April 14, 1953 P. H. BILLS ET AL 2,634,805

DUAL RATE LIQUID ATOMIZING APPARATUS AND DUAL FIRING RATE OIL BURNER EMBODYING THE SAME

Filed April 4, 1951 4 Sheets-Sheet 1

Fig. 1.

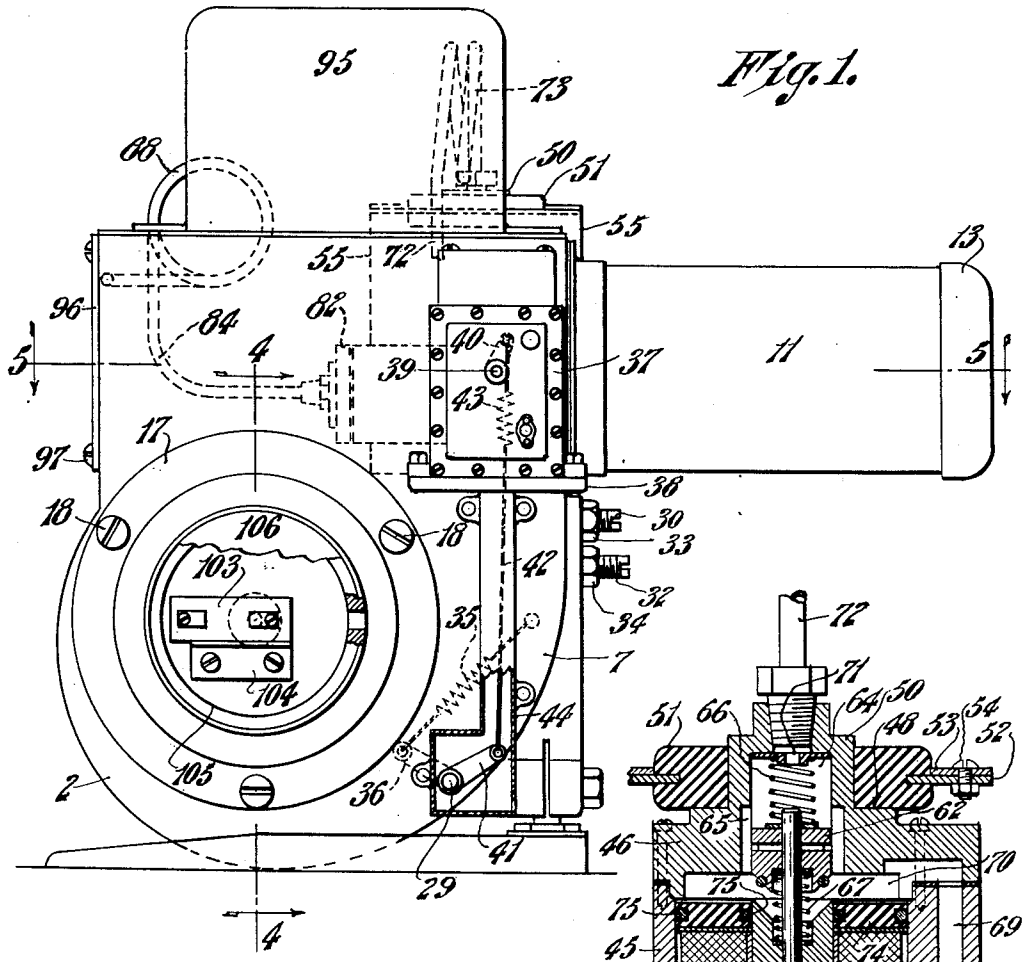
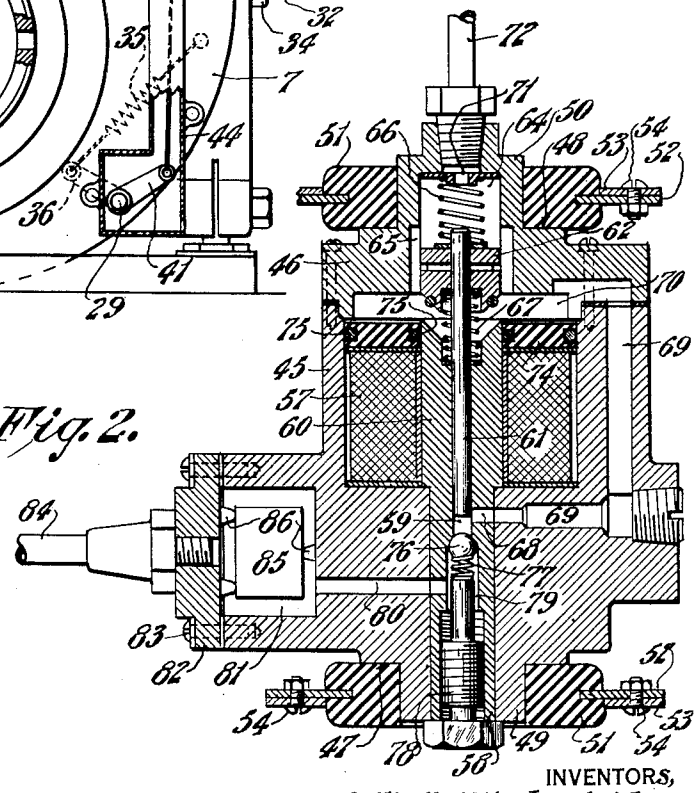


Fig. 2.



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Filed April 4, 1951 4 Sheets-Sheet 2

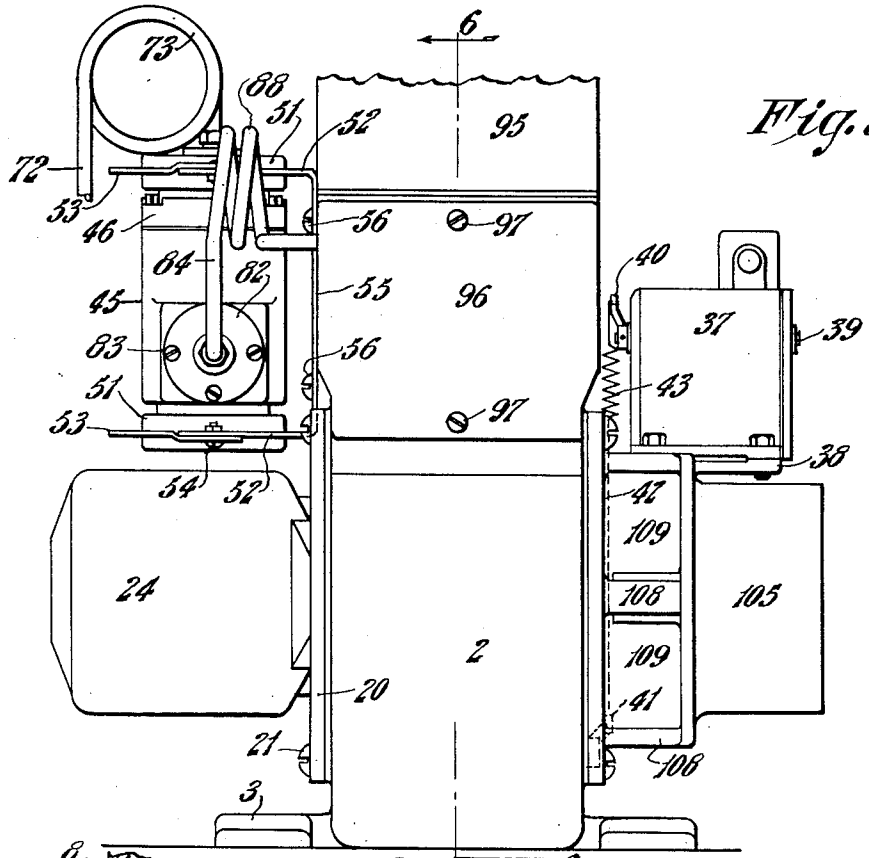


Fig. 3.

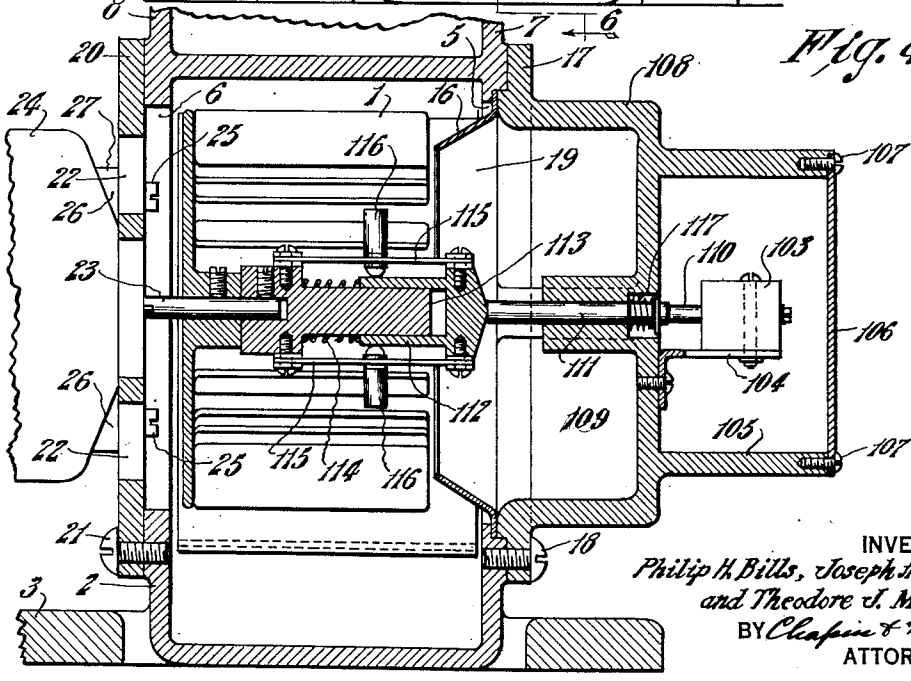


Fig. 4.

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Filed April 4, 1951 4 Sheets-Sheet 3

Fig. 5.

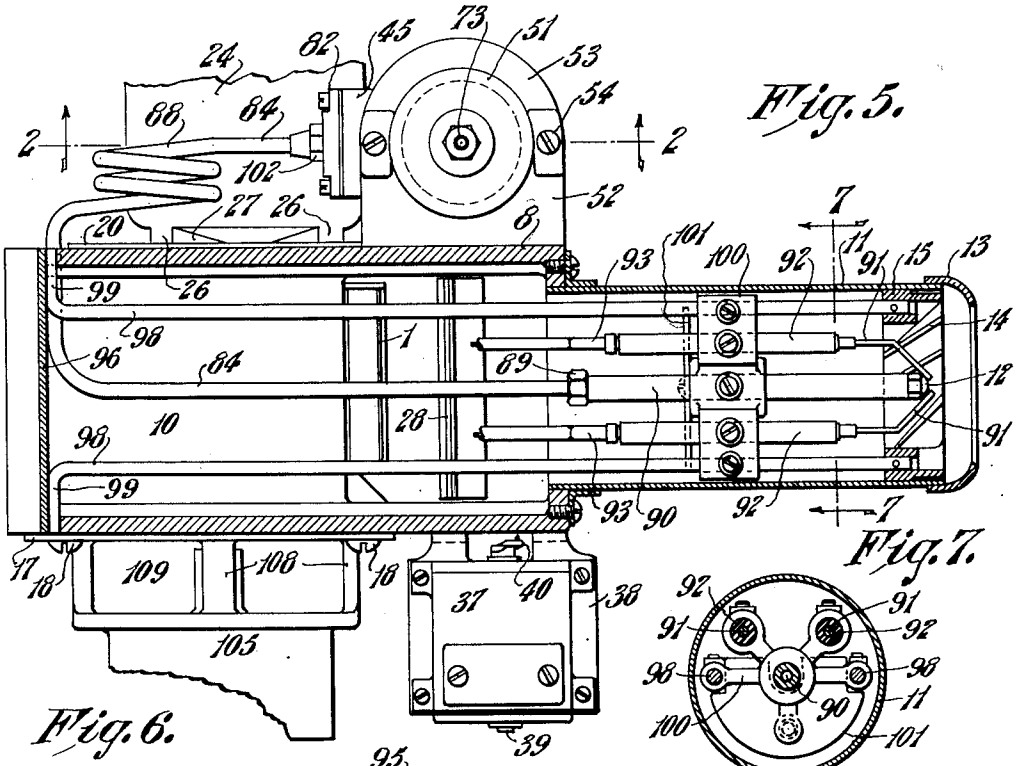
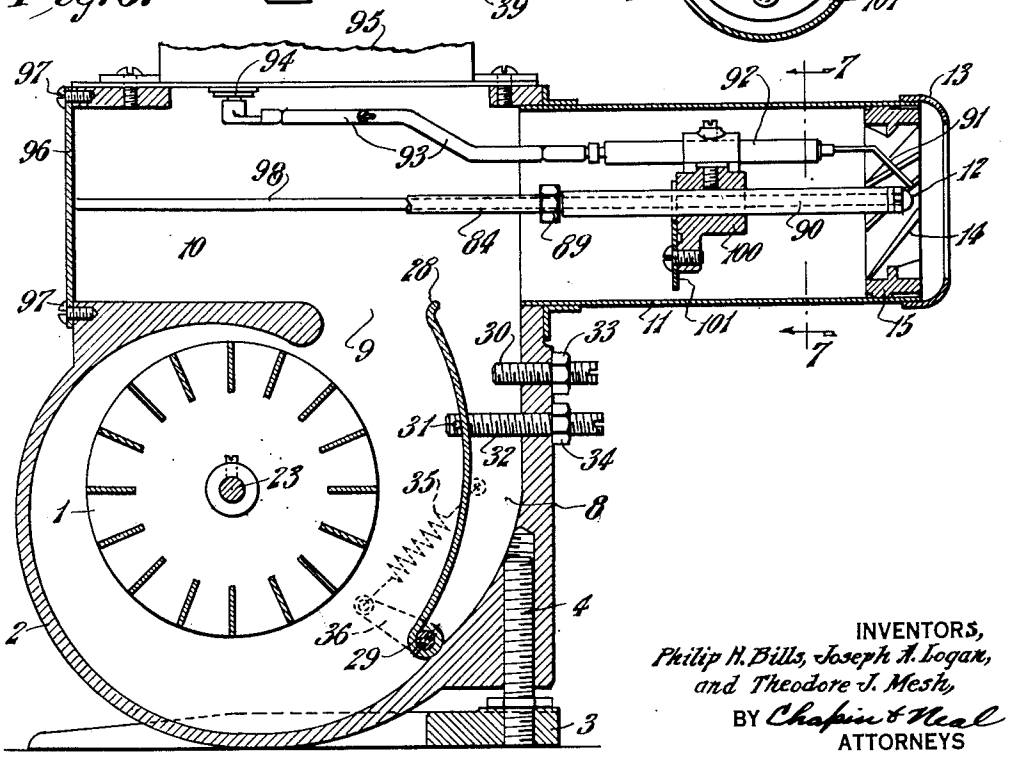


Fig. 7.

Fig. 6.



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DUAL RATE LIQUID ATOMIZING APPARATUS AND DUAL FIRING RATE OIL BURNER EMBODYING THE SAME

Filed April 4, 1951 4 Sheets-Sheet 4

Fig. 8.

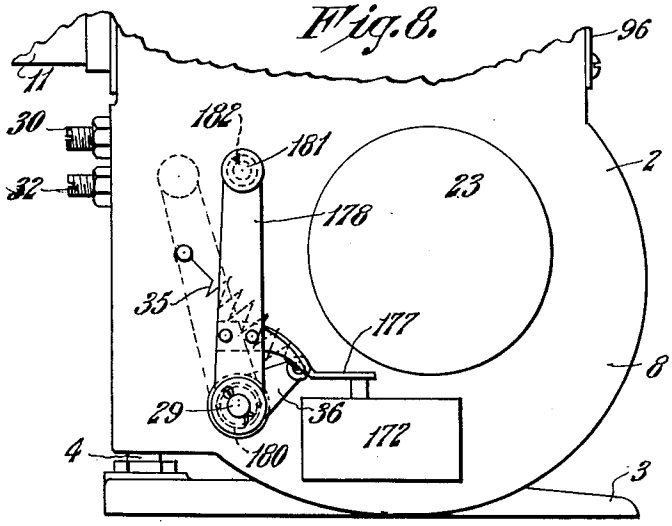


Fig. 9.

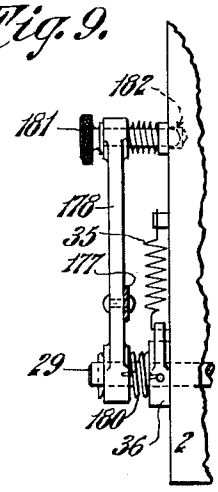


Fig. 10.

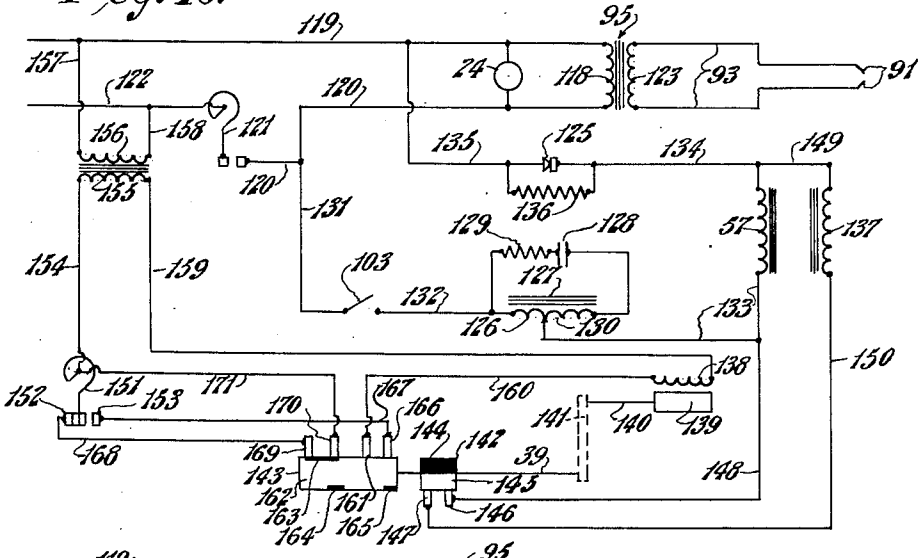
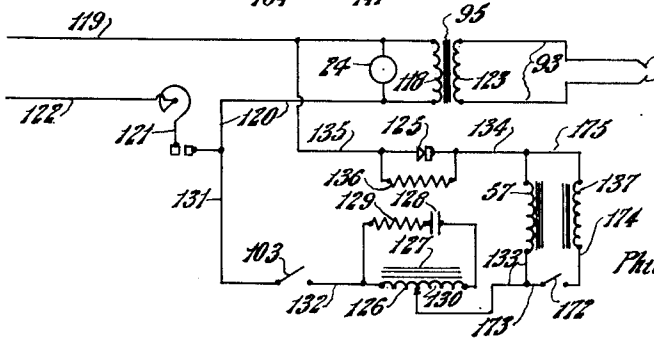


Fig. 11.



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Patented Apr. 14, 1953

2,634,805

UNITED STATES PATENT OFFICE

2,634,805

DUAL RATE LIQUID ATOMIZING APPARATUS AND DUAL FIRING RATE OIL BURNER EMBODYING THE SAME

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Application April 4, 1951, Serial No. 219,186

3 Claims. (Cl. 158—28)

1

This invention relates to the atomization of liquids by means of a mechanical or pressure atomizing nozzle at more than one rate, when supplied with liquid by an electromagnetically-controlled reciprocating-piston pump, the piston of which reciprocates at relatively high frequency, say for example, at 3600 cycles per minute.

The invention is capable of general application. However, it finds one very important specific use in connection with the atomization of liquid fuel in pressure-atomizing oil burners of the class adapted for house-heating service, where operation at more than one rate is desirable, as for example, at a relatively high rate during the more severe weather and at a relatively low rate during milder weather.

Burners of this class, heretofore, have secured the two firing rates either by providing two nozzles, each having its own oil supply with a pressure-regulating valve to maintain the pressure constant at a selected value, or by providing one nozzle and pressure-regulating valve means which can be actuated to vary the pressure of the oil supplied to the one nozzle from one to the other of two selected values. The first arrangement has the disadvantage that one nozzle is idle while the other operates, whereby carbonization at and near the idle nozzle can occur, eventually resulting in nozzle stoppage, unless special and rather elaborate provisions are provided to prevent such action. The second arrangement has the disadvantage that a wide range in the two pressures is necessary in order to secure the desired spread in the two firing rates and the high pressure is not readily obtained with the conventional gear type pump unless a relatively low pressure is used for the low rate and then the low pressure is too low to secure good atomization from the nozzle alone. The fundamental difficulty is that the rate of oil delivery from a mechanical atomizing nozzle varies as the square root of the pressures. Doubling the oil pressure increases the rate of oil delivery only 40 per cent, approximately. If one wishes to use, as the lower pressure, a good atomizing pressure, such as 100 p. s. i., then the higher pressure would have to be 200 p. s. i., in order to secure a 40 per cent increase in the firing rate. The conventional gear pump, usually used on oil burners of this class, is not adapted to produce such a high pressure.

With an electromagnetically-controlled pump, wherein the pump piston reciprocates at relatively high frequency, as for example at the 60 cycle frequency of the alternating current supply, the desired spread in oil pressures is readily obtained. Pumps of this type, one example of which is disclosed in our copending application, Serial No. 189,741, filed October 12, 1950, have a stroke, which is variable according to the power applied and the load encountered. On this account, the pressure of the pumped liquid varies rapidly with variations in line voltage, as much, for example, as 4 p. s. i. per volt variation in the electrical supply. This necessitates the use of a regulator in order to maintain the pressure at the mechanical atomizing nozzle substantially constant at a predetermined value. Assuming that normal line voltage is 115 volts, it is necessary, as a practical matter, to maintain the pressure at the nozzle substantially constant over a range of approximately 29 volts or from 98 to 127 volts. A voltage variation of this magnitude would, unless compensated for, cause a variation of 116 p. s. i., in the pressure of the pumped oil. Ordinary pressure-regulating valves, such as are commonly used in the oil supply line of pressure-atomizing oil burners, are not suitable for use with a pump of the type described for the purpose of maintaining the pressure of the pumped oil substantially constant at either of the selected values. For example, when such a valve is used and it opens at the predetermined pressure, the pump at once operates at full stroke and becomes very noisy. Also, the opening of the by-pass unloads the pump. A second outlet is provided by the opening of the by-pass valve, which outlet is relatively large in comparison with the tiny opening of the nozzle, and the pump has not enough capacity to supply the amount of oil necessary through both these openings at the same time to build up and maintain the pressure desired. While the pressure of the pumped liquid may be readily varied by varying the voltage applied to the magnet coil of the pump, this method is not feasible to use with a regulator, which acts to maintain the current at such coil substantially constant. The insertion of a resistor in series in the circuit to drop the voltage will have the effect of making the regulator try to maintain the current constant at the magnet coil and the desired effect of reduced current flow through the coil will not be obtained.

This invention has for its object the provision in an electromagnetically-controlled pump of the class described, having a regulator which functions to maintain the current in the magnet coil substantially constant over a predetermined range of variations in line voltage, of

means that can be connected in shunt with the magnet coil, whenever a lower pumping pressure is desired, in order to divert some of the current from the magnet coil and thus cause the pump to operate at a lower pressure. Thus, a divided circuit is provided for low rate operation and the regulator maintains the same total current, as it does for high rate operation, but part of the current is diverted through the shunt. This shunt should have approximately the same power factor as the electromagnet in order that the current wave in each branch of the divided circuit should have the same phase relation with the voltage wave.

The invention has for another object the provision of a dual rate oil burner, which has an oil pump of the type described with a regulator for maintaining substantially constant current and in which the two oil pressures are secured by the use of the shunt, as above described, together with means for changing the rate of air flow to the burner proportionately with the change in rate of oil flow in order to secure good combustion at either the relatively high or the relatively low rate.

These and other objects will best be understood from the detailed description of one illustrative example of the invention in the accompanying drawings, in which:

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

Fig. 2 is a sectional elevational view taken on the line 2—2 of Fig. 5 and drawn to a larger scale;

Fig. 3 is a rear elevational view of the burner;

Fig. 4 is a fragmentary cross sectional view taken on the line 4—4 of Fig. 1;

Fig. 5 is a sectional plan view taken on the line 5—5 of Fig. 1;

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

Fig. 7 is a cross sectional view taken on the line 7—7 of Fig. 5;

Fig. 8 is a fragmentary side elevational view, taken oppositely to Fig. 1 and showing a manual control for changing the firing rate of the burner;

Fig. 9 is a fragmentary view taken at right angles to Fig. 8; and

Figs. 10 and 11 are wiring diagrams showing respectively the automatic and manual firing rate control.

In these drawings, there has been shown for illustrative purposes a single example of a gun-type pressure-atomizing oil burner adapted for house heating service. This burner will serve as a background for the invention, which has to do with provisions for operating a burner of this general type at either of two selected firing rates. The details of the burner structure shown are not essential to the invention which may be embodied in any burner of the pressure-atomizing type.

The particular burner structure illustrated includes an air supply fan 1 (Fig. 6), mounted in a casing 2, which is suitably supported, as by a floor plate 3 and an adjustable post 4. Casing 2 (see Fig. 4) has openings 5 and 6 in opposite end walls 7 and 8, respectively, and has a peripheral outlet 9 (Fig. 6) leading into an air chamber 10, which overlies the fan and to which one end of a tube 11 is connected. This tube conducts all the air for combustion and has its other end open and adapted to discharge into a furnace. Near the discharge end of tube 11 is a pressure-atomizing nozzle 12, of the usual and well known form, for producing a spray, when supplied with oil under a pressure greater than a predetermined minimum value. On the outer end of the tube 11 is an air director 13 for turning the air stream into the oil spray emitted from the nozzle and in this tube is a turbulator for whirling the air, such turbulator comprising a series of spiral vanes 14 projecting inwardly from an annular ring 15. The opening 5 in the fan casing 2 (Fig. 4) receives a frusto-conical air director 16, the flanged outer end of which is clamped to end wall 7 by a ring 17, secured by screws 18 to such wall. The opening 19, within the air director, forms the main air inlet for the fan. The other opening 6 is covered by a plate 20, which is secured to end wall 8 by screws 21 and which has a plurality of openings 22 therethrough. The fan 1 has its hub fixed, as indicated, to the shaft 23 of an electric motor 24. The latter is fixed to the described plate 20 by screws 25, which pass through the plate and thread into lugs 26 on the inner end wall of the motor. Between these lugs and the end wall are passages 27, leading to the openings 22 and thus to the interior of the fan casing. Thus, air is drawn in by the fan 1, partly through the main inlet 19, and partly through the auxiliary inlet, comprising the passages 27 and holes 22, and forced out through outlet 9 (Fig. 6) into chamber 10 and from the latter through tube 11, the air being whirled by the turbulator vanes 14 just before it is directed by cone 13 into the oil spray emitted from the nozzle 12.

The rate at which air is supplied to tube 11 is variable by means of a damper 28 which is fixed to a shaft 29, rotatably mounted at its ends, one in each of the walls 7 and 8. Stops 30 and 31 are provided to respectively arrest the damper in its high rate and low rate positions. The stop 30 consists of a screw, threaded into a wall of casing 1 with its inner end so located as to be directly engaged by the right hand face of the damper, when the latter is swung to the right into its high rate position. The stop 31 consists of a pin, fixed in the inner end of a screw 32, which also is threaded into said wall of the casing 1 and passes freely through a hole in the damper. This pin is so located as to be engaged by the left hand face of the damper, when the latter is swung into its low rate position as shown. The high and low rates are independently adjustable by turning screws 30 and 32, which are provided with fine pitch threads to enable precision adjustments to be manually effected. Lock nuts 33 and 34 on screws 30 and 32, respectively, hold the stops in their various positions of adjustment.

The damper 28 may be automatically moved from its high and low rate positions by the following means. A spring 35, connected at one end to the wall 8 of casing 1 and at the other end to a crank arm 36 fixed on one end of shaft 29, tends to move damper 28 against the high rate stop 30. Movement of the damper is controlled by a small electric control motor 37 (Fig. 1), which is suitably fixed to a bracket 38, suitably secured to wall 7. Motor 37 has a shaft 39, provided on its inner end with a crank 40. This motor, when actuated by means to be described, turns shaft 39 one-half revolution and then stops. When again actuated, it turns another half revolution and stops. The crank 40 always comes to rest in a vertical position either upstanding from shaft 39 as shown or depending therefrom. The crank 40 is connected to a crank 41 on shaft 29 by a wire 42 and a spring 43. With the crank 40 in its upper position as shown, the damper 28 is held in its low rate position against the force of spring

35. The spring 43 absorbs any overtravel of crank 40 after the damper 28 has engaged stop 31. Since the low rate position may be varied by manual adjustment, the crank 40 must have sufficient travel to move the damper into the extreme left hand end of its range of adjustment. When crank 40 moves into its depending vertical position, the spring 35 swings the damper into its high rate position against stop 30 and the spring is capable of moving the damper to the right beyond the present high rate position into other high rate positions if desired. The wire 42 and crank 41 are preferably encased in a housing 44 suitably fixed to wall 7.

A control motor such as described is a standard article of commerce. It may be constructed as disclosed in Johnson Patent No. 1,835,307, granted December 8, 1931, to Minneapolis-Honeywell Regulator Company.

The oil is supplied to nozzle 12 by an electromagnetically-controlled reciprocating-piston pump, which is mounted on the side wall 8 of the casing 2, as shown in Figs. 3 and 5. This pump and the electromagnet, which actuates it, are mounted in a casing, comprising a main section 45 (Fig. 3) and a cover 46. The main section and cover are respectively provided with shoulders 47 and 48 (Fig. 2) and hubs 49 and 50, projecting in opposite directions one from each of the shoulders. A grommet 51 of rubber-like material encompasses each hub and abuts the adjacent shoulder. Each grommet has a circumferential groove in its outer periphery to receive a part of a supporting arm 52 and a U-shaped clamp 53 (Fig. 5), which is fixed at its ends to the arm by bolts 54. Both arms 52 project outwardly at right angles from a common support 55, which is fixed to casing 2 by screws 56.

Referring next to Fig. 2, the casing section 45 and cover 46 are made of suitable magnetic material, and as herein shown of cast iron. The upper portion of section 45 has a large cylindrical recess in which is mounted the annular coil 57 of the electromagnet. Section 45 has a hole coaxial with the magnet recess and extending from the latter through the section to the bottom thereof and fixed, as by a drive fit, in this opening is a rod 58 which is of suitable magnetic material and in which is formed the cylinder 59 of the pump. Rod 58 has an integral upward extension 60 projecting through the central opening in coil 57 and forming the core of the electromagnet. Slidable in cylinder 59 is a piston 61, which extends upwardly through core 60 and has fixed to its upper end, at a location above the upper end of the core, an armature 62. The latter preferably has a frusto-conical lower end to cooperate with the complementary-shaped recess in the upper end of the core 60. The cover 46 has a central opening 64 therein, which slidably receives the armature, and in this opening are a series of angularly-spaced longitudinally-extending grooves 65 to allow liquid to pass the armature. A spring 66, located in opening 64, acts between suitable seats, one on the end wall of the opening and one on the top of the armature, encircling rod 61, and tends to move the armature downwardly. A similar spring 67, mounted at its ends in suitable seats in recesses in the bottom of the armature and the upper end of core 60, tends to move the armature upwardly. The armature is balanced between these two springs, which have the same dimensions and are under the same initial stress. The armature is shown in its rest position midway of its stroke. The mass of the

armature 62 and rod 61 and the characteristics of the springs 66 and 67 are so selected as to have a natural period of vibration substantially equal to the frequency of the alternating-current supply, to which the coil 57 is adapted to be connected. As will be later described in detail, the coil 57 is connected to a 115 volt, 60 cycle, alternating source through a suitable half-wave rectifier, whereby it is energized intermittently in pulses at the rate of 3600 per minute. When coil 57 is energized, the armature 62 will be drawn downwardly toward the core 60 to actuate piston 61 on its pressure stroke, the magnetic circuit extending through core 60, across an axial air gap to armature 62, through the latter and across a small radial air gap to cover 46, outwardly through the cover in radiating paths to the annular shell which surrounds coil 57, downwardly through this shell and thence inwardly in radiating paths to the lower end of core 60. When coil 57 is deenergized in the interval between two successive energizing electric pulses, the armature 62 will move away from the core 60 and above the rest position illustrated. The stroke of the pump is variable, depending on the power applied to the coil and the resistance or load encountered by the piston. The resonant springs 66 and 67 serve to keep the armature 62 and piston 61 in vibration with only a small amount of assistance from coil 57, leaving the major part of the energy developed by the coil for the performance of useful work.

The pump cylinder 59 has an inlet port 68, communicating with a passage 69, which is formed in section 45 and extends horizontally outward and thence vertically upward to a cylindrical space 70, formed in cover 46 and located above coil 57. This space is connected by the described passages 65 and 64 to the oil inlet 71, which connects with the hole 64 by means of the central opening through the upper seat of spring 60. This inlet is connected by a suitable conduit, such as copper tubing 72, to a suitable oil supply tank (not shown), the tubing preferably having a coil 73 therein. The coil 57 is suitably sealed off from the oil-containing chamber 70, as by a circular member 74, which closely fits around core 60 and the peripheral wall of the coil-containing recess and has inner and outer seal rings 75 to engage such core and wall. The pump cylinder is provided with an outlet valve, such as the ball valve 76, which is held closed by a spring 77, acting against a seat on the upper end of a screw 78. The latter is threaded into the lower end of member 58 and closes the lower end of the opening therein. The outlet valve 76 opens into an outlet chamber 79, formed in member 58, and this chamber connects with an outlet passage 80.

The outlet passage 80 delivers the pumped oil into a cylindrical chamber 81, formed in the lower part of casing 45. A cover 82, secured to this casing by screws 83, provides access to the chamber and has a central tapped opening therein which receives an outlet conduit 84. Within the chamber 81, is a block 85 of suitable resilient material, which in this case, is composed of particles of ground cork held together by a rubber-like binder. The block is square in cross section and its corners engage the cylindrical wall of chamber 81, leaving four longitudinal passages for the oil. Protuberances 86 on the end walls of this chamber engage the ends of the block and hold them spaced from such end walls to enable oil from passage 80 to flow outwardly to said longitudinal passages and thence inwardly

from the latter to the outlet pipe 84. One purpose of this arrangement is to smooth out the pulsations in the stream of pumped oil. The pressure of the pumped oil will vary, much as the voltage and current of the alternating-current supply does, in a wave which rises from a minimum to a maximum and back again at the frequency of the alternating-current. The higher instantaneous pressures, will compress the member 85 and, at the lower instantaneous pressures, the member 85 will expand. Thus, the peaks of the wave will be removed and the valleys filled in so that the stream leaving through pipe 84 will not have wide fluctuations in pressure. A very important purpose of the described arrangement is to keep the minimum oil pressure of the stream above the lower pressure limit of the atomizing nozzle 12. As is well known, when the pressure of the oil fed to a pressure or mechanical atomizing nozzle falls below a certain value, the nozzle will not produce a spray. Hence, it is essential to provide a limiting means which will maintain minimum pressures high enough to maintain the nozzle operative for its spray producing function.

The one particular arrangement described for controlling the pressure pulsations is desirable and preferred. However, there are many other ways of accomplishing the same result. The essential thing is that there shall be in the discharge conduit of the pump some portion, which is expansible and contractible with the pressure pulsations of the pumped oil so as to make the pressure of the stream more nearly uniform and maintain the necessary minimum pressure values. The effective liquid-containing volume of the chamber increases and decreases with the increases and decreases in pressure of the oil and any other construction of the discharge conduit, which will enable such increases and decreases in volume, may be used for the purpose.

The outlet conduit 84 is connected to the atomizing nozzle 12. As shown, this conduit consists of a copper tube (Fig. 1), which extends upwardly from the outlet of the regulator, has a coil 88 formed therein and then enters through a notch (Fig. 5) in the side wall of casing 2 into the rear end of the chamber 10. The tube 84 then extends forwardly in chamber 10 and is connected by a union 89 to the rear end of a tubular support 90. The nozzle 12 is connected to the front end of this support.

Adjacent the nozzle 12 are a pair of electrodes 91, which are mounted in insulators 92 and have their rear ends connected by wires 93 with the high tension terminals 94 (Fig. 6) of an ignition transformer, mounted in a case 95, fixed on top of casing 2.

The nozzle 12, turbulator 14, and electrodes 91 may be supported in any suitable way in tube 11, desirably in a manner to permit convenient withdrawal of these parts in assembled relation from the tube 11 and the aligned chamber 10, after the closure plate 96 for the rear end of chamber 10 and its retaining screws 97 have been removed. To this end, a pair of rods 98 are fixed at one end to the ring 15 of the turbulator, one at each of two diametrically opposite points thereon, and these rods extend rearwardly in spaced, parallel relation through tube 11 and through chamber 10, terminating in outwardly-bent parts 99, the outer ends of which are received one in each of two notches formed one in each of two opposite side walls of the casing 2. The plate 96 retains these ends 99 in their notches. Fixed at its ends to rods 98 and spanning the space between them, is a support 100 having a central hub, in which the nozzle-supporting tube 90 is fixed, and two outer hubs in which the insulators 92 are fixed. The support 100 also has a central depending hub (Fig. 7), to which an air-distributing baffle 101 is fixed. It will be clear that when plate 96 is removed, the ends 99 of rods 98 are released. The high tension wires 93 may then be disconnected from terminals 94 and the oil pipe 87 may be disconnected by removing union 89 or 102, after which the nozzle 12, its support 90, the electrodes 91 with their insulators 92 and the turbulator 14—15, may be withdrawn for inspection, cleaning or repair.

One of the controls for the electromagnet coil 57 is a switch 103 (Fig. 4), the closing of which is delayed by a device responsive to the speed of the air supply fan 1. This switch 103 is shown in Figs. 1 and 4 as a micro-switch, mounted on an angle-iron shelf 104 fixed to the end wall of a cylindrical case 105, having its other end closed by a disk cover 106, secured by screws 107 to the case. This case 105 is supported by four angularly-spaced arms 108 (Fig. 3) from the described ring 17, leaving openings 109 through which air may enter to the main inlet opening 19 of the fan. The switch 103 has an actuating plunger 110 (Fig. 4) and suitable spring means (not shown), tending to move the plunger to the left into closed position. The switch plunger 110 is actuated by a plunger 111, which is slidably mounted in a hub on the end wall of case 105. This plunger 111 is shown held in its right hand and switch-opening position by the flanged and closed outer end of a tube 112, which is slidably mounted on a rod 113, which has a flanged end, fixed as indicated to the drive shaft 23 of motor 24. A spring 114 encompasses rod 113 and acts between the flange on the rod and the adjacent end of tube 112 to force the latter to the right and press the plunger 111 of switch 103 to open the switch. The flanges of rod 113 and tube 112 are interconnected by flexible metal bands 115, each having fixed to it at a point between its ends a suitable weight 116.

When the shaft 23 reaches a predetermined speed, as nearly as feasible to full speed of the motor 24, these weights 116 fly outwardly by centrifugal force and deflect the bands 115 outwardly, drawing tube 112 to the left until it allows the plunger 111 to move to switch-closing position and continuing to the left until it disengages from the plunger 111. A small spring 117 takes up the lost motion and holds plunger 111 in contact with plunger 110 and out of contact with the outer end of the rotating tube 112. Spring 117 is not strong enough to move the switch plunger 110 against its internal actuating spring (not shown).

Referring next to Fig. 10, the fan motor 24 and the primary 118 of the ignition transformer 95 are connected in parallel to wires 119 and 120 and are controlled by a room thermostat switch 121 by means of which wire 120 may be connected to a wire 122. The wires 119 and 122 are adapted for connection to a suitable source of alternating current such for example as a 115 volt, 60 cycle supply. The secondary 123 of the ignition transformer is connected by the described wires 93 to the ignition electrodes 91. When there is a demand for heat, the room thermostat switch 121 will close the circuit to fan motor 24 and the ignition transformer 95, whereby the fan 1 will be operated to supply air through tube 11 and ig-

nition sparks will be produced between the electrodes 91 adjacent the oil-atomizing nozzle 12.

The starting of the electromagnetically-controlled oil-supply pump is preferably delayed by the centrifugal switch 103, which closes only after the air supply fan has acquired considerable speed. This switch controls a branch circuit from the wires 119 and 120, which circuit includes the solenoid coil 57, a suitable half-wave rectifier 125, and a current-regulator. The latter is preferably of the type disclosed in the copending application of Theodore J. Mesh, Serial No. 189,742, filed October 12, 1950, and consists of a series impedance, comprising a saturable reactor having a winding 126 and a core 127. A capacitor 128 and a resistor 129 are suitably coupled into the reactor winding. In this case, the capacitor and resistor are connected in series with a winding 130 inductively related to the reactor winding 126 on core 127, whereby the capacitor and resistor are coupled inductively to the reactor winding 126. The arrangement is like an auto transformer in which winding 126 is the primary and windings 126 and 130 the secondary. The pump circuit includes a wire 131 between wire 120 and switch 103, a wire 132 connecting the latter to one terminal of the reactor winding 126, a wire 133 connecting the other terminal of winding 126 to one terminal of solenoid 57, a wire 134 connecting the other terminal of solenoid 57 to one terminal of the rectifier 125, and a wire 135 connecting the other terminal of such rectifier to the wire 119. When switch 103 closes, the coil 57 will be energized and the pump piston will be reciprocated to supply oil to nozzle 12 to mix with the air supplied by fan 1 and this mixture will be ignited and burn. Operation of the burner will continue until the demand for heat is satisfied when the room thermostat switch 121 will open and break the circuit to motor 24, solenoid 57 and primary 118. As the fan motor 24 slows down, switch 103 will open and provide a second break in the circuit of the oil pump somewhat before the air supply from fan 1 ceases.

The purpose of the described series impedance is to maintain the pressure of the pumped oil substantially constant over a predetermined range of variations in line voltage. In general, the result is effected by maintaining the current supplied to coil 57 substantially constant. The elements of the impedance are coupled in a resonant circuit in which the current surges back and forth and may rise to values several times the value of the current flowing in coil 57. Consequently, the core of the reactor can become magnetically saturated by the circulatory current in this resonant circuit before it could become saturated by the pump current flowing at normal line voltage in the circuit of coil 57. The core of the reactor is so designed as to become substantially magnetically saturated by such circulatory current as flows in the resonant circuit when resonance exists. This occurs when the line voltage is at some selected predetermined value which may be, and preferably is, normal line voltage, in this case 115 volts. At such voltage, the capacitative reactance and the inductive reactance within the resonant circuit have minimum values, which balance, and the effective impedance in such circuit is wholly resistive and at its minimum value. As line voltage decreases from normal, the reactance within the resonant circuit becomes capacitative and the effective impedance increases as line voltage decreases until a certain lower voltage limit is reached. As line voltage increases from normal the reactance within the resonant circuit becomes inductive and increases as the voltage increases until a certain upper voltage limit is reached. Beyond the upper voltage limit, the inductive reactance within the resonant circuit does not materially change and beyond the lower voltage limit the effective capacitative impedance within such circuit does not materially change.

Having in mind that the coil 57 is energized intermittently in pulses, the pressure of the pumped oil can be changed by varying the duration of each pulse to offset the change effected by voltage variation, which is to increase or decrease the amplitude of the pulse as the current rises or falls. For example, a decrease in line voltage from normal, which would otherwise result in a decrease in current and a decrease in the stroke of the pump with a resulting drop in oil pressure, can be offset to some extent by introducing capacitative reactance into the circuit of the coil 57. Such reactance has a tendency to prolong each pulse, making its duration somewhat more than the normal $\frac{1}{120}$ of a second in the case of 60 cycle power. Similarly, an increase in line voltage from normal, which would ordinarily result in an increase in current in the coil 57 and an increase in the stroke of the pump with a resulting increase in oil pressure, can be offset to some extent by introducing into the circuit of the coil 57 inductive reactance, which tends to shorten the pulses. Thus, at normal line voltage, the reactor and capacitor are in resonance and only the resistor, which is of constant value, is in the circuit of the coil 57. On an increase in line voltage from normal, inductive reactance is introduced to offset the effect of the voltage increase and progressively so as the voltage increases until the upper voltage limit is reached, when the inductive reactance is at its highest. On a decrease in line voltage from normal, capacitative reactance is introduced to counteract the effect of decreasing current by lengthening out the pulses and progressively so as the voltage decreases until the lower voltage limit is reached and the capacitative impedance reaches its maximum value. The resistor has the effect of providing a smooth transition from inductive reactance to capacitative reactance and vice versa and broadens out the range over which the resonant circuit is effective to change the pressure of the pumped oil.

The resonant circuit provides counter E. M. F. in the circuit to coil 57 and such counter E. M. F. is variable to some extent with line voltage variations so that the E. M. F. impressed on the coil 57 is modified to some extent by the variable voltage drop in the circuit of the reactor and this is to some extent a factor in accomplishing the result desired.

In the particular arrangement shown in Fig. 10, the capacitor 128 has a capacity of 30 mfd., the resistor 129 a resistance of 20 ohms, the winding 126 is composed of 400 turns of No. 27 wire, and the winding 130 is composed of 2000 turns of No. 33 wire. Core 23 consists of about 30 laminations of standard commercial transformer punchings No. E I–75 of silicon steel, each of about .018 of an inch in thickness. These values are not critical and are given as illustrative examples and not as imposing limitations.

The rectifier 125 preferably has a resistor 136 shunted across it for the purpose of permitting the flow of a small amount of current in the reverse direction between successive pulses for the

purpose of demagnetizing and preventing sticking of the armature to its poles.

For causing the pump to operate at another rate and supply oil at a different pressure, which has to be maintained substantially constant over the same range of variations in line voltage, a shunt has been provided for the coil 57 of the pump, which shunt can be cut in circuit with the coil whenever a lower oil pressure is desired. This shunt is preferably an inductance, indicated at 137, and preferably also it should have approximately the same power factor as the coil 57 of the pump, in this case around 50%. With this circuit, which is supplied with alternating current and which includes a rectifier 125 with a resistive shunt 136, a regulator including a transformer, a capacitor 128 and a resistor 129, and the coil 57 of the magnetic pump with the inductive shunt 137 for such coil, it is possible to maintain the oil pressure at the nozzle 12 substantially constant at 200 p. s. i. over the described range of variations in line voltage when the shunt is cut out of circuit and to maintain the oil pressure at such nozzle substantially constant at a pressure of 100 p. s. i. when the shunt 137 is connected in circuit. The burner may thus have a normal firing rate when supplied with oil at 100 p. s. i. and this rate can be increased 40% when the burner is supplied with oil at 200 p. s. i. to secure the high rate needed for better heating in severe cold weather. The impedances of the coil 57 and the shunt 137 should be, in this case, in the ratio of 1 to 3 in order to divert approximately 25% of the output current of the regulator from the coil 57.

The inductive shunt 137 may be cut into and out of circuit by a switch, which is operated automatically from, and may be and preferably is included in, the control motor 37. This switch and the electrical components of the control motor are shown diagrammatically in Fig. 10. This motor has a field winding 138, a rotor 139 a rotor shaft 140, gearing 141 which connects shaft 140 to the described shaft 39, and drums 142 and 143 fixed on shaft 39. The drum 142 has one half its surface of insulating material 144 and the other half of conducting material 145 (suitably insulated from shaft 39). Two brushes 146 and 147 engage the periphery of drum 142 and, when the control motor is positioned as shown, these brushes engage the conducting part 145. A wire 148 connects brush 146 to one terminal of coil 57, a wire 149 connects the other terminal of coil 57 to one terminal of the inductive shunt 137 and a wire 150 connects the other terminal of the shunt to brush 147. Thus, the inductive shunt 137 is connected in shunt circuit with coil 57, when the control motor is in the illustrated and low firing rate position. When the motor is actuated to turn the shaft 39 one half revolution, the non-conducting part 144 of drum 142 will be moved in under the brushes 146 and 147 and cause the inductive shunt to cut out of circuit to enable the pump to deliver oil at the high rate.

The control motor 37 may be controlled by any suitable means. One illustrative example is an outdoor thermostat switch 151 which, when the weather is mild, say 20° Fahr. or above, will engage a contact 152 and, when the weather is severe, say below 20° Fahr., will engage a contact 153. This thermostat switch controls a low voltage circuit, such as a 24 volt circuit, to the field winding 138 of the control motor 37. Thus, the switch 151 is connected by a wire 154 to one terminal of the secondary 155 of a step-down transformer, the primary 156 of which is at all times connected to the line wires 119 and 122 by wires 157 and 158, respectively. A wire 159 connects the other terminal of the secondary 155 to one terminal of field winding 138 and the other terminal of the latter is connected by a wire 160 to a brush 161 bearing on drum 143. This drum has a surface which is of conducting material 162 (suitably insulated from shaft 39) except for the portions 163, 164 and 165 which are of insulating material. The brush 161 presently rides on the conducting part 162 and is thereby connected to a brush 166, when the control motor is in its low rate position. Brush 166 is connected by a wire 167 to the contact 153. The contact 152 is connected by a wire 168 to a brush 169, presently engaging the insulating part 163, with which another brush 170 is engaged. Brush 170 is connected by a wire 171 to wire 154 and thus to the same terminal of secondary 155 that is connected to thermostat switch 151.

It will be seen that, with the parts positioned as shown, no circuit exists to the field 138 of the control motor. However, if the outdoor temperature should drop below the selected predetermined value, switch 151 will engage its contact 153 and close a starting circuit to field 138. This circuit may be traced as follows, from secondary 155, by wire 154, switch 151, contact 153, wire 167, brush 166, conductor 162 on drum 143, brush 161, wire 160, field winding 138 and wire 159 to the other terminal of secondary 155. As soon as the drum 162 has turned through a small angle the brushes 169 and 170 will engage the conducting part 162 of drum 143 and a holding circuit will be closed to the field winding 138, which circuit shunts out the switch 151. This holding circuit may be traced as follows, from one terminal of secondary 155, by wire 154, wire 171, brush 170, conductor 162 of drum 143, brush 161, wire 160, field winding 138 and wire 159 to the other terminal of secondary 155. When the drum 143 has turned one half a revolution, brush 170 will engage insulating part 164 and break the holding circuit and brush 166 will engage insulating part 165 and break the starting circuit so that the control motor comes to rest in its high rate position even though switch 151 engages contact 153.

It will also be noted that the brush 169 will be connected by drum part 162 to brush 161, so that another starting circuit to the field winding can be established when the switch 151 engages contact 152. This starting circuit is as follows, from one terminal of secondary 155, by wire 154, switch 151, contact 152, wire 168, brush 169, conducting part 162, brush 161, wire 160, field winding 138 and wire 159 to the other terminal of secondary 155. The closing of this starting circuit will turn drum 143 in the same direction as before. After the drum has turned through a small angle, brush 170 will ride off insulating part 164 and engage conducting part 162, whereby it is connected to brush 161, to establish a holding circuit by which the starting circuit is shunted out. This second holding circuit is as follows, from one terminal of secondary 155, wires 154 and 171, brush 170, conducting part 162, brush 161, wire 160, field winding 138 and wire 159 to the other terminal of secondary 155. The motor 37 will continue to turn until it has completed its second half revolution when brushes 169 and 170 will engage the insulating part 163 and open both the second holding circuit and the second

starting circuit to stop the motor 37. Also, the brush 166 will be engaged with conducting part 162 to connect thermostat contact 153 to brush 161, whereby to enable the first starting circuit to be re-established, whenever the outdoor thermostat 151 engages contact 153.

The burner described will have its firing rate automatically controlled by the switch 151, which as described responds to outdoor temperature but which is capable of responding to temperature at other locations if desired. When the switch 151 engages the "hot" contact 152, the inductive shunt 137 will be connected in circuit with pump coil 57, whereby the current flow will be divided part, say one-quarter, through the shunt and part, say three-quarters, through the coil 57, and the reduced current through the coil will cause the pump to deliver oil at the lower of the two predetermined rates. Simultaneously with the connection of the inductive shunt 137 in circuit with the pump coil 57, the control motor 37 will cause the damper 28 to move to its low rate position to reduce the rate of air flow in tube 11 to the proper value to produce with the lowered rate of oil flow a good combustible mixture. When the switch 151 engages the "cold" contact 153, the control motor 37 will cause the circuit to shunt 137 to be opened to increase the oil flow to the higher of the two predetermined rates and the damper 28 to be moved to increase the rate of air flow to that necessary to produce good combustion with the increased rate of air flow.

In many cases, it will be satisfactory if the shift from one firing rate to another is effected manually. The manual control is shown diagrammatically in Fig. 11, which is the same as Fig. 10 except that the control motor 37, the step-down transformer 156—155, the wires 157 and 158, the outdoor thermostat switch 151 and all the electrical connections between this motor, switch and transformer are omitted and the switch, comprising brushes 146 and 147 and drum 142, is replaced by a switch 172, the terminals of which are respectively connected by wires 173 and 174 to one terminal of the coil 57 and one terminal of shunt 137, the other terminals of the shunt and coil being connected together by a wire 175. The switch 172, when manually closed and opened, will respectively connect and disconnect the inductive shunt 137 in circuit with the pump coil 57 and cause the latter to operate at the selected low and high predetermined rates, respectively, in the same manner as before.

The switch 172 is shown in Fig. 8 as a micro switch, suitably supported from the side wall 8 of the fan casing 2. This switch tends to open automatically. It is shown in closed position, its plunger having been moved to such position by the outer end of spring arm 177, the inner end of which is fixed to a hand lever 178, loosely mounted on one end of the damper shaft 29. Adjacent the lever 178 and fixed to the shaft 29, is the described crank arm 36, which as before is actuated by spring 35, tending to move the damper 28 into its high rate position. The hub of crank arm 36 is connected to the lever 178 by a torsion spring 180. The lever moves the shaft 29 through the torsion spring 180 to carry the damper 28 from high rate to low rate position. After the damper has engaged the low rate stop 31, the hand lever 178 may, because of spring 180, continue to move until it is so positioned that spring-pressed pin 181 slidably mounted therein aligns with a hole 182 in wall 8 of fan casing 2, whereupon the pin 181 will enter the hole and keep the lever in its low rate position. When this pin 181 is pulled back to release lever 178, the spring 35 will move the damper 28 back into engagement with the high rate stop 30 and, at the same time, through spring 180 and crank arm 36 move hand lever 178 to lift the spring 177 sufficiently to allow switch 172 to open and disconnect the inductive shunt 137 from the circuit of the pump coil 57.

With either form of the invention the oil-rate-varying means and the air-rate-varying means are interconnected so as to operate simultaneously and effect corresponding changes in the two components of the combustible mixture. The change in firing rates may be effected wholly automatically, as in the first form of the invention, or manually, as in the second form of the invention. The invention also affords a particular means for varying the pumping rate of an electromagnetically-controlled pump, which means will operate with, and not adversely affect, a pressure regulator of the type described, which tends to maintain the output current at a substantially constant value. The invention enables the regulator to maintain the output current constant but provides a shunt circuit through which part of the current may be diverted when it is desired to lower the current flow through the magnet coil to secure a lower pumping rate.

What is claimed is:

1. An atomizing means for liquids, selectively operable at a plurality of rates, comprising, a high-pressure mechanical-atomizing nozzle, a variable-stroke reciprocating-piston pump having an inlet and a check-valve-controlled outlet, a valveless conduit connecting said outlet and nozzle, an electromagnet controlling the reciprocation of the piston of said pump and including a core and coil, a circuit for said coil adapted for connection to an alternating current supply, an inductance having substantially the same power factor as said coil and an impedance of the same order of magnitude as said coil, said inductance being connected in shunt with the coil in said circuit, a switch for closing and opening the shunt and connecting said inductance to or disconnecting it from said circuit thereby selectively controlling the rate at which liquid is atomized, whereby when said switch is closed a part of the current may be caused to flow through said coil and the rest through said inductance and when said switch is open all the current may be caused to flow through said coil, an electrical regulator in said circuit for maintaining the total current in said circuit substantially constant at one predetermined value over a predetermined range of variations in voltage of said supply, said regulator by regulating the current also regulating the stroke of the piston of said pump and thus the pumping rate thereof and maintaining the average pressure of the liquid supplied to said nozzle constant either at a high value, when said switch is opened, or at a lower value, when said switch is closed.

2. In a dual-firing rate oil burner, wherein a fan, driven by an electric motor, supplies air for combustion through a tube, in the outlet end of which is a high-oil-pressure mechanical-atomizing nozzle, and a valve is provided, movable between two positions, to vary the rate at which air is supplied by the fan to the tube from a high rate to a lower rate and wherein oil is supplied to the nozzle by a variable-stroke reciprocating-piston pump, actuated by an electromagnet, in-

cluding a coil, having an energizing circuit, adapted for connection to an alternating current source; an inductance having substantially the same power factor as said coil and an impedance of the same order of magnitude as said coil, said inductance being connected in shunt with the coil in said circuit, a switch for closing and opening the shunt and connecting said inductance to or disconnecting it from said circuit thereby selectively controlling the rate at which liquid is atomized, whereby when said switch is closed a part of the current may be caused to flow through said coil and the rest through said inductance and when said switch is open all the current may be caused to flow through said coil, an electrical regulator in said circuit for maintaining the total current in said circuit substantially constant at one predetermined value over a predetermined range of variations in voltage of said supply, said regulator by regulating the current also regulating the stroke of the piston of said pump and thus the pumping rate thereof and maintaining the average pressure of the liquid supplied to said nozzle constant either at a high value, when said switch is opened, or at a lower value, when said switch is closed, and a member for simultaneously moving said switch and valve to close the switch when the valve is in its second-named position and open the switch when the valve is in its first-named position.

3. In a dual-firing rate oil burner, wherein a fan, driven by an electric motor, supplies air for combustion through a tube, in the outlet end of which is a high-oil-pressure mechanical-atomizing nozzle, and a valve is provided, movable between two positions, to vary the rate at which air is supplied by the fan to the tube from a high rate to a lower rate and wherein oil is supplied to the nozzle by a variable-stroke reciprocating-piston pump, actuated by an electromagnet, including a coil, having an energizing circuit, adapted for connection to an alternating current source; a switch in said circuit actuated by and responsive to the speed of the fan motor for

closing and opening said circuit when the speed of the motor respectively increases to and falls below a predetermined value, an inductance having substantially the same power factor as said coil and an impedance of the same order of magnitude as said coil, said inductance being connected in shunt with the coil in said circuit, a switch for closing and opening the shunt and connecting said inductance to or disconnecting it from said circuit thereby selectively controlling the rate at which liquid is atomized, whereby when said switch is closed a part of the current may be caused to flow through said coil and the rest through said inductance and when said switch is open all the current may be caused to flow through said coil, an electrical regulator in said circuit for maintaining the total current in said circuit substantially constant at one predetermined value over a predetermined range of variations in voltage of said supply, said regulator by regulating the current also regulating the stroke of the piston of said pump and thus the pumping rate thereof and maintaining the average pressure of the liquid supplied to said nozzle constant either at a high value, when said switch is opened, or at a lower value, when said switch is closed, and a member for simultaneously moving said switch and valve to close the switch when the valve is in its second-named position and open the switch when the valve is in its first-named position.

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