Dec. 13, 1949

T. C. O'DONNELL ET AL
DUAL FIRING RATE OIL BURNER OF
THE PRESSURE ATOMIZING TYPE

2,491,201

Filed Aug. 12. 1948

5 Sheets-Sheet 1

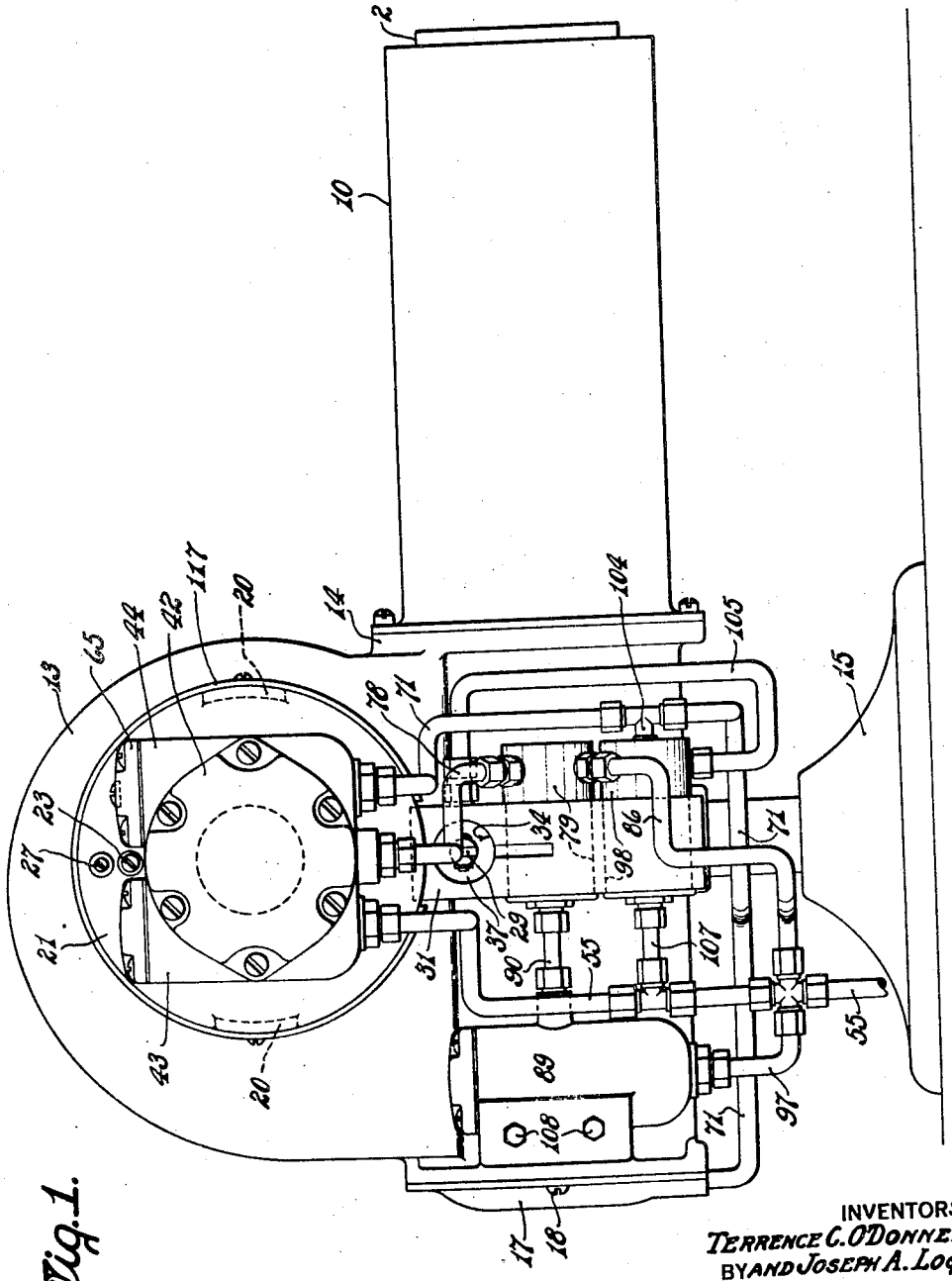


Fig. 1.

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5 Sheets-Sheet 2

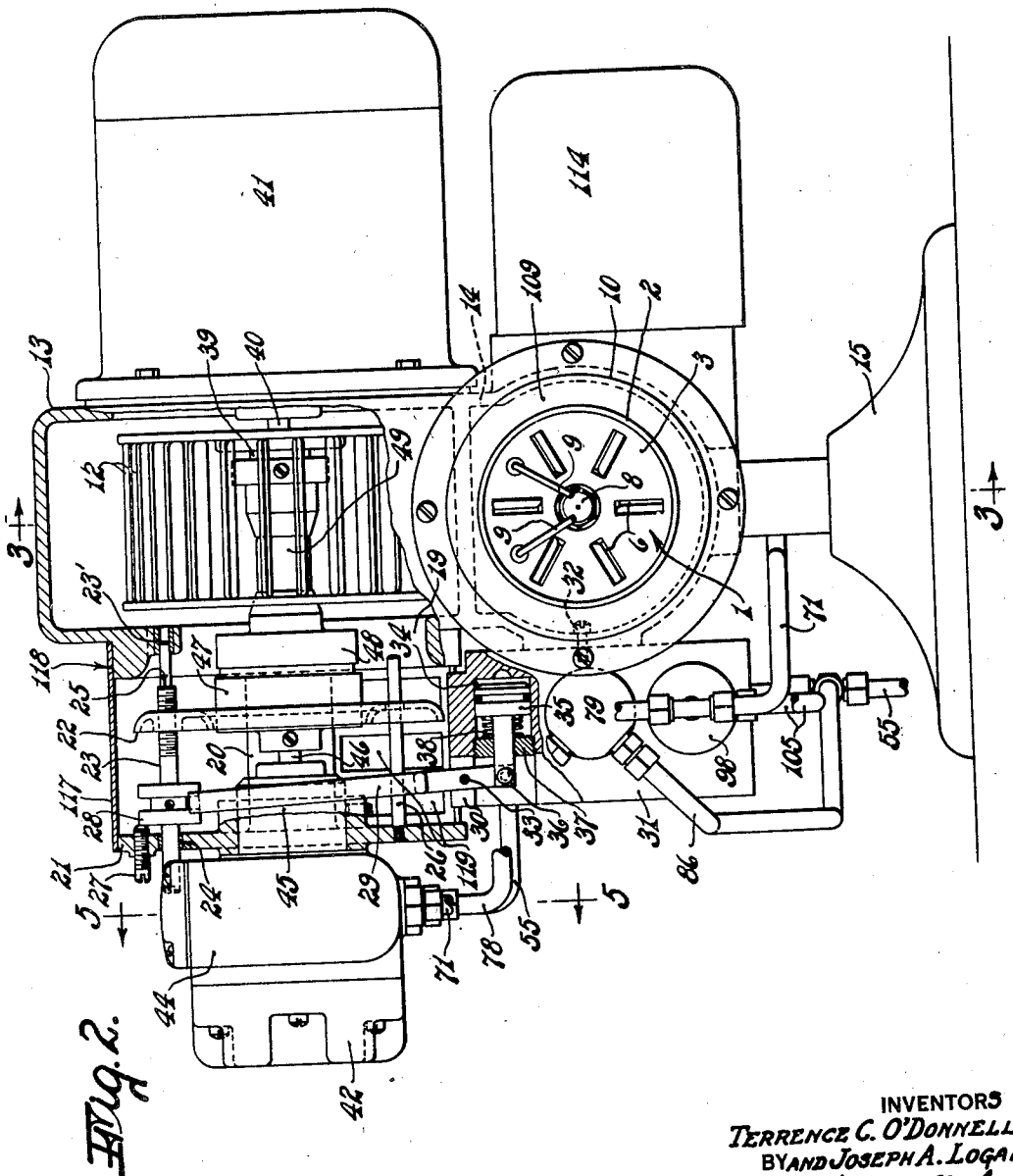


Fig. 2.

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5 Sheets-Sheet 3

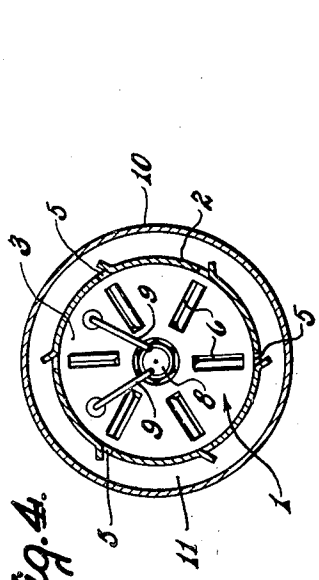


Fig. 4.

Fig. 3.

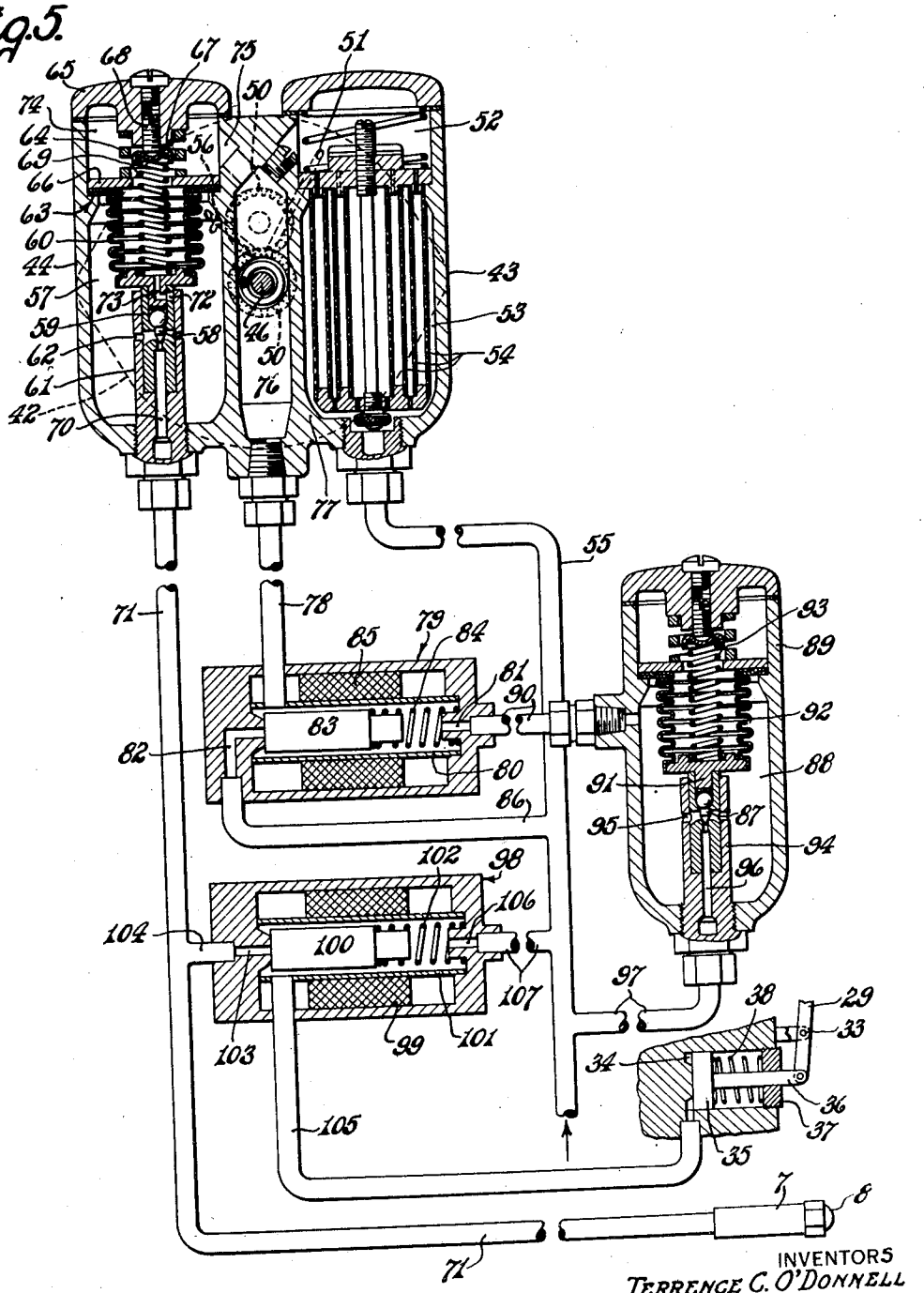
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Fig. 5.



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Fig. 6.

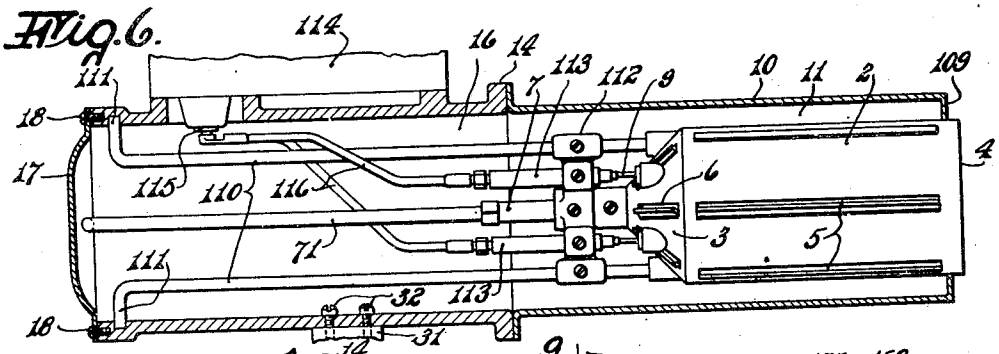


Fig. 8.

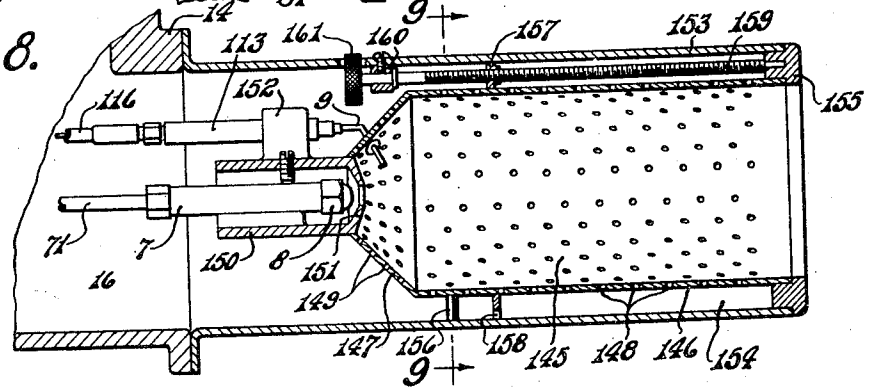


Fig. 7.

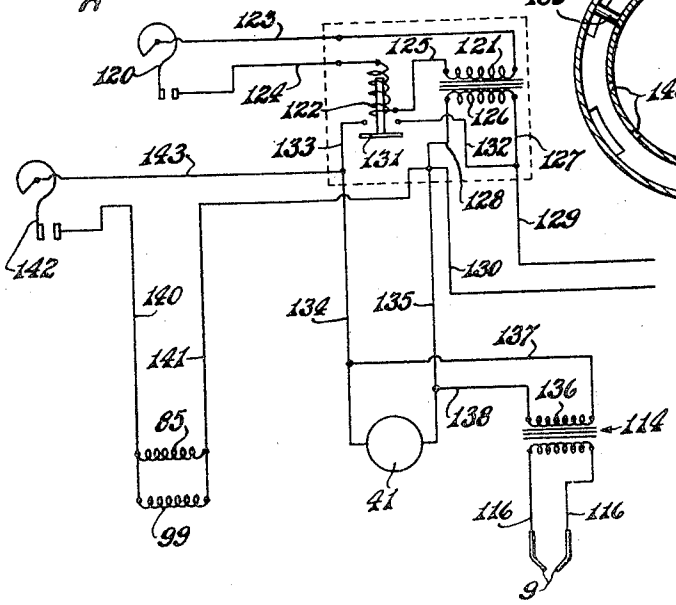
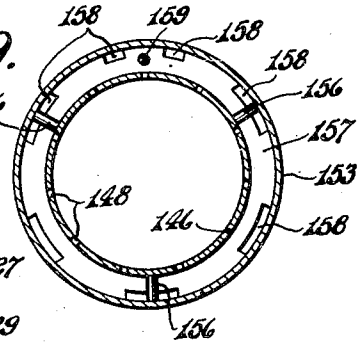


Fig. 9.



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UNITED STATES PATENT OFFICE

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DUAL FIRING RATE OIL BURNER OF THE PRESSURE ATOMIZING TYPE

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Application August 12, 1948, Serial No. 43,826

3 Claims. (Cl. 158—28)

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This invention relates to an improved dual-firing-rate oil burner, adapted for house heating service and of the type in which the two rates of flow of atomized oil are produced from a single pressure atomizing nozzle by varying the pressure of the oil fed to such nozzle.

The invention has for an object the provision in a pressure-atomizing burner of the general type disclosed in the Logan Patent No. 2,411,048, dated November 12, 1946, having within the burner structure a combustion chamber in which the greater part of the combustion occurs, of quick-acting means for changing the atomizing pressure to change the firing rate from a relatively low firing rate, lower than could be used with the same nozzle in an ordinary gun type burner, to a relatively high firing rate, higher than would ordinarily be used with the same nozzle in the ordinary gun type burner, characterized in that an ample spread between the high and low firing rates can be had with a smaller spread in atomizing pressures than could be had in an ordinary gun type burner; in that the maximum atomizing pressure is kept well within the limits of the capacity of the oil pumps usually used in gun type oil burners, and in that a wide spread in firing rates may be had because the burner operation will not be limited by the size of the firebox in the heating apparatus since the combustion chamber is provided within the burner structure.

Assuming that the new burner is to be used for house heating and that a differential of one half gallon per hour between the two firing rates is desired, and that the atomizing nozzle of the burner is, for example, one rated to give an oil burning rate of one gallon an hour at an atomizing pressure of about one hundred pounds per square inch, the way the burner of this invention operates is: the low firing rate is obtained by lowering the atomizing pressure enough below the rated pressure of the nozzle to get an oil burning rate of approximately .7 of a gallon per hour and the high rate is obtained by raising the atomizing pressure enough above the rated pressure of the nozzle to get an oil burning rate of approximately 1.2 gallon per hour. The difference between the rates is then a half a gallon an hour. Other things need to operate in the burner in relation to this dual rate operation. The oil rate needs to be changed from one to another, as a difference

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in the need for heat occurs. As such oil rate is changed, the air rate needs to be changed to give an efficient air-oil ratio for burning and the way of changing the oil atomizing pressure to change the oil firing rate needs to be considered with relation to economy, simplicity, and the coordination of its action with the action of the change in air rate all of which changes are preferably automatically controlled by thermostat action. One advantage aimed at is to provide a mode of operation which takes into account the desirability of making as few changes in construction of routine and available oil burner elements as will get the result in an inexpensive manner and utilize the mass-produced parts in the oil burner industry.

The invention will be disclosed with reference to the accompanying drawings, in which

Fig. 1 is a side elevational view of an oil burner embodying the invention;

Fig. 2 is a front elevational view of the burner with parts broken away to show the air control shutter of the fan together with the manual adjusting means and the automatic actuating means for the shutter;

Fig. 3 is a sectional elevational view taken on the line 3—3 of Fig. 2;

Fig. 4 is a cross sectional view taken on the line 4—4 of Fig. 3;

Fig. 5 is a diagrammatical view of the oil supply system of the burner;

Fig. 6 is a sectional plan view taken on the line 6—6 of Fig. 3;

Fig. 7 is a wiring diagram of the electrical controls for the burner;

Fig. 8 is a fragmentary sectional elevational view showing a different form of combustion chamber; and

Fig. 9 is a cross sectional view taken on the line 9—9 of Fig. 8.

Referring to these drawings, the burner includes within its structure a combustion chamber 1 (Fig. 3). This is formed by a tubular member having a peripheral wall 2 which is cylindrical, an inner end wall 3, which as shown is of frusto-conical form, and an open outer end 4. In the peripheral wall 2 of the combustion chamber, there are a plurality of air inlet openings, which may as shown consist of a circular series of slots 5, each opening into the chamber, as shown in Fig. 4, substantially tangentially to the inner surface

of wall 2. These slots provide for the admission of air in whirling streams extending from one end to the other of the chamber 1. There may also be a circular series of similar air inlet openings 6 in the part-conical portion of the inner end wall 3. Supported centrally from the inner end wall 3 (Fig. 3) is a tubular support 7, bearing on its outer end a nozzle 8, which is of the oil-pressure-atomizing type and is adapted to be connected at its inner end to a supply of oil under pressure. This nozzle is located near the inner end and coaxially of the combustion chamber and is adapted to emit a spray of atomized oil generally forwardly of the combustion chamber toward the open outlet end 4 thereof. A pair of ignition electrodes 9 (Fig. 4) also extend through and are insulated from the inner wall 3 with their inner ends properly located to ignite the spray emitted from nozzle 8.

The combustion-chamber-forming member described is telescoped into the outer end of an air supply tube 10, herein shown as cylindrical in form. The imperforate peripheral wall of tube 10 is radially spaced from the peripheral wall 2, forming between them an air jacket 11, which surrounds the entire combustion chamber 1 and with which the air admission openings 5 and 6 communicate. The outer end of tube 10 is inturned to engage the peripheral wall 2 near its outer end and thereby close the outer end of the air jacket 11. The inner end of tube 10 is connected to receive air from a suitable fan.

The air supply fan is shown at 12 (Figs. 2 and 3) and it is mounted in a housing 13, formed in a casting 14, suitably supported, as from the floor by a pedestal 15. In the lower part of casting 14 is a cylindrical passage 16 (Fig. 3) into the rear end of which fan 12 discharges. To the forward end of passage 16, the inner end of tube 10 is secured, as indicated. The rear end of passage 16 is normally closed, as by a cover 17, secured by screws 18 (Fig. 6) so as to be easily removable to gain access to the interior of passage 16, when required. The air inlet to fan 12 is a circular opening 19 (Fig. 2) formed in one end wall of its housing 13. Connected with and extending outwardly from this end wall are two laterally-spaced side bars 20, one of which is shown in full in Fig. 2 and both of which are indicated by dotted lines in Fig. 1. These bars 20 at their outer ends are connected with and support a circular flange 21. An air inlet control shutter 22 (Fig. 2) is movable toward and away from opening 19 to vary the effective area of the air inlet to fan 12. This shutter has a screw thread engagement with a screw 23, which has near each end a smooth cylindrical portion. These cylindrical portions are slidably, as well as rotatably, mounted one in a bearing 23', formed in the end wall having the fan inlet 19, and the other in a bearing 24, formed in the flange 21. On screw 23 is a shoulder 25 adapted to abut the adjacent end face of bearing 23' and limit the inner axial sliding movement of the screw 23 and thereby determine the position of the shutter for low firing rate operation. Such position is variable and may be adjusted by rotating screw 23 and thus moving the shutter 22 toward or away from the air inlet opening 19. A rod 26, fixed at one end to flange 21, extends in parallel and underlying relation with screw 23, is slidably engaged with shutter 22, and serves to prevent the latter from rotating when the screw is turned. A screw 27 is threaded into flange 21 adjacent screw 23 and is adapted to be engaged by a circumferentially grooved collar 28, fixed on screw 23, for the purpose of limiting the axially outward movement of screw 23. The collar, when engaged with screw 27, determines the high firing rate position of shutter 22. Such position is variable and may be adjusted by turning screw 27.

The shutter may be automatically shifted between its high and low firing rate positions by means of a lever 29, the upper end of which is engaged in the groove of collar 28. This lever is received near its lower end in a vertical slot 30 in a block 31, which is secured by screws 32 to one side wall of the casting 14. The lever 29 is fulcrumed on a pin 33 fixed in said block. Also formed in this block is a cylinder 34, containing a piston 35, the rod 36 of which is pivotally connected at its outer end to the lower end of the lever 29. The outer end of cylinder 34 is closed by an annular plug 37 which slidably engages rod 36. Between this plug and the piston is a spring 38, which tends to force the piston inwardly in its cylinder and thereby yieldingly hold the shutter 22 in the high firing rate position illustrated. When oil under pressure is admitted to the inner end of cylinder 34, by means to be described, the piston will be moved outwardly, actuating lever 29 to move the shutter 22 into its low firing rate position.

The fan 12 has its hub 39 fixed to the shaft 40 of an electric motor 41, which is secured to that end wall of the fan housing which lies opposite the air inlet 19. This motor also drives the pump for supplying oil to nozzle 8. This pump, in the present case, is combined with a filter and pressure regulating valve, these elements being respectively located in the casing parts 42, 43 and 44 (Fig. 1). These casing parts are all connected to and supported by a hub 45 (Fig. 2) which fits into a hole in flange 21 and is suitably fixed therein as indicated. The drive shaft 46 of the pump passes through hub 45 and is fixed to the driven element 47 of a centrifugal clutch, the driving element 48 of which is connected by a flexible coupling 49 to the hub 39 of fan 12. The shutter 22 has a central opening to freely receive the clutch element 47. This clutch may be like that of U. S. Logan Patent No. 1,985,934, dated January 1, 1935, and is used for the purposes fully set forth therein. The arrangement provides for starting the pump after the fan, and only after the latter has attained high speed, and for stopping the pump before the fan, and while the latter is still revolving at high speed.

The oil supply system in its entirety is shown in Fig. 5 together with the means by which the firing rate of nozzle 8 may be changed by varying the pressure at which the oil is fed to the nozzle 8. The pump in this case consists of a pair of intermeshing gears 50, both of which are housed in the casing part 42 and one of which is fixed on the described shaft 46. The intake of the pump is connected by a diagonal passage 51 to a chamber 52, formed in the upper part of the hollow casing part 43. In the lower part of the latter is a filter chamber 53, containing filters 54. The lower end of chamber 53 is connected to a pipe 55, adapted to connect with an oil supply tank (not shown). Oil is drawn up through pipe 55 into chamber 53, passes through the filters 54 and thence into chamber 52, from which it flows by passage 51 to the pump. The latter forces oil outwardly through a passage 56 into a lower chamber 57 formed in the hollow casing part 44. In chamber 57 is a cut-off valve 58, mounted on the lower end of a cylindrical member 59, which is fixed to and depends from

the lower and closed end of a bellows 60. The member 59 is slidable in a tubular member 61, which upstands from the base of chamber 57. Radial holes 62 in member 61 below member 59, enable oil to flow from chamber 57 into the interior of member 61 above the seat of cut-off valve 58. The upper and flanged end of bellows 60 is held against an annular shoulder 63 by a spring 64, acting between the cover 65 and a washer 66, bearing on the flange of the bellows. Within the bellows and acting between the closed end thereof and a spring seat 67, which is adjustable by a screw 68 in cover 65, is a spring 69. When the pressure of the pumped oil reaches a predetermined value, say for example 45 pounds per square inch, the bellows 60 will rise upwardly enough to allow oil to flow out of chamber 57 through radial holes into the outlet passage 70, which is connected by a pipe 71 to the nozzle support 7 and thus to nozzle 8.

The bellows 60 also controls a by-pass valve consisting of the cylindrical member 59, the tubular member 61 and a recess 72 in one side of member 59. This recess 72 is initially covered by the inner wall of member 61 as shown. However, when the pressure of the pumped oil reaches another and higher predetermined pressure, say for example 50 pounds per square inch, the bellows 60 will have risen far enough to lift the recess 72 above the upper end of member 61. Then some of the oil in chamber 57 will enter recess 72 and pass by way of a connecting passage 73 in member 59 into the interior of bellows 60 and thence into an upper chamber 74 formed in casing part 44. Oil flows from chamber 74 through a passage 75 into a by-pass chamber 76 formed in a casing part 77 located between the parts 43 and 44. The by-pass chamber 76 is connected by a pipe 78 to the inlet of a two-way valve 79. This valve, shown diagrammatically in Fig. 5, has a liquid-receiving chamber, which is formed within a tube 80 of non-magnetic material and which is closed at opposite ends except for outlet passages 81 and 82. A valve 83, of magnetic material and located inside tube 80, is held by a spring 84 against one end seat to close the outlet 82. A solenoid 85 encompasses tube 80 and is operable, when energized, to move valve 83 against spring 84 into engagement with its other seat to close the outlet 81 and at the same time open outlet 82. The latter is connected by a pipe 86 to suction pipe 55. Thus, when the solenoid 85 is energized, by means to be later described, the liquid flowing past the by-pass valve 72 may flow, without restriction, by way of pipe 78, tube 80, passage 82, and pipes 86 and 55 back to the suction side of the pump. The by-pass valve 72 will then determine the maximum pressure of the oil that is supplied to nozzle 8 and the cut-off valve 58 will determine the minimum pressure. The maximum pressure, thus determined is for the low firing rate of the burner.

To secure the relatively high rate of flow of oil to nozzle 8, a second by-pass valve 87 is provided in a chamber 88 formed in a casing 89. The described outlet 81 of valve 79 is connected by a pipe 90 to chamber 88. Valve 87 is mounted on the lower end of a cylindrical member 91, fixed to and depending from the lower and closed end of a bellows 92, which is held in place in casing 89 in the same way as the bellows 60 and which is forced downwardly by an adjustable spring 93 to hold the valve 87 to its seat. Member 91 is vertically slidable in a tube 94, which has radial openings 95 above the seat of valve 87 to allow

oil from chamber 88 to reach the space around valve 87. This valve controls an outlet passage 96, which is connected by a pipe 97 to suction pipe 55. Valve 87 is adjusted to open at a much higher pressure than the first by-pass valve, say for example 150 pounds per square inch. Thus, when the solenoid valve 83 is positioned as shown, the second by-pass valve 87 will control the maximum pressure of oil fed to nozzle to secure the high rate of flow.

As the rate of flow of oil from nozzle 8 is varied, the rate of flow of the air for combustion must be proportionately varied. As described, the spring 38, acting through lever 29, tends to hold the air shutter 22 in position for the higher rate of air flow. The piston 35 is moved by oil pressure into position for the lower rate of air flow. This is accomplished under the control of a second solenoid valve 98, similar to valve 79. The solenoid 99 moves a valve 100 of magnetic material, located within a non-magnetic tube 101, away from one end seat and into engagement with the other. A spring 102 normally holds valve 100 in the illustrated position, in which it closes an inlet passage 103, which is connected by a pipe 104 to the nozzle supply pipe 71. The space within tube 101 is continually connected to cylinder 34 by a pipe 105. Thus, when solenoid 99 is energized, valve 100 will open inlet 103 and allow oil under pressure from pipe 71 to flow into tube 101 and through pipe 105 into cylinder 34 to move piston 35 outwardly and carry shutter 22 into its low firing rate position. When the solenoid 99 is deenergized, the spring 102 will move valve 100 to close inlet 103 and open the passage 106, which is connected by a pipe 107 to suction pipe 55. Thus, oil will be drawn out of cylinder 34 to enable piston 35 to be moved back by spring 38 into its illustrated position.

The combined pump, filter, cut-off valve and first by-pass valve are shown in Fig. 5 reversely from Fig. 1, as if taken on the line 5—5 of Fig. 2. Fig. 5 is to a considerable extent diagrammatical and does not show all the parts in their actual locations. Fig. 1, however, locates all the parts, including the pipe connections, as they actually are in the burner. The valve casing 89 is secured by screws 108 to the wall of air passage 46 near the rear end thereof. The solenoid valves 79 and 98 are mounted in the block 31 below the cylinder 34. These valves are standard articles available in the market and they are shown only diagrammatically herein but this will suffice for an understanding of their functions. The oil pipe 71 extends through a recess in the cover 17 into the rear end of the air passage 46 and thence forwardly in the latter and tube 10 (Fig. 3) to connect with the rear end of the tubular support 7 for nozzle 8.

Referring now to some of the details of the exemplary burner, the combustion chamber 1 (Fig. 6) is supported at its forward and outlet end 4 by having its peripheral wall 2 rest on the inturned annular flange 109 of air tube 10. Suitably fixed in hubs formed on the rear side of inner end wall 3 are two laterally-spaced rods 110, which extend rearwardly in air passage 16 and terminate with outwardly turned ends 111, engaged one in each of two holes in the peripheral wall of air passage 16. These rods serve to support the rear end of the combustion chamber forming tube 2. Fixed to these rods near the inner wall 3 of the combustion chamber is a support 112, in which is fixed the rear end of nozzle support 7. The spark electrodes 9 are mounted in insulators 113,

which in turn are adjustably secured in the support 112. The ignition transformer 114, indicated in part in Fig. 6, is suitably fixed to an outer wall of passage 16 with its high tension terminals 115 extending into such passage (see also Fig. 3) and being connected by wires 116 to the electrodes 9. When the cover 17 is removed, the ends 111 of rods 110 may be drawn toward each other out of their respective holes and then the rods may be pulled rearwardly in the air passage 16 carrying with them the combustion chamber 1 with nozzle 8 and electrodes 9 in assembled relation thereon for inspection, adjustment or repair. The air shutter 22 (Fig. 2) and its adjusting means are usually enclosed by a part-cylindrical sheet metal cover 117 engaging at one end with the periphery of flange 21 and at the other end with the periphery of a flange 118 on fan housing 13 and is suitably secured to such flanges (Fig. 1). The cover 117 has a plurality of air inlet openings 119 therethrough.

A typical form of control system for a house-heating oil burner is shown diagrammatically in Fig. 7. A room thermostat switch 120 is connected in series with the secondary 121 of a step-down transformer and the coil 122 of a relay by means of wires 123, 124 and 125. The primary 126 of this transformer is respectively connected by wires 127 and 128 to the supply wires 129 and 130, which lead from a suitable source of electricity, such as a 115 volt A. C. circuit. The relay coil 122 is adapted when energized to close a switch 131, one terminal of which is connected by a wire 132 to supply wire 129 and the other terminal of which is connected by wires 133 and 134 to one terminal of motor 41. The other terminal of the latter is connected by a wire 135 to the other supply wire 130. The primary 136 of ignition transformer 114 is connected by wires 137 and 138 to wires 134 and 135, respectively. The secondary 139 of transformer 114 is connected by the described wires 116 to electrodes 9. When switch 131 closes on a call for heat, it starts the burner motor 41 and energizes the ignition transformer 114 to produce sparks between the electrodes 9. Such is a simplified and conventional illustration of the usual control for a house-heating burner. The diagram omits the various safety devices, which are usually used in conjunction with such a burner to stop it on failure of combustion and in the event of various other emergencies. It is understood that any or all such usual safety devices may be used in the present control system but, since these devices are old and well known, they have been omitted to avoid needless complications in the disclosure.

The solenoids 85 and 99 may be controlled in connection with such a control system in the following manner. These solenoids are connected in parallel to wires 140 and 141. Wire 140 connects with one terminal of a firing-rate control switch 142, the other terminal of which is connected by a wire 143 to wire 133. The wire 141 is connected to supply wire 130. Whenever, the switch 142 is closed, the solenoids 85 and 99 will be connected so as to be energized when the switch 131 closes to start the motor 41 and the solenoid valves 83 and 100 will then be operated to provide for the lower oil pressure and smaller air inlet opening required for operation at the low firing rate. If switch 142 is open, the solenoids will not be energized, when the burner starts, and the valves 83 and 100 will remain positioned as shown for the higher oil pressure and larger air inlet opening needed for operation at the high firing rate. The switch 142 may be operated manually or automatically as desired. It may be, and desirably is, a thermostat switch, responsive to the temperature at some location, where the temperature will be indicative of the need for low or high firing rate operation. It may, for example, be responsive to outdoor temperature.

In Figs. 8 and 9, there is shown another form of combustion chamber. This chamber, designated 145, like the chamber 1, is formed within a cylindrical wall 146, having a frusto-conical inner wall 147 at one end and being open at the other end. As in the first described construction, most of the air for combustion is introduced through the peripheral wall 146 around the spray of atomized oil emitted from the nozzle 8 but the air-admission openings, in this case, are radially-directed and in the form of many small and closely-spaced perforations 148 distributed over the entire area of wall 146. Similar air admission openings 149 are provided in end wall 147. The nozzle 8, in this case, is located inside a tubular shield 150, fixed to the end wall 147 and having on its inner end an inturned frusto-conical flange 151 with a central opening through which the oil spray emitted from nozzle 8 enters the combustion chamber in a direction generally lengthwise thereof. The tube 150 is spaced from the nozzle support 7 leaving a passage for air to flow into the combustion chamber, such air being deflected by flange 151 inwardly to meet the oil spray and entering with the latter through the central opening. The ignition electrodes 9 extend through and are insulated from the end wall 147 and their inner ends are properly positioned to ignite the combustible mixture. The insulators 113 for electrodes 9 are mounted in a support 152 fixed to tube 150. This combustion chamber 145 is telescoped into an air supply tube 153, as before, forming an annular air jacket 154 around the combustion chamber. This jacket communicates at its inner end with the air passage 16 from fan 12 and at its outer end is closed by an annular ring 155, fixed to tube 153 and supporting the outer end of the combustion chamber. The inner end of the latter may be supported by a plurality of pins 156 (Fig. 9).

In the air jacket 154 is a baffle, consisting of an annular ring 157 having its inner periphery slidably engaged with the outer periphery of wall 146 and its outer periphery slidably engaged with the inner periphery of tube 153. In this baffle are a plurality of air openings 158. The position of this baffle in the air jacket may be adjusted by means of a screw 159, rotatably mounted at its outer end in a ring 155 and at its inner end in a lug 160, fixed to tube 153. The screw has a threaded engagement with baffle 157 to move the latter longitudinally of jacket 154, when the screw is turned, and this may be done by a knurled knob 161, fixed to the inner end of the screw and projecting through a slot in tube 153 so that it may be actuated from outside the latter. This baffle enables the size of the jets of air, which issue through some of the perforations 148, to be varied with respect to jets of air which issue through other perforations 148. The perforations 148, which are located to the right of baffle 157, receive air only by way of the baffle openings 158, the aggregate area of which is substantially less than that of jacket 154. Because of the restriction of air flow by baffle 157,

the air issuing from the perforations 148, which are located to the right of the baffle, will be at a less rate and pressure than the air issuing from the perforations 148 which are located to the left of the baffle. The baffle 151, if not needed in any particular case, can be rendered inoperative by moving it to the front end of jacket 154 until it abuts ring 155.

The operation of the invention will next be described. The firing rate control device, in this case the switch 142, is moved to the proper position for the firing rate desired. As shown, this is done automatically by the thermostat element of the switch but obviously the switch may be manually operated, if desired. Assuming that the switch 142 is open as shown, the burner will, when started, operate at the high firing rate because neither the solenoid 85 nor the solenoid 99 will be energized, when the burner motor switch 131 closes on a demand for heat, evidenced by the closing of room thermostat switch 120. When switch 131 closes, the motor 41 starts, driving with it the fan 12 and, after the motor and fan have acquired considerable speed, the clutch 47, 48 will engage to drive the oil pump 50. Air flow through tube 10 and jacket 11 will be started before oil flow from the nozzle 8. The air will be supplied at the high rate because the air shutter 22 will be held by spring 38 in the high rate position shown in Fig. 2. Also the cylinder 34 is connected, as shown in Fig. 5, by pipe 105, tube 101, passage 106 and pipe 107 to the suction pipe 55 of the pump, thus supplementing the action of spring 38 in holding shutter 22 in the high rate position. Oil will be supplied by the means shown in Fig. 5. The cut-off valve 58 will open, when the minimum oil pressure has been attained, and oil will flow through conduit 71 and support 7 to nozzle 8. As the pressure of the pumped oil increases, by-pass valve 72 will open allowing some of the pumped oil to flow by way of passage 73 hollow bellows 60, chamber 74, passage 75, chamber 76, pipe 78, tube 80, passage 81 and pipe 90 into the chamber 88 of the second by-pass valve 87, which will not open until the maximum pressure needed for high firing rate operation has been established. The second by-pass valve then opens to allow excess oil to pass through pipe 97 to pipe 55 and thus to the suction side of the pump. The oil spray from nozzle 8 (Fig. 3) is emitted into the combustion chamber 1 and there mixed with air, some entering through the slots 6 in the inner end wall 3 of the combustion chamber but the larger part entering through the slots 5 in the peripheral wall 2 of the chamber. The combustible mixture is ignited by a spark produced between the electrodes 9 and burns to a large extent within the limits of the combustion chamber. The flame does not extend very far beyond the open outer end 4 of the chamber, say for a distance about equal to one quarter of the length of the combustion chamber. This distance that the flame extends from the open end of the chamber is so short that it is unnecessary to build a combustion chamber in the heating apparatus, which is to be fired by the burner, as is necessary in the case of the ordinary gun-type burner. It might be desirable to place a refractory brick in front of the nozzle against the wall toward which the flame is directed, but nothing more would be required in the ordinary installation. The burner will ordinarily continue to operate at the high rate until the demand for heat is satisfied, when the motor 41 (Fig. 7) is stopped and the ignition transformer 114 is deenergized by the opening of switch 131, caused by the opening of the room thermostat switch 120.

Assuming now that the switch 142 is set for low firing rate operation. When the switch 131 closes on a demand for heat from the burner, the motor 41 will be started and the ignition transformer 114 energized as before, but in addition, both solenoids 85 and 99 will be energized because switch 142 is now closed. Thus, when the burner starts, the valves 83 and 100 will be moved by the solenoids 85 and 99 into their extreme right hand positions. The outlets 81 and 106, which were formerly open for the high firing rate operation, will now be closed and the previously-closed passages 82 and 103 will be opened. The cut-off valve 58 will open at the minimum pressure, as before, and allow flow of oil to nozzle 8 and, after the pressure increases slightly, the first by-pass valve 72 will open and allow some of the pumped oil to flow directly back toward the suction side of the pump. Such oil flows by way of passage 73, bellows 60, chamber 74, passage 75, chamber 76 and pipe 78 into tube 80, as before, but this oil now has to leave through the outlet 82, which is connected by pipe 86 to the suction pipe 55 of the pump. Oil is thus supplied to nozzle 8 at the low pressure for low firing rate operation. At the same time that oil flows to nozzle 8, some oil is admitted through pipe 104 and passage 103 into the tube 101 and passes out through pipe 105 to cylinder 34, forcing piston 35 to the right and causing air shutter 22 to be moved into its low rate position. The combustible mixture is ignited, as before, and operation of the burner at the low firing rate ordinarily continues until the demand for heat is satisfied, when switch 131 opens to stop motor 41 and deenergize the ignition transformer 114 and the solenoids 85 and 99.

A change from one firing rate to another can occur while the burner is operating. The firing rate control switch 142 can move from open to closed position or vice versa, whenever desired, or whenever the demand, which influences the thermostat switch 142, changes. A change from one firing rate to another can occur without any interruption in the flow of oil to nozzle 8. Oil is supplied to the nozzle as soon as the cut-off valve 58 opens and, so long as the minimum pressure is maintained, this valve will remain open and allow oil to reach the nozzle. If the burner is operating at the low firing rate and a change to the high firing rate is made, the valves 83 and 100, which were previously held in their right hand positions by the energized solenoids 85 and 99, are moved back by springs 84 and 102, respectively, into their illustrated positions. Valve 83 now directs the oil, which is by-passed from the first by-pass valve 72, into passage 81 and pipe 90 and thence into the chamber 88 of the second by-pass valve 87. The oil pressure will now increase until the high firing rate pressure is attained, when valve 87 will open, as before described to maintain such pressure constant. But the oil flow to the nozzle 8 is not cut-off during the transition from the low to the high firing rate. The oil supplied to nozzle 8 gradually increases in pressure. The valve 100 will now connect cylinder 34 by way of pipe 105, tube 101, passage 106 and pipe 107 to the suction pipe 55 of the pump. The spring 38 will now move air shutter 22 into its high rate position.

Assume now that a change from high firing rate operation back to low firing rate operation is desired. The firing rate control switch 142 will

close, causing the solenoids 85 and 89 to be energized, drawing valves 83 and 100 into their extreme right hand positions. Valve 83 will then cut off the flow of oil which is by-passed by valve 72 to the second by-pass valve 87 and direct such by-passed oil through outlet 82 and pipe 86 directly into the suction pipe 55. The oil supplied to nozzle 8 will rapidly decrease in pressure until it reaches that for which the first by-pass valve is set. The valve 100 enables the cylinder 34 to be supplied with oil under pressure to cause air shutter 22 to be moved into its low firing rate position. The transition from high to low oil pressure does not interrupt the flow to nozzle 8.

The operation of the burner shown in Figs. 8 and 9, is the same as that described except that the air is introduced into the combustion chamber 145 by way of a large number of perforations 148 and 149 in the peripheral wall 146 and inner end wall 147, respectively. The air is fed through these walls in jets which are directed radially of the combustion chamber from a large number of angular positions closely spaced all around the entire circular extent of the spray and also closely spaced along the length of the spray. The jets through the peripheral wall 146 are at right angles to the axis of the spray while those through the end wall 147 are at an acute angle to such axis and have a component acting in a forwardly direction along the spray.

In the case of the Fig. 3 arrangement, the air is introduced through the peripheral wall 2 of the combustion chamber 1 in whirling streams which surround the spray and to a considerable extent keep it from impinging on the wall of the combustion chamber and in any event keep such wall within reasonable temperature limits. In the Fig. 8 arrangement, the radial jets of air have a similar effect. In each case, the effort is to restrain the flame, as much as possible, from impinging on the walls of the combustion chamber and to keep such walls relatively cool. In each case also, there is a controlled distribution of the air along most of the length of the flame, which results in better carburetion than could be had by the ordinary method of blowing the air from the open mouth of an air supply tube in a direction generally lengthwise along an oil spray produced by an atomizing nozzle located in such mouth. Particularly, where the nozzle is operated at a pressure much less than its rated pressure, the ordinary method of feeding air more or less lengthwise along the oil spray will not result in good carburetion because there is not efficient atomization of the oil and a full spray is not produced. It is necessary to compensate for the inefficient atomization of the oil and this can be done with either of the combustion chambers shown. The flame is fed with air by jets or streams entering through the peripheral wall of the combustion chamber and providing a well distributed feed of air along a substantial length of the flame within the chamber. Except for the described distribution of air to the combustion chamber, efficient combustion could not be had when the nozzle is operated at much less than its rated pressure.

Assume as one specific example that the nozzle used is rated to produce a flow of atomized oil at the rate of one gallon per hour when operated at a pressure of 100 pounds. By the use of a combustion chamber of the general type described and the special air feed through the walls of such chamber, the nozzle can be operated at one half of its rated pressure, or 50 pounds, to secure a low firing rate of about .7 gallon per hour. Then by increasing the oil pressure to say 150 pounds, a high rate of flow of about 1.2 gallons per hour can be produced. There is, it will be seen, a good range in the firing rates available from a standard one-gallon per hour nozzle. The example described is conservative. It is possible to reduce the oil pressure to about 25 pounds per square inch and secure a low firing rate of one-half gallon per hour from this one particular size of nozzle. This will increase the firing range to .7 gallon. Generally the half-gallon range in firing rates suffices for a nozzle of the one gallon per hour rating. This particular size of nozzle is the smallest that is ordinarily thought feasible to use except under special conditions. It does not, when used in the conventional way, enable a low enough rate of oil flow for the low firing rate. It might perhaps be operated in the conventional way at a pressure slightly under 100 pounds per square inch but the difference in rate of flow produced would not be appreciable.

For any given range of firing rates desired, the range of oil pressures necessary to produce the change in such rates from a nozzle of any given characteristics, increases rapidly as the low firing rate is increased. The flow from an orifice of any given size varies approximately in proportion to the square root of the pressures used. In the example given, one-half gallon range is had from a nozzle rated to produce a flow of one gallon per hour when operated at 100 pounds, by varying the pressure from 50 to 150 pounds per square inch—a pressure range of 100 pounds per square inch. It was shown that a pressure range of 225 pounds per square inch is necessary to get the same range in firing rates if the low firing rate is one gallon per hour. If the low firing rate is lowered to one half gallon per hour by using an oil pressure of about 25 pounds per square inch, the high firing rate can be one gallon per hour and the high pressure 100 pounds per square inch. Here, the range in oil pressures is only 75 pounds per square inch. This last-named example probably represents the lowest limit feasible. It illustrates the point that the lower the low firing rate, the less is the increase in pressure necessary to get the high firing rate with any given range in firing rates. Starting at 25 pounds per square inch pressure, the pressure range is 75 pounds per square inch for the half gallon range in firing rates; if the low pressure is 50 pounds per square inch, the pressure range will be 100 pounds per square inch, and if the low pressure is 100 pounds per square inch, the pressure range is 125 pounds per square inch for the same firing range.

The invention enables an ample spread between the low and high firing rates for a dual firing rate burner; it enables the use of a low firing rate, lower than can be normally had with a pressure atomizing nozzle in a gun type burner; it provides for the change in firing rates by changing the pressure of the oil fed to the atomizing nozzle and with a smaller spread in oil pressure than could be had from a pressure atomizing nozzle in a conventional gun type oil burner; it keeps the maximum oil pressure within the limits of the capacity of the oil pumps usually used in gun type oil burners; and it provides, within the burner structure, a combustion chamber in which the greater part of the combustion occurs, so that the wide spread in firing rates may be had because the burner operation

will not be limited by limitations of size of the firebox in the heating apparatus.

We claim:

1. In a pressure-atomizing oil burner of the electrically-operated type, the combination comprising a single atomizing nozzle of fixed sized orifice and of the type adapted for atomizing efficiently at a substantially predetermined oil pressure at a single oil firing rate when used in the conventional gun type burner, an oil supply pump, a conduit connecting the pump and nozzle, an automatic oil-pressure-regulating valve apparatus for regulating the pressure of the oil supplied by the pump to said conduit and nozzle valve-setting means to set such apparatus to predetermine a pressure for the oil supply to the nozzle substantially lower than the pressure for which its atomizing efficiently is predetermined, another valve-setting means interlocked with said first valve-setting means to alternately and only alternately set such apparatus to predetermine a pressure for the oil supply to the nozzle substantially higher than the pressure for which its atomizing efficiency is predetermined, whereby the regulating apparatus may be set for a firing rate lower or higher than said first-named rate, an air supply fan, an air tube of the gun-burner type connected to receive the air from the fan, an adjustable shutter for the fan to determine the rate at which air is supplied to said tube, a second tube forming within it a combustion chamber and mounted in spaced coaxial relation in the air tube forming between it and the air tube a jacket, a closure for the forward end of the jacket, the rear end being open to receive air from the fan, the rear end of the second tube being partially closed and its front end being open, the peripheral wall of the second tube having openings therein for air to enter the combustion chamber from said jacket, said nozzle being positioned in the rear end of the combustion chamber to emit oil forwardly toward its open front end to mix with air supplied through the openings in the peripheral wall of the combustion chamber to compensate for lowered efficiency of atomization at the low firing rate, a power operated device to move said shutter to one predetermined position to secure a relatively low rate of air flow and provide for an efficient air-oil burning ratio for the low pressure setting of said valve regulating means and to another predetermined position to secure a relatively high rate of air flow and provide for an efficient air-oil burning ratio for the high oil pressure supply setting of said valve regulating means, and means interlocking said power device and said pressure-regulating valve apparatus to cause the shutter to be moved to said low rate or high rate position when said apparatus is respectively set for said low or high pressure.

2. In an oil pressure atomizing burner of the kind having an oil pressure atomizing nozzle, adjacent ignition means, power mechanism to pump oil through the nozzle at a predetermined constant pressure according to adjustment, a power fan to supply air at a predetermined constant rate according to adjustment, and an air tube to direct air from its supply to meet the oil from its supply, the combination of a tube spaced within the air tube and forming a combustion chamber, the nozzle and the ignition means being positioned at the rear portion of the combustion chamber to project atomized oil lengthwise thereof, the forward end of the combustion chamber being open adjacent the forward end of the air tube and the space between said tubes being closed off at such forward end while its rear end is open to receive air from the fan, shielding walls at the rear end of the combustion chamber to direct air from the fan for the most part to the space between the tubes, and thence tangentially through slotted openings into the combustion chamber to meet the atomized oil along its length in the form of a forwardly pressed whirling layer of the air supply, adjustable pressure-regulating valve means for regulating the pressure of the oil supplied by the pump to said nozzle and thus the pressure at which oil is atomized, quick-acting power-operated means for changing the adjustment of said valve means from one constant predetermined rate to a substantially different one to change the oil burning rate of the burner from a relatively low rate to a relatively high rate of substantial difference due solely to the change in the amount of the atomizing pressure, and interlocked operating means between the pressure changing means and said air supply shutter to cause the latter to take a position to correspond with a change in atomizing pressure.

3. In an oil pressure atomizing burner of the gun type for domestic heating and of the kind having a motor-operated air-supply fan and oil-supply pump, an air tube connected to receive air from the fan, an atomizing nozzle, a conduit connecting the pump and nozzle, and ignition means adjacent the nozzle for igniting the air and oil mixture, such as is generally adapted for operation at a single firing rate due to a predetermined size of nozzle which is rated for a predetermined pressure for atomizing oil to give such firing rate, the combination of additional elements for and some rearrangements of the elements of such a burner to convert it to a dual rate burner, comprising an automatic pressure-regulating-valve mechanism for regulating the pressure of oil supplied by the oil pump to said atomizing nozzle, such mechanism having a hand-operable precision-adjustable device to predetermine a relative low pressure operation for such regulating valve mechanism and a second and similar precision device to predetermine a relative high pressure operation for such valve mechanism, quick-acting power means to set such mechanism in condition to automatically regulate the pressure of the oil as pumped for the low or the high pressure delivery to the nozzle, a shutter mechanism for the fan to determine a high or low rate of air supply for the burner operation, the latter mechanism also having two hand-operable precision-adjustable devices, one for its low air rate and one for its high air rate, said shutter mechanism having means to set it for one or the other of said air rates, such last-named means being actuated by and interlocked with the aforesaid quick-acting power means so that the shutter is set for the high or low rate of air supply when said mechanism is respectively set for high or low pressure, and means to compensate for the lack of atomizing efficiency of said rated nozzle when operated at a lower oil pressure than the nozzle rating, said last-named means comprising a combustion-chamber-forming inner tube built within said air tube in spaced and coaxial relation, said nozzle and said adjacent ignition means being positioned at the rear end of such combustion chamber, said inner tube forming the combustion chamber having air feed openings adapted to feed the air to the oil in a whirling sheet extending around the com-

bustion chamber and throughout its length to envelope the burner flame within the combustion chamber, such inner tube being provided with a partial closure in its rear end and with an open front end close to the front end of the air tube, the space between such tubes at the latter end being closed and open at the opposite end of such space all for the purpose described.

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