Nov. 4, 1952 F. C. MOCK 2,616,257
COMBUSTION CHAMBER WITH AIR INLET MEANS PROVIDING A PLURALITY
OF CONCENTRIC STRATA OF VARYING VELOCITIES
Filed Jan. 9, 1946 2 SHEETS--SHEET 1

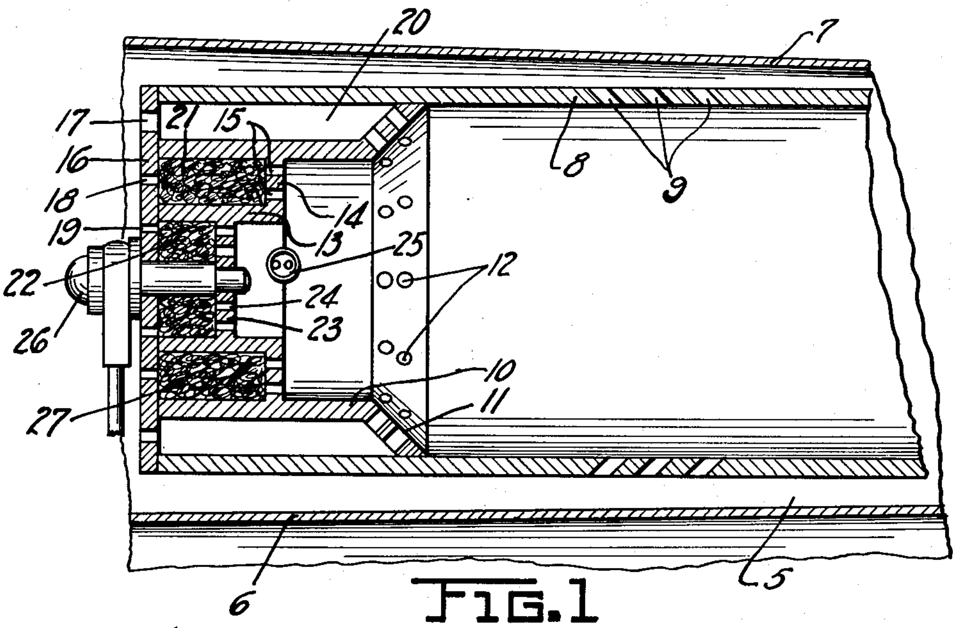

FIG. 1

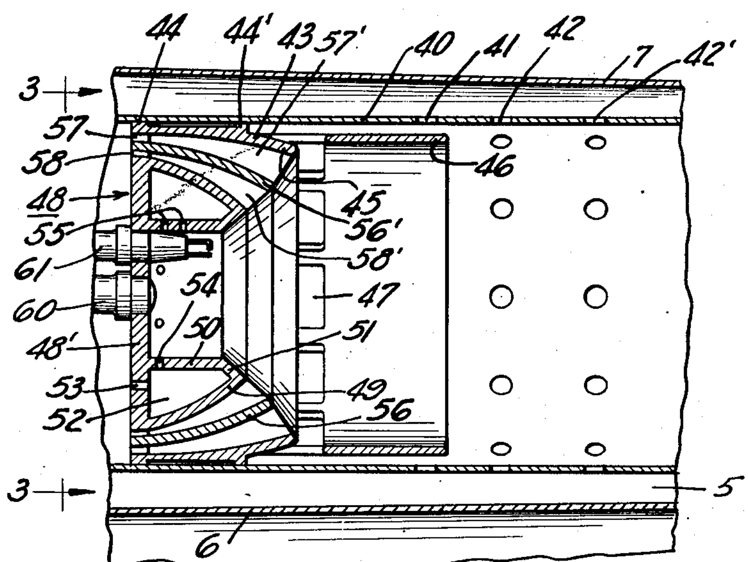

FIG. 2

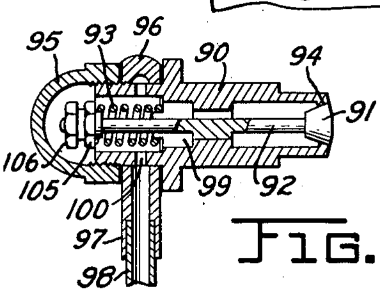

FIG. 6

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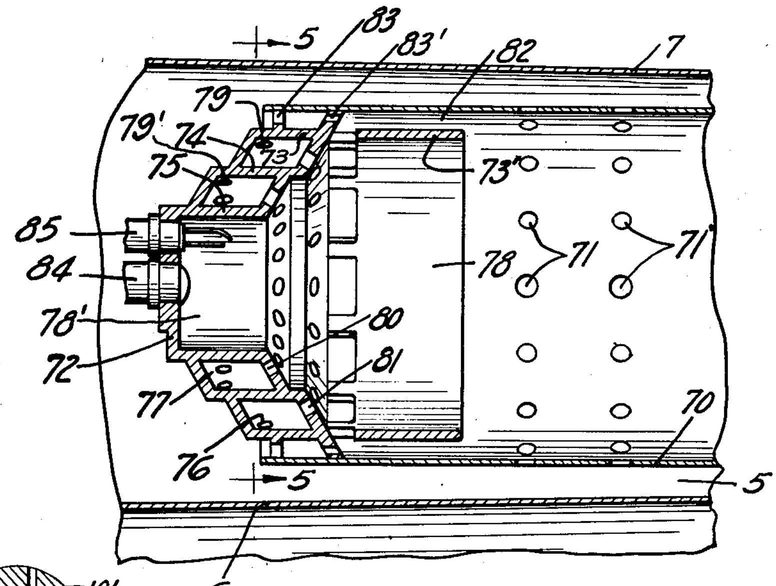

FIG.4

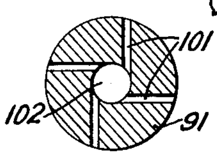

FIG.8

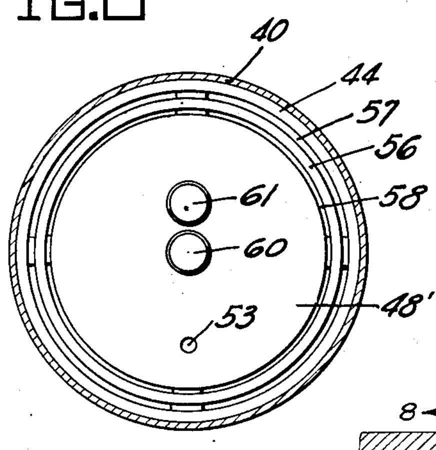

FIG.3

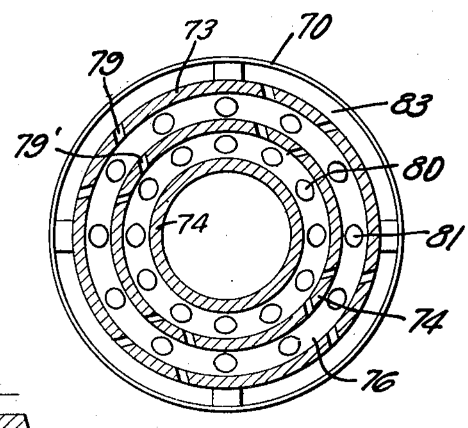

FIG.5

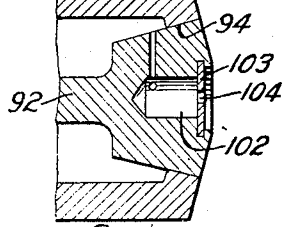

FIG.7

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COMBUSTION CHAMBER WITH AIR INLET MEANS PROVIDING A PLURALITY OF CONCENTRIC STRATA OF VARYING VELOCITIES

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Application January 9, 1946, Serial No. 640,018

7 Claims. (Cl. 60—39.65)

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The present invention relates to burners, and particularly to burners wherein a fuel, either gaseous, liquid or powdered solid fuel, is injected into and burned in a moving column of air. Such burners are particularly adapted for use in aircraft power plants or engines of the gas turbine and/or jet propulsion types wherein compressed air is supplied to a chamber constituting part of the burner, at which point it is heated by the combustion of fuel and the expanded air and products of combustion discharge through a gas turbine for driving an air compressor and/or a propeller, after which the gases may be discharged through a reaction tube to propel the aircraft or to assist the propeller in propelling the aircraft.

This application contains subject matter divided out of my co-pending application Ser. No. 557,812 filed October 9, 1944, now Patent No. 2,581,275 plus modifications thereof, and hence may be considered as a continuation-in-part of Ser. No. 557,812.

A burner of the aforesaid type is ofttimes subjected to conditions which render it extremely difficult to maintain stable operation of the burner, or to obtain proper flame propagation and an effective fuel/air ratio over the wide range of air flows to which the burner is subjected. Thus, flow of fuel to the burner may at times be suddenly reduced to reduce engine speed, resulting in a low flame at the burner nozzle while at the same time the momentum of the engine may momentarily produce a high air flow tending to blow out the flame. Again, it is desirable that the burner ignite or start quickly and easily under all conditions of air flow, both at the start of a flight and during flight of an aircraft. If there is delay in igniting the burner during the initial starting operation, excess fuel accumulates in both the burner tube and adjacent chambers, and then when the engine does start, there is an intense flame and heat produced while the accumulated fuel is burning which tends to burn and warp parts in the immediate region of the flame. Another factor is so-called "detonation" or "blow-out" which may be a cause of burner failure, particularly at high engine powers. One source of this trouble, especially in tubular burners, is the tendency of the burner to become unstable and reverberate somewhat like an organ pipe of similar dimensions; and sometimes these reverberations build up to an intensity such that the burner flame goes out altogether or the burner fails. In the burner herein disclosed, a separate "resonator"

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chamber is provided at the breech end of the burner tube in communication with the main burner chamber and having a resonance frequency tending to neutralize or dampen out the reverberations of the main burner chamber or tube.

An object of the invention is to provide a burner or generator of the type specified which will admit air under pressure into the burner chamber, and particularly the breech portion thereof in a manner such as to render the burner flame stable under widely varying conditions of air flow to the burner.

Another and more specific object is to provide a burner or generator for heating and expanding air flowing thereto under pressure having calibrated air-inlet means which directs the air into the breech portion of the burner chamber in a plurality of concentric masses or strata of varying velocities with the mass of lowest velocity in the immediate region of the burner nozzle.

Another object is to provide means in a burner whereby carbon formation on the fuel-delivery nozzle or nozzles as well as on the spark plugs or analogous ignition means is reduced to a minimum.

Another object is to provide an improved burner or generator unit particularly adapted for power plants of the gas turbine an/or jet propulsion types, and wherein burner failure due to the foregoing and other causes is reduced to a minimum.

A further object is to improve and render more efficient burners or heat generators.

The foregoing and other objects and advantages will become apparent in view of the following description taken in conjunction with the drawings, wherein:

Figure 1 is a substantially central longitudinal sectional view of a burner embodying the features of the invention;

Figure 2 is a similar view of a modification in structure;

Figure 3 is an end view of Figure 2 taken as indicated by the section line 3—3;

Figure 4 is a substantially central longitudinal section of a further modification in structure;

Figure 5 is a section taken on the line 5—5, Figure 4.

Figure 6 is a central longitudinal section of a spray nozzle adapted for use with the burners illustrated in the preceding figures;

Figure 7 is an enlarged section of the end portion of the nozzle of Figure 6; and

Figure 8 is a section taken on the line 8—8 of Figure 7.

Burners of the type disclosed herein when used as part of a jet engine or a gas turbine for aircraft power plants are usually mounted in annular formation in an annular air chamber 5 defined by inner and outer annular casings 6 and 7, air being supplied under pressure to the chamber 5 in a direction from left to right as viewed in Figure 1 by suitable means such as a rotary compressor, not shown, driven by a turbine, also not shown, having blades subjected to the dynamic action of heated and expanded air and products of combustion generated in the burner.

The burner of Figure 1 is similar to that disclosed in my copending application above noted; it consists of an outer cylindrical shell or wall 8 provided with a plurality of air inlet ports 9, to which air is supplied under pressure through the chamber 5. Within the breech portion of the outer shell 8 is another shorter cylinder or annulus 10 having an outwardly tapered or inclined baffle wall 11 provided with a series of calibrated air inlet orifices 12. Within the annulus 10 is a third, still shorter cylinder or annulus 13 provided with an end baffle wall 14 also formed with a series of air inlet orifices 15. The air impact or breech end of the burner is provided with a baffle wall 16 formed with a series of annularly-arranged air-inlet orifices 17, 18 and 19, which are preferably of progressively decreasing area or flow capacity as they approach the center of the said wall 16, said orifices 17, 18 and 19 opening into velocity-reducing chambers 20, 21 and 22 defined by the stepped cylinders 10 and 13 and a central baffle wall 23 formed with calibrated air inlet orifices 24. An ignitor 25, which may be of the electric sparking type supplied with current from a suitable source, not shown, is projected into the burner cylinder adjacent the tip of a burner nozzle 26.

To more effectively obtain this velocity-reducing action, the aggregate area of orifices 12 is greater than the aggregate area of orifices 17, the aggregate area of orifices 15 is greater than the aggregate area of orifices 18, and the aggregate area of orifices 24 is greater than the aggregate area of orifices 19.

A combustion chamber constructed in this manner coacts with the fuel feeding system which supplies fuel to the chamber through the burner nozzle to insure localized fuel/air proportioning and flame propagation throughout periods of low fuel feeds and permits low fuel feeds at low air flows or low power conditions, and also at high air flows as on engine deceleration, without burner failure. Purely by way of example, it may be desired to meter to the burner nozzle 1.2 pounds of fuel per hour at minimum air flows or low power conditions and up to 26.3 pounds of fuel per hour at maximum air flows or full power conditions. A spray of 1.2 pounds per hour will produce a rather sensitive flame which can be quickly snuffed out by the sudden injection of air above a certain velocity, or by an oversupply of air within the region of the flame. By suitably calibrating the air inlet and baffle orifices, the velocity of the air flowing into the combustion chamber may be adjusted with respect to a plurality of combustion zones to insure proper or efficient flame propagation at all air flows or power conditions. Thus the velocity within the central burner zone in the immediate region of the nozzle 26 may be held within a relatively low range, for example, of from 9 to 30 feet per second, the velocity within the intermediate zone from 18 to 60 feet per second, and within the outer zone from 27 to 90 feet per second. The total inlet capacity of all the openings which determine the respective zones should be such as to give the proper amount of air at full power conditions for efficient combustion with, for example, 6 pounds of fuel per hour. The air flowing through the ports 9 may be moving at a velocity of say 36 to 120 feet or more per second.

In order to more effectively diffuse the air as it passes into the burner chamber, suitable baffle material such as steel wool or the like, indicated at 27, may be disposed in the chambers 21 and 22, and also in the outer chamber 20 if desired.

Figures 2 and 3 illustrate a burner of modified construction with respect to Figure 1, the burner being illustrated as one of any number of similar burners mounted within the chamber 5 defined by the annular concentric walls 6 and 7 in the same manner as in Figure 1. The burner of Figures 2 and 3 comprises an outer shell 40 formed with a series of high velocity air inlet holes 41, 42 and 42′ outwardly from the breech portion thereof. Within the outer shell 40 is mounted a breech assembly comprising an outer, generally cylindrical member 43 formed with circumferential rings or bosses 44 and 44′ by means of which it may be suitably secured to the shell 40 as by welding or in any other suitable manner. An annular inwardly or convergingly curved wall 45 forms an extension of the member 43, and another substantially straight cylindrical wall 46 extends forwardly from the wall 45 and is connected thereto by web portions or openwork structure defining openings 47.

The cylindrical wall 46 soon becomes heated to a high temperature after the burner starts, since it lies in the low flame area, and thereafter it furnishes a hot vaporizing surface against which spray from the nozzle 60 impinges. Among other advantages, this reduces the tendency toward collection of unburnt fuel in the breech area at low fuel delivery pressures and subsequent explosion and dangerously high heat conditions when the fuel delivery is increased. The openings 47 facilitate access of hot gases to the exterior surface of the wall 46.

An inner breech unit, generally indicated at 48, is provided and comprises an end wall 48′ from the periphery of which a converging or radially-inwardly curved wall 49 projects and is joined at its inner edge to a straight cylindrical wall 50 by means of a wall 51. The walls 49, 50, 51 and adjacent part of the wall 48′ form the boundary of a chamber 52; and the end wall 48′ is formed with a plurality of calibrated air-inlet openings 53 for admitting controlled quantities of air to the chamber 52, and from this chamber air may pass into the nozzle area of the breech chamber at a reduced velocity through calibrated holes 54 and 55, the aggregate area of holes 54 and 55 being greater than the aggregate area of the holes 53.

Between the outer cylindrical member 43 and the inner unit 48 is an annulus 56 having a forwardly-projecting axially-converging wall 56′ which lies between the similarly curved walls 45 and 49. The walls 45, 56′ and 49 define a plurality of annular air-inlet slots 57 and 58 which feed air to passages 57′ and 58′ of gradually increasing cross-sectional area in order to produce an expansion effect and diffuse and reduce the velocity of the air passing into the breech chamber immediately forwardly of the burner nozzle.

The end wall 48' supports a spray nozzle 60 and a spark plug or other suitable ignition device 61.

Air under pressure moving in a direction from left to right as viewed in Figure 2 is directed into the outer chamber 5 and passes beyond the breech portion of the burner to the holes 41, 42, 42' and is fed into the burner chamber at this point at a relatively high velocity of say 215 feet per second; and at the same time air is fed into the annular slots 57, 58 and passes into the breech portion of the burner through the expanding chambers 57' and 58' which tend to reduce the velocity of and diffuse the air as it enters the breech chamber. Thus the velocity of the air entering through the outer passage 57' might be forty feet per second, while the air entering through the inner pasage might have a velocity of fifteen feet per second. The inlet slots 57, 58 and the chambers 57', 58' may be calibrated to provide the required amount of air at predetermined velocities to obtain the most efficient combustion and flame propagation within the breech area of the burner chamber without danger of blowing out the flame at the burner nozzle during low fuel feeds and high air flows.

The holes 53 admit air into the chamber 52 from which it passes at a reduced velocity through the calibrated holes 54 and 55 and is projected onto the tip of nozzle 60 and also on the exposed outer surface of the spark plug 61. This controlled supply of air tends to reduce carbon formation by furnishing sufficient oxygen to this region for admixture with the fine mist of oil, usually present in this area, to support combustion, or burn the oil without permitting it to cake on the surfaces of the nozzle and the plug.

Any convenient method of manufacture of the burner parts may be adopted. For example, the outer shell 40 may be of heat resistant sheet metal, refractory material or the like, while the outer and inner units 43 and 48 may be in the form of castings and the intermediate unit 56 of sheet metal, the parts being joined or bridged by connecting bosses and welded or otherwise secured together to form a complete assembly. Obviously other materials or methods of fabrication may be used.

Figures 4 and 5 illustrate a further modification in burner structure for carrying out the objects of the present invention. The burner as shown in Figures 4 and 5 is mounted in a chamber 5 similar to the burners of Figures 1 and 2; it comprises an outer shell 70 formed with a series of holes 71, 71' outwardly from the breech portion of the burner, for admitting high-velocity air into the burner along the length thereof. The breech portion of the burner comprises a unit having an end wall 72, which as shown is of radially outwardly stepped construction, and projecting forwardly from the end wall are a series of concentric cylindrical walls 73, 74 and 75 which define a plurality of chambers 76 and 77, a main breech chamber 78 and a supplemental breech chamber 78'. A wall 73' surrounds the breech chamber forwardly of the nozzle, to provide a vaporizing surface in a manner similar to the wall 46 of Fig. 2. The outer face walls of the chambers 76 and 77 are supplied with air through a plurality of openings 79 and 79', preferably arranged tangentially in order to produce a baffle effect by causing the air to pass into the chambers 76 and 77 to be "broken up" or have its velocity reduced by circulation and friction loss in said chambers. This obviates the need for steel wool or other packing material as illustrated in Figure 1, although steel wool or like material may be used if desired. From the chambers 76 and 77 air may pass into the breech chamber 78 through holes 80 and 81. Between the outer shell 70 and the concentric cylinder 73 is a chamber 82 which is supplied with air through annular slots 83 and holes 83'.

The end wall 72 may be bored or cast with holes or suitable openings to receive a spray nozzle 84 and a spark plug 85.

Air at high velocity entering the chamber 5 from left to right as viewed in Figure 4 is directed into the holes 71 and 71' at for example 215 feet per second. Air also impacts the end breech wall 72 and is fed through the tangential holes 79 and 79' into the chambers 76 and 77 which action reduces the velocity of the air in the manner heretofore explained, and from these chambers the air is fed into the breech chamber 78 at a somewhat further reduced velocity through the annular series of holes 80 and 81. Thus, for example, the air entering the breech chamber through the holes 80 may be at a velocity of forty feet per second; while the air entering the breech chamber through the holes 81 may be at a velocity of fifteen feet per second. The whirling motion imparted to the air entering chambers 76 and 77 also tends to distribute the air equally throughout the area of the said chambers before passing into the breech chamber 78. If desired, additional holes may be formed in the wall 75 to direct air against the tip of the nozzle 84 and the spark plug 85 and furnish sufficient oxygen to support combustion in the immediate region of the nozzle tip and the spark plug and thereby reduce the tendency toward carbon formation on these parts.

While any suitable type of fuel spray nozzle 26, 60 or 84 may be used, it is preferred to use a nozzle which will operate to discharge a cone-shaped spray of fuel when the latter is under low pressures in the area of lowest velocity of the incoming air, and as the fuel delivery pressure increases, the fuel spray cone will progressively lengthen and intersect the respective masses or strata of incoming air. A nozzle suitable for use with burners of the type herein disclosed is shown in Figures 6, 7 and 8.

The nozzle illustrated in Figures 6, 7 and 8 consists of a flanged body 90 having therein a spray head 91 provided with a stem 92 encircled by a spring 93 which urges the head to seated position with the flared tip or end portion thereof engaging in the similarly-contoured main discharge orifice or jet 94. A cap 95 is threaded on the rear extremity of the body 90, and between this cap and the body flange is a fitting 96 having a tubular portion 97 to which a fuel supply tube 98 is connected. Fuel passes into nozzle chamber 99 through ports 100; and at low pressures flows through small bores 101 formed in the spray head, note Figure 7, at a tangent to a central cavity or recess 102 having therein a member 103 provided with a small low-pressure discharge orifice 104. The seating tension of spring 93 is adjustable by means of thrust nut 105 and lock nut 106. The tangential arrangement of the bores 101 causes the spray to swirl as it leaves the low pressure orifice at an angle determined by the relative areas of bores or passages 101 and 104.

The tension of spring 93 may be adjusted to a point where at predetermined low pressure the spray head 91 remains seated and discharge is by way of small bores 101 and low pressure discharge orifice 104, but as pressure builds up, discharge is principally through the high pressure discharge orifice 94 with a certain additional discharge through orifice 104, the spray issuing at high pressures in a cone-shaped fog, the spray cone angle being determined by the angle of the cone-shaped head 91. Thus at low fuel pressures when the air is likewise at its lowest pressure, the velocity of the fuel is stepped-up by the small bores 101 and small jet 104, while at higher pressures, the outer cone-shaped discharge orifice takes over, producing a well-diffused spray in all directions. The adjustability of the spray head permits accurate synchronization of an entire set of burner nozzles.

As heretofore noted, burners of the type with which the present invention is primarily concerned are subject to a building up of reverberations, particularly at high air flows and rich fuel air ratios, which may reach an intensity such as to cause the burner flame to become extremely unstable and finally fail entirely; it is characterized by an irregular exhaust sound accompanied by an irregular flame length and a strong odor of unburnt fuel. In the burner disclosed herein, any or all of the breech chambers 20, 21 and 22 of Figure 1, 52 of Figure 2, or 76 and 77 of Figure 4, may have an individual resonance frequency which is variable in direct relation to the volume of the resonance chamber and the area of its air-inlet and discharge ports, and since these chambers have a resonance frequency different from that of the main burner chamber or tube at a given air flow and fuel feed, their resonance frequencies tend to neutralize or dampen out the reverberations of the main burner chamber. Such resonance chamber, while preferably having air-inlet and discharge ports, need only have the latter ports, or need only be in communication with the breech or main burner chamber to function as a reverberation dampener.

It will be understood that the drawings are simply illustrative, and that certain changes in construction, design and arrangement of the respective parts fall within the scope of the invention as defined by the appended claims.

I claim:

1. In a generator for heating and expanding air flowing thereto under pressure, an outer shell defining an elongated combustion chamber provided with a fuel-discharge nozzle at one end thereof, an end wall mounting said nozzle and having a series of calibrated air-inlet orifices of varying flow capacity arranged in generally annular formation with the orifices of lowest flow capacity located centrally of said wall and the remaining orifices progressively increasing in capacity as they approach the periphery of the wall, a plurality of spaced annuli projecting forwardly from said end wall to provide flow passages for the air admitted through said orifices and at their inner ends terminating in spaced stepped relation with the shortest annulus surrounding said nozzle, and baffles coacting with said annuli and adapted to reduce the velocity of the air flowing into the combustion chamber in the region of the nozzle through said calibrated air-inlet orifices.

2. In a generator for heating and expanding air flowing thereto under pressure, an outer shell defining an elongated generally cylindrical combustion chamber provided with an end wall mounting a fuel-discharge nozzle, said end wall being provided with a series of calibrated air-inlet orifices of varying area or flow capacity with the orifices of lowest flow capacity surrounding the nozzle and the remaining orifices progressively increasing in area as they approach the periphery of the wall, a plurality of substantially cylindrical walls projecting from said end wall and arranged in spaced substantially concentric formation and at their inner ends terminating in stepped relation with the shortest annulus surrounding the nozzle, said annuli separating the inlet or breech end of the combustion chamber into a plurality of sub-chambers which tend to equalize the air flowing in through said air-inlet orifices, and baffle means coacting with said latter chambers constructed and arranged to direct the air into the combustion chamber in masses of reduced and varying velocities with the mass of lowest velocity in the immediate lee of the nozzle.

3. In a generator or burner for heating and expanding air flowing thereto under pressure, an outer shell defining a combustion chamber having a breech portion at one extremity thereof, a breech unit at the air-inlet end of said breech portion provided with an end wall formed with a plurality of radially spaced air-inlet openings, a series of radially-inwardly converging substantially cylindrical radially-spaced walls projecting forwardly from said openings and defining a plurality of air passages of gradually increasing cross-sectional area adapted to direct air into the breech portion of the combustion chamber, said passages receiving air from said inlet openings and producing an expansion effect on the air as it flows therethrough to reduce the velocity thereof and diffuse the air as it passes into the said breech portion.

4. In a generator or burner for heating and expanding air flowing thereto under pressure, an outer substantially cylindrical shell defining a combustion chamber having an air inlet or breech portion at one extremity thereof, a breech unit at the air inlet end of said chamber made up of a series of outer substantially concentric cylinders and a central member having an end wall mounting a fuel spray nozzle, said outer cylinders having their rear edges lying in the plane of said end wall and arranged in radially-spaced relation to provide air-inlet openings, the walls of said cylinders projecting forwardly from said openings in axially converging formation and in progressively-increasing radially-spaced relation to define air inlet passages tending to expand the air entering the breech portion of the combustion chamber and reduce the velocity thereof, said central member having forwardly-projecting walls defining a chamber surrounding said nozzle, said end wall having openings for admitting air to said latter chamber at a reduced pressure, and means for admitting a controlled quantity of air from said latter chamber into the breech portion of the combustion chamber in the immediate region of said nozzle to reduce carbon formation thereon by furnishing sufficient oxygen to support combustion in said region.

5. In a generator or burner for heating and expanding air flowing thereto under pressure, an outer substantially cylindrical shell defining a main combustion chamber having a breech portion at the air-inlet extremity thereof, a breech unit for controlling the supply of air to said chamber including an outer substantially cylin-

drical wall projecting forwardly in radially-inwardly-curved formation into said breech portion, another substantially similarly shaped cylindrical wall arranged concentrically within said first-named cylindrical wall, said walls projecting forwardly in progressively radially-spaced relation to define a series of air-inlet passages of gradually increasing cross-sectional area which tend to expand the air and reduce the velocity thereof as it flows into the breech portion of the combustion chamber.

6. In a generator or burner for heating and expanding air flowing thereto under pressure, an outer shell defining a main combustion chamber having a breech portion at one extremity thereof, an end wall overlying the air-inlet end of said breech portion, a fuel spray nozzle located in said breech portion, a plurality of radially-spaced walls projecting forwardly from said end wall into said breech portion and defining a plurality of air chambers therebetween in restricted communication with said breech portion, a series of tangentially-disposed air-inlet passages for admitting air to said air chambers in a manner such as to produce a baffle effect on the air and at the same time facilitate distribution of the air in said latter chambers.

7. In a generator or burner for heating and expanding air flowing thereto under pressure, an outer substantially cylindrical shell defining a main combustion chamber having a breech portion at one extremity thereof, a breech unit mounted in the air inlet end of said shell and comprising an end wall lying in a plane generally normal to the axis of said combustion chamber and a plurality of substantially cylindrical radially-spaced walls projecting forwardly from said end wall into said breech portion, said cylindrical walls defining a plurality of air chambers surrounding said breech portion and in restricted flow communication therewith, said end wall being provided with a series of tangentially-disposed air-inlet holes for communicating air to said air chambers and at the same time produce a baffle effect on the air and facilitate distribution thereof in said latter chambers, said shell being formed with a series of air inlet openings forwardly of said breech portion.

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