Jan. 5, 1932. A. U. WETHERBEE 1,839,515

GAS BURNER

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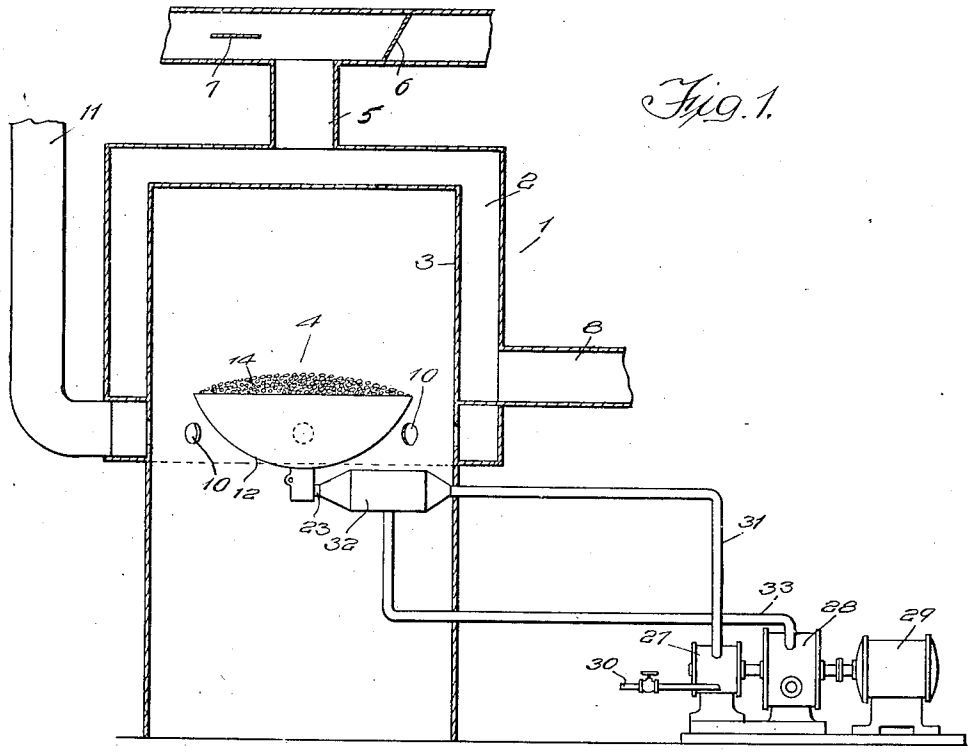
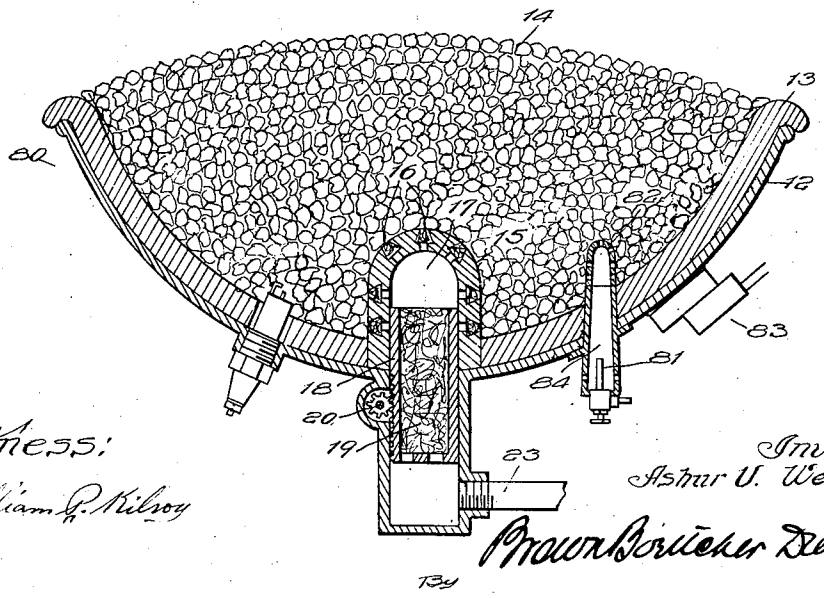


Fig. 1.

Fig. 2.



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GAS BURNER

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Fig. 3.

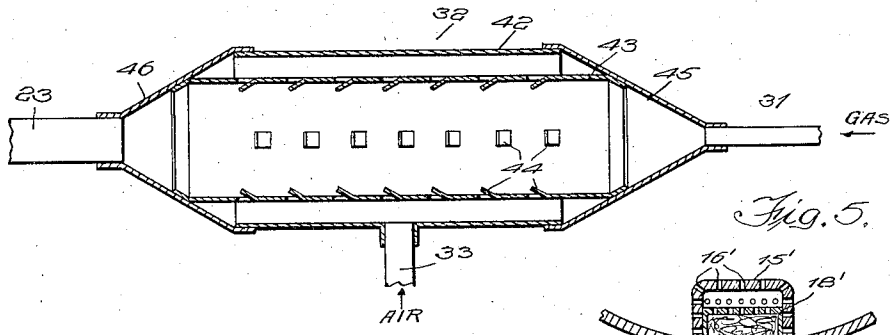


Fig. 5.

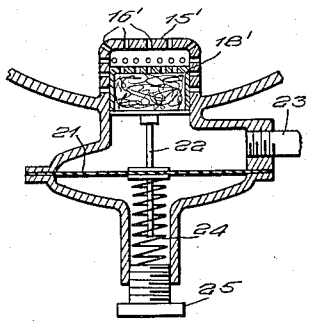


Fig. 4

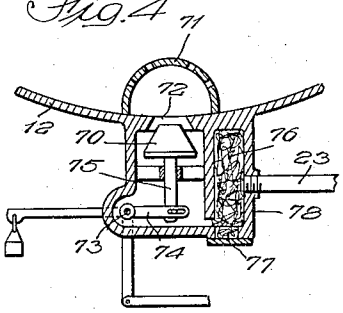


Fig. 7.

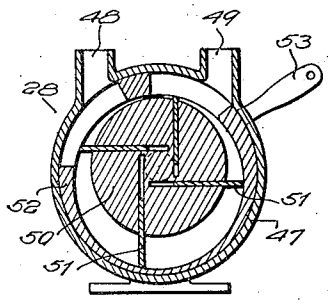


Fig. 6.

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GAS BURNER

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Fig. 8.

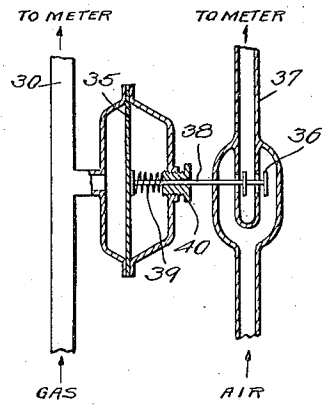


Fig. 10.

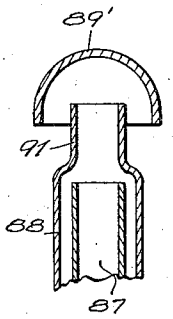


Fig. 9.

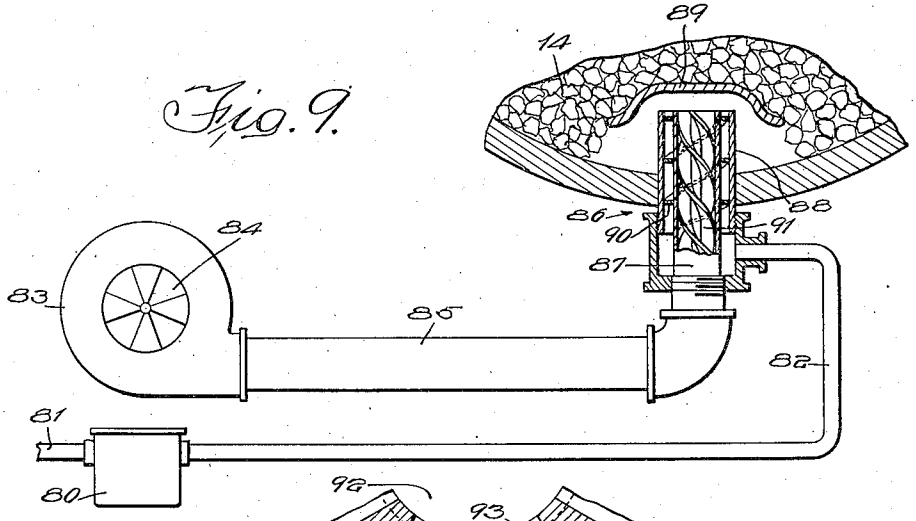
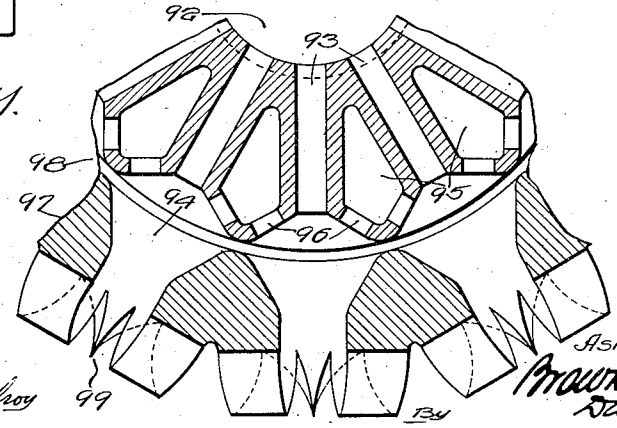


Fig. 11.



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Patented Jan. 5, 1932 1,839,515

UNITED STATES PATENT OFFICE

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GAS BURNER

Application filed January 15, 1927. Serial No. 161,296.

My invention relates to means for burning gaseous fuel for the production of heat for heating homes.

It is intended that the burner of my invention shall be applied to any suitable heater, such as is employed in house heating as, for example, a hot air furnace, a hot water heater, or a steam or vapor boiler.

The heating of houses, garages, and such like detached buildings which do not conveniently support expert firemen and burn fuel on a large scale could, theoretically, be best performed by burning gas since it is at once cleanly and convenient and easily controllable.

The great difficulty heretofore has been that the cost of burning gas in furnaces of the known construction has entailed too great an expense. I have conceived the possibility of employing the fuel in the most efficient form commercially possible, so as to minimize the objection of high cost of gaseous fuel. It is a well known fact that the transfer of heat from the fire to a heated surface is performed more efficiently if the heat can be applied in the form of radiant energy as distinguished from heating a current of air and then transferring the heat of the air to the surface, as by convection. Since air is a poor conductor of heat at best, and since it has low specific heat, the passing of large quantities of air through a furnace is highly undesirable. I have, therefore, employed the type of combustion known as surface combustion in which the heat of the gaseous fuel is developed mainly as a radiant heat and I employ only so much air flow as is necessary to support combustion. In the usual open flame type of combustion a large amount of excess air is permitted to pass through the furnace, and it carries a large amount of heat out the stack. This loss is greatly reduced in surface combustion where the amount of air used is intended to be only sufficient to support combustion.

So far as I am aware heretofore surface combustion has not been employed in an off and on type of burner and, in fact, so far as I am aware, no means for varying the effective size of the mass of incandescent refractory has heretofore been devised.

In supplying gaseous fuel to burners of this kind there is the distribution difficulty which has heretofore been encountered and that is that, due to pipe friction, heavy demands by many users reduce the pressure at the outlet to such an extent that unsatisfactory combustion results.

According to one phase of my invention I overcome this difficulty of pipe friction by employing a positive metering device, that is, a device which, by suction, draws the gas from the main and compresses the same in predetermined quantities, so that the variations of pressure in the main do not disturb the efficiency of combustion, nor in fact, the rate of combustion.

I provide, in addition to the above, means for maintaining the delivery pressure substantially constant; that is, the delivery pressure of either the gas or the fuel, or the mixture of gas and fuel, and provide means for varying the size of the mass of incandescent material simultaneously with the variations of delivery as, for example, in accordance with thermostatic regulation.

Where there is likelihood of relatively great fluctuations in the gas or air pressure, I provide regulating means on the intake side of the metering devices to regulate the rate of air inflow in proportion to the rate of gas inflow. The air is preferably introduced into the burner by a positive metering device which is driven in unison or synchronously with the gas metering device and is preferably of the same type, so that the two streams; namely, gas and air, are delivered under pressure to a mixing device and thence conveyed to the burner.

In the connection between the mixing device and the burner I interpose a flame arrester in order to prevent the flame from striking back from the burner when the fire is shut off.

This flame arrester should preferably be placed as close as possible to the burner so that a minimum disturbance will be created when the fire is shut off. I may embody the

flame arrester in the valve which controls the size of the mass of incandescent refractory.

The gas entering from the nozzle of the burner may be ignited either by a pilot light, a hot wire, or by a spark plug embedded in the mass of refractory.

A further feature of my invention resides in having the air and gas come together in such a manner and at such location as to maintain at all times a minimum of combustible mixture. This is highly desirable to prevent explosion by back firing, or from any cause at all. I find that even with interposed flame arresters it is difficult to prevent back firing when the burner is stopped and started. Hence there is the desirability of mixing the gas and air as close to the point of burning as possible to lessen the volume of mixture, and also by mixing the gas and air within the confines of the furnace any slight popping noise which might arise from such back fire will be masked.

Now in order to acquaint those skilled in the art with the manner of constructing and operating a device embodying my invention, I shall describe in connection with the accompanying drawings a system in which my invention appears.

In the drawings:—

Figure 1 is a side elevational view of a system embodying my invention showing a hot air furnace partly in vertical section;

Figure 2 is a vertical section on an enlarged scale showing the burner of Figure 1;

Figure 3 is a vertical section on an enlarged scale showing the gas and air mixer in vertical section;

Figure 4 is a fragmentary vertical section of the bottom part of the burner showing a modified form of valve and flame arrester;

Figure 5 is a similar fragmentary section of an automatic regulating valve for the nozzle of the burner;

Figure 6 is a diagrammatic view similar to Figure 1 showing a thermostatic control for simultaneously controlling the delivery of gas meter and the air meter and the regulating valve for the burner nozzle;

Figure 7 is a transverse vertical section through one of the meters showing the regulating means for regulating delivery;

Figure 8 is a diagram illustrating the control valve between the gas line and the air line running to the meter;

Figure 9 is a diagram of a modified form of my invention in which the mixing of gas and air occurs within the bowl of the burner;

Figure 10 is a fragmentary section of a modified form of mixer; and

Figure 11 is a horizontal section through a further modified form of burner nozzle in which the mixing occurs within a series of short passageways disposed in the bowl of the burner.

Referring now to Figure 1, I provide a hot air furnace 1 having a suitable air space 2, the interior of which is defined by the inner furnace wall 3, which wall is adapted to be heated by the burner 4 and the products of combustion escaping therefrom. The hot air space 2 communicates by way of a delivery pipe 5 to the registers of the house through suitable pipes or trunks controlled by regulating valves, such as 6 and 7. Air to be heated enters by way of the pipe or trunk 8. The burner 4 is provided with a vent space 9 below the same and the outlets 10 to the stack or chimney 11 are located preferably at a level considerably below the burner 4. The burner 4 comprises preferably a metal shell 12 in the general shape of a bowl or the like having a lining 13 of plastic refractory material and a mass 14 of broken refractory material or refractory bodies within which mass the combustion of the mixture of gas and air is carried on.

The bowl 12 has a distributor nozzle 15 projecting into the mass of refractory 14, this nozzle being in the nature of a tunnel preferably disposed in a vertical direction with a plurality of nozzle openings 16 communicating with the interior 17. Preferably, the character of the mixture as delivered to the nozzle 15 is such that complete combustion is carried on in the mass of refractory 14 a short distance below the surface of the same. That is to say, with a given delivery pressure and the proper velocity through the nozzle 15, the upper nozzles will deliver the combustible mixture into the mass 14 in such a manner that the flame remains within the mass of refractory

Now it will be observed that the nozzle 15 is of tubular form with a rounded or semi-spherical upper end and the nozzle openings may extend over substantially the entire outer surface of the same. These nozzle openings are preferably packed with fibrous refractory material disposed in dovetail openings in the surface of the nozzle 15. A combined valve and flame arrester 18 is arranged within the nozzle 15 in such a manner that by raising this member 18 the lower nozzle openings will be closed off to limit the amount of refractory material in which the flame occurs. When the valve member 18 is lowered the lower nozzle openings 16 are uncovered and delivery of combustible mixture through them occurs, with the result that the mass of refractory material in which combustion occurs is increased. In other words, the valve 18 regulates the delivery of the combustible mixture in such a manner that for a small flame only the central part of the mass of refractory material 14 is heated to maximum temperature, and for a larger fire the flame of the burner is increased to heat a larger amount of the refractory material in a lateral direction. Hence for variable delivery, assuming a substantial constant pressure, the amount of re-

fractory material which is included in the flame is regulated.

It will be seen that by this means a minimum loss of heat occurs since a small flame means that only a small part of the refractory is heated to incandescence, but that is close to the surface so that the heat may be transferred to the furnace walls by radiation directly.

Since it is an important part of this invention to convert as large a proportion of the heat of combustion to radiant heat as is possible, and since the heat radiated increases in quantity faster than the increase in temperature, it is desirable to have a small area at a high temperature rather than a larger area at a lower temperature.

I believe that this manner of regulating surface combustion is broadly new. Heretofore, so far as I am aware, the nozzle opening has been fixed with the result that variations in rate of delivery have prevented the maintenance at incandescence of a mass of refractory proportional to the rate of delivery. The theory of surface combustion includes the idea of burning the mixture at the point where the rate of flame propagation is substantially equal to the rate of mixture flow. Heretofore, when the rate of mixture flow has decreased the flame has gone down into the mass of refractory, and if the flame has not been sufficient to maintain the entire mass incandescent, the incandescent zone has traveled down inside of the mass of refractory with the result that the desired effect of transmitting the heat by radiant energy has been, to a large extent, defeated. Consequently, heretofore, it has been the desire to hold the delivery constant and at such a point that the zone of incandescence was substantially at the surface of the mass of refractory, so as to secure a maximum of radiant energy. By my scheme I maintain the delivery substantially constant in pressure but not in volume and, as a result, I maintain invariably a mass of incandescent material adjacent the surface of the burner so that a maximum of radiant energy may be developed, and when the amount of mixture delivered is increased I increase the mass of incandescent material aiming always to keep the flame so disposed that the zone of incandescence will not travel up and down, but laterally.

I pack the interior of the valve member 18 with metal wool, or may employ a mass of metal screen, to form the flame arrester 19. As shown in Figure 2, the valve member 18 is moved up and down by means of a ratchet pinion 20, this pinion being mounted on a shaft which extends out laterally to a suitable hand wheel (not shown). This hand wheel may be disposed outside of the furnace if so desired.

In Figure 5 I have shown automatic means for controlling the position of the valve member 18′, this means comprising a diaphragm 21 connected to the stem 22 of the valve member 18′ and arranged to vary the position of the valve member 18′ in response to the delivery pressure of gas entering through the delivery pipe 23. The diaphragm 21 is loaded by a spring 24, the pressure of which is regulated by a regulating screw 25. By this means the combined outlet opening of the nozzle openings 16′ is so regulated as to maintain the delivery pressure on these nozzles substantially constant and to vary the number of such nozzle openings which are, in effect, to correspond to the amount of mixture which is delivered to the nozzle.

The valve 18, shown in Figure 2, may be actuated in unison with the means which controls the output of the gas and air metering devices, as will be explained more fully in connection with Figure 6.

The gas and air are delivered by a motor driven metering outfit which comprises the gas meter 27 and the air meter 28. While I speak of these devices as meters they are, more accurately, designated as pumps, but since their purpose is to deliver the gas and air under pressure and to draw the same by suction, I term them meters or metering pumps. These metering pumps 27 and 28 are driven by an electric motor 29, preferably directly connected to each other and to the motor, and they comprise preferably eccentric vane pumps or equivalent devices such as Root blowers, which deliver with great accuracy predetermined quantities of gas and air. The gas is supplied from the gas main through a pipe 30, which pipe leads to the suction side of the metering pump 27. The gas is delivered through delivery pipe 31 to the gas and air mixer 32. Air is delivered from the metering pump 28 through the pipe 33 which also leads to the mixer 32. Since the metering pump 27 draws from the gas main by suction and delivers at a pressure above atmospheric the variations in gas pressure are relatively inconsequential. I find, however, that I can regulate the air supply in accordance with the intake gas pressure by means of a control valve, such as is shown in Figure 8. In this case the gas pipe 30 communicates with a diaphragm chamber having a diaphragm 35 and the diaphragm in turn controls an air control valve 36, which is preferably of the balanced pressure type, to regulate the flow of air to correspond to the flow of gas to the respective meters. The air pipe 37 leads to the suction side of the air metering pump 28. The diaphragm 35 is connected by a suitable stem 38 to the stem of the air valve 36. The diaphragm 35 is controlled by a control spring 39 which is adjustable by means of an adjusting screw 40. It will be seen that if pipe 30 is put under suction the diaphragm 35 moves to the left, as viewed

in Figure 8, tending to close the choker valve 36 in the air pipe 37 so as to reduce the rate of air drawn by the metering pump 28 to correspond to like variations in the amount of gas drawn by the metering pump 27.

Ordinarily such regulating mechanism is unnecessary where the variation in gas pressure is not considerable.

I do not wish to limit the metering devices to high pressure devices, as fans may within certain limits be employed. This all depends upon the force required to secure the desired result.

The gas mixer 32 comprises a generally cylindrical body having an outer shell 42 and an inner shell 43 concentric with the same. The gas is delivered into one end of the inner shell 43 and the mixture of gas and air is discharged out of the opposite end to the burner 4. The inner shell 43 is perforated by pushing in lips or vanes which have the effect of breaking up the gas flow and also of introducing the air in a generally diagonal direction. The vanes 44 may be disposed in a circumferential direction to give the resultant flow of gas and air a spiral mixing effect. The two sleeves are joined by generally conical heads 45 and 46. Air is delivered by the air pipe 33 into the space between the two sleeves 42 and 43. The mixer 32 is preferably disposed as closely adjacent the burner 4 as possible in order to decrease the amount of mixture which may be contained in the system when the burner is shut off. The air and gas connections may be reversed.

In Figure 6 I have shown a system in which the deliveries of the metering pumps are simultaneously varied.

The metering pump 28 is shown in section in Figure 7. It comprises an outer shell or casing 47 having inlet and delivery ports 48 and 49, respectively. A rotatable drum or impeller 50 has a series of sliding vanes 51 therein, these vanes being of substantially the width of the casing and being adapted to slide in and out in slots formed in the drum 50, as is well understood by those skilled in the art. The drum 50 has a driving shaft mounted in a bearing concentric with the shell 47. Within the shell 47 there is an eccentric cylinder 52 which has suitable ports for intake and delivery, said cylinder being connected to a regulating lever 53 and being supported in the casing 47 so that angular movement of the lever 53 varies the eccentricity of the drum 50, with respect to the working cylinder 52. By this means the displacement of the pump is controlled. The shaft 57^a of the metering pump 28 is connected to the shaft 54 of the gas metering pump 27. The two shafts in turn are connected through a pair of flexible couplings 55 to the motor shaft of the motor 29. The two metering pumps are simultaneously varied, as to delivery, by means of a common yoke or connecting member 57 which is connected to the arm 53 of the air metering pump 28 and to the arm 56 of the gas metering pump 27. This yoke member 57 is suitably guided to insure the same degree of angular motion of each of said arms so as to control the delivery in unison. The yoke 57 is connected to a lever 58 pivoted to a stationary pivot at 59, the other end of said lever 58 being connected to a valve operating lever arm 60 for controlling the valve 18 of the burner nozzle 15. The housing of the valve 18 has an extension 62 in which is mounted a rock shaft 63, said rock shaft being connected to the lever arm 60 and having a valve operating arm or arms 64 for raising and lowering the valve 18. The levers 60 and 58 are connected by a link 65 so that simultaneously with decrease in the delivery of the air and gas metering pumps the nozzle valve 18 is shifted to decrease the size of the fire in the burner 4.

The arm 60 is adapted to be controlled either by automatic or manual means so as to regulate the amount of heat generated by the burner. I have shown the lever 60 as connected by a link 66 with the diaphragm 67 of an air thermometer 68 which has a tube 69 relatively small bore extending throughout the building or portion of the building to be heated.

Instead of using the valve 18 to regulate the number of nozzle openings which are active in the nozzle 15, I may permit the fire within the mass of refractory 14 to move in and out if so desired. That is to say, the means for controlling the output of the two pumps in unison may be synchronized with the control valve 18 for the nozzle, or may be independent. As shown in Figure 4, I may employ merely a control valve 70 at the burner nozzle 71 for regulating the back pressure according to delivery to maintain substantially constant pressure on the mixer and on the deliveries of the pumps for the purpose of minimizing the variations of intake pressure. In this case the valve 70 controls the port 72 in the bottom of the bowl 12 of the burner, the position of the valve 70 being regulated by a rocker shaft 73, and arm 74 connected through a linkage to the valve stem 75. The rocker shaft 73 may be connected by suitable linkage to the lever 58 which controls the delivery of the metering pumps in any suitable manner. The distributor nozzle 71 may be omitted, the refractory material serving to cause distribution. This is satisfactory only if the delivery velocity is substantially constant. In this form of the burner I have shown the flame arrester, comprising a metal wool 76, as disposed in a pocket over the end of the mixture delivery pipe 23 so that the flame cannot strike back through the pipe 23. The metal wool 76 is introduced through an opening 77 in the bot-

tom of the housing 78, which opening is thereafter closed with a plate or plug.

In the operation of the burner as above described, I preferably employ two controls. One control is the so-called off and on control; namely, a thermostatic control which stops the electric motor 29, when the temperature of the space to be heated attains the desired maximum. Such a system of off and on control requires, in addition, means for igniting the mixture when the burner is to be started.

I have shown in Figure 2 two devices for igniting the mixture, the first of which is the spark plug 80 disposed in the mass of refractory material at a point sufficiently remote from the nozzle 15 that the velocity of the gas may be relatively low so that ignition is easily accomplished and ignition may then strike back towards the burner if desired.

It is highly desirable to ignite the mixture as soon as possible in order that no appreciable amount of combustible mixture escapes above the mass of refractory 14 and I have, therefore, disposed the spark plug 80 within the confines of the mass of refractory material 14 so that ignition of the mixture may occur before the same escapes into the furnace where it might cause a noticeable noise and flash.

The spark plug should not be placed too close to the nozzle 15 since the velocity of the gases at this point is relatively high and ignition is not accomplished with the same degree of certainty as if it is placed further away. However, there is the advantage in placing the spark plug quite close to the nozzle 15 in that the flame then occurs beyond the spark plug tending to keep the spark plug cool and prolonging the life of the same. I consider it broadly new, however, to place the ignition device within the mass of refractory since it performs the useful result of obtaining ignition before the escape of combustible mixture outside of the mass of refractory.

If desired, a gas pilot may be employed to the same purpose, but instead of permitting the flame to be placed within the refractory where it might be blown out by ignition of the combustible mixture, I dispose the pilot burner 81 in a tube projecting through the bowl 12 and having an upper end made preferably of a lava or porcelain tip 82 with perforations formed therethrough for maintaining the lava tip and the mass of refractory about the same in substantially incandescent condition so that the incandescent mass forms the igniting means for the mixture escaping from the nozzle 15. In this manner the ignition is certain and there is a minimum of danger of blowing out the pilot flame.

I find by experiment that it is relatively easy to ignite the gas mixture within the mass of refractory. After the mass has apparently cooled down below any visible incandescence, it will still light the mixture readily. There seems to be a catalytic action promoting ignition.

I provide a thermostat 83 in conjunction with the pilot nozzle 81 to prevent closing of the motor circuits for the motor 29 in the event that the pilot does not maintain the refractory tip 82 hot enough to serve as an igniting device. Thus if the pilot should go out the motor 29 will not start. The pilot burner 81 may be ignited by a suitable hole formed in the side wall of the vertical tube 84.

The system of Figure 1 is, therefore, adapted to off and on control under a suitable thermostatic regulator, such as the well known Minneapolis heat regulator.

In addition to the off and on control I have found that it is possible with the device of my invention to provide a so-called up and down control, that is, controlling the amount of fuel burned in accordance with the temperature requirements. As a matter of fact, either off and on control or up and down control alone may be provided, or the two controls may be conjointly employed.

The up and down control is illustrated in Fig. 6 wherein the delivery output of the metering pumps and the position of the nozzle valve 18 is jointly controlled by the air thermometer 68 so that within limits the temperature of the space to be heated may be maintained by increasing or decreasing the size of the fire in the mass of refractory 14. By the means which I have disclosed the amount of refractory material which is maintained at incandescence is varied in accordance with the amount of delivery of combustible mixture. In this manner the most efficient type of heat transfer is maintained by maintaining a mass of incandescent refractory in the center of the bowl as close to the upper surface as is possible. In this manner the fire remains on as long as is possible and hence the delay of bringing the refractory mass to incandescence is avoided.

We have found that when the pressure does not vary too greatly, it is possible to use fans instead of the positive meters shown. A fan with suitable well known means such as a damper in the suction or discharge is satisfactory for the handling of the air under any conditions.

Where there is a moderate variation in gas pressure, it is possible to use fans for both gas and air, using a device similar to Figure 8, except connected to the discharges of said fans.

For example, I have shown in Fig. 9 a system in which the incoming gas is regulated by a pressure regulator 80 between the supply main 81 and the delivery pipe 82.

The air is delivered to the burner by a fan

or blower 83 which has an inlet opening controlled by a suitable valve or damper 84. This valve or damper 84 is preferably manually controlled, but may be automatically controlled to keep the delivery pressure substantially constant.

The air is delivered by an air delivery pipe 85 terminating in a nozzle structure 86 which consists of a pair of concentric pipes 87 and 88, the inner pipe 87 being a continuation of the air delivery pipe 85 and the space between said pipes being in communication with gas pipe 82. These two pipes terminate substantially coextensively under a refractory cap 89 which is supported over the top of said pipes 80 as to form a small pocket or chamber opening peripherally into the bed of refractory material 14.

The space between pipes 87 and 88 is preferably narrow radially and spiral vanes 90 and 91 directed in opposite directions are preferably disposed in the gas and air passages, respectively. The connection between gas pipe 82 and the outer pipe 88 is preferably made by means of a T, the lower end of which is shut off. In one example the pipe 87 is a standard 1½" pipe and the outer pipe 88 is a standard 2" pipe.

The nozzle structure may be constructed as shown in Figure 10; i. e., the pipe ends are not co-terminal. The outer pipe has a reducer 91 connected thereto and into this short reducer 91 the two pipes 87 and 88 discharge.

The reducer 91 in turn discharges under the cap 89' of refractory material and the mixture escapes from under the edges of the same into the mass of granular refractory, which preferably extends over the top of the cap.

Where a larger size of burner is desired the distribution may be bettered by a concentric distribution of nozzles as shown in Fig. 11. In this case the gas enters the central passageways 92 and flows out the radial passageways or nozzles 93 being discharged into the throats of Venturi shaped mixing passageways 94.

The central passageway is surrounded by an annular chamber or manifold 95 opening into pairs of converging passageways or nozzles 96, 96 lying on opposite sides of radial passageways 93.

These converging nozzles 96 discharge in convergence upon the jet from the radial nozzle 93 within the throats of the Venturi passages 94 which are formed on the rim or edge of the cap 97.

The cap 97 may have throats 94 disposed over its entire surface like a rose nozzle if so desired. In that case the groups of nozzles in the central casting 98 are arranged to register with the same.

It is to be observed that the outer or discharge ends of passageways 94 are notched as indicated at 99 to give the effect of providing an outlet to the refractory granular bed without danger of stopping up the outlet thereof. In this manner the mixture of gas and air is made as close as possible to the point of combustion. Obviously the air and gas connections may be interchanged. Instead of having the two pipes or connections concentric they may lead in parallel into the bed of refractory.

I believe that I am the first to apply surface combustion to the service of house heating where an off and on fire is employed, and I believe that I am the first to place such combustion under thermostatic control for varying the size of the incandescent mass of fuel in proportion to the temperature requirements. I believe that it is broadly new to regulate the lateral extent of the flame in the incandescent mass. I believe also that I am the first to provide positive metering means which renders the delivery of gas and air relatively independent of the pressure of the gas main so that variations in pressure in the gas mains are relatively unimportant. So far as I am aware it is also broadly new to regulate the amount of air input to a pump or fan in accordance with the pressure at the delivery pipe of the gas main.

There are other features of novelty as will be apparent from the appended claims.

I claim:—

1. In combination, a burner comprising a bed of refractory, means for injecting a fast burning mixture of gas and air into said bed of refractory, said means including positively driven metering and injecting means for gas and for air, and means acting upon the mixture to maintain a substantially uniform pressure of the mixture delivered to the burner.

2. In combination, a burner comprising a bed of refractory, means for injecting under pressure a fast burning mixture of gas and air into said bed of refractory, a fixed nozzle projecting into the bed of refractory for introducing the mixture thereinto, and means for simultaneously regulating the delivery of the injecting means and of the nozzle, said regulating means including a member operable within the nozzle.

3. In a burner, a bed of refractory, a fixed nozzle projecting into the bed of refractory for injecting a fast burning mixture into said bed, said nozzle including a plurality of ports, and valve means movable relative to the nozzle for progressively closing said ports.

4. In a burner, a mass of refractory material, means for delivering combustible materials to the central part of the mass at substantially a uniform pressure, and means for increasing the extent of the flame laterally within the mass of combustible material comprising a series of regulable nozzle openings.

5. In combination, a mass of refractory material, a nozzle projecting into said refrac-

tory material, said nozzle having a plurality of ports including ports for delivering a combustible mixture centrally of the mass of material, and ports for delivering combustible mixture laterally of said central portion, and movable means for regulating the delivery of combustible mixture through said ports.

6. In combination, a burner comprising a fixed nozzle having a plurality of vertically spaced ports, vertically movable means for opening and closing some of said ports, and automatic means for controlling the delivery of the mixture to said nozzle and regulating said opening and closing means.

7. In combination, a burner of the surface combustion type, a nozzle for the burner, a valve adjacent the nozzle for controlling the nozzle, metering pumps for gas and air for delivering a mixture of gas and air to said nozzle, and means for regulating the output of said metering pumps.

8. In combination, a burner of the surface combustion type, a nozzle for the burner, a valve for controlling the nozzle, metering pumps for gas and air for delivering a mixture of gas and air to said nozzle, means for regulating the output of said metering pumps, and common means for controlling said nozzle valve and said delivery regulating means.

9. In combination, a mass of refractory material, a nozzle for injecting a combustible mixture thereinto, and ignition means disposed within the mass of refractory material, said means comprising a pilot burner disposed without said mass and a second refractory mass within the first mentioned refractory mass and maintained at incandescence by said pilot burner.

10. In combination, a burner comprising a bed of refractory material having passages extending therethrough for free flow of a combustible mixture throughout the mass of material, and means for injecting a combustible mixture into the refractory bed and for regulating the zone of injection of such mixture in such manner as to vary the area of the mass heated by the combustion of the mixture in accordance with variations in the amount of combustible mixture injected into the mass.

11. In combination, a burner comprising a mass of refractory material having passages extending therethrough for free flow of a combustible mixture throughout the mass, and means for injecting a combustible mixture into the mass and for raising and lowering the zone of injection of such mixture in accordance with variation in the amount of combustible mixture injected into the mass.

12. In combination, a burner comprising a mass of refractory material having passages extending therethrough for free flow of a combustible mixture throughout the mass and means for injecting a combustible mixture upwardly into the mass and for raising and lowering the zone of injection of the mixture in accordance with decrease and increase in the amount of combustible mixture injected into the mass.

13. In a burner, in combination, a mass of refractory material, a nozzle projecting into the mass for injecting a combustible mixture thereinto, a tube projecting into the mass of refractory, and a pilot burner housed within the tube and acting to maintain the same at a sufficiently high temperature to ignite the combustible mixture injected into the refractory mass.

14. In a burner, in combination, a mass of refractory material, a nozzle projecting into the mass for injecting a combustible mixture thereinto, a tube projecting upwardly into the mass and provided at its upper end with a perforated refractory tip, and a pilot burner housed within the lower portion of the tube and disposed below said mass of refractory.

In witness whereof, I hereunto subscribe my name this 11th day of January, 1927.

ASHUR U. WETHERBEE.