Oct. 4, 1949. A. M. I. HOOGENDAM 2,483,975

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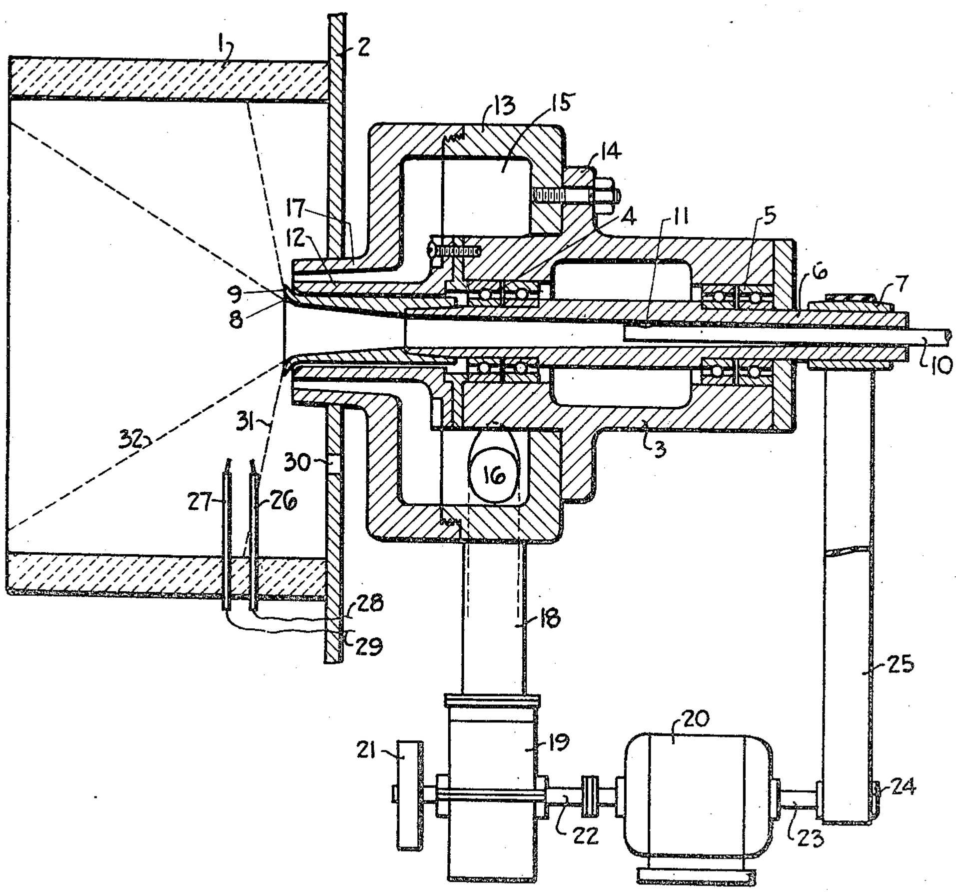
Filed July 14, 1947



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Patented Oct. 4, 1949 2,483,975

UNITED STATES PATENT OFFICE

2,483,975

ROTATING ATOMIZING CUP BURNER AND METHOD OF IGNITING AND BURNING FUEL THEREIN

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Application July 14, 1947, Serial No. 760,900
In the Netherlands June 6, 1944

Section 1, Public Law 690, August 8, 1946
Patent expires June 6, 1964

5 Claims. (Cl. 158—77)

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This invention relates to the combustion of liquid fuel which is atomized by being discharged from the tip of a rotating atomizing cup into a surrounding stream of advancing air, and is concerned particularly with an improved construction and method of operation for igniting the fuel-air mixture when starting up the burner.

Burners of this type have heretofore been ignited usually by a gas flame, such as a pilot flame. Fixed arc-electrodes have been used, but difficulty has been experienced due to deposition of carbonaceous matter on the electrodes and because the flame would be blown away from the electrodes. One possible solution is suggested by Thomas in U. S. Patent No. 2,214,568, but this is complicated because it necessitates the feeding to the burner head of an auxiliary fuel, to be supplied through an auxiliary atomizing cup when starting up the burner.

It is, therefore, an object of the present invention to provide an improved rotating atomizer cup burner constructed to permit ready ignition of the fuel-air mixture by means of fixed arc-electrodes, which will not require the use of an auxiliary rotating cup or auxiliary fuel supply.

It is a further object to provide an improved method of combustion wherein the fuel-air mixture, produced by discharging oil outwardly from a rotating atomizer cup into an advancing body of air, may be ignited by fixed arc-electrodes.

It is a specific object of the invention to provide an improved burner and an improved method of combustion wherein the air supply is regulated so as to provide a moderately low quantity of air to the burner when starting it up and a larger quantity of air after ignition, said quantity being so regulated that the fuel-air mixture will sweep the fixed arc-electrodes during the ignition phase of the operation and will advance forwardly of said electrodes during the subsequent operation of the burner.

Still another object of the invention is to provide an improved burner of the type described and an improved method of combustion wherein the ratio of air to fuel is lower during the ignition phase of the operation and is thereafter increased; ancillary thereto, it is an object to provide an improved burner and method of operation wherein the supply of air is continued for a short period of time after the fuel supply is shut

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off when putting the burner out of operation, whereby carbon which may be formed on the electrodes will be burned away and the burner will be ready for immediate operation.

With these and other objects in view, which will become apparent from the following description, reference is made to the drawings forming a part of this specification, illustrating one embodiment thereof, wherein the single figure is a vertical, longitudinal cross-sectional view of the burner installed in a furnace, parts being shown in elevation.

Briefly, according to this invention, fixed arc-electrodes are placed forwardly and somewhat to the side of the front of a rotating cup atomizer burner of the type described, and the flow of air to the burner is so controlled that, when the burner is first put into operation, the electrodes lie in the path of the mixture of air and atomized fuel discharged from the burner head; during subsequent operation the rate of air supply is increased so that the mixture of air and atomized fuel has a more forwardly direction, passing by the electrodes instead of sweeping them. Thus, in the case of the normal burning the electrodes will lie outside of the flame. The fuel stream leaving the atomizer cup can be given the desired direction in a simple way with the aid of the air stream, which seizes the fuel stream after the latter has left the atomizer cup; if only a small quantity of air is supplied, which will be done when the burner is put into operation, the fuel mist is pushed forwardly less intensively than if a larger quantity of air, having a correspondingly greater forward velocity, entrains the fuel stream. In the case of fuel which is difficult to ignite the supply of a small quantity of air when putting the burner into operation has the additional advantage that with the normal quantity of fuel this air forms an abnormally rich mixture which is more readily ignited by the arc.

The regulation of the air supply can be effected in various ways. It can be effected manually, as by providing a hand-operated damper or valve in the air supply ducts, or a rheostat on the motor which drives the air fan. Automatic arrangements are, however, preferred; they may, for example, take the form of a heavy fly wheel on the shaft which drives the air fan, whereby the fan will attain its normal speed slowly and supply a less than normal amount of air during the period of acceleration; electrically controlled devices may also be used, such as a resistance element in series with the fan motor, which is cut out after a predetermined time by a time delay relay. Such electrical circuits for short-circuiting a resistance after a time delay being per se known in the art, it is believed to be unnecessary to include a wiring diagram or a detailed description thereof in this specification, which will confine itself to the description of one simple and effective form using a fly wheel.

Referring to the drawing, the burner is shown attached to fire a furnace comprising a fire box formed of refractory walls 1 and an apertured back wall 2, to which the burner may be bolted or otherwise secured by means not shown. The burner may comprise a housing 3 having bearings 4 and 5 for rotatably mounting a hollow shaft 6. The hollow shaft is generally cylindrical throughout most of its length, but its bore is tapered slightly beginning at a point between the bearing 4 and 5 and becoming wider towards the front. A belt pulley 7, mounted on the shaft 6, permits the shaft to be rotated rapidly in the manner hereafter described, for example, between 2,000 and 23,000 revolutions per minute at normal operating speed.

The atomizer cup 8 is rigidly mounted at the forward end of the shaft 6 by any suitable means, such as screw threads. The inner surface of the cup is partly conical and partly calyx-shaped: the rear part of the cup is conical, having a greater conicity than the weakly conical taper of the shaft 6; the forward part joins smoothly with the conical part and increases progressively toward the sharp edge 9, forming a calyx, i. e., a surface of revolution flaring outwardly along a smooth curve. In the embodiment shown, only the forward quarter length of the cup is calyx-shaped, and the tangent to the inner surface in the plane of the axis makes an angle of about 78½° with the axis. Other angles, e. g., from 30° to 90° may be employed. Liquid fuel, such as oil, is introduced into the hollow shaft 6 through a stationary pipe 10, mounted concentrically therein and connected to a source of fuel by flow control means, not shown. Oil flows from the supply pipe through an orifice 11 directed laterally against the inner surface of the shaft 6.

The outer surface of the cup 8 is generally cylindrical but is curved outwardly at the forward end to terminate in a knife edge 9, whereby the external diameter of the cup in back of the edge 9 is less than the edge diameter. By this construction the tendency of oil to creep over the cup edge along the outer surface is obviated. The cup is surrounded by a stationary jacket 12, secured to the front of the housing 3 by screws, and extending almost to the cup edge 9. The outer diameter of this jacket is substantially the same as that of the cup edge, or slightly larger, as shown. While the jacket 12 may in certain cases be omitted, it is desirable to provide it to avoid imparting to the advancing air a rotational velocity component in the same direction as the cup.

The air nozzle and whirl chamber housing may be constructed in two parts. The rear part 13 is shaped as a cylindrical housing bolted to a flange plate 14 formed on the housing 3, and providing an annular whirl chamber 15 between the forwardly extending portion of the housing 3 and the inner wall. One or more tangentially directed air ports 16 are formed for the supply of

the form of a tubular air nozzle 17, having an enlargement at the rear provided with threads for engagement with the rear part 13 and forming a forward continuation of the whirl chamber. The forwardly extending tubular portion is slightly convergent, and provides an annular air passage between the nozzle 17 and the jacket 12.

Air supply conduit 18 may be formed integrally with the whirl chamber housing 13, and is connected to an air fan 19 driven by an electric motor 20. A fly wheel 21 is mounted on the drive shaft 22. The motor is also connected to a shaft 23 carrying a belt pulley 24; the latter is connected by a belt 25 to rotate the pulley 7 and shaft 6.

The refractory wall 1, which may be cylindrical and forms a fire box of circular cross-section, is provided with electrodes 26 and 27, having the terminals thereof projecting through the surrounding insulation supports and forming a spark gap between them. The terminals are located to the side and slightly forwardly of the cup edge 9. One of the electrodes may be grounded, or both may be provided with electrical conductors 28 and 29 and connected thereby with a suitable high tension source of current supply whereby a spark is caused to occur across the spark gap. An opening 30 is provided in the back wall 2 approximately in rear of the electrode terminals through which opening a small quantity of air may flow.

In the operation of the burner, oil is supplied to the supply pipe 10 at the desired normal rate at about the same time as the motor 20 is energized. It is preferred to use electrically operated valves, such as solenoid-actuated valves, energized by the circuit (not shown) which energizes the motor 20 so that the fuel valve will be opened as soon as the motor is started and closed as soon as the power to the motor is shut off. The shaft 6 and cup 8 are rotated through the belt 25 and the liquid oil impinges against the inner wall of the shaft 6, being evenly distributed thereon. The oil advances toward the atomizing cup as a result of the centrifugal force, brought into play by the conical shape of the inner wall. Due to the great distance between the orifice 11 and the cup edge 9 the advancing layer of oil has ample opportunity to become evenly distributed circumferentially over the interior surface and to be in the form of a thin film when it reaches the calyx-shaped portion of the cup. In this calyx-shaped portion the film is gradually curved outwardly, approaching a direction transverse to the cup axis, and being accelerated by centrifugal force. After the even circumferential distribution in the conical part, the film is more rapidly thinned in the calyx-shaped part in a relatively short time and issues from the sharp knife edge as a fine mist. This mist is caught and atomized by the advancing current of air flowing through nozzle 17 at a high velocity, which is moving forwardly.

Simultaneously, the fan 19 causes air to flow upwardly through the air supply conduit 18 and enter the whirl chamber 15 through tangential inlet 16. The angular velocity of the rotating air is somewhat greater in the nozzle 17 than in the whirl chamber due to the restricted diameter. The whirling gives the air a greater total velocity. The direction of motion of the cup 8 is, moreover, opposite to that of the whirling air, whereby the oil is caught by the air at a greater relative velocity, resulting in a finer atomiza-

When the burner is first put into operation a high tension source of electricity is connected to the conductors 28 and 29, causing a spark. The fan will not attain its normal operating speed at once, due to the rearding action of the heavy fly wheel 21. Hence, only so much air will be supplied through the nozzle 17 that the fuel cone leaving the atomizer cup assumes a shape approximately corresponding to the dotted line 31. The electrode terminals are within the cone swept by the fuel and are, accordingly, flushed by the fuel-air mixture, which is rich because of the relatively small proportion of air supplied during this phase of the operation; this causese the ignition of the mixture by means of the spark or arc formed. Once the mixture is burning, the proportion of air is increased until the atomized fuel and flame cone assumes approximately the outline indicated by the dotted line 32, so that the electrodes will then lie outside of this cone. This increase in the air supply can be attained by any means, but will occur automatically in the embodiment shown by virtue of the fly wheel, which permits the fan to accelerate gradually. After ignition of the rich fuel-air mixture has been achieved the refractory wall 1 becomes heated and facilitates the vaporization and combustion of the atomized fuel by its radiation. Power to the electrodes may then be turned off.

Under normal burning conditions a small quantity of air enters through the opening 30; this flushes the electrode terminals. This flushing, in combination with the radiant heat of the flame and refractory wall 1, causes any carbon that might have been deposited on the electrodes to be burnt away. Thus, when the burner is again put into operation after having been shut down the electrodes will be perfectly clean.

When the burner is shut down the supply of fuel to the supply pipe 10 is stopped; the fly wheel 21 will, however, cause the parts to continue rotating for some time afterwards, permitting the oil to be discharged from the cup and, after the exhaustion of the fuel and extinction of the flame, will feed pure air into the combustion space, thereby freeing the latter from hot gases. This cleans the burner automatically and avoids the danger of explosion if the burner is restarted soon after having been shut down.

The rotating atomizer cup oil burner described herein, apart from the electrodes and arrangement for varying the rate of flow of air during starting, is claimed in my copending application, Serial No. 760,899, filed July 14, 1947. While this improved form of burner was described in connection with the instant invention, it is possible to apply the combustion method and the arrangement for varying the air flow to other forms of rotating atomizer cup burners.

I claim as my invention:

1. A burner for liquid fuel comprising a rotating atomizing cup, a surrounding air nozzle shaped to advance air in a forwardly direction, a blower fan driven by a motor for supplying air to said air nozzle, means for supplying liquid fuel into said atomizing cup, means for rotating said atomizing cup for discharging fuel laterally from the front of the cup into said air, whereby the fuel is atomized and carried forwardly by the air to form an atomized fuel and air mixture divering forwardly as a cone having a cone angle dependent upon the forward velocity of the air, arc electrodes disposed forwardly and laterally of the atomizing cup outside of the cone of fuel and air mixture formed when air is supplied at a rate for normal burning and within the cone of fuel and air formed when air is supplied at a smaller rate for starting up the burner, and a fly wheel arranged to delay acceleration of the fan when the motor is energized for controlling the rate of air supplied to said nozzle so as to flow only such a small quantity of air to the nozzle when the burner is started up to cause the resulting mixture of atomized fuel and air to sweep the electrodes, and so as to flow a greater quantity of air to the air nozzle after ignition of the fuel and air mixture sufficient to cause the flame to pass forwardly past the electrodes during normal burning.

2. The burner according to claim 1 wherein the motor and fly wheel are connected to the atomizing cup for driving the said cup, whereby the fan and cup will rotate after the burner has been shut off.

3. A method of burning liquid fuel in a liquid fuel burner having a rotatable atomizing cup and an ignition element having electrodes disposed forwardly and laterally of said cup, which comprises the steps of rotating said cup, supplying liquid fuel to the interior of the rotating cup, simultaneously flowing a limited amount of atomizing air forwardly about said cup as an enveloping forwardly moving stream, discharging the fuel from the rotating cup into said enveloping stream and laterally in the line of said electrodes thereby forming an atomized fuel-air mixture diverging forwardly as a cone passing between the electrodes of the ignition element, said cone having a cone angle dependent upon the forward velocity of the air, igniting said mixture by passing a spark between said electrodes, and thereafter increasing the rate of flow of atomizing air to reduce the cone angle and cause the resulting ignited fuel-air mixture to flow substantially forward of and out of line of said electrodes during normal burning.

4. The method according to claim 3 wherein the rate of flow of liquid fuel during said initial flow of a limited quantity of atomizing air is maintained substantially the same as when the ignited fuel-air mixture flows substantially forward of said electrodes, whereby the fuel-air mixture is richer during the initial flow than during normal burning.

5. The method according to claim 3, wherein a small quantity of flushing air, separate from and in addition to said atmozing air, is caused to flow between the electrodes during normal burning.

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