April 17, 1945. A. P. SAHA 2,374,041

VARIABLE CAPACITY ATOMIZING DEVICE

Filed Jan. 31, 1942

FIG.1.

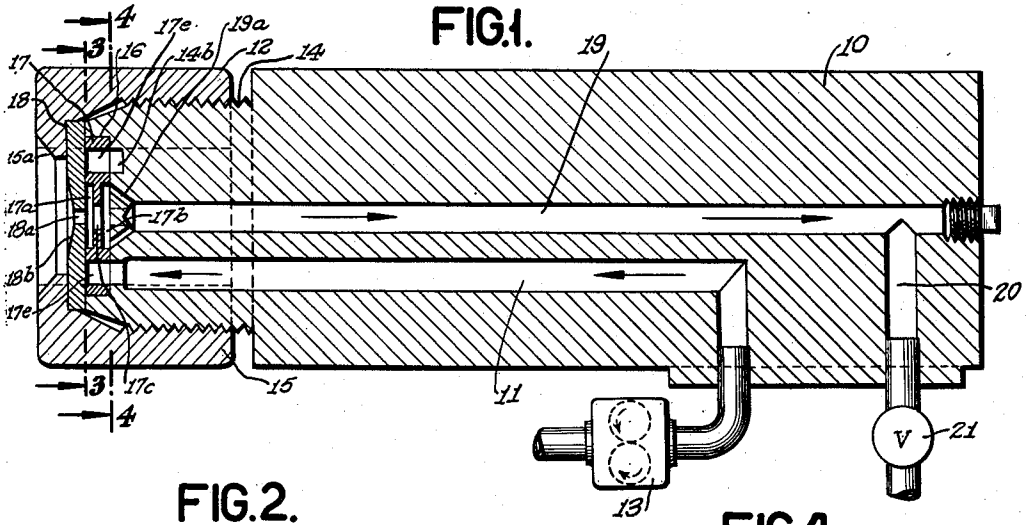


FIG.2.

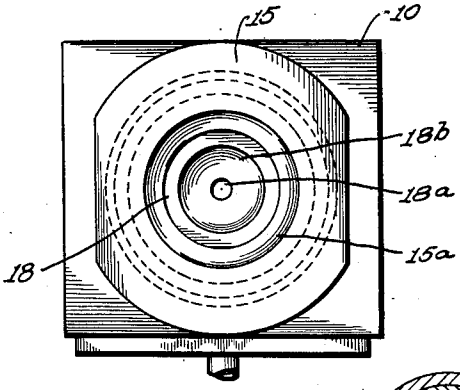


FIG.4.

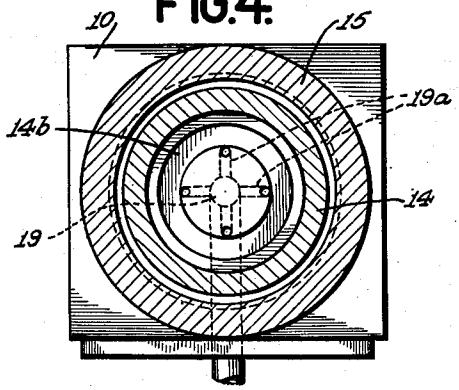


FIG.6.

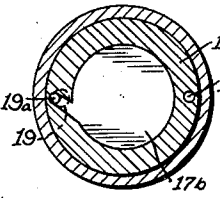


FIG.5.

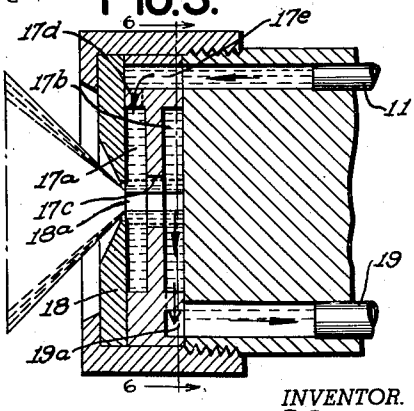
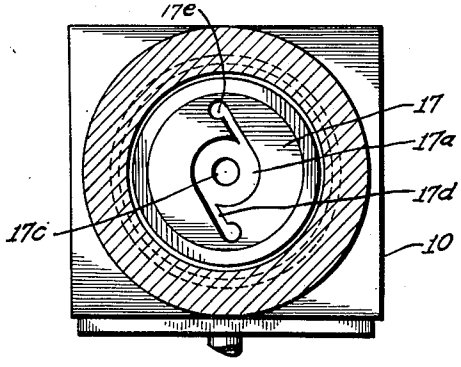


FIG.3.



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VARIABLE CAPACITY ATOMIZING DEVICE

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10 Claims. (Cl. 299—120)

This invention relates to atomizing nozzles and relates more particularly to improvements in atomizing nozzles for fuel oil burners in which the volume of atomized oil can be varied over a wide range while maintaining a uniformly good atomization at different loads.

One of the practices in the oil burner art, particularly in firing marine boilers, is to utilize a number of burners for each boiler and to operate each nozzle at a fixed optimum capacity. Variations in rate of firing are obtained by turning on or off a different number of burners.

Variable volume fuel burner nozzles have been proposed heretofore and are desirable especially in small installations where only one or a few burners are used and where accurate control is required. But none of the nozzles heretofore known has been capable of maintaining an entirely uniform type of atomization throughout a wide capacity range.

One of the prior variable capacity nozzles includes a so-called whirl chamber having a discharge or atomizing orifice and tangentially disposed oil inlets which impart rotation to the oil in the whirl chamber. The back of the whirl chamber is provided with a plurality of oil escape passages communicating with a return pipe.

The disadvantage of this type of nozzle is that the oil escape passages are in the path of the oil entering the whirl chamber through the tangential inlets, thereby permitting the oil to escape and lowering the pressure in the chamber as the amount of oil escaping through the passages increases, thereby decreasing the atomizing power of the nozzles.

Another type of nozzle includes a whirl chamber provided with tangential oil inlets, an axial discharge or atomizing outlet and an axial oil escape passage of somewhat larger diameter than the discharge outlet. The oil entering the chamber tangentially will acquire a rotating motion which acts to atomize the oil flowing in the form of an annular stream over the edges of the discharge outlet. The oil escaping through the discharge passage also will have a rotating motion which is imparted to the column of oil being returned to the tank. The rotation of the long column of return oil absorbs energy and acts as a drag on the rotation of the oil in the chamber. As a result, extra power is required to supply the oil and, under constant pressure feed conditions, variation in the amount of oil returned will vary the kinetic energy of the oil in the chamber, thereby varying the atomizing power of the nozzle.

Expedients have been suggested for overcoming the disadvantages of the nozzles described above. In one suggested type of nozzle, a whirl chamber, including tangential inlets and an axial discharge outlet, is disposed behind a second chamber having an exit port in alignment with the discharge port of the whirl chamber. The second chamber is provided with oil return passages disposed radially outwardly of the exit port.

With this arrangement oil is diverted from the annular stream discharged from the whirl chamber and is returned through an oil line to the supply tank. As the volume of return oil is varied, greater or lesser amounts of the oil may be atomized through the exit port. However, the kinetic energy of the oil issuing from the exit port will vary depending upon the amount of energy absorbed by rotation of the oil in the second chamber. The oil will have the greatest amount of kinetic energy possible at the time it passes through the discharge port and cannot have energy added to it. However, the relatively small volume of oil passing across or through the second chamber supplies energy for rotating the body of oil in the second chamber and thus a portion of its atomizing power is lost and cannot be recovered. As the volume of oil passing through the second chamber varies, the amount of energy absorbed is increased or decreased with the result that the energy remaining in the oil passing through the exit port and the atomizing power of the nozzle varies at the different discharge rates.

The present invention has as its principal object the provision of a nozzle which overcomes the defects of the nozzles described above in that, regardless of the volume of oil being atomized, the kinetic energy and tangential velocity of the oil in any portion of the atomizing outlet will remain constant.

Atomizing nozzles in accordance with the present invention may include an outer whirl chamber having at least one tangential oil inlet which causes the oil in the chamber to flow vortically, and coaxial atomizing and return ports in opposite sides of the whirl chamber. A second inner whirl chamber may be disposed rearwardly of the first chamber, and communicates with the latter through the return port. The second chamber is provided with one or more of oil return ducts near or at its periphery which communicate with a pipe having a flow control valve therein for regulating the amount of oil returned through this pipe.

In nozzles of this type, the oil discharged

through the tangential duct or ducts into the outer whirl chamber is given a vortical motion setting up a free vortex therein so that the oil attains an annular form having a hollow core. In setting up the vortical motion in the outer chamber, substantially all of the pressure head on the oil is converted into kinetic energy. When the oil escape port is of larger diameter than the atomizing port, the flow of oil through the atomizing port may be prevented by releasing the back pressure against the discharge or escape port and allowing the oil to flow freely therethrough with the whirling motion which it has acquired. This oil upon entering the inner whirl chamber tends to flow spirally outwardly in a manner substantially the reverse of the flow in the whirl chamber, but in the same direction of rotation with the result that the kinetic energy thereof is converted back into pressure.

As the flow of oil through the return pipe is diminished, as by closing or partially closing the valve therein, less oil can escape through the port between the outer and the inner whirl chambers with the result that the core which is free of oil becomes smaller and more oil can escape through the atomizing or discharge port.

By drawing the oil off through the escape port or ports in the inner whirl chamber, any tendency for the escaping oil to rotate in the return pipe is completely eliminated and the returning column of oil cannot absorb kinetic energy to decrease the tangential velocity of the oil in the outer whirl chamber. Also, the construction is such that none of the pressure on the incoming oil is used for return of discharged oil prior to the conversion of the pressure into kinetic energy. Moreover, inasmuch as the discharged oil has attained maximum kinetic energy and escapes freely, the kinetic energy of the discharge oil is not absorbed or diminished by acting upon any other body of oil of substantial volume to impart a rotating motion thereto. Therefore, the atomizing effect of nozzles embodying the present invention is substantially the same on the oil being atomized regardless of the volume of oil being discharged.

For a better understanding of the present invention, reference may be had to the accompanying drawing in which:

Figure 1 is a view in section of a typical form of nozzle embodying the present invention;

Figure 2 is an end view of the nozzle;

Figure 3 is a view in section taken on line 3—3 of Figure 1;

Figure 4 is a view in section taken on line 4—4 of Figure 1;

Figure 5 is a diagrammatic showing of the action of a nozzle of the type embodying the present invention;

Figure 6 is a view in section on a reduced scale taken on the line 6—6 of Figure 5.

As shown particularly in Figure 1, a typical form of atomizing nozzle of the type embodying the present invention may include an elongated casing 10 having a bore 11 therein through which oil may be supplied to the atomizing nozzle 12 by means of any suitable type of pump 13. The nozzle 12 may include a threaded reduced portion 14 on one end of the casing 10 upon which is received a cap 15 that retains the various elements of the nozzle in fixed position adjacent to the end of the extension 14. The outermost end of the extension 14 is provided with a recess 16 in which is mounted a disc-like member 17 having circular recesses or chambers 17*a* and 17*b* in opposite sides thereof which are the outer and inner whirl chambers referred to heretofore. The chambers are shown as cylindrical, but may be conical, hemispherical or any other desired shape. These chambers are connected by means of a bore or oil return port 17*c*. Communicating with the whirl chamber 17*a*, as best shown in Figure 3, are a pair of tangentially inclined grooves 17*d* which terminate in enlarged openings 17*e* that extend entirely through the disc-like member 17 and communicate with an annular groove 14*b* in the end of the extension 14. The disc member 17 may have one or more of the tangential inlets 17*d*. The groove 14*b* communicates with the passageway 11 so that oil may flow therethrough into the openings 17*e* in the disc 17 and thence into the chamber 17*a* through the tangential inlets 17*d*.

Overlying the disc 17 and retaining it in fixed position is an atomizing disc 18 which is provided with an atomizing or discharge orifice 18*a* in the center thereof. The orifice 18*a* and the return port 17*c* may be the same or different in diameter, but I prefer to make the return port somewhat larger in order to obtain a wider range of control of the volume of oil atomized. The outer surface of the disc 18 may be dished or have a concave recess 18*b* in order to decrease the effective thickness of the disc and permit unobstructed discharge of the oil. The cap 15 has an inwardly extending annular flange 15*a* which overlies the edges of the atomizing disc 18 and clamps it against the end of the extension 14.

Oil may be returned from the atomizing nozzle through a passageway 19 extending along the casing 10 which terminates adjacent the disc 17 in one or more narrower passages 19*a* which are so arranged that they communicate with the inner chamber 17*b* adjacent its periphery or eccentrically to the return port 17*c*. The passage 19 adjacent its opposite end may have a right-angularly related passage 20 connected to a conduit having manually or automatically controlled valve 21 therein by means of which the flow of return oil may be regulated.

Referring now to Figure 5, in operation oil is fed by the pump 13 into the passageway 11 and from the passageway into the opening 17*c*, through the tangential passage 17*d* into the outer whirl chamber 17*a* where the oil is given a whirling motion and the oil pressure is converted substantially completely into kinetic energy of rotation. For simplicity, only one tangential inlet 17*d* and one tangential discharge passage 19*a* are shown in Figures 5 and 6. The outer whirl chamber 17*a* and inner whirl chamber 17*b* and inlets and outlets thus are identical, although rotated with respect to each other at about 180°. As the oil flows into the chamber 17*a*, it will be whirled in free vortical flow in the form of an annulus of gradually increasing width. As the oil continues to flow into the chamber 17*a* the hollow core in the center of the annular whirling mass of oil will become narrower with the result that the oil will reach the edge of the escape port 17*c* and will tend to flow along this opening into the chamber 17*b* as indicated by the dotted line in Figure 5. The oil leaving the opening 17*c* and entering the inner whirl chamber 17*b* will be rotating in the same direction and will flow outwardly in an expanding vortex so that its kinetic energy will be reconverted into pressure in the exact reverse of the manner in which the oil pressure was converted into kinetic energy in the whirl chamber 17*a*. The oil will flow through the

passageway 19a under pressure and without rotation into the passage 19 and thence through the valve 21, if open, back into the supply tank, not shown. If the valve is closed completely, or partially closed, so that oil enters the whirl chamber 17a faster than it is discharged through the passage 19, the hollow core of whirling vortex of oil in the whirl chamber 17a will be reduced to a smaller diameter than the diameter of the orifice 18a and oil will begin to flow into the discharge or atomizing orifice 18a and is thrown therefrom in the form of a conical spray, as shown in Figure 5. The amount of oil passing through the atomizing orifice 18a is dependent, of course, upon the amount of oil fed to the nozzles, less the amount returned through the passageway 19.

Irrespective of the amount of oil passing through the discharge orifice 18a, the amount of energy tending to throw the oil tangentially will remain the same for the reason that the flow of oil through the discharge orifice 18a is unaffected by any other factors which would tend either to diminish the pressure of the oil, and hence its kinetic energy, which has reached a maximum at the discharge port 18a, will be diminished only to the extent of losses through friction in passing through the discharge port.

The whirl chamber 17b in which the kinetic energy of the oil flowing through the opening port 17c is reconverted into pressure contains only a very small amount of oil even when full. This mass of oil will, at best, absorb only an inappreciable amount of energy and this energy is absorbed at a zone spaced from the oil passing through the discharge orifice 18a.

The only effect that an increase or decrease in the amount of oil escaping through the passageway 19 will have is in the shape of the spray. An increase in the flow of liquid through the discharge orifice, by decreasing the flow in the passage 19, will make the spray take the form of a narrow and long cone and a decrease in the flow through the discharge orifice 18a will make the cone shorter and wider. This variation in the shape and the length of the cone spray is advantageous in that it permits a more efficient mixing of the atomized oil with the air that is fed for combustion purposes. The amount of air that is fed is usually substantially proportional to the amount of oil that is atomized and thus the volume and velocity of the air are decreased when the amount of oil atomized is decreased. In order to cause thorough mixing of the oil and the air, the oil should be directed at such an angle to the direction of flow of the air that the spray will intersect and spread across the column of air.

When larger volumes of oil are to be burned, the air volume must be increased and, therefore, better mixing and more efficient combustion can be obtained with a longer flame. The narrower and longer cone obtainable by feeding a larger volume of oil, therefore, is most satisfactory for efficient combustion at increased air velocities.

From the foregoing description of typical forms of my invention, it will be clear that a nozzle has been provided by means of which uniform atomization can be obtained regardless of the volume of liquid atomized within the operating range of the nozzle. Although the form of nozzle described above is preferred, it will be understood that the number of tangential passageways for providing vortical movement of the liquid, the shape and disposition and number of liquid escape passageways communicating with the chamber 17b can be varied and the size of the nozzle may be altered as may be desired without departing from the invention. Moreover, the nozzle is not restricted to use in fuel oil burners, but may be used in water sprinkler systems and the like. Therefore, the above-described form of nozzle should be considered as illustrative only and not as limiting the scope of the following claims.

I claim:

1. An atomizing nozzle comprising means forming a pair of coaxial inner and outer circular chambers of substantially the same capacity, means for introducing a liquid substantially tangentially into said outer chamber, means forming a circular atomizing orifice communicating with said outer chamber, means forming a circular liquid return port coaxial with, of smaller diameter than, and connecting said inner and outer chambers, means forming at least one passage communicating with said inner chamber at a point spaced from the axis of said inner chamber a distance greater than the radius of said return port for withdrawing liquid from said inner chamber, and means for regulating the amount of liquid withdrawn from said inner chamber.

2. An atomizing nozzle comprising means forming a pair of coaxial inner and outer circular chambers of substantially the same capacity, means for introducing a liquid substantially tangentially into said outer chamber, means forming a circular atomizing orifice communicating and coaxial with said outer chamber, means forming a circular liquid return port coaxial with, of smaller diameter than, and connecting said inner and outer chambers, said atomizing orifice being of lesser diameter than said return port, means forming at least one passage communicating with said inner chamber at a point spaced from the axis of said inner chamber a distance greater than the radius of said return port for withdrawing liquid from said inner chamber, and means for regulating the amount of liquid withdrawn from said inner chamber.

3. An atomizing nozzle comprising a casing, means in said casing forming a pair of coaxial spaced apart circular chambers of substantially the same capacity, means forming a port coaxial with, of smaller diameter than, and connecting said chambers, means forming an atomizing orifice in one end of said casing communicating and coaxial with one of said chambers, means for introducing liquid substantially tangentially into said one of said chambers, means forming in said casing at least one liquid return passage communicating with the other chamber tangentially to the periphery thereof at a distance from the axis of said other chamber greater than the radius of said port, and means for regulating the amount of liquid returned from said other chamber.

4. A method of atomizing a liquid, which comprises introducing liquid under pressure into a whirl chamber to create a free vortex and convert the pressure of said liquid into kinetic energy, discharging liquid freely from the center zone of said vortex to atomize said liquid by the kinetic energy thereof, withdrawing liquid from the center zone of said vortex in a direction opposite to the direction of discharge of said liquid to control the volume of liquid atomized, forming an expanding vortex rotating in the same direction as said free vortex in said withdrawn liquid, and substantially immediately converting the kinetic energy of said liquid in said expanding vortex into pressure by withdrawing the liquid in the expanding vortex from adjacent its outer periphery.

5. A method of controlling the rate of atomization of a liquid which comprises forcing a liquid under pressure tangentially to form a free vortex for converting the pressure into kinetic energy, discharging a portion of said liquid from the interior of the said vortex directly into a free space forming a spray, withdrawing the remaining portion of said liquid in the opposite direction, forming in said remaining portion of said liquid a shallow expanding vortex rotating in the same direction as said free vortex for converting the kinetic energy thereof into pressure, and regulating the volume of the withdrawn portion by controlling the pressure of the withdrawn liquid.

6. An atomizer having a supply conduit and a return conduit and a tip having a whirl chamber terminating in an orifice through which fluid is discharged for atomization, means including inlet ducts for supplying fluid from said supply conduit to said whirl chamber and for causing the fluid to rotate therein, said whirl chamber having a rear wall provided with an axial unobstructed return opening of smaller diameter than said whirl chamber and of a diameter at least as great as that of said orifice, said rear wall providing a smooth unbroken annular surface in contact with the whirling fluid in said whirl chamber, and an inner whirl chamber between said return opening and said return conduit of greater diameter than said return opening, said return opening and said inner whirl chamber being so constructed and connected as to provide direct and unobstructed communication between said return opening and said inner whirl chamber, whereby said return fluid can form an expanding vortex, said return conduit and said inner whirl chamber being connected at a point spaced from the axis of the chambers a greater distance than the radius of said return opening.

7. An atomizing nozzle comprising means forming a whirl chamber having atomizing and liquid return ports of smaller diameter than said whirl chamber on opposite sides of and coaxial with said chamber, means for introducing a liquid into said chamber to cause said liquid to form a free vortex, means forming a second whirl chamber having a length not substantially exceeding the length of said first mentioned whirl chamber and of greater diameter than said return port for receiving liquid escaping through said return port, said return port and said second whirl chamber being so constructed and connected as to provide direct and unobstructed communication between said return port and said second whirl chamber, means communicating with said second whirl chamber adjacent to the periphery thereof through which said liquid may escape from said second whirl chamber, and means for returning the escaping liquid to a zone of lower pressure than the pressure at said means for introducing liquid.

8. An atomizing nozzle comprising means forming a whirl chamber having atomizing and liquid return ports of smaller diameter than said whirl chamber on opposite sides of and coaxial with said chamber, said return port being of greater diameter than said atomizing port, means introducing liquid into said chamber to cause said liquid to form a free vortex, means forming a second whirl chamber having a capacity not substantially greater than the capacity of said first mentioned whirl chamber and of greater diameter than said return port for receiving liquid escaping through said return port, said return port and said second whirl chamber being so constructed and connected as to provide direct and unobstructed communication between said return port and said second whirl chamber, means communicating with said second whirl chamber adjacent to the periphery thereof through which said liquid may escape from said second whirl chamber, and means for regulating the amount of liquid escaping from said second whirl chamber.

9. An atomizing nozzle comprising means forming a circular whirl chamber having atomizing and liquid return ports of smaller diameter than said whirl chamber on opposite sides of and coaxial with said chamber, means for introducing a liquid into said chamber to cause said liquid to form a free vortex, means forming a second circular whirl chamber having a capacity not substantially greater than the capacity of said first mentioned whirl chamber and of greater diameter than said return port for receiving liquid escaping through said return port, said return port and said second whirl chamber being so constructed and connected as to provide direct and unobstructed communication between said return port and said second whirl chamber, means communicating tangentially with said second whirl chamber adjacent to the periphery thereof through which said liquid may escape, and means for regulating the amount of liquid escaping from said second whirl chamber.

10. An atomizing nozzle comprising means forming a whirl chamber having atomizing and liquid return ports of smaller diameter than said whirl chamber on opposite sides of and coaxial with said chamber, means for introducing a liquid into said chamber to cause said liquid to form a free vortex, means forming a second whirl chamber having a capacity not substantially greater than the capacity of said first mentioned whirl chamber and of greater diameter than said return port for receiving liquid escaping through said return port, said return port and said second whirl chamber being so constructed and connected as to provide direct and unobstructed communication between said return port and said second whirl chamber, means communicating with said second whirl chamber eccentric to said return port for withdrawing liquid from said second whirl chamber, and means for regulating the amount of liquid escaping from said second whirl chamber.

AATTO P. SAHA.