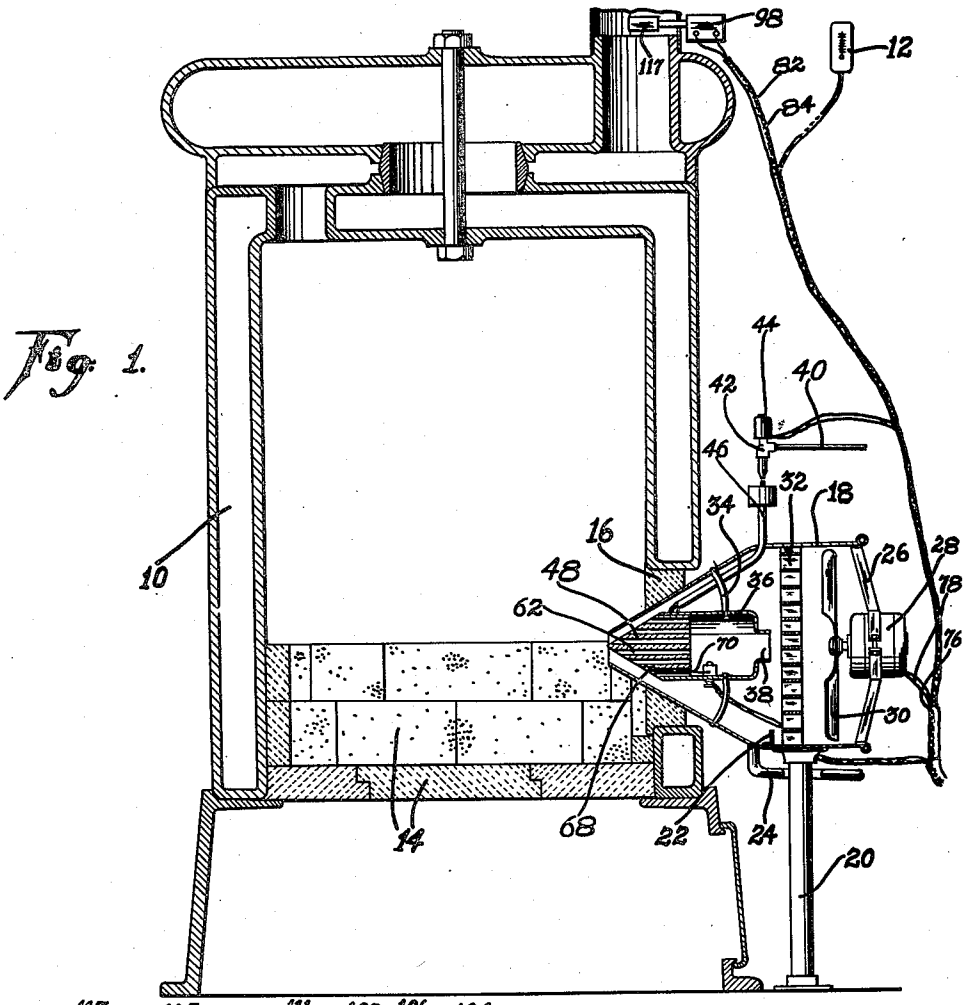
Oct. 3, 1939. K. P. BRACE 2,174,818

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Fig. 1.



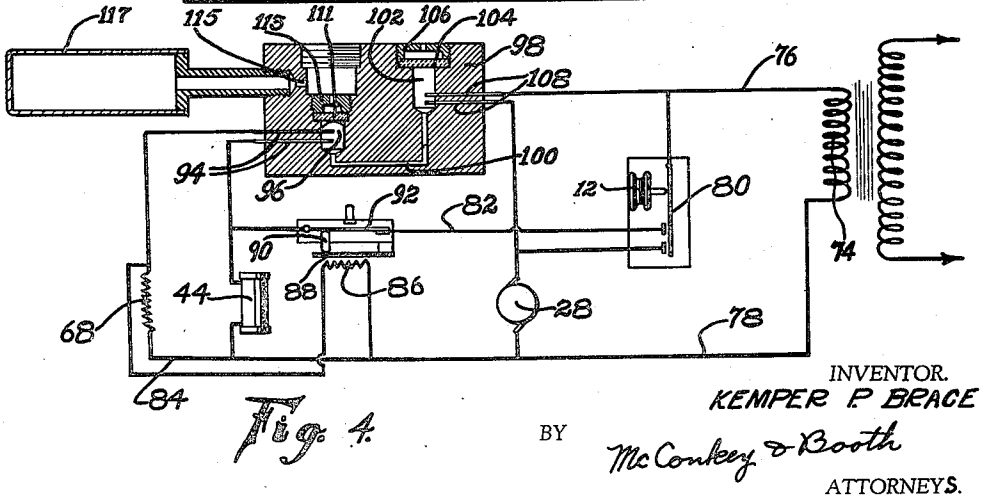


Fig. 4.

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ATTORNEYS.

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Fig. 2

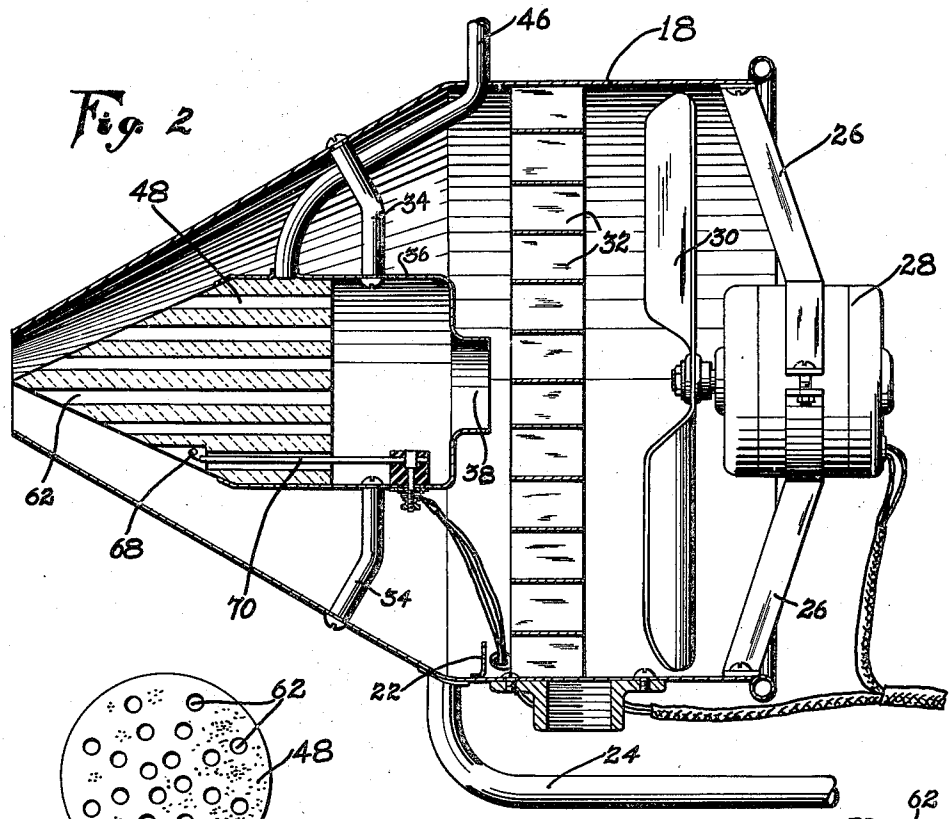


Fig. 5

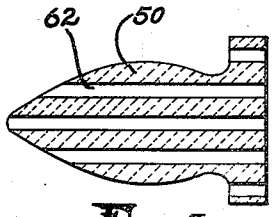


Fig. 5

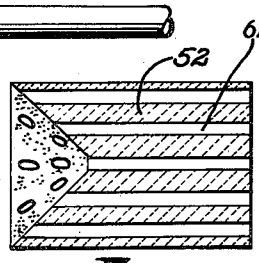


Fig. 6

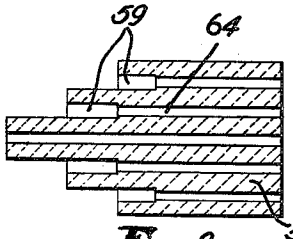


Fig. 9



Fig. 8

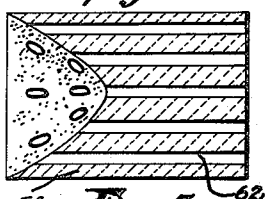


Fig. 7

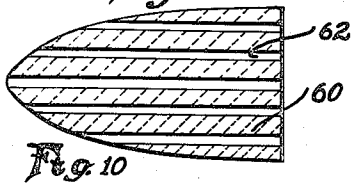


Fig. 10

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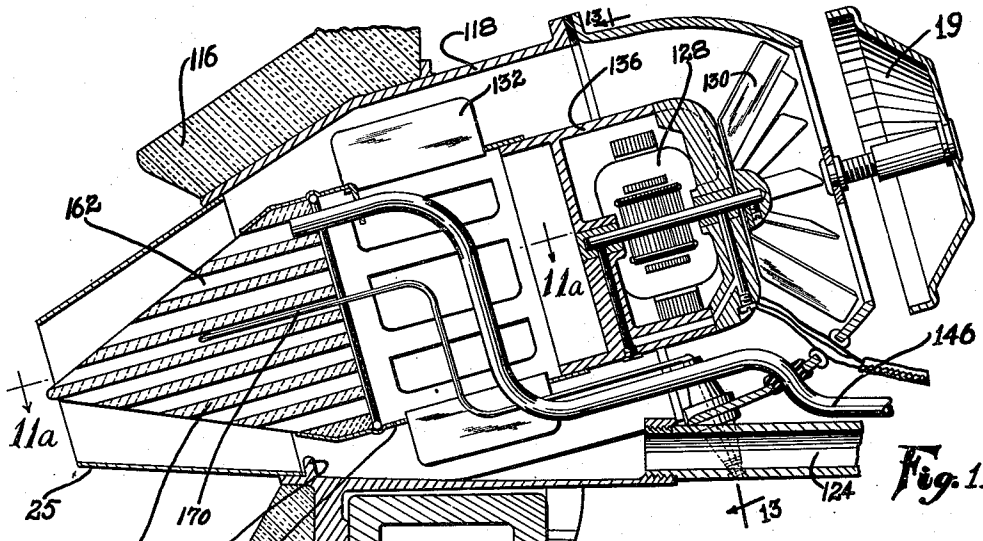


Fig. 11

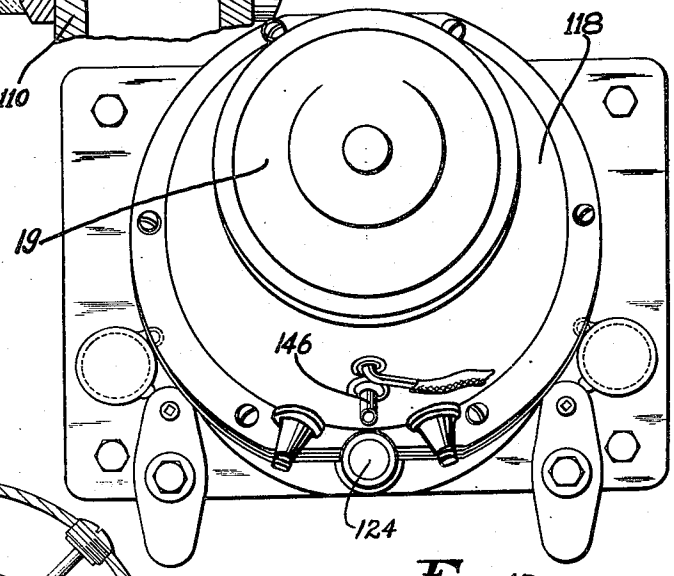


Fig. 12

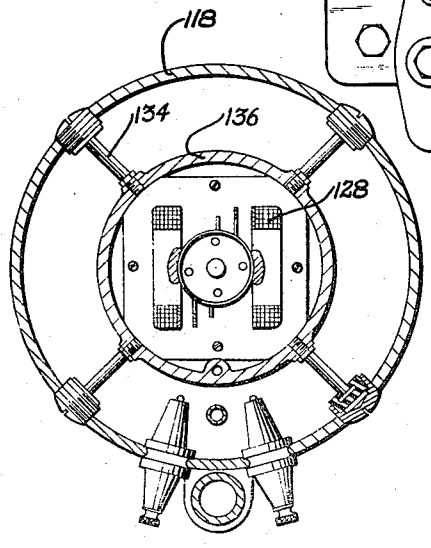


Fig. 13

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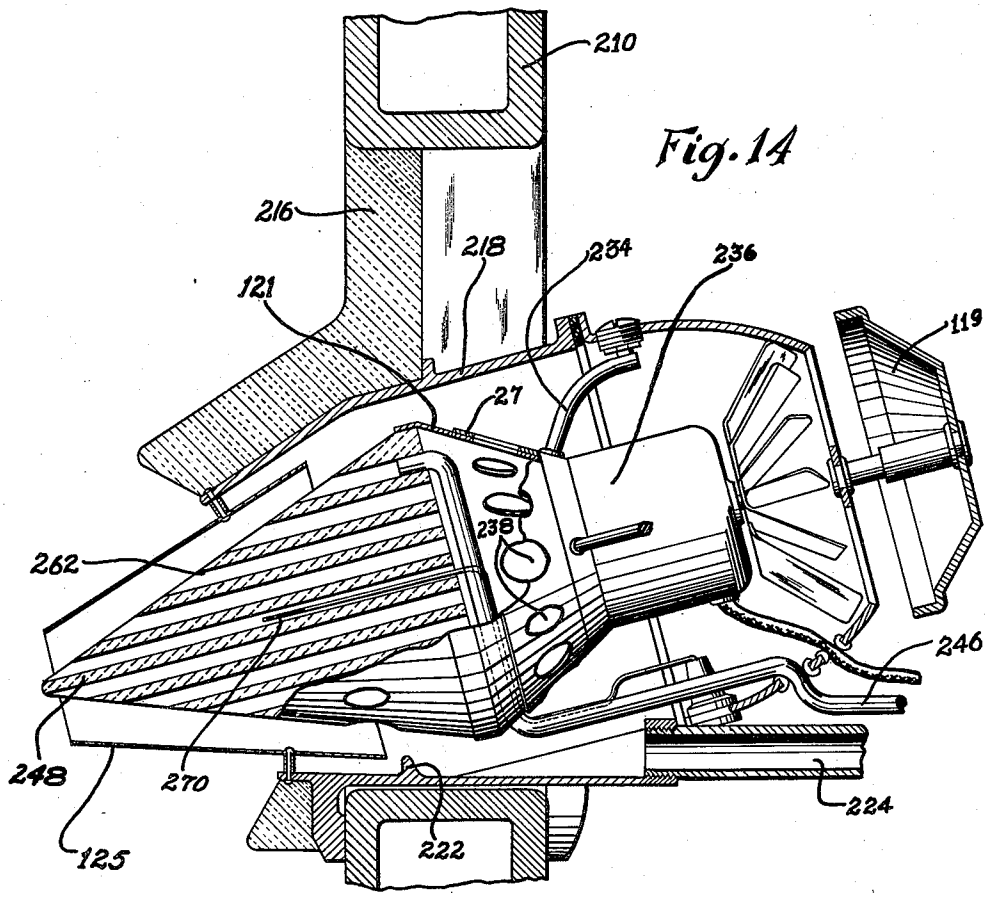


Fig. 14

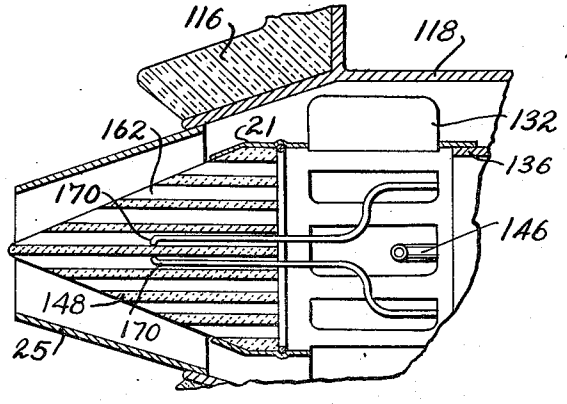


Fig. 11a

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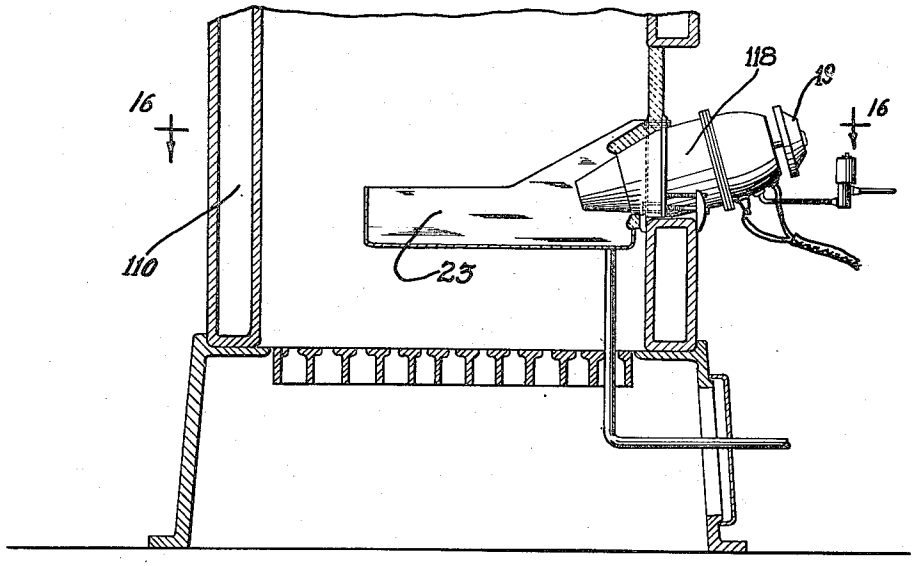


Fig. 15

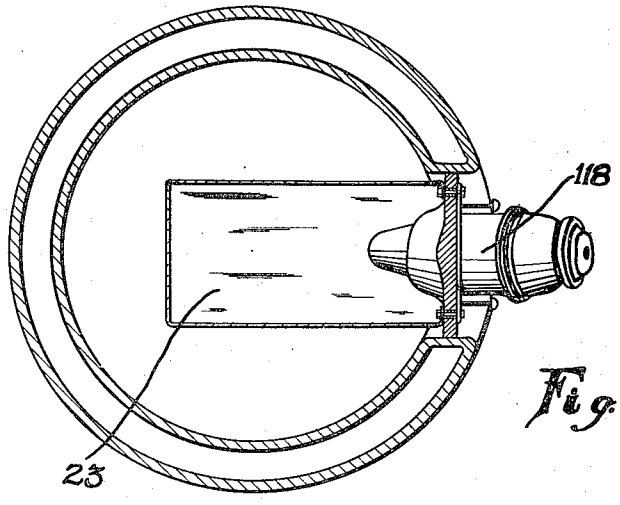


Fig. 16

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Patented Oct. 3, 1939

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UNITED STATES PATENT OFFICE

2,174,818

BURNER

Kemper P. Brace, South Bend, Ind., assignor to International Engineering Corporation, Chicago, Ill., a corporation of Illinois

Application June 1, 1937, Serial No. 145,706

26 Claims. (Cl. 158—96)

This invention relates to heating systems, and is illustrated as embodied in a domestic heating system utilizing an oil burner.

An object of the invention is to provide effective carburetion of large volumes of air, such as are necessarily handled in domestic heating plants, by spreading the fuel over a very large heated surface over which the air is forced. Preferably this is accomplished by causing the fuel to seep through a porous refractory member arranged in the path of the air and preferably of such shape and so arranged that the combustion of the fuel has a considerable heating effect on the refractory.

Various features of novelty relate to the cooperative arrangement of the refractory member and the air circulating means to insure the most effective action, and to the structure and arrangement in the burner of the refractory element, and to the arrangement of the parts in a casing adapted to be mounted in the wall of a furnace and shaped to provide an adequate supply of secondary air for the burner.

Another feature of the invention relates to a novel control system especially adapted for a burner of this character, in that while the fuel and the air-supplying fan are all turned on when the room temperature drops to a predetermined level, when the temperature rises again only the fuel supply is turned off, the fan continuing to operate as long as there is any fuel still burning. Since the porous refractory member in effect stores up a substantial amount of fuel, this novel method of operation insures that it will be entirely burned before the air supply stops, thereby guarding against explosions. This method of operation also has the effect of burning off any deposits of carbon which may have formed during extended periods of operation. Preferably the circuit for this control system also includes a novel safety igniter circuit associated with the fuel-supply and fan-motor circuits.

The above and other objects and features of the invention, including a novel igniter arrangement and various other novel arrangements of the parts and certain desirable mechanical constructions thereof, will be apparent from the following description of the illustrative embodiments shown in the accompanying drawings, in which:

Figure 1 is a vertical section through a domestic steam heating boiler and furnace showing an installation of my novel burner;

Figure 2 is a vertical section on a larger scale through the burner shown in Figure 1;

Figure 3 is a front elevation of the refractory vaporizer element of the burner of Figure 2 showing a hot-wire ignition coil;

Figure 4 is a wiring diagram of an automatic control circuit;

Figures 5–10 inclusive are longitudinal sections through several modified forms of refractory vaporizer elements suitable for use in my novel burner;

Figure 11 is a vertical section through a modified form of my novel burner;

Figure 11*a* is a partial section on the line 11*a*—11*a* of Figure 11, showing a spark type igniter;

Figure 12 is a rear elevation of the burner of Figure 11;

Figure 13 is a section on the line 13—13 of Figure 11;

Figure 14 is a view similar to Figure 11 of still another modification of my invention;

Figure 15 is a partial vertical section through a boiler and furnace showing an installation of the burner shown in Figure 11 with a novel fire-box unit; and

Figure 16 is a section on the line 16—16 of Figure 15.

In the arrangement illustrated in Figure 1, a suitable furnace 10 of any desired type is provided for heating a house or the like space under the control of a room thermostat 12. The bottom of the furnace 10 is lined with fire-brick 14 or equivalent refractory material, to such height as may be necessary. My novel oil burner is mounted to discharge through a refractory shield 16 into the interior of the furnace.

The burner, in the form illustrated, includes a generally cylindrical casing 18 having a conical end projecting through the shield 16 and open at the end opposite the furnace, for the intake of air. The casing 18 is mounted on a suitable support 20. Inside the casing there is a ledge or dam 22, forming a sump into which excess fuel drains, and directing the fuel away through a suitable drain conduit 24. This conduit may, if desired, lead to one of the standard commercial safety devices (not shown) for opening the control circuits of the burner in case of excessive drainage of fuel therethrough.

In the open end of the casing 18, and arranged coaxially with respect thereto, suitable brackets 26 support a motor 28 provided with air-circulating means such as a fan 30 on the motor shaft. The blast of air from the fan 30 is preferably directed through a set of guide vanes 32, which are mounted in the casing 18 just beyond the fan, and which in the form shown insure a sub-

stantially straight flow of the air current and prevent other movement of the air. The shape and arrangement of these vanes may be suitably modified if it is desired to direct the air otherwise than in a straight path.

In the conical end of the casing 18 suitable brackets 34, riveted at their outer ends to the casing, support (coaxially of the outer casing 18) an inner casing 36. The space between the casings 18 and 36 provides an annular outer passage for secondary air from the fan 30. The inner casing 36 has in its end adjacent the fan 30 a reduced-diameter opening 38 forming an intake for primary air from the fan 30.

The oil or other fuel is supplied, for example through a conduit 40 controlled by a suitable fuel valve 42 operated by a solenoid 44, and in the arrangement illustrated feeds slowly through a feed conduit 46, to a porous refractory member 48, and seeps down through the porous structure of that member to be vaporized and taken up by the primary air.

The fuel need not necessarily be supplied on the upper surface of the refractory member, as the capillary action of its porous structure will distribute the fuel satisfactorily even if it is supplied at a lower point.

In the form shown in Figures 1 and 2, the refractory member 48 has its outlet end conical in form, so that its surface parallels the conical outlet end of the casing 18. Thus combustion of vaporized fuel and air serves to heat the tip and thereby increases the capacity of the burner. Other suitable shapes are shown in Figures 5, 6, 7, 8, 9, and 10.

The member 50 shown in Figure 5 has its intake end cylindrical, to fit into the casing 36, then has a reduced-diameter neck from which it flares outwardly and then converges again to form a generally-conical end. The member 52 shown in Figure 6 is cylindrical, and has a conical recess in its discharge end. The member 54 in Figure 7 is cylindrical, the same as member 52, but has a generally conical recess in its end. The member 56 of Figure 5 is cylindrical, as is the member 58 in Figure 9, but the former has a series of annular grooves 57 in its outlet end and the latter has two successively smaller cylindrical bosses projecting from annular recesses 59 on its outlet end. The member 60 of Figure 10 has a surface generated by rotating a parabola about its axis.

The members 48, 50, 52, 54, 56, 58, and 60 have straight passages 62 or 64 therethrough parallel to their axes. The passages 64 of the members 56 and 58 open respectively into the annular grooves 57 and 59.

The fuel conduit 46 discharges onto the refractory member 48, or one of the illustrated equivalents, on the upper surface thereof in the arrangement of Figures 1–3, and the fuel seeps through the porous structure thereof and crosswise of the passages 62 or 64. The heat of the combustion taking place around the end of and in the passages of the refractory member vaporizes the fuel and it is taken up by the primary air. This gives unusually effective carburetion for the large volume of primary air required in a burner of this character.

The lower part of the member 48, at its outlet end, has arranged crosswise thereof a hot-wire igniter 68, connected by supporting posts 70 to the lead wires described below. This igniter is arranged in a recess formed in the refractory member, out of the direct path of the primary air, in a sort of eddy current due to the passage of the primary air. Preferably it is in direct contact with the surface of the refractory member, so that a small part of the latter is heated up to vaporize the fuel therein and bring about immediate ignition thereof in the air of the eddy current.

It will be seen that so long as fuel is supplied and the motor 28 operates, the fuel and primary air mixed in the passages 62 burns and then in turn is mixed with an outer envelope of secondary air from the annular passage between the casings 36 and 18. It will be noted that the combustion takes place immediately adjacent the refractory member, and to some extent actually in the passages 62, heating the refractory member to a high enough temperature to cause rapid vaporization of the fuel.

Figure 4 shows one manner of controlling the described burner. A source of current, such as the secondary of a transformer 74, is connected through line wires 76 and 78, one of which has connected thereto a switch 80 operated by the room thermostat 12, to the motor 28. The switch 80 has a second contact so that it also closes a parallel circuit through wires 82 and 84 and the igniter 68. The wires 82 and 84 have connected therebetween, in parallel with the igniter 68, the fuel-valve solenoid 44. Thus closing the switch 80 closes three circuits through (1) the motor, (2) the igniter, and (3) the fuel valve solenoid.

As a safety measure, in order to shut off the fuel supply after a predetermined interval if the igniter does not operate, there is connected in shunt with the igniter a heating resistance 86 which, after the desired time interval, deflects a bimetallic strip 88, causing a plunger 90 to open a switch contact 92 in the line 82, thereby shutting off both the fuel valve and the igniter.

The wires 78 and 82 terminate in contacts 94 in an enlarged upwardly extending space 96 in a member 98 of suitable insulating material. This member is formed with a lower horizontal passage 100 of capillary size, communicating at its ends with the space 96 and with another and somewhat higher upwardly-extending enlarged space 102 which is open to the atmosphere through a porous plug 104 held by a perforated threaded cap 106. The space 102 contains contacts 108 connected to the lines 76 and 78 around the room-thermostat switch 80.

The above passages form a U-shaped passage containing a globule of mercury, shown in the space 96. The mercury can pass through the passage 100 only when forced by a substantial pressure thereon. The mercury cannot pass the porous plug 104, nor a similar plug 111 held by a perforated locking ring 113 leading to a passage 115 communicating with the mouth of a sealed air bulb 117.

The bulb is arranged in the path of the burned gases from the burner, for example in the flue connection from the furnace as shown in Figure 1. It is not necessary that the burned gases actually impinge on the bulb, but the air in the bulb must be subject to the heat of the gases so that it expands when the burner is going and contracts when it is not going.

The above-described stack control shown in Figure 4 is claimed in my application No. 184,971, filed January 14, 1938.

In operation, when the room temperature drops to a predetermined level, the thermostat 12 closes the double contact switch member 80, thereby closing the three circuits through the motor and the solenoid 44 and the igniter. The globule of

mercury is at this time in the space 96, and completes the igniter circuit.

As soon as the burner ignites, the hot exhaust gases act on the bulb 117 to expand the air therein, driving the globule of mercury through the capillary tube 100 into the space 102, thereby breaking the igniter circuit at 94 and closing the contacts 108.

When the room temperature rises, the thermostat 12 operates switch member 80 to open the circuits it controls, breaking the circuit through the solenoid 44 and shutting off the fuel supply. A substantial amount of fuel remains in the pores of the member 48, however, so the burner is not immediately extinguished. The motor circuit remains closed through contacts 108, therefore, until this fuel is all burned. Thereupon the air in the bulb 117 cools and contracts, and the atmospheric pressure in space 102 pushes the mercury globule back through the capillary passage 100 into the space 96, leaving the circuits ready for the next cycle. Excess air, after the mercury has been pushed from one side to the other, merely bubbles idly through the mercury.

Figures 11 and 12 and 13 show a second embodiment of my invention incorporating some features claimed in application No. 117,459 filed December 24, 1936 by Kendall Clark. In these figures, parts corresponding to parts in Figures 1–10 are indicated by the same reference characters increased by 100.

The principal differences are in the provision of an adjustable air intake cover 19, and in the arrangement by which the primary air circulates to the interior of the inner casing 136 through peripheral openings formed by striking up the vanes 132 from a cylindrical sheet-metal member 21 which forms the forward portion of the inner casing 136 and which holds the porous refractory member 148 in place. Also the motor 128 is housed in the end of the inner housing 136.

Another difference is that the rear part of the outer casing 118 is made of a casting and is provided at its discharge end with a generally conical extension 25, preferably composed of stainless steel, and which extends to the tip of the refractory 148. This member is intended to confine the flame around the refractory and to radiate heat to it to increase its vaporizing capacity. It will be noted that the forward portion of the outer casing in the first modification performs this same function.

In Figure 14, which shows a third modification of my invention, parts corresponding to parts in Figures 1–10 and 11–13 are indicated by the same reference numerals plus 200 and 100 respectively.

In this modification the portion of the inner casing 236 containing the motor is substantially reduced and the sheet metal member 121, which forms the forward portion of the inner casing, is tapered outwardly to receive the base of a much larger refractory 248. Primary air is admitted through a series of peripherally spaced openings 238 which may be adjusted by rotation of a ring 27 closely surrounding the member 121 and having correspondingly spaced openings.

Still another difference resides in a further division of the air passing through the burner by insetting the stainless steel extension 125 of the outer housing 218 and thus providing a peripheral opening between the cast part of the housing and the extension. It is found that in some cases to introduce all the air required for complete combustion as secondary air somewhat reduces the evaporating capacity of the refractory by cooling it. By subdividing the secondary air as described only approximately as much air as will combine with the fuel within the extension is introduced as true secondary air and the remainder is introduced as what may be called tertiary air through the peripheral opening outside of the stainless steel cone 125, to combine with the unburned fuel in the fire box.

While the proportion of secondary to tertiary air can be made adjustable by providing means for shifting the extension 125 longitudinally of the burner, it is believed that satisfactory operation under most conditions can be obtained without such an adjustment.

Figures 15 and 16 illustrate how the burner of Figures 11–13 or 14 may be mounted in the side wall of a furnace 110, discharging at an angle downwardly into a fire-box or pan 23 of stainless steel, which in use becomes heated sufficiently to transfer most of the heat as radiant heat directly to the furnace walls. I have found that this construction amply fulfills the requisite that all oil burners must be supplied with a fire box of a particular size and shape, and at the same time is very cheap to manufacture and install in comparison to the old practice of building up the fire-box with firebrick as shown in Figure 1.

The igniters 170 and 270 illustrated in the second and third embodiments are of the spark-gap type, arranged as shown in Figure 11a, and include two electrodes arranged in adjacent passages 62, the spark passing freely through the porous wall between the passages.

While three illustrative embodiments have been described in detail, it is not my intention to limit the scope of the invention to those particular embodiments, or otherwise than by the terms of the appended claims.

I claim:

1. A liquid fuel burner comprising a porous refractory element having generally horizontal air passages therethrough, means for delivering liquid fuel to said element to seep through the porous structure thereof, and a casing open at its ends and within which said element is mounted and one end of which is adapted to project into a furnace beyond said element and to be heated by the burning fuel and to radiate heat back to said element to aid in vaporizing the fuel.

2. A liquid fuel burner comprising a casing formed with an air outlet and provided with means for directing a current of air through said outlet including a porous refractory element mounted in the casing in line with said outlet and in intimate contact with which the current of air passes to the outlet, said element having a considerable number of parallel generally horizontal passages directing portions of the air current through said element and through said outlet, and means for feeding liquid fuel to said element to seep therethrough and be taken up by the air.

3. A liquid fuel burner comprising a casing formed with an air inlet opening at one end and with an air outlet at its other end and adapted to project through the side wall of a furnace with said outlet inside the furnace and provided with means for directing a current of air from the inlet opening through said outlet including a porous refractory element in said casing, said element having closely-spaced horizontal parallel passages directing air in intimate contact with the porous structure of said element and through

said outlet, and means for feeding liquid fuel to said element to seep therethrough and be taken up by the air.

4. A liquid fuel burner comprising a casing having an air outlet in one end and constructed and arranged at its other end for the intake of air, said casing being adapted for mounting in an opening in the side wall of a furnace, a motor-driven fan in said casing for forcing air through said outlet, a porous refractory element arranged between the fan and said outlet and which is formed with a plurality of passages through which the fan forces air to said outlet, and means for supplying liquid fuel to said element to seep through the porous structure thereof and be taken up by the air.

5. A liquid fuel burner comprising a casing having an air outlet in one end and constructed and arranged at its other end for the intake of air, a motor-driven fan in said casing for forcing air through said outlet, a porous refractory element arranged between the fan and said outlet and which is spaced from the wall of the casing to form an annular air passage around the refractory element leading to said outlet and which is formed with a plurality of passages through which the fan forces air to said outlet, and means for supplying liquid fuel to said element to seep through the porous structure thereof and be taken up by the air.

6. A liquid fuel burner comprising a casing having an air outlet in one end and constructed and arranged at its other end for the intake of air, a motor-driven fan in said casing for forcing air through said outlet, a porous refractory element arranged between the fan and said outlet and which is formed with a plurality of passages through which the fan forces air to said outlet, air-directing means between the fan and the refractory element including vanes to control the direction of the air currents, and means for supplying liquid fuel to said element to seep through the porous structure thereof and be taken up by the air.

7. A liquid fuel burner comprising a casing having an air outlet in one end and constructed and arranged at its other end for the intake of air, a motor-driven fan in said casing for forcing air through said outlet, a porous refractory element arranged between the fan and said outlet and which is spaced from the wall of the casing to form an annular air passage around the refractory element leading to said outlet and which is formed with a plurality of passages through which the fan forces air to said outlet, air-directing means between the fan and the refractory element including vanes to control the direction of the air currents, and means for supplying liquid fuel to said element to seep through the porous structure thereof and be taken up by the air.

8. A liquid fuel burner comprising a casing having an air outlet in one end and constructed and arranged at its other end for the intake of air, a motor-driven fan in said casing for forcing air through said outlet, a porous refractory element arranged between the fan and said outlet and which is spaced from the wall of the casing to form an annular air passage around the refractory element leading to said outlet, air-directing means between the fan and the refractory element including vanes to control the direction of the air currents, and means for supplying liquid fuel to said element to seep through the porous structure thereof and be taken up by the air.

9. A burner comprising an outer casing having an air outlet in one end and air intake means at the other end, an inner casing supported in the outer casing and spaced therefrom to leave between the two casings an annular air passage leading to said outlet, a porous refractory element mounted in one end of the inner casing in line with the outlet, said inner casing having means for admitting air to the face of the refractory element opposite said outlet, a motor-driven fan in the outer casing adjacent said air intake means and arranged to force air through said annular passage and into the inner casing and thence through the refractory element, and means for supplying fuel to the refractory element to seep therethrough and be taken up by the air forced through said element.

10. A burner comprising an outer casing having an air outlet in one end and air intake means at the other end, an inner casing supported in the outer casing and spaced therefrom to leave between the two casings an annular air passage leading to said outlet, a porous refractory element mounted in one end of the inner casing in line with the outlet, and having passages therethrough opening into said outlet, said inner casing having means for admitting air to the face of the refractory element opposite said outlet, a motor-driven fan in the outer casing adjacent said inlet and arranged to force air through said annular passage and into the inner casing and thence through the refractory element, and means for supplying fuel to the refractory element to seep therethrough and be taken up by the air forced through said element.

11. A burner comprising an outer casing having an air outlet in one end and air intake means at the other end, an inner casing supported in the outer casing and spaced therefrom to leave between the two casings an annular air passage leading to said outlet, a porous refractory element mounted in one end of the inner casing in line with the outlet, said inner casing having an opening in its opposite end so arranged that the air intake means and the outlet of the outer casing and said refractory element and said opening in the end of the inner casing are all in line, a motor-driven fan supported in the outer casing between said air intake means and the end of the inner casing formed with the opening, and means for supplying fuel to said refractory element to seep therethrough and be taken up by the air forced through said element by the fan.

12. A burner comprising an outer casing having an air outlet in one end and air intake means at the other end, an inner casing supported in the outer casing and spaced therefrom to leave between the two casings an annular air passage leading to said outlet, a porous refractory element mounted in one end of the inner casing in line with the outlet and having passages therethrough opening into said outlet, said inner casing having an opening in its opposite end so arranged that the air intake means and the outlet of the outer casing and said refractory element and said opening in the end of the inner casing are all in line, a motor-driven fan supported in the outer casing between said air intake means and the end of the inner casing formed with the opening, and means for supplying fuel to said refractory element to seep therethrough and be taken up by the air forced through said element by the fan.

13. A burner comprising an outer casing having an air outlet in one end and air intake means at the other end, an inner casing supported in the outer casing and spaced therefrom to leave between the two casings an annular air passage leading to said outlet, a porous refractory element mounted in one end of the inner casing in line with the outlet, said inner casing having a motor in its opposite end and having an air space between said motor and the refractory element and formed with openings in its walls providing communication between said air space and the annular space between the two casings, a fan driven by said motor and arranged adjacent said air intake means and forcing air through said annular space toward said outlet, and means for supplying fuel to said refractory element to seep therethrough and be taken up by the air forced through said element by the fan.

14. A burner comprising an outer casing having an air outlet in one end and air intake means at the other end, an inner casing supported in the outer casing and spaced therefrom to leave between the two casings an annular air passage leading to said outlet, a porous refractory element mounted in one end of the inner casing in line with the outlet and having passages therethrough opening into said outlet, said inner casing having a motor in its opposite end and having an air space between said motor and the refractory element and formed with openings in its walls providing communication between said air space and the annular space between the two casings, a fan driven by said motor and arranged adjacent said air intake means and forcing air through said annular space toward said outlet, and means for supplying fuel to said refractory element to seep therethrough and be taken up by the air forced through said element by the fan.

15. A burner comprising an outer casing having an air outlet in one end and air intake means at the other end, an inner casing supported in the outer casing and spaced therefrom to leave between the two casings an annular air passage leading to said outlet, a porous refractory element mounted in one end of the inner casing in line with the outlet, said inner casing having a motor in its opposite end and having an air space between said motor and the refractory element and formed with integral vanes turned outwardly from the walls around said space and leaving openings providing communication between said air space and the annular space between the two casings, said vanes being arranged to extend parallel to the axis of the casing and forming means to straighten out the air current flowing through said annular passage, a fan driven by said motor and arranged adjacent said air intake means and forcing air through said annular space toward said outlet, and means for supplying fuel to said refractory element to seep therethrough and be taken up by the air forced through said element by the fan.

16. A burner comprising an outer casing having an air outlet in one end and air intake means at the other end, an inner casing supported in the outer casing and spaced therefrom to leave between the two casings an annular air passage leading to said outlet, a porous refractory element mounted in one end of the inner casing in line with the outlet and having passages therethrough opening into said outlet, said inner casing having a motor in its opposite end and having an air space between said motor and the refractory element and formed with integral vanes turned outwardly from the walls around said space and leaving openings providing communication between said air space and the annular space between the two casings, said vanes being arranged to extend parallel to the axis of the casing and forming means to straighten out the air current flowing through said annular passage, a fan driven by said motor and arranged adjacent said air intake means and forcing air through said annular space toward said outlet, and means for supplying fuel to said refractory element to seep therethrough and be taken up by the air forced through said element by the fan.

17. A liquid fuel burner comprising a casing formed with an air outlet and provided with means for directing a current of air through said outlet, a porous refractory element mounted in the casing in line with said outlet and in intimate contact with which the current of air passes to the outlet, said element having a considerable number of parallel generally horizontal passages directing portions of the air current through said element and through said outlet, means for feeding liquid fuel to said element to seep therethrough and be taken up by the air, and an ignition device arranged immediately adjacent said refractory element.

18. A burner comprising an outer casing having an air outlet in one end and air intake means at the other end, an inner casing supported in the outer casing and spaced therefrom to leave between the two casings an annular air passage leading to said outlet, a porous refractory element mounted in one end of the inner casing in line with the outlet, said inner casing having means for admitting air to the face of the refractory element opposite said outlet, a motor-driven fan in the outer casing adjacent said inlet and arranged to force air through said annular passage and into the inner casing and thence through the refractory element, means for supplying fuel to the refractory element to seep therethrough and be taken up by the air forced through said element, and an ignition device arranged immediately adjacent said refractory element.

19. A liquid fuel burner comprising an outer casing, an inner casing supported within the outer casing and spaced therefrom to form an annular air passage, a motor in one end of the inner casing, a refractory vaporizer element in the other end of the inner casing having passages therethrough, said inner casing being formed with openings intermediate the motor and the refractory element to admit primary air to the passages in the refractory element, means to vary the effective size of said openings, a fan driven by said motor for supplying air to pass through said openings and through said annular air passage, and means for supplying liquid fuel to the fractory element.

20. A liquid fuel burner comprising an outer casing, an inner casing supported within the outer casing and spaced therefrom to form an annular air passage, a motor in one end of the inner casing, a refractory vaporizer element in the other end of the inner casing having passages therethrough, said inner casing being formed with openings intermediate the motor and the refractory element to admit primary air to the passages in the refractory element, means to vary the effective size of said openings, said means comprising a ring surrounding the portion of the inner casing formed with said openings, said ring having corresponding openings and being rotatable to close or open said openings, a fan driven by said motor

for supplying air to pass through said openings and through said annular air passage, and means for supplying liquid fuel to the refractory element.

21. A liquid fuel burner comprising an outer casing, an inner casing supported within the outer casing and spaced therefrom to form an annular air passage, a motor-driven air-circulating device adjacent one end of the inner casing, a refractory vaporizer element in the other end of the inner casing having passages therethrough, said inner casing being formed with openings intermediate the motor and the refractory element to admit primary air to the passages in the refractory element, a sheet metal extension of said outer casing surrounding and spaced outwardly from the refractory element to form an annular secondary air passage and spaced inwardly from the outer casing to form an annular tertiary air passage, a fan driven by the motor to force air through said passages, and means to supply liquid fuel to the refractory element.

22. In a liquid fuel burner, a refractory vaporizer element having passages therethrough for primary air, a casing part surrounding said element in spaced relationship thereto for directing secondary air in an envelope closely surrounding the refractory element, a casing surrounding said element and the end of said part and which is larger than said part for directing tertiary air in an envelope outside of and separated from the refractory element, and means for supplying fuel to the refractory vaporizer element.

23. A liquid fuel burner comprising an outer casing, an inner casing supported within the outer casing and spaced therefrom to form an annular air passage, means for circulating air through said annular passage and through said inner casing, a refractory vaporizer element in the path of the air passing through the inner casing, said inner casing being formed with openings to admit air to the refractory element, a sheet metal extension of said outer casing surrounding and spaced outwardly from the refractory element to form an annular secondary air passage and spaced inwardly from the outer casing to form an annular tertiary air passage, and means to supply liquid fuel to the refractory element.

24. A burner comprising a generally conical-ended porous refractory element having passages therethrough parallel to its axis and having means to supply fuel thereto, and means for directing primary air through said passages and secondary air over the conical end surface of said element, said means including a conical metal member directing the secondary air over the end face of the refractory element and arranged to be highly heated when the burner is in operation and to radiate heat onto said refractory element to aid in vaporizing the fuel seeping through said element.

25. A burner comprising a porous refractory element having passages therethrough and having means to supply fuel to seep through the porous structure thereof, means for directing primary air through said passages and secondary air to be mixed with the primary air after issuing from the passages, and a hot-wire igniter in contact with the refractory element between said passages, said igniter being out of but immediately adjacent the path of the primary air.

26. A burner comprising a porous refractory element having passages therethrough and having means to supply fuel to seep through the porous structure thereof, means for directing primary air through said passages and secondary air to be mixed with the primary air after issuing from the passages, and a spark type igniter having electrodes arranged in adjacent ones of said passages and discharging through the wall between said adjacent passages.

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