Oct. 18, 1938. R. M. SHERMAN ET AL 2,133,485

APPARATUS FOR BURNING LIQUID FUEL

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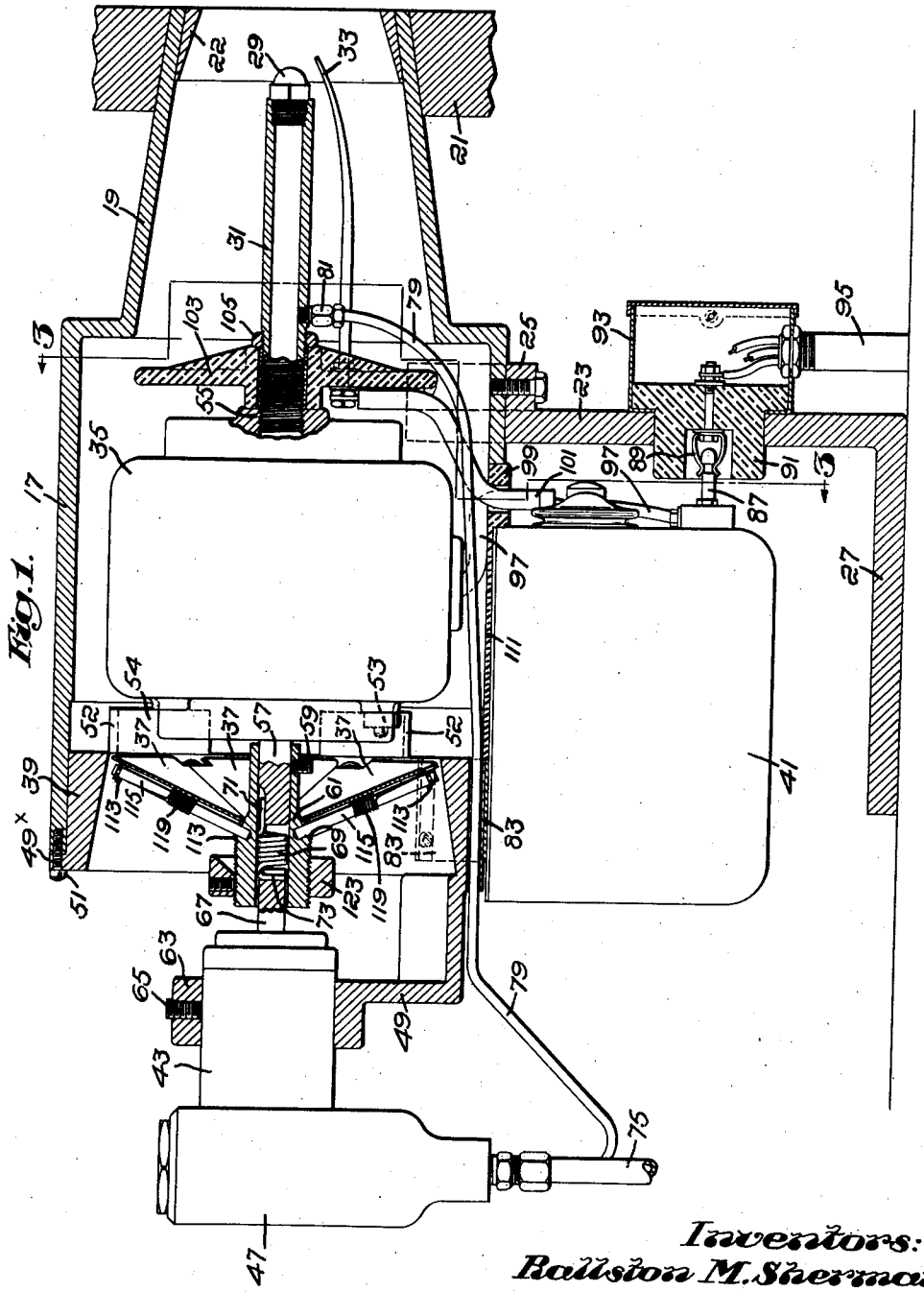


Fig. 1.

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APPARATUS FOR BURNING LIQUID FUEL

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Fig. 3.

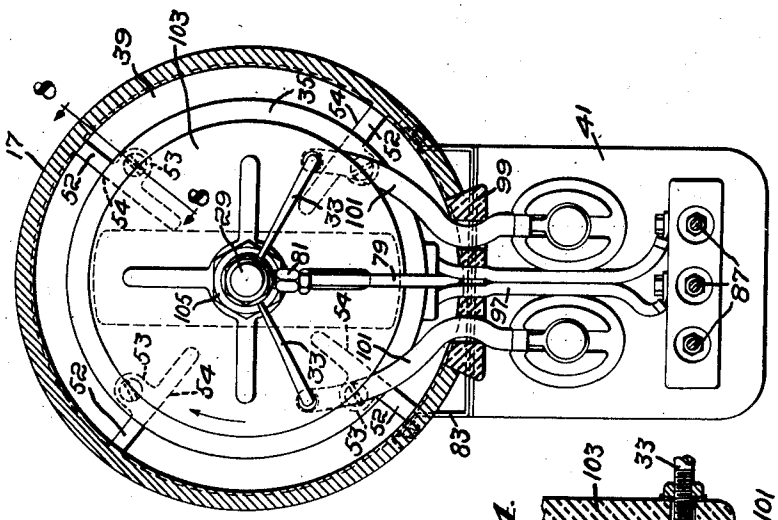


Fig. 4.

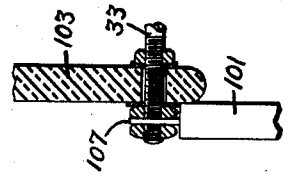
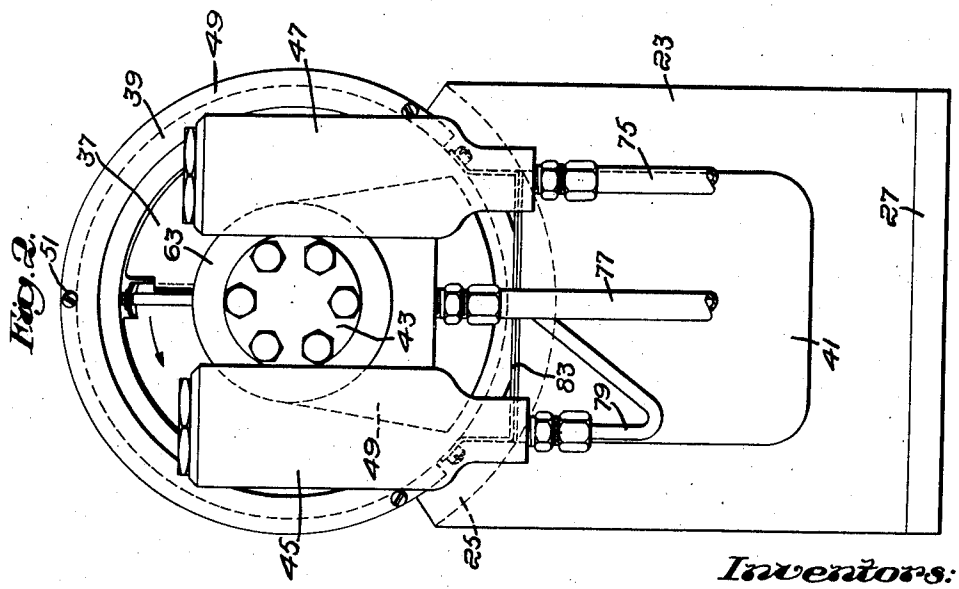


Fig. 2.



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APPARATUS FOR BURNING LIQUID FUEL

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Fig. 5.

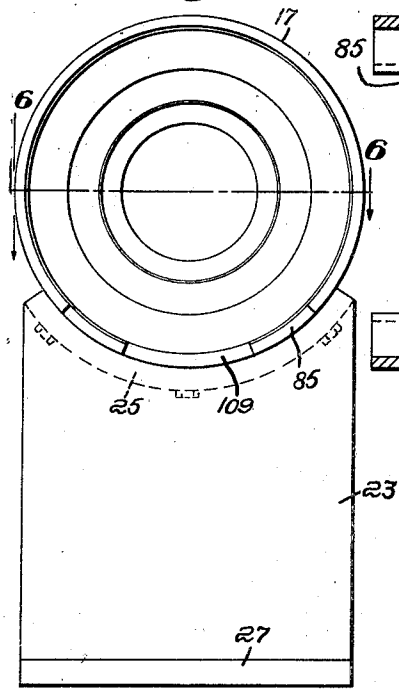


Fig. 6.

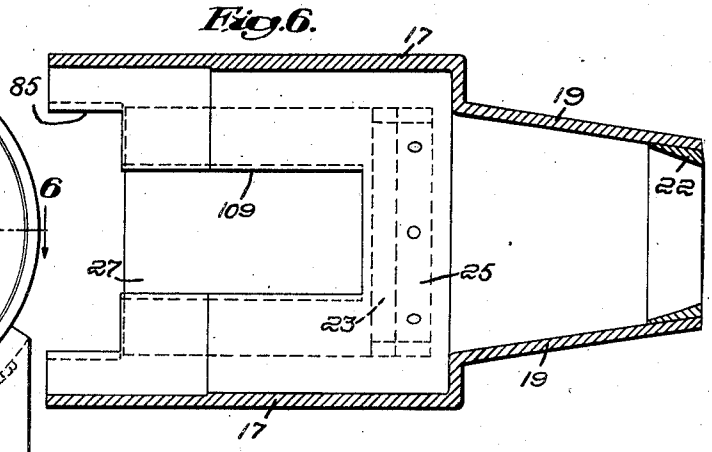


Fig. 8.

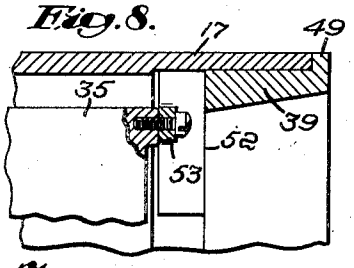
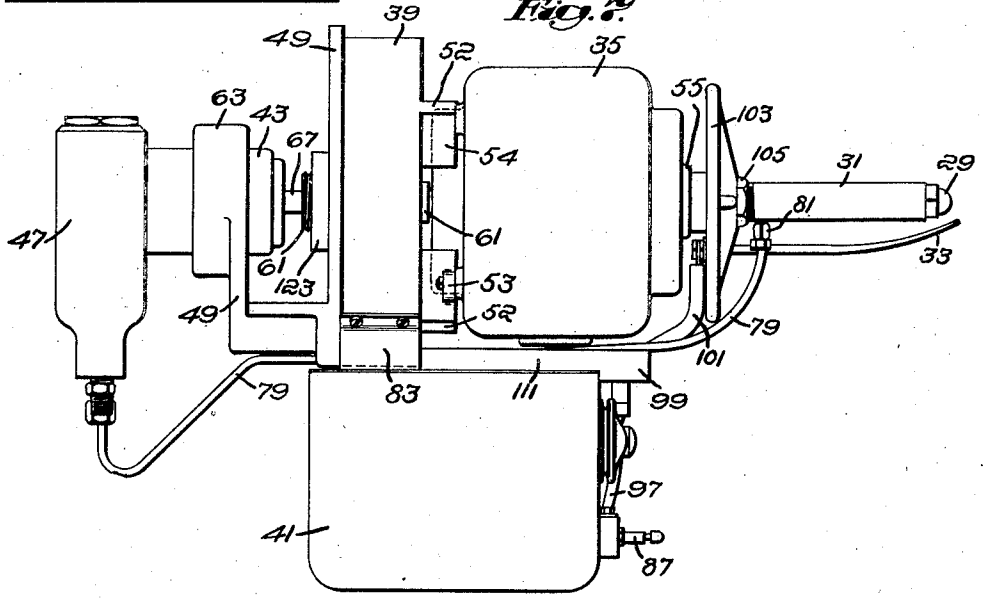


Fig. 7.



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APPARATUS FOR BURNING LIQUID FUEL

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Fig. 9.

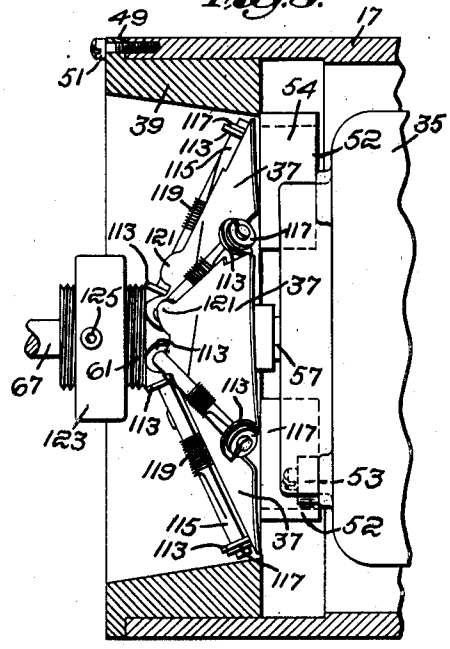


Fig. 10.

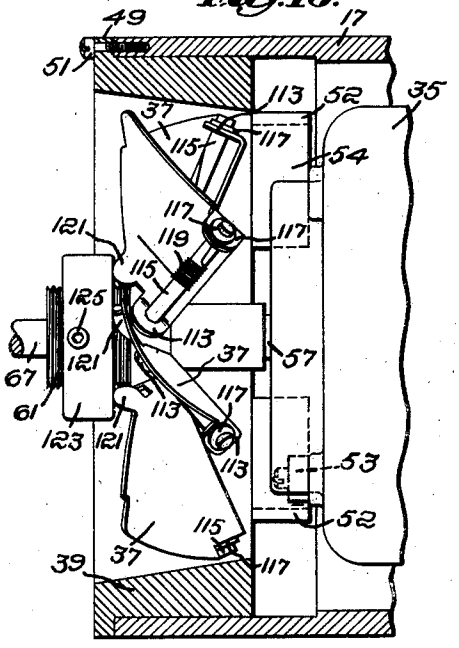


Fig. 11.

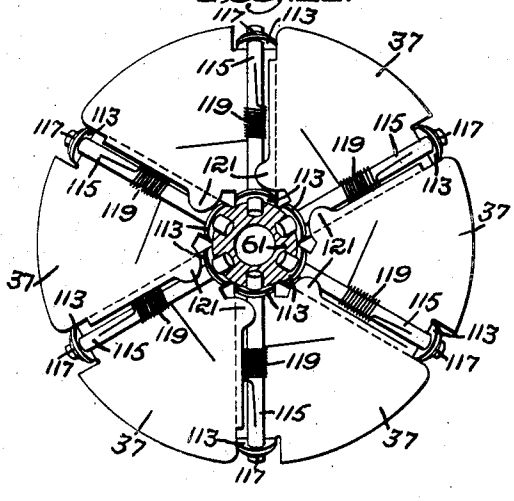
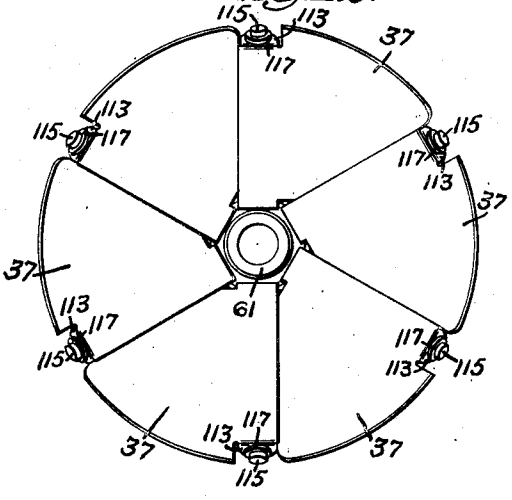


Fig. 12.



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UNITED STATES PATENT OFFICE

2,133,485

APPARATUS FOR BURNING LIQUID FUEL

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Application December 27, 1935, Serial No. 56,334

14 Claims. (Cl. 158—76)

This invention relates to apparatus for burning liquid fuel (herein referred to for descriptive purposes as oil), and deals more particularly with burners of the so-called gun type.

The invention has among other objects to improve conditions of combustion and more particularly through the method of controlling and applying the air supply for commingling with the oil, to increase the efficiency in respect to both combustion and oil and power consumption, to simplify and improve the mechanical and electrical construction, to conserve the heat imparted to the combustion chamber, to reduce cost of manufacture and provide mechanical compactness, and to provide such an arrangement and assemblage of parts as to facilitate and simplify servicing requirements.

These and other objects of the invention will be best understood by reference to the following description when taken in connection with the accompanying illustration, while its scope will be more particularly pointed out in the appended claims.

In the drawings:

Fig. 1 is an elevation, partly in central longitudinal section, showing a burner embodying one form of the invention;

Fig. 2 is a rear elevation of the burner shown in Fig. 1;

Fig. 3 is a front elevation of the same burner in section, on the line 3—3 in Fig. 1;

Fig. 4 is a detail in section showing the electrical connections to the sparking electrodes;

Fig. 5 is a rear elevation of the main supporting casing shown in Fig. 1, together with its supporting standard but with the working unit removed;

Fig. 6 is a section, in plan view, of the main supporting casing, on the line 6—6 in Fig. 5;

Fig. 7 is a side elevation of the working parts assembled as a unit and shown as removed from the casing;

Fig. 8 is a section, taken on the line 8—8 in Fig. 3, showing one of the motor supporting lugs;

Fig. 9 is a side elevation of the air impeller fan with the blades closed, showing the relation of the fan to the motor and surrounding walls of the conduit;

Fig. 10 is a similar side elevation showing the blades open;

Fig. 11 is a front elevation in partial section showing the air fan with the blades in closed position looking from the open or air entering end; and

Fig. 12 is an elevation showing the air fan looking from the air delivery side, also with the blades in closed position.

In burners of the so-called "gun" type, liquid fuel is delivered under relatively high pressure to a nozzle from which it is forcibly discharged through a relatively small nozzle aperture into the combustion chamber of a furnace, without pre-mixture with air but in the form of finely divided atomized oil and in a generally cone-shaped path. To provide a combustible mixture, air is discharged into the combustion chamber, usually under the forced draft of a motor driven air impeller, through a conduit surrounding the oil nozzle and opening into the combustion chamber, the latter being otherwise sealed off so that substantially the entire air available for combustion is delivered through such conduit about the nozzle and is intended to intermingle with the atomized oil.

Referring to the drawings and more particularly to Fig. 1, the working parts of the burner are supported by and mainly contained within a barrel like casing having a cylindrical body 17 and a tapered forward end 19, this casing forming the air conduit through which air is supplied to the combustion chamber. The casing may be permanently installed with the forward end of the tapered part 19 entered into and sealed within the inside surfaces of the walls 21 of the combustion chamber of the furnace, the open mouth of the air conduit thus provided terminating preferably flush with the inner surfaces of the walls of the combustion chamber and the latter being sealed against any substantial admission of air other than that through the air conduit. The tapered end 19 provides a contracted mouth for the air conduit and further contraction thereof may be had by inserting in the end thereof a suitably shaped sleeve, such as is shown at 22.

The casing itself is carried by any suitable support, such as the upright standard or plate 23. The latter has a curved top flange 25 to which is secured the under forward side of the cylinder portion 17 and has a foot 27 secured to the floor.

Within the casing (the detail construction of which is shown by Figs. 5 and 6) are contained the principal working parts of the burner, including (Fig. 1) the oil nozzle 29, the oil delivery pipe 31, the sparking electrodes 33 and other electrical connections, the electric motor 35 and the air impeller 37, these being so related to each other and to a supporting sleeve 39 telescopically fitting the rear end or breech of the cylindrical

portion 17 that they are carried by the sleeve as a unit and, as a unitary assemblage, may be readily withdrawn from or replaced in the casing at will.

Herein such unitary assemblage comprehends also the transformer 41 depending below the casing together with its electrical connections to the motor and to the sparking electrodes, as well as the oil pump 43 and associated pressure regulating valve 45 and strainer 47. The pump, valve and strainer are carried at the rear of the casing by a bracket 49 connected to the supporting sleeve 39.

The sleeve 39 has a sliding fit within the end of the barrel 17, the sleeve and barrel being accurately machined to bring all necessary parts in axial alignment with the casing. The sleeve has a flange 49× which overlies and seats against the rear end of the barrel 17 and is held in place therein by one or more (herein three) screws 51. The inner surfaces of the walls of the sleeve are tapered inwardly and forwardly, providing a bore having a contracted air delivery mouth for the purpose hereinafter described.

The casing of the motor is supported by the sleeve through a plurality of equally spaced arms 52 (herein four in number) formed integrally with the sleeve and extending part way radially inward, each arm carrying a laterally extending lug 53 bolted to a boss on the motor casing. The shape and arrangement of such supporting lugs are best indicated in Figs. 3, 7 and 8. This arrangement suspends the motor on the supporting sleeve in overhanging relation within the barrel 17 just beyond the contracted mouth of the sleeve, leaving an annular space between the cylindrical casing and the motor to serve as a part of the air conduit. The faces 54 of the arms 52 which confront the closely adjacent rotating blades of the air impeller serve as air deflecting surfaces, as is hereinafter more fully explained.

The forward end of the motor casing is provided with a central boss 55 into which the rear end of the oil delivery pipe 31 is threaded and by which it is supported and maintained in coaxial relation to the mouth of the conduit, the importance of which will be understood from subsequent explanation. The motor is provided with a shaft 57, the rear end of which (Fig. 1) protrudes from the motor casing and has removably connected to it, as by the set screw 59, the sleeve-like hub 61 of the air impeller 37, which latter herein is of the propeller or pitched-blade type of a novel construction to be described.

To additionally support the pump, valve and strainer, the sleeve 39 has formed integrally therewith a rearwardly extending supporting bracket 49, the upright part of which carries a sleeve 63, the bore of which is accurately machined to bring it in axial alignment with the motor shaft. Within the sleeve is a barrel-like casing comprising the body of the oil pump 43 removably held therein by a set screw 65. The usual pressure relief valve 45 and oil strainer 47 (Fig. 2) may be separate from the pump but herein they are formed integrally with the pump casing so that they are supported as a unit by the bracket 49.

To drive the oil pump, the latter has a forwardly protruding driving shaft 67, the end of which (Fig. 1) enters the bore within the fan boss 61 and faces but is spaced from the end of the motor shaft 57. A resilient driving connection is interposed between the motor and pump shafts, this being provided by means of a coiled spring 69 held loosely within the fan boss bore in the space between the ends of the two shafts. This spring terminates at one end in a longitudinally straight piece 71 which lies loosely within a longitudinal key-way or slot in the motor shaft and at the opposite end in a transversely bent piece 73 which lies within an open slot cut transversely in the opposing end of the pump shaft.

When the parts are thus assembled, the motor is connected to drive the pump through the resilient connection, the spring acting to open more or less when the motor starts, thereby equalizing the pump load on the motor and cushioning the effect of the pump load in starting the motor.

This relationship permits the parts to be withdrawn as a unitary structure from the casing, leaving the assemblage of the motor, fan and pump intact. The pump assemblage and the spring 69, with the unit either removed or in place within the casing, may be withdrawn from its association with the other parts by loosening the set screw and withdrawing the pump from the sleeve 63 and may be reassembled with equal ease. The spring 69 provides a resilient driving connection between the pump and the motor which is protectively enclosed by the surrounding walls of the fan boss 61 but may be readily removed or slipped into place in separating or assembling the parts. This assemblage of the pump, fan and motor supported by the sleeve 39 furthermore provides and maintains an accurate alignment of the motor and pump shafts.

Referring now to the path of the oil to the nozzle, the strainer 47 (Fig. 2) has connection to the usual tank or main source of oil supply (not herein shown) through the feed pipe 75, the oil passing up to the suction side of the pump and thence through the delivery side of the pump to the pressure relief valve 45 through passages contained within the casing (not herein shown). The pump has the usual bypass leading back to the main tank through pipe 77. Both the tank pipes 75 and 77 are provided with separable pipe connections by means of which the pump and strainer may be quickly disconnected from the tank pipes, leaving the working unit free for removal from the burner casing.

The oil entering the pressure relief valve from the pump leaves the valve through the oil delivery pipe 79 which (see Fig. 1) extends forwardly through an opening in the walls of the supporting sleeve 39, thence through the annular space between the motor 35 and barrel 17 into the tapered forward end 19 of the casing, where it has a connection 81 with the hollow interior of the oil delivery pipe 31. The latter has a bore of substantial diameter so as to provide a self-contained chamber of appreciable capacity, the reserve amount of oil contained within the bore of the pipe tending to maintain a cooling effect on the nozzle and prevent carbonization of the oil thereat.

Referring now to the transformer and electrical connections, the transformer 41 is also supported on the sleeve 39 by means of a U-shaped suspension bracket 83 (Figs. 2, 3 and 7). This bracket has a flat bottom which extends transversely across and is fastened to the flat top of the transformer at the rear thereof. The upright ends of this bracket are bent to lie flush with and are bolted to the outer peripheral walls of the sleeve 39, and the latter is slightly flattened at the point of contact with the flat bottom of the bracket so that the transformer is held in firm seating relation to the supporting sleeve.

To permit the insertion of the supporting sleeve **39** carrying the attached bracket **83** into the barrel casing, the rear end of the casing (as best seen in Figs. 5 and 6) has its walls cut out to form an arc-shaped recess **85** of a sufficient size to admit the side arms of the bracket **83**.

Readily separable electrical connections from the transformer to the source of power are provided in the form of stud connections **87** (Figs. 1 and 3), herein three in number, protruding from the front lower end of the transformer and slidably engaging with corresponding jacks **89** positioned in an insulating block **91** supported in the standard **23**. The block **91** forms an outlet for the junction box **93** through which the jacks are permanently connected to the cable **95** leading to a source of electric current. When the unit with the transformer is withdrawn from the casing, contact between the studs and jacks is automatically broken, and when the unit is reinstalled such contact is automatically made.

From the stud terminals **87** suitable connection is made directly to the motor **35** by the insulated motor leads **97** passing upwardly through the insulating block **99**, the latter extending over and beyond the top front edge of the transformer.

The transformer secondary has connection to the sparking electrodes through two highly insulated cables **101** which also pass upwardly through openings in the insulating block **99** (Figs. 1 and 3). The mounting of the electrodes **33** and the secondary connections thereto present certain novel features of improvement.

As best seen in Figs. 1, 3 and 4, the electrodes are supported at their rear ends by a porcelain insulating disk **103**. The latter is mounted on and coaxial with the oil delivery pipe **31**, being provided with a hub which fits over the pipe and is held in abutting relation to the motor boss **55** by means of the clamping nut **105**. The electrodes **33**, which herein are bare metallic conducting rods, are secured in the disk in the spaced relation indicated in Fig. 3, extending forwardly therefrom and suspended thereby, their ends being brought into the desired sparking relation to each other and to the nozzle **29**.

The rear of each electrode rod is clamped to a portion of the disk and extends through the latter, and at the back of the disk (Fig. 4) has suitable electrical connection to a terminal **107** on the secondary cable **101**.

The use of the porcelain supporting disk near the rear end of the oil supply tube permits the use of relatively small, light electrode rods without the necessity of other supporting devices which tend to interfere with the designed air flow through the tapered conduit **19** and without the need of porcelain or other insulating sleeves thereon. The disk (as best seen in Fig. 3) maintains the uninsulated exposed surfaces of the electrodes and connections in such spacial relation as to provide both the required air gap separation and the required minimum of creepage surface from such uninsulated surfaces to the nearest grounded conductive element of the apparatus. The use of the porcelain disk furthermore provides a heat baffle protecting the motor from the radiant heat of the combustion chamber, its white color aiding in reflecting the heat instead of absorbing and transmitting it to the motor at the rear.

To permit removal of the motor and electrode connections with the transformer and other parts of the unit, the bottom of the barrel casing **17** is provided with a longitudinal slot **109** (seen best in Fig. 6) extending forwardly from the cut-away recess **85** for a sufficient distance to accommodate the insulating block **99**.

To provide for the closure of the bottom of the air conduit where it otherwise would be opened by such slot in front of the contracted mouth of the supporting sleeve **39**, the transformer carries means for closing such slot. Herein this is conveniently provided by the insulating block **99** which has a rearward extension **111** the flat top of which is secured to the top of the transformer casing and abuts at its rear end against the front edge of the bracket **83**. The insulating block, it will be observed, is of rectangular shape in plan corresponding to the shape of the slot **109**. Herein both the forward end and the extension **111** of the insulating block are shown as provided with beveled sides (as best seen in Fig. 3) which have a sliding fit in the correspondingly beveled side walls of the slot **109** (Figs. 5 and 6), so that, when the unit is entered into place within the barrel, the block completely fills the slot and closes up the bottom of the air conduit thereat.

The described construction greatly simplified, improves the servicing of installed burners, and reduces expense attendant thereon. Trouble in the operation of burners of this class has heretofore required the presence of an experienced service man at the point where the burner is installed. After locating the cause of the trouble, which in itself may require considerable time, the fault must be corrected. This usually requires dismantling the burner or parts thereof and replacing a faulty part, if such part is at hand, or sending back to the service station for a duplicate part. This not only interrupts the operation of the burner for periods of greater or lesser length, during which time the user of the burner is deprived of possibly greatly needed heat, but also adds both to the expense and annoyance incidental to servicing.

The described construction not only provides an extremely compact assemblage, but one in which these disadvantages of service are in large part avoided. Where trouble arises in the operation of the burner and the service station has been notified, the trouble may be remedied almost immediately by an inexperienced service representative.

The latter, by loosening the three screws **51** and the two pipe connections to the tank, may, within a very few minutes of time, remove the entire assembled unit from the permanently installed part of the burner casing by sliding it back and out of the rear of the casing. The unit removed may then, in an equally short time, be replaced by sliding in through the rear or breech of the casing another duplicate assembled unit brought with him for that purpose, thereby permitting the burner to resume operation in the least possible time after notification has been received of burner trouble. The entire removed assembled unit is then taken back to the service station for inspection and such repair as may there be found necessary. This permits the prompt correction of burner troubles at a minimum expense, since the labor required at the point of installation for removing and replacing the unit is relatively inexpensive.

It will be observed that the assembled unit when removed presents the parts all exposed for complete inspection so that they may be readily examined at the service station or at the point

of installation if, for any reason, servicing seems there desirable.

Referring now to the construction of the air impeller, which is best shown in Figs. 9 to 12, inclusive, the fan comprises a series of thin, light, metallic blades 37 (herein six in number) approximately flat but slightly concaved toward the air delivery side of the fan, each blade being of generally triangular shape with an outer arc-shaped edge.

Each blade has at the inner and outer ends of one edge a small corner flange 113 bent at right angles, by means of which flanges the blade is pivotally mounted on a pin or small rod 115 and on which it is held by the small disk-shaped cap piece 117 fixedly secured on the end of the pin. Each rod is fixedly secured to the fan hub 61 and projects outwardly therefrom but is also pitched somewhat forwardly in the direction of air delivery.

A torsion spring 119 encircles each pin having one end fixed to the pin and the other end extending over and lying against the face of the adjacent fan blade so that normally when the fan is at rest the blades are urged by the light pressure of the spring in a direction causing them to assume a closed position, or that shown in Figs. 9, 11 and 12, in which position they are each maintained by the small stop finger 121 projecting from the lower end of the free side of the blade. In the described relationship this finger encounters and is stopped by the pivoting pin 115 of the next adjoining blade.

The pivoted edge of each blade extends somewhat beyond the pivoting rod 115, and, when the blades are in closed position, this extension is there overlapped by the free edge of the next adjoining blade. Accordingly, when the fan is at rest and the blades closed, the latter form a substantially continuous closure in the general form of a truncated cone substantially closing the contracted mouth of the sleeve 39, as best seen in Fig. 9, there being left between the edges of the blade and the mouth of such closure only a reasonable mechanical clearance to permit the rotation of the fan and the subsequent resulting opening movement of the blades.

When the fan is started into rotation, however, the forward pitch of the pivotal axes of the blades causes the latter to move under centrifugal force about the pivot pins and to open up against the opposing pressure of the springs 119 into some such position as is represented in Fig. 10. This opening movement continues as the speed of rotation increases, until either positively arrested or until the center of gravity of each blade reaches its maximum radial distance from the axis of rotation. As soon as the opening movement of the blades has been initiated under centrifugal force, it is further aided by the re-action of the air across which the blades are then cutting. The walls of the air conduit within the sleeve are rearwardly flared to permit the required opening movement of the blades.

The working pitch of the blades and the resulting capacity of the fan for air delivery are dependent on the extent of this opening movement. This may be predetermined and the air supply for the burner definitely fixed by the simple use of an adjustable blade stop. This is herein provided by means of the sleeve 123 which is adjustably threaded on the outside of the fan hub 61 and has its forward edge presented to the stop finger 121 of each blade, as shown in Fig. 10. The stop 123 may be adjusted to any desired position lengthwise the threaded portion of the fan hub and there held fixed by the set screw 125, thereby providing a means whereby the opening of the blades may be adjusted to any point between zero opening and maximum. The air supply for the burner may therefore be pre-adjusted by the adjustment of the fan alone and without the disadvantageous use of any valve or shutter extraneous to the fan.

The use of self-closing air impeller blades provides the important function of automatically stopping further passage of cold air into the furnace as soon as the burner stops and as soon as the fan ceases to function in creating its forced draft. When the fan is at rest it effects a substantial closure of the air conduit and automatically seals off the furnace from the entrance of cold air, whether induced by the natural draft of the chimney or otherwise, thereby protecting the walls of the combustion chamber and the furnace from the chilling effect of such cold entering air and conserving the heat previously imparted to such walls.

The use of a propeller type of fan with pitched blades provides a smooth, even delivery of the air free from pulsations which are characteristic of the so-called "Sirroco" fan or similar centrifugal fans of the radial blade type. The adjustment of the air supply by varying the capacity of the air impeller itself further avoids those irregularities and pulsations in the air flow which are characteristic of the employment of shutters or valves used for throttling the air supply within an amount which is less than the capacity of the air impeller to carry.

The disclosed method of air regulation further eliminates much of the noisy operation, which is characteristic of former methods of valve-controlled air regulation, and also permits the fan to run under efficient conditions for all varying air supplies to which it may be adjusted with an increased efficiency and reduced expenditure of power.

A further advantage of the air impeller herein described lies in the fact that the starting load on the burner is relatively small when the fan blades are closed, so that the motor is given opportunity to get up to speed while the blades are opening and before its full load comes on the motor, thereby correspondingly lowering the starting torque required of the motor. A further advantage in the functioning of the burner is also had in that in starting up the burner the full supply of air is momentarily retarded, resulting in an initially richer and more readily combustible mixture at the nozzle, thereby insuring greater certainty of ignition the instant the burner starts into operation.

The efficiency of combustion and the desirable form, position and other characteristics of the resulting flame are to a large extent dependent on the relative movement of the air and oil in leaving the mouth of the air conduit and entering the combustion chamber and on the point at which intermingling of the air and oil and resultant combustion takes place.

It has been found that to provide a fat smokeless flame evidencing complete combustion, the air delivered to the air impeller should advance progressively through the air conduit with a helical rotary movement and emerge from the mouth of the conduit as an air body rotating under a high momentum, free from the effect of turbulence or other disturbing factors which interfere with its vertical movement, and assuming the

form of an advancing helix of progressively moving air at or about the contracted mouth of the conduit. Such an air helix tends slightly to contract on emerging from the conduit and then to expand. By suitably relating the oil spray to this progressively moving air body, the cone-shaped spray of atomized oil and the expanding body of air may be brought into such coincidence at a point in advance of the mouth of the conduit that a complete intermingling of the air and oil takes place with substantially no tendency for the dispersion of oil particles outside of the enveloping and expanding air helix, thereby eliminating the main cause of a smoky flame, and with substantially no tendency for the dispersion of any substantial amount of air required for combustion outside of the expanding cone of oil spray thereby eliminating the main cause for the formation of thin torch-like flames. This tends to produce a fat, well defined and developed smokeless flame having an unvarying and substantially fixed position.

We have found that to secure the required movement of the air in relation to the oil spray, not only should there be prevented the turbulence of the air arising through the presence of obstructions, such as mechanical baffles or turbulators, at or near the mouth of the conduit, but certain other air conditions should be maintained which have heretofore been lost sight of but which are best reached by the cooperation of agencies embodying the principles characteristic of the construction herein described.

One condition which should be maintained, and the absence of which interferes with the required coordination between the oil and air bodies on emergence from the conduit, is a smooth, even flow of the air from the conduit mouth free from pulsations or flutter. Another condition is a substantially uniform density of the air at all points in the periphery of the progressively rotating air body where it leaves the mouth of the conduit. Both of these conditions are promoted by the use of the propeller type of fan, and particularly where its capacity is adjusted by adjusting the pitch of the blades. The delivery of the air is then unaffected by variations in the area of the air intake and is proportional to the openings of the blades, so that each blade impels the air in a smooth, steady flow of uniform peripheral density.

Another condition is the maintenance of a proper relation at the mouth of the conduit between the density or pressure of the air at the periphery of the rotating air body and its density or pressure around and about the nozzle.

Initial combustion should take place and should be maintained at a point well in advance of the nozzle where the air has become heated and has had opportunity to undergo a substantial expansion. Otherwise a noisy, imperfect combustion may follow with an irregular, wavering flame.

If the flame is drawn back against or close to the nozzle, the latter becomes overheated and troubles from carbonization arise. If the flame is allowed to float too far away from the nozzle it tends to become extinguished, so that the undesirable practice of maintaining a continuous ignition at the sparking electrodes must be followed.

The maintenance of initial combustion at the desired point is influenced to a large extent by air pressure conditions. The rotary movement of the air at and in front of the mouth of the air conduit tends to create a vacuum or subnormal pressure along the axis of the air helix. This is due to the fact that the rotary movement of the air induces an air density or pressure relatively high in the outer periphery of the helix and relatively low along the axis of the helix. The vacuum thus produced in advance of the nozzle should be sufficient to prevent the flame from floating away from the position at which ignition is desired but should be inappreciable or at the most very slight at the nozzle to avoid drawing the flame in proximity thereto.

While it is desirable that the air leave the conduit mouth with a definite rotary movement, we have found that an excessive rotary movement of the air in relation to its progressive movement tends to create such a partial vacuum at and in the vicinity of the nozzle as to draw the flame away from its desired point of ignition to or toward the nozzle, disturbing the conditions which it is desired to maintain. It is therefore desirable to provide such a balance between the progressive and rotary movement of the air body which will be maintained under varying conditions of air supply, that a non-disturbing flame relation is established at the axis of the air helix and particularly about the nozzle.

In the described construction, when the burner is started and the air impeller reaches normal speed (rotating in a counter-clockwise direction as viewed from the rear and as indicated by the arrows in Figs. 2 and 3), the free edges of the blades cut across the air producing a very intense rotary movement of the air in which the air is forced outward toward the periphery of the conduit. The fan thus provides the agency for the rotation of the air delivered through the conduit, and for any given speed of the fan such rotation is substantially constant. It will also be seen that the tapered interior of the end of that part of the conduit surrounding the nozzle is free from any mechanical obstructions which interfere with the rotary movement established by the fan.

To induce the required progressive movement of the air which is thus rotated by the fan and to establish the required balance between its rotary and progressive movement is one function herein of the air deflecting surfaces **54** on the arms **52** which, it will be observed, lie immediately in front of the fan and project radially inward across the annular path of the rotating air body as it leaves the fan. If the number or effectiveness of such cut-off members is increased, the rotary movement of the air is diminished and its progressive movement further increased. If such number or effectiveness is lessened, the rotary air movement is increased and the progressive movement lessened. But in any case the relation between the progressive and rotary movement thus established is maintained up to the time the air helix emerges from the mouth of the conduit. In a burner of the size and air capacity herein shown and with arms of the dimensions indicated, four of such cut-off faces have been found to establish the desired relation between the progressive and rotary movements to prevent an appreciable vacuum or backward flame suction at the nozzle while yielding the required high momentum rotary air movement at the conduit mouth.

Features of the air impeller and automatic shutter, independent of their cooperative relation to the features of a liquid fuel burner, are separately claimed in our copending divisional application, Serial No. 84,694, filed June 11, 1936.

While we have herein shown and described for purposes of illustration one specific embodiment of the invention, it is to be understood that extensive changes may be made in the form, relative arrangement and details of the parts herein shown, all without departing from the spirit of the invention.

We claim:

1. A liquid fuel burning apparatus having an air conduit for delivering air to a combustion chamber, a motor in said conduit, a supporting member for the motor adapted to be installed in or removed from said conduit, said member having arms connected to and supporting the motor in overhanging relation from said member but leaving an air admission passage to the air conduit, a nozzle in said conduit carried by said supporting member for delivering liquid fuel to said combustion chamber, and an air impeller axially aligned with and driven by said motor operatively mounted in said air conduit and also connected to said supporting member.

2. In a liquid fuel burning apparatus having fuel and air supply means and a tubular air conduit, the combination of a motor, fuel delivery nozzle and sparking electrodes all positioned within said conduit, a removable structure on which said motor, nozzle and electrodes are assembled in operative relationship to each other and on which said structure as an assembled unit they may be installed within or withdrawn from said conduit at will through the rear thereof, and a transformer outside of said conduit electrically connected to said electrodes and attached to said structure by a connection passing through the walls of said conduit, the latter being longitudinally slotted to permit the withdrawal of said motor, fuel delivery nozzle and sparking electrodes and the removal of the attached transformer.

3. In a liquid fuel burning apparatus having fuel supply means, the combination of a tubular air conduit provided with an air discharge opening at one end and an opening at the opposite end, a motor, an air impeller driven thereby and a fuel delivery nozzle all positioned within said conduit, and a removable sleeve member fitting the opposite end opening in said conduit and constituting a removable structure on which said motor, air impeller and nozzle are supported and assembled in operative relationship to each other and on which sleeve member as an assembled unit they may be installed within or withdrawn from said conduit at will through the opposite end thereof.

4. In a liquid fuel burning apparatus having fuel supply means, the combination of a tubular air conduit having a substantially straight portion with an air discharge opening at one end and an opening at the opposite end, a motor, a fuel delivery nozzle supported by the motor near the discharge end of the conduit and an air impeller driven by the motor near the opposite end thereof, and a removable structural member on which the motor, air impeller and nozzle are assembled in operative relationship to each other and on which structure as an assembled unit they may be installed within or withdrawn from said conduit at will through the opposite end thereof, said structure being removably fitted to said conduit to carry said motor, air impeller and nozzle in coaxial relationship thereto when installed therein.

5. In a liquid fuel burning apparatus having fuel supply means, the combination of a tubular air conduit provided with an air discharge opening at one end and an opening at the opposite end, a motor, an air impeller driven thereby and a fuel delivery nozzle all positioned within said conduit, and a removable structural member on which the motor, air impeller and nozzle are assembled in operative relationship to each other and on which member as an assembled unit they may be installed within or withdrawn from said conduit at will through the opposite end thereof, said structure being removably fitted to said conduit to carry said motor, air impeller and nozzle in coaxial relationship to said conduit when installed therein.

6. In a liquid fuel burning apparatus having fuel delivery means, the combination of a tubular air conduit provided with an air discharge opening at one end and an opening at the opposite end, a motor, a fuel delivery nozzle and an air impeller driven by said motor all positioned within said conduit, a removable structure on which said motor, nozzle and air impeller are assembled in operative relationship to each other and on which said structure as an assembled unit they may be installed within or withdrawn from said conduit at will through the opposite end thereof, a pump outside of said conduit driven by said motor and carried by said removable structure in operative relationship to said motor and connections for supplying liqiud fuel from said pump to said nozzle.

7. In a liquid fuel burning apparatus having fuel and air supply means, the combination of a tubular air conduit provided with an air discharge opening at one end and an opening at the opposite end, a motor, a fuel delivery nozzle and sparking electrodes all positioned within said conduit, a removable structure on which said motor, nozzle and electrodes are assembled in operative relationship to each other and on which structure as an assembled unit they may be installed within or withdrawn from said conduit at will through the opposite end thereof, and a transformer also attached to and carried by said structure in assembled operative relationship to said sparking electrodes.

8. In a liquid fuel burning apparatus having fuel supply means, the combination of a tubular air conduit provided with an air discharge opening at one end and an opening at the opposite end, a motor, an air impeller driven thereby, a fuel delivery nozzle and sparking electrodes all positioned within said conduit, and a removable structure on which said motor, air impeller, nozzle and electrodes are assembled in operative relationship to each other and on which structure as an assembled unit they may be installed within or withdrawn from said conduit at will through the opposite end thereof.

9. In a liquid fuel burning apparatus having fuel and air supply means, the combination of a tubular air conduit provided with an air discharge opening at one end and an opening at the opposite end, a motor, a fuel delivery nozzle and sparking electrodes all positioned within said conduit, and a removable structure on which said motor, nozzle and electrodes are assembled in operative relationship to each other and on which structure as an assembled unit they may be installed within or withdrawn from said conduit at will through the opposite end thereof.

10. A liquid fuel burning apparatus having means for delivering liquid fuel to a combustion chamber, an air delivery conduit for delivering air to said chamber, a motor for driving said fuel

delivery means, a rotatable structure having parts movable on and with relation to said structure and of such size, shape and relation as to serve as a substantial closure for said air conduit when said structure is at rest but movable in response to centrifugal force to open said conduit when said structure is rotated, and a driving connection between said structure and motor for driving the former from the latter.

11. A liquid fuel burning apparatus having means for delivering liquid fuel to a combustion chamber, an air delivery conduit for delivering air to said chamber, a motor for driving said fuel delivery means, a rotatable structure having a plurality of blades mounted to turn each on an axis extending outwardly from but inclined to the axis of rotation of said structure, the blades being of such size, shape and relation as to form a substantial closure for said conduit, means responsive to centrifugal force on rotation of said structure for moving said blades to a conduit opening position, means for moving said blades to a conduit closing position on the stoppage of rotation, and a driving connection between said structure and the motor for driving the former from the latter.

12. A liquid fuel burning apparatus having means for delivering liquid fuel to a combustion chamber, an air delivery conduit for delivering air to said chamber, a motor for driving said fuel delivery means, an air impeller for forcing air through said conduit and comprising a rotatable support having blades movable relatively to the support, means for moving said blades to normally provide a substantial closure for the conduit, means responsive to centrifugal force created by the rotation of the impeller for opening said blades to an air impelling position, and a driving connection between said impeller and the motor for driving the former from the latter.

13. A liquid fuel burning apparatus having means for delivering liquid fuel to a combustion chamber, an air delivery conduit for delivering air to said chamber, a motor for driving said fuel delivery means, a rotary air impeller having impelling blades mounted each to turn on an axis extending outwardly from the axis of rotation of the impeller, means responsive to centrifugal force following the rotation of said impeller to move said blades about their axes to augment their air impelling effect, means effective on the stoppage of such rotation to move said blades about their axes in an opposite direction, and a driving connection between said impeller and said motor for driving the former from the latter.

14. A liquid fuel burning apparatus having a nozzle for the delivery of liquid fuel to a combustion chamber, an air delivery conduit surrounding said nozzle for delivering air to said chamber to be commingled with said fuel, a motor, a pump driven by said motor for forcing liquid fuel to said nozzles, a rotatable air impeller structure having blades movable on and with relation to said structure, serving as a substantial closure for said air conduit when said structure is at rest but movable under centrifugal force to open said conduit and impel the air therethrough when said structure is rotated, and a driving connection between said structure and the motor for driving the former from the latter.

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