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[54] **COMBUSTION APPARATUS**

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[52] **U.S. Cl.** **431/329,** 431/347, 431/353, 431/208, 431/210, 431/243

[51] **Int. Cl.** **F23d 13/14**

[58] **Field of Search** 431/208, 210, 211, 243, 431/328, 329, 346, 347, 353

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[57] **ABSTRACT**

Combustion apparatus having a combustion plate separating the mixing chamber from the combustion chamber, and a plurality of flow obstacles disposed above some of the flame holes of the combustion plate whereby a mixture of vaporized fuel and combustion air passed through the combustion plate is ignited, the collision of the mixture with the flow obstacles resulting in turbulent flow flame patterns. In addition, a wire net is disposed between the combustion plate and the flow obstacles for further dividing the gas mixture into fine segments, which in conjunction with the flow obstacles, results in stable combustion.

4 Claims, 5 Drawing Figures

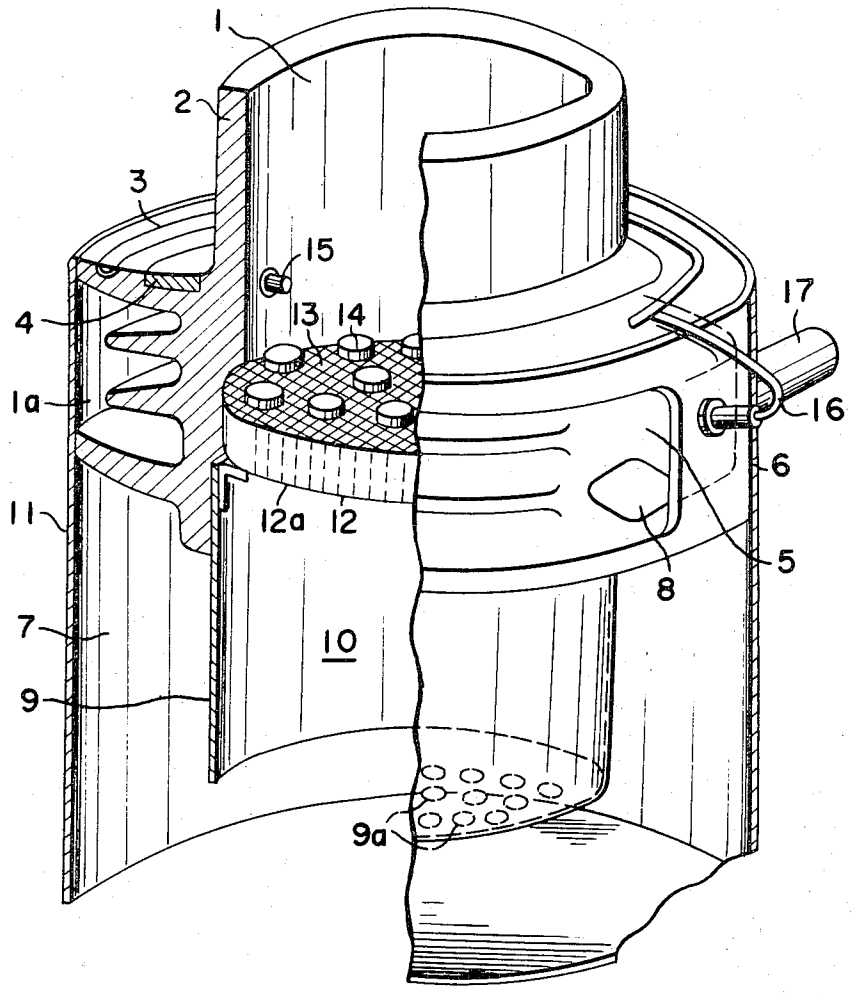


FIG. 1

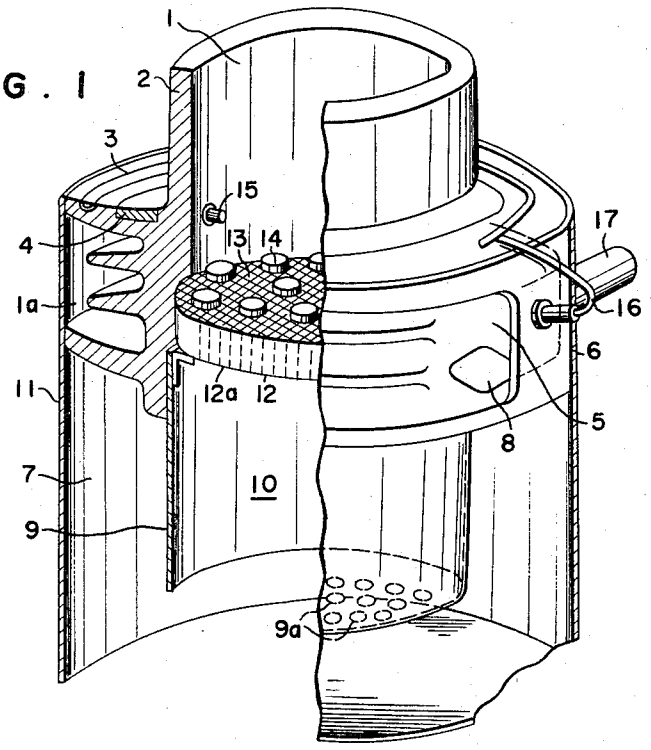


FIG. 2

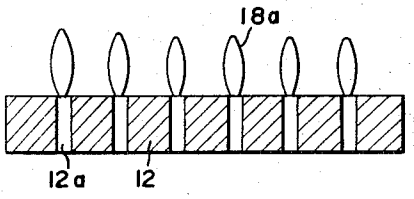


FIG. 3

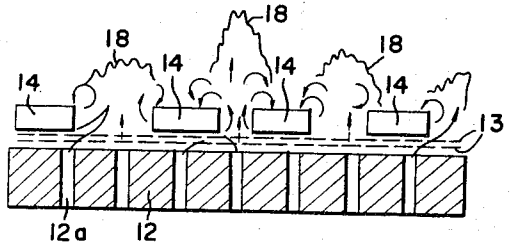


FIG. 4

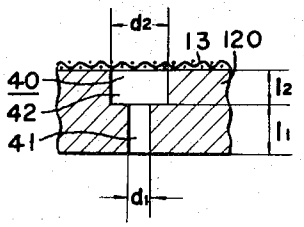
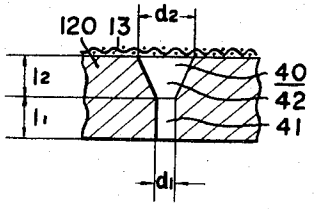


FIG. 5



COMBUSTION APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to combustion apparatus and more particularly to an improved combustion apparatus for burning a mixture of vaporized fuel and combustion air.

2. Description of the Prior Art

When formulating a design for a combustion apparatus burner, it is necessary to consider those characteristics which will affect flame blow-out, back fire, the formation of soot, and the generation of combustion noise. In combustion, the formation of soot increases as the supply of primary air decreases. Similarly, flame blow-out and back-fire are dependent upon a proper ratio of primary air to fuel at the flame holes of the burner, as well as the velocity of the mixture of fuel and air. When for example, the ratio of primary air to fuel is one, if the velocity of the mixture at the flame holes is high, flame blow-out is easily caused, while if the velocity of the mixture at the flame holes is low, back fire is easily caused. The higher the ratio of primary air to fuel, the narrower the range of the velocity of the mixture within which both flame-out and back-fire will not occur. A conventional burner, such as, for example, a Bunsen burner, wherein the primary air and the secondary air are separately used as sources of combustion air, is of complicated structure. Similarly, the red flame type burner causes a great deal of soot. Accordingly, in order to simplify the structure and prevent the formation of soot, various burners were considered which utilized, as combustion air, the primary air and an excess of primary air which was more than the theoretically useable combustion air. Consequently, such conventional burners has the disadvantage in that they decreased the stability for flame blow-out or back fire, while large conventional burners had the added disadvantage of combustion noise.

Furthermore, in the conventional apparatus in which the combustion conditions are obtained by a complete premixing process, the range of stable combustion is quite narrow, so that a fluctuation in shape of the flame could be easily caused, thus resulting in the creation of a back fire, a low frequency sound, or a flame blow out phenomenon which was the result of, a change in the output resistance of an apparatus connected to the combustion apparatus, such as, for example, a heat-exchanger, or a change in the excess air coefficient of the combustion air depending upon the temperature of the environment. Heretofore, in order to overcome the aforementioned disadvantages and to stabilize the flame, it has been proposed to finely divide the flame holes of the combustion plate and to control the combustion air by an air shutter. In said cases, however, the shape of the flame has been a lamina flow flame **18***a*, as shown in FIG. **2**. Accordingly, it has been hard to obtain a complete stable combustion because of changes in the air density caused by a change in the environmental temperature and a consequent effect upon the resistance at the output side.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an improved combustion apparatus which will overcome the disadvantages noted heretofore.

Another object of the present invention is to provide an improved combustion apparatus which will provide easy control of the mixture velocity as well as the combustion reaction velocity.

Still another object of the present invention is to provide an improved combustion apparatus which will maintain stable combustion without the formation of soot, flame blow-out, or back-fire.

The foregoing objectives are achieved according to this invention through the provision of a combustion plate disposed between a combustion chamber and a mixture chamber, the plate having a plurality of flame holes over which are disposed a plurality of flow obstacles, the number of obstacles being less than the number of holes, thereby covering some and not others. Disposed between the holes and the obstacles is a wire net which finely divides the mixture prior to ignition. Issuance of the mixture through the holes causes collision with the obstacles, resulting in turbulent flame flow patterns upon ignition. The cross-sectional configuration of the flame holes may vary, such aiding in the attainment of stable combustion.

BRIEF DESCRIPTION OF THE DRAWINGS

Various other objects, features and attendant advantages of the present invention will be more fully appreciated as the same becomes better understood from the following detailed description when considered in connection with the accompanying drawings, in which like reference characters designate like or corresponding parts throughout the several views, and wherein:

FIG. **1** is a partial sectional view of one embodiment of a combustion apparatus constructed according to this invention;

FIG. **2** is a schematic view of the shape of the flames formed by conventional apparatus;

FIG. **3** is a schematic view of the improved shape of the flames by the combustion apparatus constructed according to this invention; and

FIGS. **4** and **5** are sectional views of the combustion plate for the combustion apparatus constructed according to this invention, showing two embodiments of flame holes.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, and more particularly to FIG. **1**, thereof, the combustion apparatus comprises an axially located combustion chamber **1** for burning a gas mixture of vaporized fuel and combustion air, and a peripherally located heating chamber **1***a*, partially surrounding combustion chamber **1**, for heating the combustion air which is supplied to the combustion chamber **1**. A cylindrical wall portion **2** of the combustion chamber **1** has heat accumulation properties while a vaporizing tube **3**, for vaporizing the liquid fuel by means of the accumulated heat, and a heater **4**, for providing heat to the wall portion **2** at the initiation of the operation, are located in an upper, radially extending wall portion of combustion chamber **1**. A mixing compartment **5**, for mixing the vaporized fuel, sprayed from a spray nozzle **6**, and the combustion air, passed through the combustion air heating chamber **1***a*, is connected to a substantially annular gas mixture passage **7** via an inlet port **8**. An axially located cylinder **9** forms a gas mixture collector **10** below the combustion chamber **1**, a plurality of flow regulating holes **9***a* being pro-

vided within the bottom wall portion of cylinder **9** for connecting the gas mixture passage **7** to the gas mixture collector **10.** The mixing chamber thus comprises the mixing compartment **5,** the gas mixture passage **7,** and the gas mixture collector **10.**

An outer cylindrical housing **11** separates, in conjunction with the radially extending wall portion of combustion chamber **1,** the combustion air heating chamber **1***a* from the gas mixture passage **7.** Furthermore, an axially located combustion plate **12,** having a plurality of cylindrical flame holes **12***a*, separates the gas mixture collector **10** from the combustion chamber **1.** A wire net **13** is provided above the combustion plate **12,** while a plurality of discrete, three dimensional type of flow obstacles **14,** being of a number less than that of the flame holes **12***a*, are mounted upon the wire net **13,** so as to be respectively disposed above only some, but not all, of the flame holes **12***a*, the burner for combustion thus comprising the combustion plate **12,** the wire net **13** and the flow obstacles **14.** A radially extending spark plug **15** is provided within the wall of combustion chamber **1,** while an inlet pipe **16** supplies the vaporized fuel from the vaporizing tube **3** to the spray nozzle **6** which leads into the mixing compartment **5.** An inlet pipe **17** similarly supplies combustion air from a blower, not shown in the drawings, to the heating chamber **1***a*.

The operation of the combustion apparatus will now be described. During a specific time before the initiation of combustion, the heater **4,** an oil pump, now shown in the drawing, and the air blower also not shown in the drawing, are operated so that the wall **2** of the combustion chamber **1** may accumulate heat by means of heater **4.** Vaporizer tube **3** is likewise heated, and when liquid fuel is supplied to the vaporizing tube **3** by the oil pump, such is vaporized by the accumulated heat.

Similarly, combustion air is supplied by means of the inlet **17** to the combustion air heating chamber **1***a*, the air then being mixed within compartment **5** with the vaporized fuel sprayed from the spray nozzle **6** to result in the gas mixture. The gas mixture is subsequently passed through the inlet **8** to the gas mixture passage **7** for consequent passage through the flow regulating holes **9***a* to the gas mixture collector **10.** The gas mixture is then divided at the flame holes **12***a*, of the combustion plate **12,** and the wire net **13,** the mixture then being ignited by the spark plug **15** to initiate the combustion within the combustion chamber **1.**

Referring now to FIG. **3,** it will be noted that a part of the gas mixture passing through the flame holes **12***a* of the combustion plate **12** collides with the flow obstacles **14** whereby a plurality of turbulent flow flame patterns **18** are formed. It has been confirmed that stable combustion can be attained with the combustion apparatus of the present invention even though the ratio, of excess air supplied to the theoretical supplied amount of the combustion air, is 1.0, whereas the air excess ratio of conventional apparatus was 1.4. In operation, the gas mixture collides with the flow obstacles **14** so as to produce a negative pressure area around the flow obstacles **14,** whereby the results are turbulent flow conditions around the flow obstacles **14,** the flame, by chemical reaction, as shown by the arrows, and the concentration of the ions, is increased and the velocity of flow passing through the flame holes **12***a*, as well as the combustion reaction velocity, are controlled.

Referring now to FIGS. **4** and **5,** there is shown, respectively, other burner embodiments constructed according to this invention. The flame holes **40** of the combustion plate **120** consist of first flame hole passages **41** and second flame hole passages **42.** The first flame hole passages **41** are respectively opened to the rear or lower surface of the combustion plate **120** and each one of the first flame hole passages has a depth of l_1 and an inner diameter of d_1. The second flame hole passages **42** are respectively opened to the front or upper surface of the combustion plate **120** and each one of the second flame hole passages has a depth of l_2 and an inner diameter of d_2, the diameter d_2 being equal to depth l_2 and wherein the diameter d_2 of the embodiment of FIG. **4** is constant, whereas, in that embodiment of FIG. **5,** d_2 is the maximum diameter of passage **42,** the passage being frusto-conical and therefore tapering downward from diameter d_2 to diameter d_1 of passage **41.**

Still referring to FIGS. **4** and **5,** the gas mixture is injected through the first flame hole passages **41** and the second passages **42** whereby they then collide with the wire net **13** which finely divides the gas mixture so that fine flames providing a lower noise of combustion are formed within the area downstream of the wire net **13.** When such burners are used, the limit of back fire is dependent upon the inner diameter d_1 of the first flame hole passage **41.** However, the limit of flame blow-out can be increased, by the effect of the wire net **13,** in addition to the limit defined by the inner diameters d_1 and d_2 of the first and second flame hole passages, **41** and **42,** respectively.

The second flame hole passages **42** can be used as an expansion area for the flow of the gas mixture injected from the first flame hole passages **41.** In the structures shown in FIGS. **4** and **5,** when $d_2 > 1.5\ d_1$, the flash back region of the gas mixture having the theoretical mixing rate, can be decreased, to be about one-third. Similarly, when $l_1 \geqq 2\ d_1$, the unstable combustion, caused by a change in pressure within the ignition area, can be avoided so that highly stable combustion can be attained. It has also been confirmed that the effect of the wire net can be high when the mesh of the wire net is higher than **10.**

It will be noted that in the above embodiments, the cross-section of the flame holes **40** of the combustion plate **120** is circular in shape. However, it is not necessary that they be of circular cross-section, and when they are not the inner diameters d_1 and d_2 can be considered to be equivalent to the corresponding linear dimensions.

Obviously many modifications and variations of the present invention are possible in light of the above teachings. It is to be understood therefore, that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

What is claimed as new and desired to be secured by letters patent of the United States is:

1. Combustion apparatus comprising:

a mixing chamber for mixing combustion air and vaporized fuel;

a combustion chamber for burning said mixture of combustion air and vaporized fuel;

a combustion plate, having a plurality of substantially evenly spaced flame holes, disposed between said mixing chamber and said combustion chamber;

a wire net supported on said combustion plate on the combustion chamber side thereof; and

a plurality of discrete flow obstacles having a lower substantially planar surface, being less in number than the number of said flame holes, and substantially evenly spaced apart in a given plane so as to be disposed above only some of said flame holes of said combustion plate to thereby deflect the flow of said gas mixture which passes through said combustion plate from the flame holes obstructed by said flow obstacles substantially laterally into the flow of said gas mixture from flame holes which are unobstructed by said flow obstacles.

2. Combustion apparatus comprising:

a mixing chamber for mixing combustion air and vaporized fuels;

a combustion chamber for burning said mixture of combustion air and vaporized fuel;

a combustion plate having a plurality of flame holes disposed between said mixing chamber and said combustion chamber; and

a plurality of discrete flow obstacles disposed above only some of said flame holes of said combustion plate whereby said gas mixture which passes through said combustion plate from flame holes obstructed by said flow obstacles collides with said flow obstacles to be deflected substantially laterally into the flow of said gas mixture from said flame holes which are unobstructed by said flow obstacles,

wherein said flame holes comprise a first flame hole passage, open to the rear surface of said combustion plate, having a depth l_1 and a diameter d_1, and a second flame hole passage, connected to said first flame hole passage, have a depth l_2 and a diameter d_2 at the front surface of said combustion plate, wherein d_2 is substantially equal to l_2, $d_2 > 1.5d_1$, and $l_1 = 2d_1$.

3. Combustion apparatus as set forth in claim **2,** wherein said wire net has a mesh greater than **10.**

4. Combustion apparatus comprising:

a mixing chamber for mixing combustion air and vaporized fuel;

a combustion chamber for burning said mixture of combustion air and vaporized fuel;

a combustion plate, having a plurality of flame holes, disposed between said mixing chamber and said combustion chamber, wherein said flame holes comprise a first flame hole passage, open to the rear surface of said combustion plate, having a depth l_1 and a diameter d_1, and a second flame hole passage, connected to said first flame hole passage, having a depth l_2 and a diameter d_2 at the front surface of said combustion plate, wherein d_2 is substantially equal to l_2, $d_2 > 1.5\ d_1$, and $l_1 \cong 2d_1$; and

a wire net disposed above said combustion plate, said net having a mesh greater than **10.**

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