

April 9, 1946.

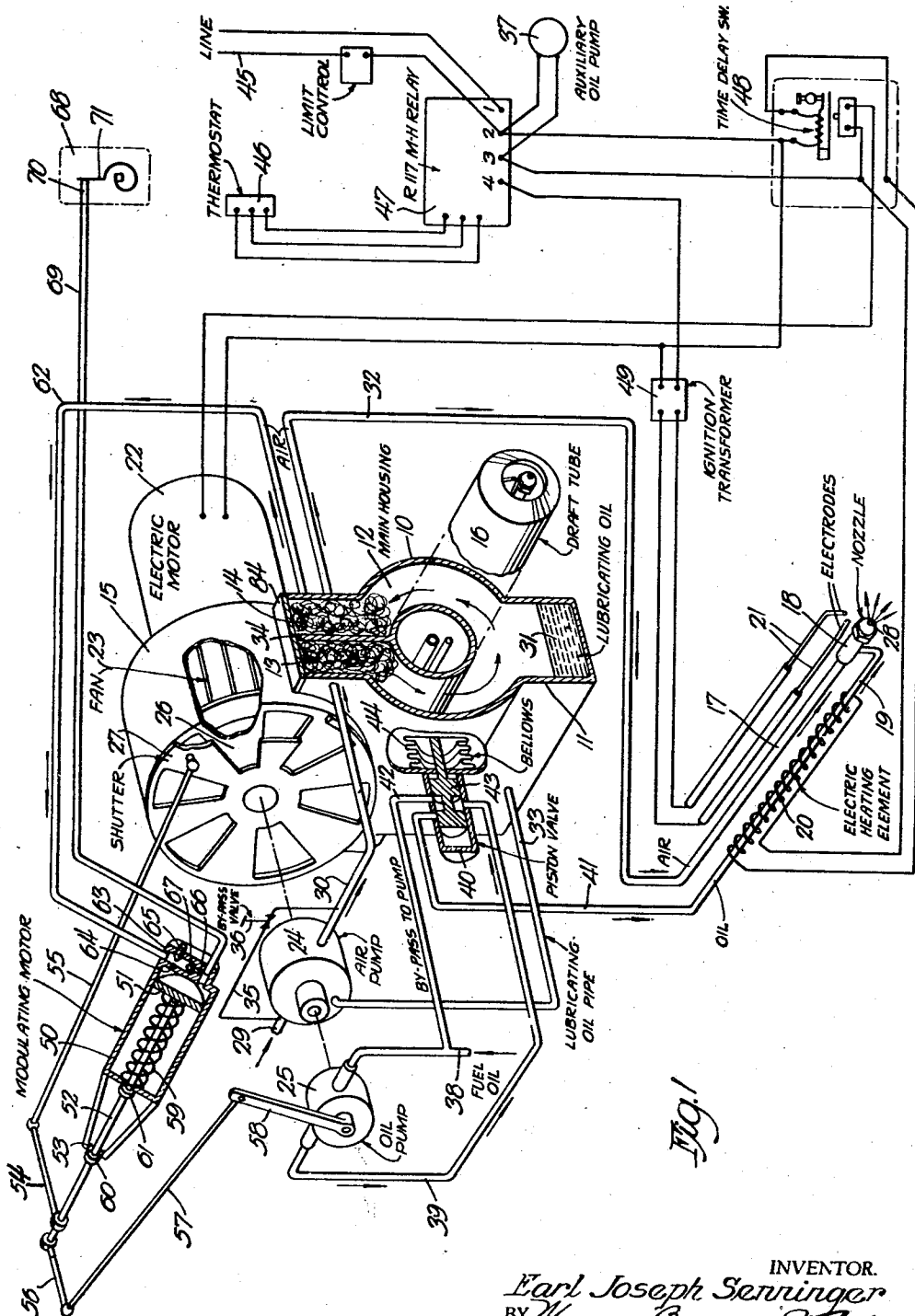
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LIQUID FUEL BURNER SYSTEM

Filed Jan. 27, 1942

5 Sheets-Sheet 1.



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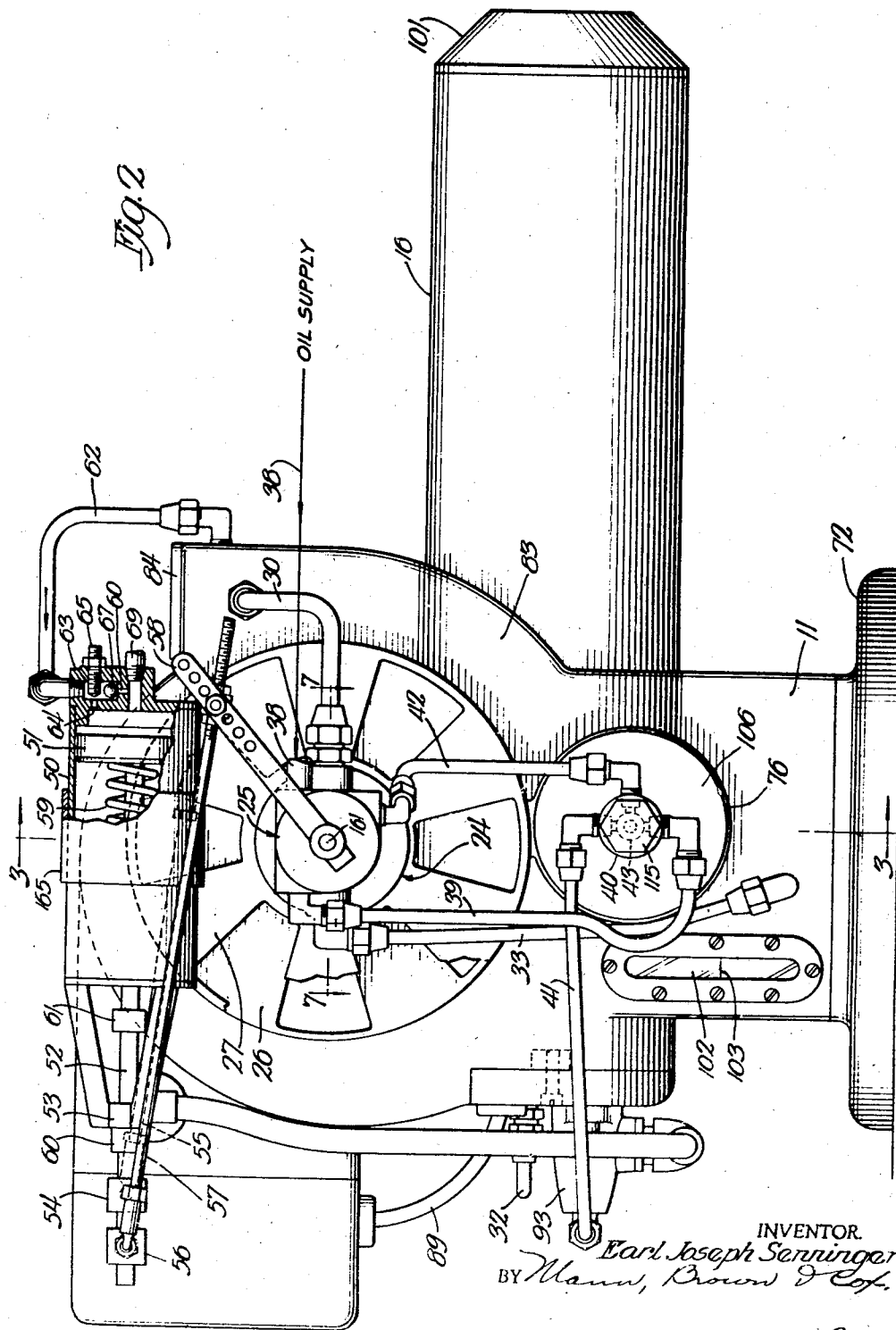
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LIQUID FUEL BURNER SYSTEM

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5 Sheets-Sheet 2



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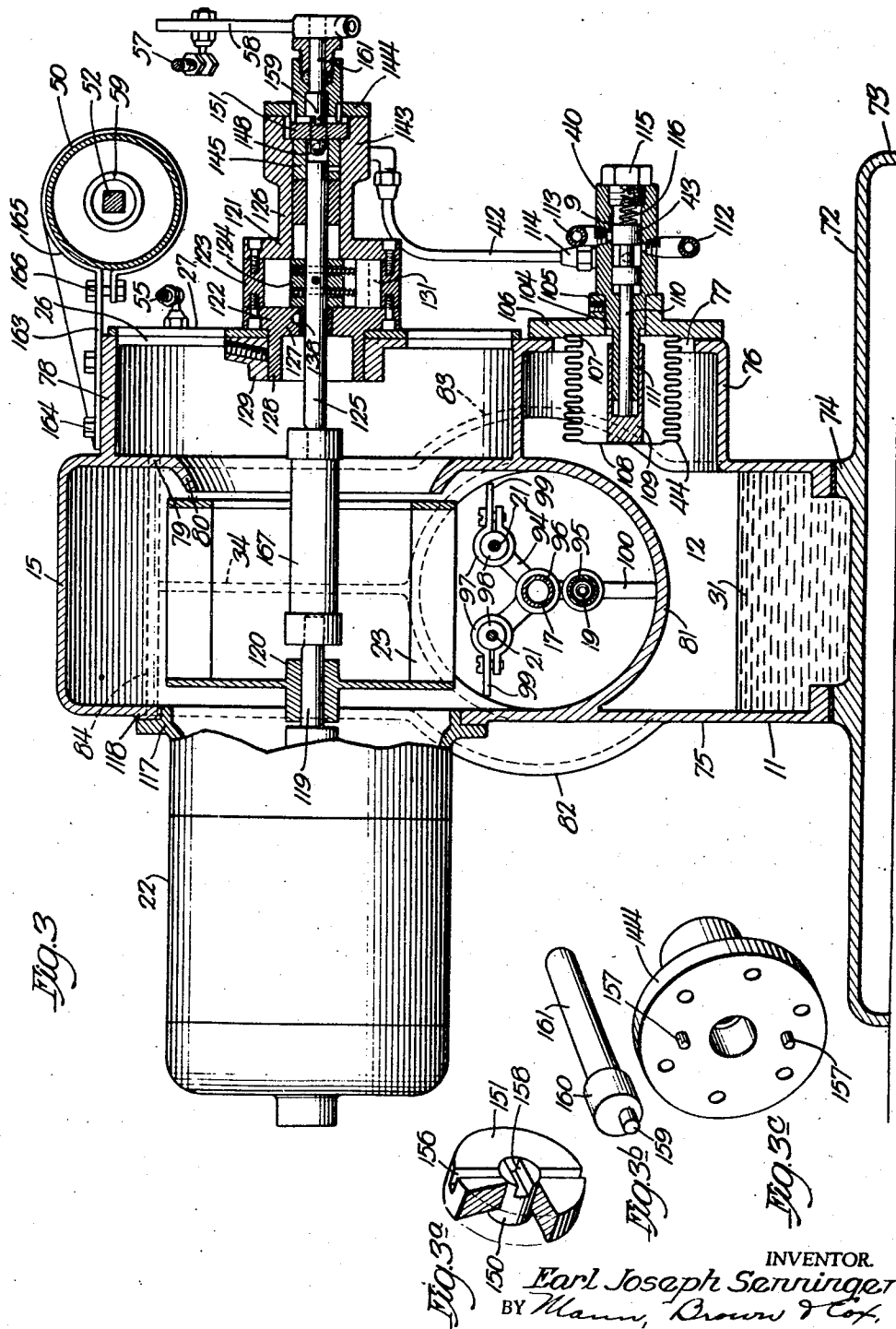
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LIQUID FUEL BURNER SYSTEM

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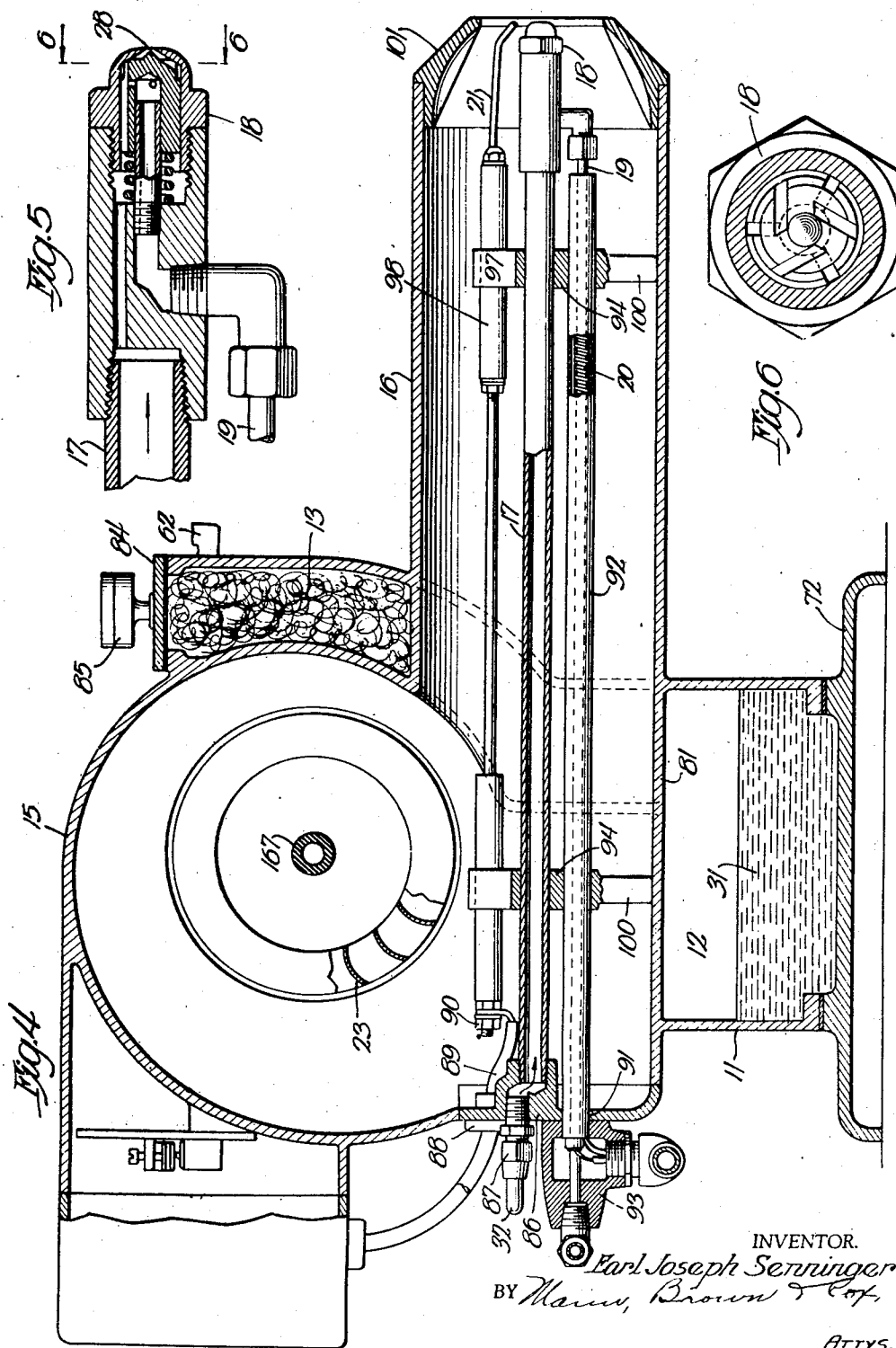
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LIQUID FUEL BURNER SYSTEM

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5 Sheets-Sheet 4



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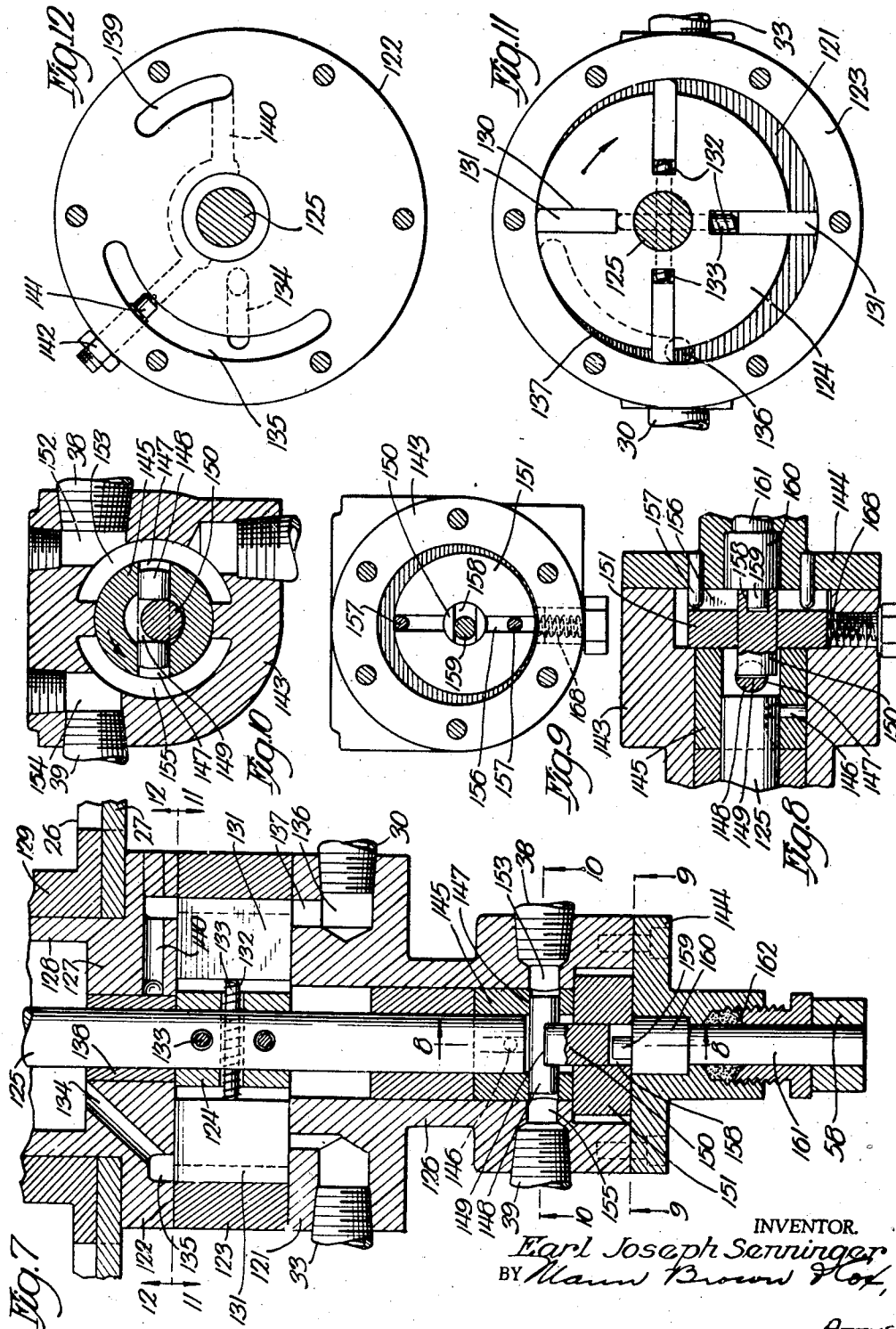
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LIQUID FUEL BURNER SYSTEM

Filed Jan. 27, 1942

5 Sheets-Sheet 5



UNITED STATES PATENT OFFICE

2,397,987

LIQUID FUEL BURNER SYSTEM

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Application January 27, 1942, Serial No. 428,391

25 Claims. (Cl. 155--23)

This invention relates to liquid fuel burner systems and has for its principal object to make the burner come on with a very small fire when it starts, built up to the size required by the demand and modulated between high fire and low fire in accord with the varying demand for heat.

The preferred improvement of the invention specifically disclosed in this application is designed especially for use with the scheme forming the subject matter of my companion application, Serial Number 428,390, filed concurrently, in which fuel is delivered by a metering pump of variable capacity subject to a sufficient pressure of primary or atomizing air and the delivery of secondary air can be varied by opening and closing the inlet to the fan or blower.

Generally speaking, the object of this invention is attained by making the pressure of primary or atomizing air act with appropriate delay at starting to increase the delivery of fuel and air to the burner and afterwards making the temperature or pressure in the space to be controlled vary the effect of the primary air pressure on the delivery of fuel and air in accord with the varying demand for heat.

Further objects and advantages of the invention will appear as the disclosure proceeds and the description is read in connection with the accompanying drawings, in which

Fig. 1 is a diagram of the system with the parts displaced in such a way as to reveal an organic whole in one drawing;

Fig. 2 is a side elevation of a commercial burner unit embodying the invention with a portion of the modulating motor broken away;

Fig. 3 is a vertical section taken on the line 3--3 of Fig. 2;

Fig. 3a is a perspective view of a disk forming part of the means for adjusting the capacity of the oil pump;

Fig. 3b is a perspective view of a crank cooperating with the disk shown in Fig. 3a;

Fig. 3c is a perspective view of the end portion of the oil pump casing;

Fig. 4 is a vertical section through the commercial oil burner unit shown in Fig. 2, taken approximately along the axis of the draft tube;

Fig. 5 is an enlarged longitudinal section of the burner nozzle and associated parts;

Fig. 6 is a transverse section on the line 6--6 of Fig. 5;

Fig. 7 is an enlarged longitudinal section taken on the line 7--7 of Fig. 2, and

Figs. 8, 9, 10, 11, 12, are sectional views taken

on the lines 8--8, 9--9, 10--10, 11--11, 12--12, respectively, of Fig. 7.

But these specific illustrations and the corresponding description are used for the purpose of disclosure only and are not intended to impose unnecessary limitations on the claims, or confine the patented invention to a particular use.

General description

In the diagram (Fig. 1) a main housing 10 provides a tank or reservoir 11, for lubricating oil, a chamber 12 for primary or atomizing air above the oil tank, two air filters or cleaners and oil separators 13 and 14, and a secondary fan or blower casing 15, communicating with a horizontally directed draft tube 16, passing out through the chamber 12 and within which are the following parts, which have been displaced and shown below in the diagram;

The primary air line 17, supplying the nozzle 18, the oil line 19 with its associated heater 20, also delivering oil to the nozzle 18, and the electrodes 21 associated with the nozzle for igniting the mixture of oil and air when the burner is started.

The main housing also forms a support for an electric motor 22 which drives the secondary fan or blower 23, a primary or atomizing air pump 24 and an oil pump 25, here shown as arranged in alignment crosswise to the main housing.

The secondary air fan or blower 23 takes air through the slotted side wall 26 of the fan casing 15 under control of the rotary shutter 27 and delivers it through the draft tube 16 around the mixture of oil and air discharged from the orifice 28 of the nozzle 18. The volume is varied by adjusting the rotary shutter 27.

The primary or atomizing air pump 24 takes air in at 29 and delivers it through a pipe 30 into the upper portion of the main housing through the filter 13, which is charged with bronze wool, into the chamber 12 through which it passes over the supply of lubricating oil 31 and up through the filter 14 out through the pipe 32 leading to the air line 17. In fact, that air line, the pipes 30 and 32 and the chamber 12, may be considered as forming a single air line with a storage or pressure chamber in an intermediate position which insures an even flow to the nozzle and forms pressure for several other purposes.

The lubricating oil tank 11 is connected near the bottom by a pipe 33 with the pump 24 and by reason of the air pressure within the chamber 12 oil from the supply 31 in the tank 11 is continuously delivered to the air pump. As a result, this

pump delivers a mixture of air and oil or air and oil foam to the pipe 30 whereby the bronze wool in the filter 13 is made to serve as an oil separator and an air cleaner and the lubricating oil collected there drops down over the outside of the draft tube 16 and returns to the tank 11. The filter 13 is separated from the filter 14 by a partition 34, and the air compressed in the chamber 12 passes up through a second mass of bronze wool in the filter 14 before entering the pipe 32.

In practice, the apparatus is so designed that a pressure from five pounds to twelve pounds, for example, may be built up and maintained in the chamber 12. The pressure in the primary or atomizing air system is regulated by a bypass 35 connected across the inlet and outlet of pump 24 and controlled by an adjustable valve 36. In this diagram the bypass is shown as external piping, but in practice is worked out through the body or casing of the pump.

The oil pump 25 is preferably built for metering purposes only and should not be used to draw oil from the storage tank. Where gravity feed cannot be used, auxiliary pumping equipment 37 should be provided. The oil pump 25 takes oil from the supply line at 38 and delivers it to a pipe 39 leading to a cylinder 40 of a piston valve which connects it with the pipe 41, leading to the pipe 19, which delivers to the nozzle 18. The cylinder 40 is also connected by a bypass 42 with the intake or low pressure side of the pump 25, either directly by connection, for example, with the supply line 38, or indirectly. The piston 43 movable in the cylinder 40 serves to connect the line 39 with the line 41 or with the bypass 42, as occasion may require. The piston is associated with an air motor, here shown as a Sylphon bellows 44 located in the primary air chamber 12 and subject to the pressure in the chamber. As a result of this arrangement, oil from the pump 25 is bypassed back to the supply line until there is sufficient pressure in the air chamber 12 to insure delivery of a proper amount of primary or atomizing air to the nozzle 18, when the pressure in the chamber 12 will overcome the Sylphon 44 and shift the piston valve to a position in which it connects the pipe 39 with the pipe 41 and that, with the pipe 19, becomes one oil supply line from the pump to the nozzle. When, for any reason, the air pressure in the chamber 12 drops below that for which the device is designed and adjusted, the piston valve will shift to the right, cut off the supply of oil to the burner and connect the pump 25 with the bypass 42.

By making the presence of a considerable amount of lubricating oil in the primary air pump 24 necessary to seal it and give it the required capacity, it becomes impossible to run the pump long with insufficient lubrication for, as soon as the pressure in the chamber 12 drops below that required, the supply of oil is cut off and the control of any one of the customary forms will put the apparatus on safety and shut the burner down entirely. The presence of the lubricating oil in the air pump 24 in such quantity as to form a foam makes it possible to provide a very efficient filter with the bronze wool in the filter 13, which also serves as an oil separator and delivers the excess of oil back to the supply in the tank 11.

Any one of the many types of oil burner controls may be used with this system and none will be described in the interest of brevity. It will be sufficient to refer to "Oil Heating Hand Book," by Hans Kunitz, second edition, and "The Starbuck Oil Burner Manual, 1941."

Electric power for the liquid fuel burner system described may be taken from the house line 45 and the apparatus shown in the diagram will be understood from the following description of the operation.

When the room thermostat or boiler control 46 calls for heat Minneapolis-Honeywell R 117 relay 47 will be energized and close an electric circuit to the delayed action switch 48 allowing current to flow to the oil heater 20 and the ignition transformer 49. After a delayed action, for example, twenty-five seconds, switch 48 will close the circuit to motor 22, which will start the secondary air fan or blower 23, the primary or atomizing air pump 24 and the oil pump 25. While the pump 24 is building up the necessary pressure in the chamber 12, oil from the pump 25 is recirculated through the bypass, and the heater 20 is conditioning the oil in the pipe 19 and warming up the associated parts of the burner. When the pressure in chamber 12 reaches the selected amount the Sylphon 44 will be compressed and the piston valve 43 will cut out the bypass 42 and connect up the oil line leading to the nozzle 18. As the mixture of air and atomized heated oil is discharged from the orifice 28 of the nozzle, sparks from the electrodes 21 ignite it and the flame is further fed by the supply of secondary air delivered by the fan or blower 23 through the draft tube 16. After a short interval relay 47 will shut off the current to the ignition transformer 49. The resistance of the heater element 20 increases with the rise in temperature and the wattage drops to the selected limit for the particular design.

Mention of Minneapolis-Honeywell R 117 relay is merely by way of example. Many other controls can be used and some other controls must be used when the fire adjusting apparatus, later described, is associated with the burner.

Adjusting the fire

According to this invention, the operation of the apparatus described is modified to make the burner come on with a very small fire built up to the size required by the demand and thereafter vary with the varying demand. One embodiment of means to that end includes an air motor comprising a cylinder 50, equipped with a piston 51 whose piston rod 52 runs through the guide 53 and has one arm 54 connected by a link 55 with the rotating shutter 27 of the secondary air fan or blower and another arm 56 connected by a link 57 with a lever 58 on the oil pump 25 by which its capacity may be adjusted and enlarged as the shutter 27 is opened to increase the delivery of secondary air by the fan or blower 23.

The piston 51 is normally urged to the position shown by a spring 59 and its limit in that direction is determined by a low fire stop 60, its limit in the other direction being determined by a high fire stop 61, both adjustable on the piston rod 52 and made fast by set screws or the like.

In order to move the piston against the resistance of spring 59, air from the chamber 12 is conducted by a pipe 62 and delivered to a head chamber 63 in the air end of the cylinder 50 from which it passes by a port 64 into the cylinder and exerts its pressure against the piston 51. The length of the pipe 62 and the adjustment of a needle 65 will make the flow of air involve the time interval desired for response to change in demand, and the supply of air and oil will be increased or decreased in relation to the pressure permitted to build up against the piston head, this function,

however, being limited by the adjustment of low fire stop 60 and high fire stop 61. In some designs, the length of the pipe 62 will have a negligible effect and the control will be effected chiefly by adjusting the needle valve 65.

With this arrangement the burner will start with a very small flame and gradually build up to the required size, as determined by the design and adjustment, and will stay there until the burner is stopped, at which time the spring will force the piston to low fire position. During the movement to low fire position, the air in the cylinder will escape through the orifice 66 and the check valve 67, back to the chamber 12 and be discharged through the nozzle.

However, it is preferable to add a modulating control, one embodiment of which includes a pneumatic temperature or pressure device 68, connected with the cylinder 50 by a pipe 69, ending in a nozzle 70, when the temperature or pressure of the device 68, or the space to which it is subject, reaches the point at which it is set, the arm 71 will uncover the orifice 70, allowing some air to escape, thus lowering the pressure in the cylinder 50 and allowing the piston to move toward the air end of the cylinder under the action of the spring 59, thus reducing the supply of secondary air and oil. The piston will adjust itself to some point between high fire and low fire positions, depending on the demand indicated by the arm 71. If the temperature or pressure at the device 68 should drop or increase, the port 70 will be opened or closed correspondingly and, hence, the fire will be adjusted to correspond with the demand.

The device 68 may be any pneumatic control that will open a port on an increase of temperature or pressure and bleed the air from the line 69 to the atmosphere, or close the port on a decrease of temperature or pressure, such, for example, as Minneapolis-Honeywell L-092D. These devices are available in a number of scale ranges and may be used as a warm air control by mounting in the air stream, as an immersion aquastat by inserting it in the liquid to be controlled or as the steam pressure control, by mounting it in the boiler water just below the water line. The boiler water temperature changes with the steam pressure in accordance with familiar steam tables. As these devices and their applications are familiar, specific disclosure is omitted in the interest of brevity.

To summarize the sequence of operation which takes place whenever the burner is started:

First, the thermostat 46 closes the circuit through the relay 47 which in turn causes current to flow through the heating element 20 and to the ignition transformer 49. After a given time interval, for example 25 seconds, the circuit through the electric motor 22 is closed which starts the primary air pump 24, the secondary air blower 15 and the oil pump 25. In approximately two or three seconds after the air pump 24 is placed in operation, the pressure in the chamber 12 is sufficient to open the fuel valve to the nozzle and the fuel in the oil line immediately adjacent to the nozzle has, in the meantime, been heated to a temperature which is sufficient to bring about quick ignition when atomized at the nozzle and subjected to the ignition spark. When the fuel valve is opened, causing oil to flow to the nozzle, the modulating motor is at low fire position, as shown in Fig. 1, because the escape of primary air through the nozzle prior to the opening of the fuel valve holds down the primary air

pressure to such a point that it will not overcome the force of the spring 59 and furthermore, the needle valve 65 of the modulating motor prevents the pressure which is built up by the primary air pump prior to ignition from throwing the modulating motor off of low fire position. However, as soon as the oil begins to flow through the nozzle, a back pressure is created in the primary air line which is transmitted through the needle valve 65 to the modulating motor and within a few seconds, say three or four seconds, after ignition has taken place, the piston 51 of the modulating motor begins to move slowly outwardly thereby gradually building up the fire to the desired point. This gradual building up of the flame from a low fire start to the size of flame called for by the burner load demand (which may take 15 or 20 seconds) is very important for proper operation of the burner because experience shows that a sudden change from low fire to high fire at the beginning of burner operation will cause the stack to choke and set up back pressures which will cause smoking and otherwise interfere with proper burner operation. By gradually building up the flame from a low flame which is easy to ignite to a higher flame gives the hot gases a chance to clean out the stack of cold air and produce proper draft conditions for efficient burner operation.

Second, after the primary air pressure has been built up to move the modulating motor to high fire position, the control of the modulating motor is automatically transferred to the regulator 63 which either holds the pressure in the primary air line or bleeds it out in proportion to the load demand.

Main housing

Referring to Figs. 2, 3 and 4, it will be seen that the bottom of the main housing is formed by a base 72, having a downturned edge 73 and a machined rib 74 on its upper face to receive and be secured to the bottom of the generally rectangular wall 75, which surrounds the lubricating oil space and with the base forms the oil tank or reservoir 11.

Just above the lubricating oil tank, and at the right in Fig. 3, there is a hollow cylindrical projection 76, open at 77, to receive the air operated shut-off valve for the oil supply.

Above the projection 76 is a larger hollow cylindrical projection 78, the right side of which, in Fig. 3, is formed by the slotted wall 26 and the left side of which is formed by the partition wall 79, which is curved at 80 to form the throat or entrance to the Sirocco fan or blower 23.

The draft tube 16 intersects the main housing somewhat below the mid portion, and the lower wall 81, Fig. 4 of the draft tube, extends across the main housing above the lubricating oil tank 11 and, in effect, forms the upper portion of the chamber for primary or atomizing air.

Referring to Figs. 3 and 4, it will be seen that the sides of the main housing are bulged at 82 and 83 to form passages upwardly around the draft tube and leading to the space for the filters 13, 14 (Fig. 1) which is closed at the top by a cap plate 84, secured in place by bolts and carrying an air pressure gauge 85. The bronze wool which really forms the filtering and oil separating elements of the filters 13 and 14, fills the spaces above the draft tube divided by the wall 34 and closed by the cap 84. Removing that cap permits access for cleaning the bronze wool, which should

be done at suitable periods by removal and washing in kerosene or some similar solvent.

The upper portion of the draft tube at the left in Fig. 4, opens into the secondary air fan or blower casing 15 which is generally eccentric with respect to the fan or blower 23, but affords direct and proper communication for air from the blower into and through the draft tube 18.

Just below the fan casing 15 and opposite to the draft tube the main housing has an opening closed by a cap 86, into which the air tube 17 is fitted at the end opposite to that connected with the nozzle 18. The cap also carries an appropriate nipple, etc., 87 for connection with the air pipe 32, thus establishing the complete air line from the primary or atomizing air pump to the nozzle.

At each side of the nipple 87, and slightly above, are open insulated fittings 88 to admit wires 89, the inner ends of which are secured to the electrodes 21 by nuts 90, (Fig. 4).

Beneath the nipple 87 the cap 86 has an opening 91 to admit the heater tube 92 which surrounds the heater 20, and the oil line 19, leading to the nozzle 18. Suitable mounting for the electrical connections and the end of the oil pipe 19 are provided by a large cast fitting 93, secured to the cap 86.

Forked pedestals 94 (Figs. 3 and 4) have openings 95 and 96 to receive the air pipe 17 and the heater tube 92 and clamps 97 to receive the insulating tubes 98 for the electrodes 21. Projections 99 on the clamps 98 and a leg 100 engage the inside of the draft tube and form a support for the assembly bound together by the pedestals 94. By removing the fastenings for the cap 86 this assembly, called in practice the drawer assembly, may be withdrawn as a unit from the draft tube. The delivery end of the draft tube is equipped with a suitable converging fitting 101 (Fig. 4) to direct the secondary air against the mixture of oil and primary air discharged from the nozzle 18. The detailed construction of the nozzle, its connection with the primary air pipe 17, the oil pipe 19 and its operation in use will be sufficiently clear from the enlarged section in Fig. 5, without specific description.

The size of the orifice, the spray angle and such like will vary with conditions and personal preference.

The rectangular portion 75 of the main casing surrounding the lubricating oil space, is provided at one side in Fig. 2, with a non-breakable sight glass 102, through which the lubricating oil can be readily observed in order to maintain it at the appropriate level indicated by the line 103.

The air operated shut-off valve for oil

Referring to Fig. 3, it will be seen that the cylinder 40 of the air operated piston valve, described in connection with the diagram, Fig. 1, has a reduced portion 104, received in and secured fast to the hollow flange 105 of a disk 106, bolted to the main casing to close the opening 77. The Syphon bellows 44 has one end 107 soldered, or otherwise properly secured to the inner face of the disk 106 and its opposite closed end 108, cooperates with the cartridge shaped plunger 109, the bottom of which acts directly on the stem 110 of the piston valve and the wall of which telescopes over the nipple 111 on the cylinder 40.

The oil pipes 39 and 41 and the bypass pipe 42 are secured to the cylinder 40 by nipples 112, 113 and 114, respectively (Fig. 3) which connections are threaded to nipples, which in turn, are

threaded into openings forming proper communication with the interior of the cylinder 40, which will be understood without specific description. The right end of the cylinder 40 in Fig. 3 is closed by a screw-headed cap 115 which serves to compress a spring 116 against the end of the piston 43 and normally urge it to the position shown.

When pressure of the air in the chamber 12 collapses the Syphon towards the right in Fig. 3, it will move the piston to the right and compress the spring 116. When the pressure in the chamber 12 is relieved, the spring 116 will move the parts back towards the position shown in Fig. 3 and under proper conditions will shut off the oil from the burner and connect the oil pipe 39 with the bypass 42, Fig. 1.

The shut off movement of the piston 43 produces a partial vacuum in the right end of the cylinder 40, which is relieved through the passage 9 (Fig. 3) by flow from the nozzle and prevents dripping at the orifice. Thus as an incident to stopping the flow of oil to the burner when the supply of atomizing air is insufficient, there is a slight withdrawal of oil from the nozzle that prevents dripping and a corresponding accumulation in the cylinder 40 which is immediately forced towards the nozzle when the air operated shut off valve is again shifted to permit the oil to flow to the burner.

The motor and secondary fan

The casing of the electric motor 22 is provided with a shouldered flange 117 (Fig. 3) to fit wall 118 of the fan casing 15 and be secured to it by bolts. The motor shaft 119 is fitted into the hubs 120 of the secondary fan or blower 23 which is preferably of the Siroco type.

The primary air pump

Referring to Figs. 3, 7, 11 and 12, it will be seen that the primary air pump casing is formed by two disks 121 and 122, spaced apart and secured to a cylindrical ring or shell 123 within which is an eccentric rotor 124, keyed to a shaft 125, journaled in the hub portions 126 and 127 of the disks 121 and 122. The disk 122 has a cylindrical flange 128, which telescopes with and is secured to the boss 129 on the slotted wall 26 of the housing.

The eccentric rotor 124 is provided with four slots 130 (Fig. 11) to receive reciprocating vanes 131, the outer edges of which engage the inner perimeter of the ring 123, and serve to propel the air through the pump. The vanes are urged radially outward by springs 132 surrounding guide pins 133, extending through the shaft 125.

As will be seen from Fig. 7, the air inlet 134 in this instance is through the disk 122 and leads to a curved inlet passage 135 (Fig. 12) open to the inside of the pump chamber. The outlet 136 for air leads through the periphery of the disk 121 to a curved passage 137 (Fig. 11) in communication with the pump chamber.

From this it will be apparent that rotating the shaft 125 clockwise in Fig. 11 will cause the air to enter through the inlet passage 134 and be compressed by the vanes 131 successively and driven through the outlet into the pipe 30 leading to the main housing, Fig. 1.

The disk 122 is provided with a bushing 138 in which the shaft 125 is journaled, and the disk is provided with a curved bypass inlet 139 (Fig. 12) communicating with a cored passage 140 leading to the curved inlet passage 135. Flow through this bypass is controlled and adjusted

by the screw valve 141 locked in place by the nut 142. By adjusting that valve the bypassed air can be cut off or increased in any amount to regulate the delivery of the pump to anything within its capacity.

As heretofore stated, the screw valve 141 is adjusted to maintain some normal pressure in the chamber 12, for example a normal pressure within the range of five to twelve pounds. A feature of the present form of the invention, however, is that the moving parts of primary air pump 24 are dimensioned with such liberal clearances that plentiful lubrication of the pump interior is required to cause and maintain the normal pressure. If internal lubrication of the pump is non-existing or is insufficient to adequately seal the clearance spaces, the pump will function at a lower level of efficiency, the pressure in the chamber 12 then being too low to contract the Sylphon 44 to close the fuel pump bypass but high enough to force lubricant through pipe 33 to the air pump.

Clearance may be provided between any of various cooperating surfaces. Thus clearance may be between the edges of blades 131 and adjacent surfaces of discs 121 and 122 (Fig. 7), or between faces of rotor 124 and corresponding faces of the discs 121 and 122, or between faces of blades 131 and corresponding faces or walls of slots 130. (Fig. 11.) The provision of such clearance requires only the ordinary skill expected in this art, especially since the pressure created by the pump running without lubricant is not critical. To prevent actuation of the valve piston 43, it is sufficient that the pressure from the pump drop to any value below five pounds and a minimum pressure of only one pound will lift oil from the sump a vertical distance of over thirty inches. Thus the clearance in the working parts of the pump may be such as, in the absence of lubricant, to drop the output pressure to any value between one and five pounds.

The oil pump

Refer to Figs. 3, 7, 8, 9 and 10.

The casing of the oil pump 24 is formed by a cylinder 143 integral with the hub 126 of the primary air pump and a disk-like cylinder head 144 secured by bolts. Within this cylinder 143 is a bronze rotor 145 keyed to the end of the shaft 125 by a pin 146. Adjacent to the end of the shaft 125, the rotor is provided with a transverse bore 147 in which is a double ended piston 148, the intermediate portion of which is cut away to form a notch 149, which receives an eccentric pin 150, projecting through the disk 151, which bears against the end of the rotor 145.

Refer to Fig. 10.

The inlet for oil 152 through the cylinder 143 is in communication with a curved inlet passage 153 extending partially around the rotor 145 coincident with the cylindrical bore 147. The outlet for oil 154 in the cylinder 143 communicates with a curved outlet passage 155, also coincident with the bore 147 in the rotor 145.

From this it will appear that when the shaft 125 is driven, the double ended piston 148 will reciprocate back and forth and oil entering the inlet 152 will be forced out the outlet 154.

By changing the eccentricity of the pin 150, the stroke of the double ended piston can be changed and thus the capacity or the delivery of the oil pump can be varied within the limits of the design. To accomplish this adjustment, the disk 151, bearing the pin 150, is provided with a slot 156 (Figs. 3a, 9 and 10) which receives guiding

pins 157, carried by the head 144. And these pins allow the disk 151 rectilinear motion crosswise to the axis of the shaft 125, but no rotation.

The end of the pin 150, opposite to that which engages the disk 151, is provided with a socket 158, which receives a crank pin 159 on the shaft 160, the reduced end portion 161 of which projects through the stuffing box 162 on the head 144 and is equipped with the lever 58.

By rotating the shaft 160, the crank 159 can be made to change the eccentricity of the pin 150 from nothing to the extreme within the range of the design and to that extreme in either direction, thus the stroke of the piston can be adjusted from neutral to maximum and the same pump may be made to act as a pressure pump or a vacuum pump or, in other words, the intake and exhaust sides can be reversed by simply rotating the shaft 160 and the length of the stroke in either phase of operation can be adjusted from zero to a maximum.

In this particular liquid fuel burner system the pump will not be reversed, but it will be adjusted from various small capacities to the largest within the limit of the design, and that is accomplished in the organization shown in Fig. 1 by the operation of the lever 58 through air pressure or the spring 59 in the cylinder 50.

Referring again to Fig. 3, it will be seen that the shutter 27 for the secondary air is rotatably mounted on the cylindrical flange 128 by which the pump assembly is mounted on the main housing. The connection allows free rotation of the shutter without unnecessary play in operation by the link 55 when the modulating motor is used, or by other means when the modulating motor is not used. The cylinder 50 is supported by a bracket 163 bolted to the main housing at 164 and provided with a clamp 165 made fast by bolts 166. This means of mounting it affords ready adjustment in connection with the stops 60 and 61.

For convenience in manufacture and assembly the three pumps and the motor for driving them have a common axis. The shaft for the primary air pump and the oil pump is in one piece and is connected with the shaft of the secondary air fan 23 by a yielding flexible coupling 167.

The oil pump here disclosed has a positive displacement and, being double acting, its delivery for a given adjustment and speed is constant for all practical purposes. For that reason, when it is used as a metering pump the apparatus can operate successfully in No. 5 oil.

The use of a double ended piston also has the advantage of giving the required capacity in very small size.

When the stroke of the piston is increased by movement of the lever 58, as described, the delivery of oil to the nozzle is positively increased. The increased delivery of oil results automatically in increased air pressure in the air line as required for proper atomization of the increased oil flow. In a domestic oil burner adjusted for a normal pressure of five pounds in the primary chamber 12, the pressure in the chamber has been observed to build up as high as ten pounds when the rate of fuel delivery is substantially increased.

One reason for the automatic rise in pressure is that the increased flow of oil at the burner nozzle offers increased resistance to air flow from the nozzle thereby tending to increase air pressure in the air line back of the nozzle.

At first thought it would seem that the increase of air pressure resulting from increasing the oil

flow would undesirably cause the modulating motor to shift the adjustment lever 58 in the direction for still greater increase in oil flow. However, the building up of primary air pressure due to the increased oil pressure does not appreciably affect the operation of the modulating motor because it merely causes the piston to move outwardly a little more than it would otherwise, but this excess movement is very quickly compensated for by the reduced temperature demand at the thermostat.

By operating the adjustment of the oil pump and secondary air shutter with the pressure of atomizing air, the adjustment of fuel and total air becomes automatic for increasing the fire after a start and for modulating it in accord with the varying requirements for heat.

The oil pump also has its advantages when used without the automatic adjustment and some will desire to have it so. In such instances the cost can be somewhat reduced by replacing the shaft 160 with its crank 159, the lever 158 and associated parts, by a screw threaded in the cylinder and cooperating with the pin 150, to shift it in accord with the length of the stroke or capacity of the pump required. In that instance, and in other instances, some will wish to provide a spring 168 (Figs. 8 and 9) to constantly urge the pin 150 in one direction.

The automatic increase from low fire to high fire position will not work with Minneapolis-Honeywell Relay 117 because the stack control will throw the device on safety at low fire position. In such instances the R 117 relay should be replaced by one of the many other controls as, for example, those actuated by the light of the flame instead of the stack temperature.

I claim:

1. In an oil burner, the combination of a nozzle, fuel and primary air lines to the nozzle, a primary air pump for forcing air under pressure to the primary air line, a positive displacement variable capacity oil pump for supplying metered quantities of oil through the oil line to the nozzle regardless of the viscosity of the oil, valve means for bypassing oil from the delivery side of the oil pump to the intake side thereof whenever the primary air pressure is below a predetermined value, and means for varying the amount of oil pumped by said oil pump in response to burner load demand.

2. In an oil burner, the combination of a nozzle, fuel and primary air lines to the nozzle, a positive displacement variable capacity oil pump having its discharge side connected to the fuel line, and means for varying the amount of oil pumped by said pump in response to burner load demand, said means including a cylinder receiving air from the primary air system through a restriction, a piston in the cylinder connected with said pump for capacity control thereof, a spring opposing movement of the piston in response to the pressure of the primary air line, said restriction serving to delay movement of the piston in response to an increase in the pressure of the primary air line.

3. In an oil burner, the combination of a nozzle, fuel and primary air lines to the nozzle, means, including a draft tube telescoped over a portion of said lines for supplying secondary air to the space around the nozzle, a primary air pump for forcing air under pressure to the primary air line, a positive displacement variable capacity oil pump having its discharge side connected to said line for supplying metered quantities of oil

through the oil line to the nozzle regardless of the viscosity of the oil, valve means for bypassing oil from the delivery side of the oil pump to the intake side thereof whenever the primary air pressure is below a predetermined value, and means for varying the amount of oil pumped by said oil pump in response to burner load demand.

4. In an oil burner, the combination of a nozzle, fuel and primary air lines to the nozzle, means including a draft tube telescoped over a portion of said lines for supplying secondary air to the space around the nozzle, a primary air pump for forcing air under pressure to the primary air line, a positive displacement variable capacity oil pump for supplying metered quantities of oil through the oil line to the nozzle regardless of the viscosity of the oil, and means for starting the burner with a low flame and gradually increasing it to the size required by burner load demand, said means including a device for gradually increasing the amount of oil pumped to the nozzle by said oil pump.

5. In an oil burner, the combination of a nozzle, fuel and primary air lines to the nozzle, means including a draft tube telescoped over a portion of said lines for supplying secondary air to the space around the nozzle, a primary air pump for forcing air under pressure to the primary air line, a positive displacement variable capacity oil pump for supplying metered quantities of oil through the oil line to the nozzle regardless of the viscosity of the oil, and means for starting the fire with a low flame and then gradually increasing the supply of oil to enlarge the flame to correspond with burner demand, said means including an air motor operatively connected to the oil pump to change the rate of oil delivery, means for actuating the air motor from the primary air line, and a timing device for delaying the action of the air motor in changing the rate of oil flow in response to changes in the primary air pressure.

6. In a device of the character described having a burner, means to deliver primary air to the burner, a secondary air passage to the burner, means to deliver oil to said burner, and means to deliver air to said secondary air passage, the combination therewith of means to vary the rate of oil delivery, means to vary the rate of secondary air delivery, fluid-pressure-responsive means operatively connected with both of said delivery varying means, and passage means connecting said responsive means with said primary air passage whereby said responsive means increases the rates of oil and secondary air delivery in response to the initial establishment of operating pressure in said primary air passage, said passage means being restricted to delay the response of said responsive means to said establishment of pressure.

7. In a device of the character described having a burner, means to deliver primary air to the burner, a secondary air passage to the burner, means to deliver oil to said burner, and means to deliver air to said secondary air passage, the combination therewith of means to vary the rate of oil delivery, means to vary the rate of secondary air delivery, fluid-pressure-responsive means operatively connected with both of said delivery varying means, and passage means connecting said responsive means with said primary air passage whereby said responsive means increases the rates of oil and secondary air delivery in response to the initial establishment of operating pressure in said primary air passage, said

passage means being sufficiently restricted both to delay response of said responsive means to said establishment of pressure and to retard the rate of response thereby to cause the increase of oil and air delivery to occur gradually over a period of time after a delay period.

8. In a device of the character described having a burner, means to deliver primary air to the burner, a secondary air passage to the burner, means to deliver oil to said burner, and means to deliver air to said secondary air passage, the combination therewith by means to vary the rate of oil delivery, means to vary the rate of secondary air delivery, fluid-pressure-responsive means operatively connected with both of said delivery varying means, passage means connecting said responsive means with said primary air passage whereby said responsive means increases the rates of oil and secondary air delivery in response to the initial establishment of operating pressure in said primary air passage, said passage means being restricted to delay the response of said responsive means to said establishment of pressure, a bleeder passage from said fluid-pressure-responsive means, means to control the rate of flow through said bleeder passage thereby to determine the adjustment of said responsive means relative to pressure in said primary air passage and means to operate said control means in response to the demand for heat.

9. In an oil burner, the combination of a nozzle, fuel and primary air lines to the nozzle, a positive displacement variable capacity oil pump having its discharge side connected to the fuel line, means for varying the amount of oil pumped by said pump, an air motor actuated by air pressure from said primary air line to control said varying means, and means to modify the action of said air motor in response to demand for heat.

10. In a device of the character described, a burner, an oil passage to the burner, an air passage to the burner, means to deliver oil to said oil passage, means to deliver air to said air passage, a first fluid-pressure-actuated means connected with said air passage for response to pressure therein, a second fluid-pressure-actuated means connected with said air passage for response to pressure therein, a first control means responsive to said first fluid pressure means effective to initiate oil delivery to said oil passage at a predetermined rate for starting said burner, and a second control means responsive to said second fluid pressure means effective to increase the rate of oil delivery gradually from said predetermined rate to a desired operating rate.

11. In a device of the character described, a burner, an oil passage to the burner, an air passage to the burner, means to deliver oil to said oil passage, means to deliver air to said air passage, a first fluid-pressure-actuated means connected with said air passage for response to pressure therein, a second fluid-pressure-actuated means connected with said air passage for response to pressure therein, a first control means responsive to said first fluid pressure means effective to initiate oil deliver to said oil passage at a predetermined rate for starting said burner, a second control means responsive to said second fluid pressure means effective to increase the rate of oil delivery gradually from said predetermined rate to a desired operating rate, and means to vary the responsiveness of said second control means in response to demand for heat.

12. In a device of the class described, a burner, an oil pump for supplying oil to the burner, an

air pump for supplying primary air to the burner, means for supplying secondary air to the burner, means comprising an air motor responsive to primary air pressure and including a restriction in the primary air line leading to the air motor for starting the burner with a low flame and then relatively gradually increasing the supply of oil and secondary air until the flame reaches its desired size, and means for thereafter varying the size of flame with the demand for heat.

13. In a device of the class described, a burner, means for supplying air to the burner, modulating means comprising an air motor responsive to primary air pressure and including a restriction in the primary air line leading to the air motor for starting oil feed to the burner at a relatively low rate for starting the burner with a low flame, and automatic means responsive to such initiation of oil feed to increase the oil feed relatively gradually until the flame reaches a desired size, said modulating means thereafter varying the size of the flame with the demand for heat.

14. In a device of the character described, a burner, an oil passage to the burner, means to deliver air under pressure to said oil passage, means to deliver oil to said passage after delivery of air thereto is started thereby to increase the air pressure in the passage by a throttling action, said oil delivery means including means operating initially to deliver oil to the nozzle at a minimum rate to support a low burner flame, and means responsive to said increase in pressure in said passage to increase the rate of oil delivery at a relatively gradual rate thereby to increase the burner flame to a desired size, and means for thereafter fully modulating the size of the flame with the demand for heat.

15. In an oil burner, the combination of a nozzle, fuel and primary air lines to the nozzle, a primary air pump for forcing air under pressure to the primary air line, a positive displacement variable capacity oil pump for supplying metered quantities of oil through the oil line to the nozzle regardless of the viscosity of the oil, means for shutting off the supply of oil to the nozzle whenever the primary air pressure is below a predetermined value, and means for varying the amount of oil pumped by said oil pump in response to burner load demand.

16. In an oil burner, the combination of a nozzle, fuel and primary air lines to the nozzle, a primary air pump for forcing air under pressure to the primary air line, a positive displacement variable capacity oil pump for supplying metered quantities of oil through the oil line to the nozzle regardless of the viscosity of the oil, adjustable means for supplying secondary air around the nozzle, means for shutting off the flow of oil to the nozzle whenever the primary air pressure is below a predetermined value, and means for varying the amount of oil pumped by said oil pump and the volume of secondary air delivered around the nozzle in response to burner load demand.

17. In a device of the class described, a burner, an oil pump for supplying oil to the burner, an air pump for supplying primary air to the burner, means for supplying secondary air to the burner, means comprising an air motor responsive to primary air pressure and including a restriction in the primary air line leading to the air motor for starting the burner with a low flame and then relatively gradually increasing the supply of oil and secondary air until the flame reaches its desired size, means for thereafter varying the size

of the flame with the demand for heat, and means for automatically resetting the air motor to low fire position promptly upon stopping of the burner whereby a quick re-start of the burner will always begin with a low flame and then gradually increase to its desired size.

18. In an oil burner, a nozzle, means for delivering oil to the nozzle, means including a burner motor for delivering primary air under pressure to said nozzle, and means for modulating the amount of oil delivered to the nozzle in response to burner demand, said modulating means including an air motor responsive to primary air pressure and operatively connected to said oil delivery means, adjustable means for preventing the air motor from cutting down the supply of oil to the nozzle below a predetermined minimum, and additional means for completely shutting off the flow of oil to the nozzle when the burner motor is not in operation.

19. In an oil burner, a nozzle, means for delivering oil to the nozzle, means including a burner motor for delivering primary air under pressure to said nozzle, and means for modulating the amount of oil delivered to the nozzle in response to burner demand, said modulating means including an air motor responsive to primary air pressure and operatively connected to said oil delivery means, adjustable means for preventing the air motor from cutting down the supply of oil to the nozzle below a predetermined minimum, adjustable means limiting the volume flow of oil to the nozzle under maximum oil burner demand, and additional means for completely shutting off the flow of oil to the nozzle when the burner motor is not in operation.

20. In an oil burner, a nozzle, means for delivering oil to the nozzle, means for delivering primary air under pressure to said nozzle, and means for modulating the amount of oil delivered to the nozzle in response to burner demand, said modulating means including an air motor having an air chamber with a wall thereof movable in response to air pressure in the chamber and operatively connected to said oil delivery means to control the amount of oil fed to the nozzle, and means for connecting the air chamber to the primary air delivery means through a restricted orifice.

21. In an oil burner, a nozzle, means for delivering oil to the nozzle, means for delivering primary air under pressure to said nozzle, and means for modulating the amount of oil delivered to the nozzle in response to burner demand, said modulating means including an air motor having an air chamber with a wall thereof movable in response to air pressure in the chamber and operatively connected to said oil delivery means to control the amount of oil fed to the nozzle, and means for connecting the air chamber to the primary air delivery means through a restricted orifice, said orifice being adjustable as to size to thereby vary the responsiveness of the air motor to rapid increases in primary air pressure.

22. In an oil burner, a nozzle, means for delivering oil to the nozzle, means for delivering primary air under pressure to said nozzle, and

means for modulating the amount of oil delivered to the nozzle in response to burner demand, said modulating means including an air motor having an air chamber with a wall thereof movable in response to air pressure in the chamber and operatively connected to said oil delivery means to control the amount of oil fed to the nozzle, means for connecting the air chamber to the primary air delivery means through a restricted orifice, and means for bypassing the restricted orifice to obtain a quick equalization of pressure between the air chamber and the primary air delivery means whenever there is a relatively quick drop in pressure in said latter means.

23. In an oil burner, a nozzle, means for delivering oil to the nozzle, means for delivering primary air under pressure to said nozzle, and means for modulating the amount of oil delivered to the nozzle in response to burner demand, said modulating means including an air motor having an air chamber with a wall thereof movable in response to air pressure in the chamber and operatively connected to said oil delivery means to control the amount of oil fed to the nozzle, means for connecting the air chamber to the primary air delivery means through a restricted orifice, and means for bypassing the restricted orifice to obtain a quick equalization of pressure between the air chamber and the primary air delivery means whenever there is a relatively quick drop in pressure in said latter means, said bypass means around the orifice including an air passage between the air chamber and the primary air delivery means and a check valve in said passage.

24. In an oil burner, a nozzle, means for delivering oil to the nozzle, means for delivering primary air under pressure to said nozzle, and means for modulating the amount of oil delivered to the nozzle in response to burner demand, said modulating means including an air motor having an air chamber with a wall thereof movable in response to air pressure in the chamber and operatively connected to said oil delivery means to control the amount of oil fed to the nozzle, means for connecting the air chamber to the primary air delivery means through a restricted orifice, and means for quickly releasing the pressure in the air chamber whenever the burner is stopped.

25. In an oil burner, a nozzle, means including a positive displacement pump for delivering oil to the nozzle at rates independent of viscosity changes, means for delivering primary air under pressure to said nozzle, means for supplying secondary air to the vicinity of the nozzle in a predetermined volume relationship to the rate at which oil is being fed to the nozzle, means for modulating the amount of oil delivered to the nozzle and the secondary air delivered in its vicinity in response to burner demand, said modulating means being constructed and arranged so that throughout its range of operation it substantially maintains the predetermined volume relationship between the oil and secondary air being delivered to and in the vicinity, respectively, of the nozzle.

EARL JOSEPH SENNINGER.

Certificate of Correction

Patent No. 2,397,987.

April 9, 1946.

EARL JOSEPH SENNINGER

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 7, first column, line 12, claim 8, for the words "therewith by" read *therewith of*; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 4th day of June, A. D. 1946.

[SEAL]

LESLIE FRAZER,*First Assistant Commissioner of Patents.*