, be considerably weaker than would be necessary to close the valve under any differential pressure encountered during operation of the burner.

The invention has the advantage that it lends itself to remote control of the burner, and to individual or simultaneous control of a number of burners. For simultaneous control, it is only necessary to arrange that the valve means shall be common to all the burners served by the same pump, or to one or more groups of such burners, while for individual control separate valve means are provided for each burner.

The invention will be further described with reference to the accompanying drawing forming a part of this specification and showing by way of example a preferred embodiment, wherein:

Figure 1 is a longitudinal section through a burner connected with a valve for reversing the flow therethrough; and

Figures 2 and 3 are flow diagrams showing the complete apparatus and illustrating, respectively, normal and reversed fuel flows.

Referring to Figure 1, the liquid fuel-atomizing burner comprises an outer casing or hollow body **1** having a threaded cap nut **2** which retains a flanged sleeve **3** and an orifice wall or jet plate **4** within and in front of the body **1**, respectively. A valve member **5**, disposed within the body **1**, comprises a tip valve **6**, a hollow stem **7** and a hollow, enlarged piston **8**, the tip valve **6** being formed on the end of a rod **9** of reduced diameter which is integral with the stem **7**. The piston **8** has a close sliding fit in the cylindrical bore of the body **1** and the forward part of the stem **7** has a similar fit within the cylindrical bore of the sleeve **3**, so that the valve member **5** is capable of sliding axially within the burner.

The annular space **10** between the body **1**, on the one hand, and the stem **7** and sleeve **3**, on the other, constitutes the fuel supply duct of the burner; it communicates with a fuel supply pipe **11**. Formed within the jet plate **4** is a conical swirl or vortex chamber or pre-chamber **12** which has a final orifice **13** and communicates with the fuel supply duct **10** by way of tangential swirl ports **14**. The outer ends of these ports communicate with an annular groove **15** formed in the rear face of the plate **4** so as to be always in communication with holes **16** formed in the flange of the sleeve **3** and arranged along a circle. The sleeve **3** has an inwardly projecting flange **17** forming the rear wall of the swirl or vortex chamber **12** and providing a central opening through which the rod **9** of the tip valve projects with an annular clearance **18**.

The interior of the stem **7** and the piston **8** constitute the spill return duct **19** of the burner, which communicates with the vortex chamber **12** by way of the annular clearance **18** and a plurality of holes **20** extending through the shoulder formed by the junction of the rod **9** and the stem **7**. The rear end of the spill duct **19** communicates with a discharge pipe **21** by way of holes **22** in a cap **23** which closes the rear of the body **1** and a groove **22*a*** formed in the body **1**.

The pipes **11** and **21** lead to ports in a rotary, four-way valve **24** comprising a cylindrical body in which is rotatably mounted a valve member **25**. The latter has recesses **26** to **29**, inclusive. Recesses **26** and **27** are inter-connected by a bore **30** formed in the member **25**, and recesses **28** and **29** are inter-connected by a separate bore **31** also formed in member **25**. The valve member **25** can be rotated by a lever **32** between two portions limited by stops not shown in the drawings. In the position shown in Figure 1, discharge pipe **21** is connected by recess **26** with a return pipe **33** which is provided with a spill control valve **34**; and supply pipe **11** is connected by recess **28**, bore **31** and recess **29** with a pipe **35** through which fuel under pressure is supplied from a pump. When the valve member **25** is rotated clock-wise to its other position, in which the lever **32** occupies the position shown in chain lines in Figure 1, supply pipe **11** is connected by recess **27**, bore **30** and recess **26** with the return pipe **33**; and discharge pipe **21** is connected by recess **28**, bore **31** and recess **29** with the pipe **35**. Thus, rotation of the valve member **25** has the effect of reversing the connections of pipes **11** and **21** on the one hand with pipes **33** and **35** on the other, and the valve is seen to be of the type adapted to connect the pipes **35** and **33** to the pipes **11** and **21** selectively either in corresponding or reversed relation.

As shown diagrammatically in Figures 2 and 3, the fuel-burning apparatus comprises in addition to the liquid-atomizing burner indicated as a whole by number **36**, a reservoir **37** containing liquid fuel, the spill control valve **34**, a fuel pump **38** having the usual relief valve **39**, and the four-way valve **24**.

Figure 2 shows the direction of fuel flow when the lever **32** of the four-way valve **24** is in the position for operation of the burner. In this position, the fuel flows from the reservoir through a pipe **40** to the pump **38** and thence through the pipes **35** and **11** to the fuel supply duct **10** of the burner **36**. From this duct, it enters the vortex chamber **12** and a part of the swirling fuel emerges from the final orifice **13** as a spray **41**, while the remaining part flows out through the clearance **18**, holes **20** and spill return duct **19**. This spill fuel, the proportion of which is controlled by the spill control valve **34**, flows by way of pipes **21** and **33** back to the reservoir **37**.

Figure 3 shows the direction of fuel flow when the lever **32** is in the position for circulation of fuel flow when the burner is out of operation. In this position, the fuel flows from the pump **38** through pipes **35** and **21** into the spill return duct **19** and thence forwardly into the vortex chamber **12**. The tip valve **6** being now closed, the whole of the fuel flows through the swirl ports **14** into the fuel supply duct **10** and thence through the pipes **11** and **33** back to the reservoir **37**.

With the fuel flow as shown in Figure 2, the differential pressure between the fuel supply duct **10** and the spill return duct **19**, acting on the piston **8**, serves to hold the tip valve **6** in the withdrawn or open position. When the fuel flow through the burner is reversed, as shown in Figure 3, the differential pressure, again acting on the piston **8**, serves to hold the tip valve in the forward or closed position in which it seats on the wall of the final orifice **13**. Thus, with the lever **32** in the Figure 3 position, as long as the pump **38** is operating the tip valve is held closed and fuel can be circulated freely at any desired pressure, the latter being controlled jointly by the pump and the valve **34**. In order, however, to prevent dribble from the final orifice **13** when the pump **38** is not in operation, a weak compression spring **42** is provided which urges the valve member **5** into the forward or closed position. When the lever **32** is in the Figure 2 position, the tip valve is held firmly open at any operating fuel pressure, even at full burner output when the spill control valve **34** is nearly or fully closed, since the opening of the valve is opposed only by the spring **42**, which is rated to exert a pressure substantially below that due to the minimum operating differential pressure between ducts **10** and **19**. Instead of placing the spring **42**, as shown in Figure 1, in an enlargement of the duct within the hollow piston **38**, the spring may be situated in the duct **10** or in any other convenient position.

I claim as my invention:

1. A liquid fuel-atomizing burner for spill return systems that have means for reversing the flow of fuel comprising: a housing having a fuel supply duct; a pre-chamber communicating with said duct; an orifice wall forming a wall of said pre-chamber and containing a final orifice for said pre-chamber; a tip valve adapted to close said orifice; a spill return duct communicating with said pre-chamber and open for fuel flow in both directions; and means responsive to the direction of fuel flow through said open spill return duct for closing said tip valve upon flow of fuel in one direction and opening the tip valve

upon flow of fuel in the opposite direction, said means including a differential pressure-responsive device having movable surfaces disposed to act in opposition to each other and exposed to fluid pressures substantially at the pressures of liquid fuel in said fuel supply duct and spill return duct, respectively.

2. A burner according to claim 1 wherein said surfaces have substantially equal areas and the tip valve is provided with a weak spring biasing said valve to closed position, whereby said valve is closed when said pressures in the fuel supply duct and in the spill return duct are substantially equal.

3. A liquid fuel-atomizing burner for spill return systems that have means for reversing the flow of fuel comprising: a housing having a fuel supply duct; a vortex chamber communicating with said fuel supply duct through one or more ports tangential to the axis of said chamber; an orifice wall forming a wall of said chamber and containing a final orifice for said chamber; a reciprocable tip valve having a closed position for closing said orifice and an open position; a spill return duct communicating with said vortex chamber and open for fuel flow in both directions; and means responsive to the direction of fuel flow through said open spill return duct for closing said tip valve upon flow of fuel in one direction and opening the tip valve upon flow of fuel in the opposite direction, said means including a movable member having opposed surfaces exposed to fluid pressures substantially at the pressures of liquid fuel in said fuel supply duct and spill return duct, respectively.

4. A burner according to claim 3 wherein said housing has a cylindrical bore and said movable member is a piston reciprocable within said bore.

5. A liquid fuel-atomizing burner for spill return systems that have means for reversing the flow of fuel comprising: a housing having an axial bore and providing a fuel supply duct; a hollow piston in the rear part of the housing axially reciprocable within said bore having the forwardly facing surfaces thereof exposed to fuel in said fuel supply duct, the interior of said piston defining a spill return duct that is open at the rear of the piston, whereby the rearwardly facing surfaces of the piston are acted upon by fuel in the spill return duct; a wall structure at the front of the housing defining a vortex chamber having one or more ports tangential to the axis of the vortex chamber for admitting fuel from the fuel supply duct tangentially into the vortex chamber; an orifice wall at the front of said vortex chamber having a final orifice; an opening in said wall structure in rear of said vortex chamber, the front of said spill return duct being constantly in communication with said vortex chamber through said opening for fuel flow in both directions; a stem at the front of said hollow piston projecting forwardly into the vortex chamber through said opening with a clearance permitting the flow of fuel; and a tip valve at the front of said stem situated to close said final orifice when the piston is in the forward position and retractable with said piston to open the orifice.

6. A burner according to claim 5 having a spring acting between said housing and the piston biasing said piston to forward position.

7. A burner according to claim 6 wherein the rear part of said spill return duct is enlarged in relation to the forward part and said spring is situated within said enlarged part.

8. Apparatus for burning liquid fuel comprising: a source of liquid fuel under pressure; a liquid fuel-atomizing burner having a fuel supply duct, a pre-chamber with an orifice wall containing a final orifice, a tip valve adapted to close said orifice, a spill return duct communicating with said pre-chamber, and a differential pressure-responsive device having movable surfaces disposed to act in opposition to each other and exposed to fluid pressures substantially at the pressures of liquid fuel in said fuel supply duct and spill return duct, respectively, operatively connected to said tip valve to close the tip valve when the fuel pressure in the spill return duct exceeds that in the fuel supply duct and to open the tip valve when the fuel pressure in the fuel supply duct exceeds that in the spill return duct; and a diverting valve adapted to connect said source of fuel under pressure at will either to said fuel supply duct or to the spill return duct.

9. In combination with the apparatus according to claim 8, a liquid fuel reservoir; and valve means associated with said diverting valve for connecting either said fuel supply duct or the spill return duct, whichever is not connected to said source of fuel under pressure, to the reservoir to discharge fuel to the reservoir.

10. Apparatus for burning liquid fuel comprising: a liquid fuel reservoir; a liquid fuel pump having the intake thereof connected to said reservoir; a fuel return pipe connected to discharge oil into the reservoir; a liquid fuel burner having fuel supply and spill return ducts communicating with each other within the burner, a wall structure at the front of the burner having a final orifice, a tip valve for said orifice, and differential pressure-responsive means responsive to the pressures of liquid fuel in said ducts adapted to open the tip valve when the fuel pressure in the fuel supply duct exceeds that of the spill return duct and to close the tip valve when the fuel pressure in the spill return duct exceeds that in the fuel supply duct; and valve means adapted to connect the discharge of said pump and the said oil return pipe selectively either to the fuel supply duct and spill return duct, respectively or to the spill return duct and to the fuel supply duct, respectively.

11. Apparatus for burning liquid fuel comprising: a diverting valve of the type adapted to connect a first pair of conduits to a second pair of conduits selectively either in corresponding or reversed relation; a liquid fuel reservoir; a liquid fuel pump having the intake thereof connected to said reservoir and the discharge thereof connected to said diverting valve as one of said first pair of conduits; a fuel return pipe connected to said valve as the other of the first pair of conduits and connected to discharge fuel into said reservoir; a spill control valve in said fuel return pipe for regulating the rate of fuel flow to the reservoir; and a liquid fuel-atomizing burner comprising a housing having a fuel supply duct connected to said diverting valve as one of said second pair of conduits, a vortex chamber communicating with said fuel supply duct through one or more ports tangential to the axis of said vortex chamber, an orifice wall for said vortex chamber containing a final orifice for said vortex chamber, a reciprocable tip valve for said orifice having closed and open positions, a spill return duct communicating with said vortex chamber and connected to said diverting valve as the other of said second pair of conduits, and a movable member having opposed surfaces exposed to liquid fuel substantially at the pressures of the fuel in said fuel supply and spill return ducts, respectively, operatively connected to said tip valve to move the tip valve to closed position when the fuel pressure in the spill return duct exceeds that in the fuel supply duct and to move the tip valve to open position when the fuel pressure in the fuel supply duct exceeds that in the spill return duct, whereby said tip valve can be opened or closed at will by operation of said diverting valve to flow liquid fuel through the burner in one direction or the other.

References Cited in the file of this patent

UNITED STATES PATENTS

1,644,372	Gray	Oct. 4, 1927
1,824,952	Graham et al.	Sept. 29, 1931
2,579,004	Joyce	Dec. 18, 1951
2,579,829	Joyce	Dec. 25, 1951

FOREIGN PATENTS

536,331	Great Britain	May 12, 1941