Oct. 17, 1944. L. F. CONWAY 2,360,548

COMBUSTION METHOD

Original Filed Dec. 27, 1940 2 Sheets-Sheet 1

Fig. 1.

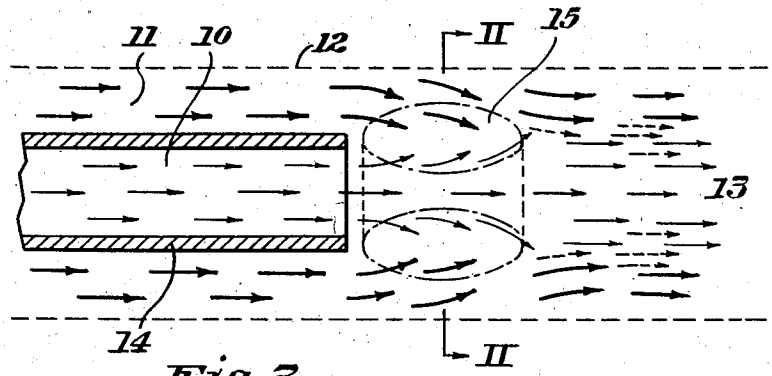


Fig. 3.

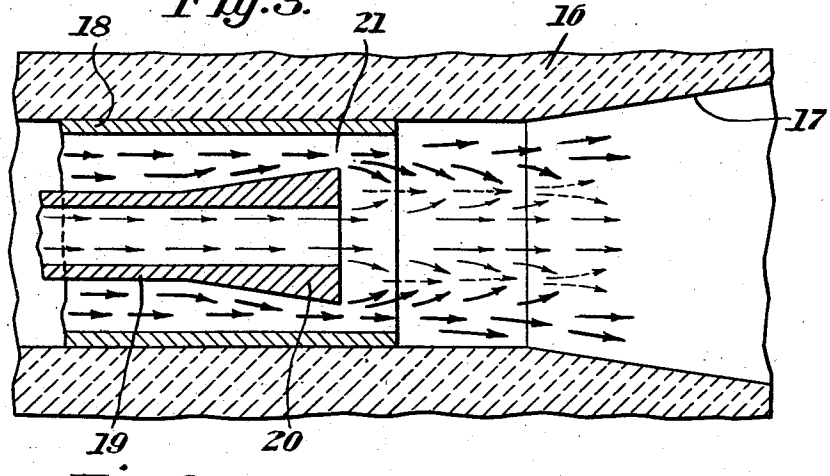


Fig. 2.

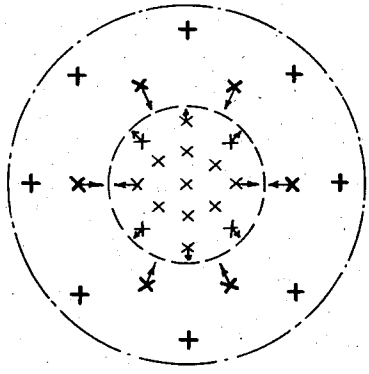
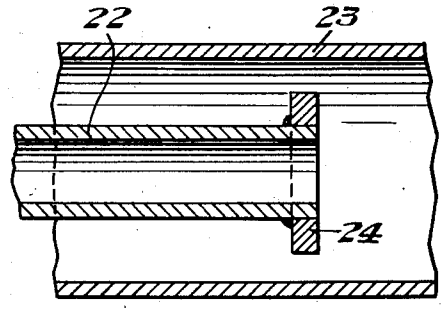


Fig. 4.



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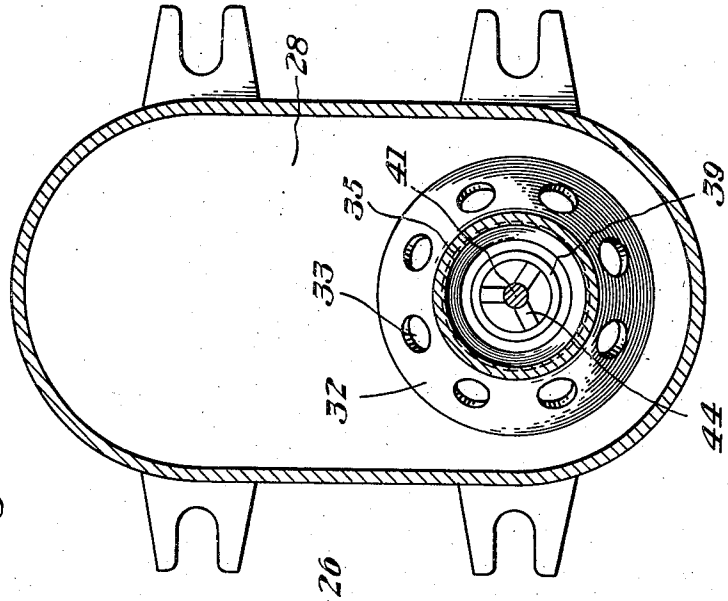


Fig. 6.

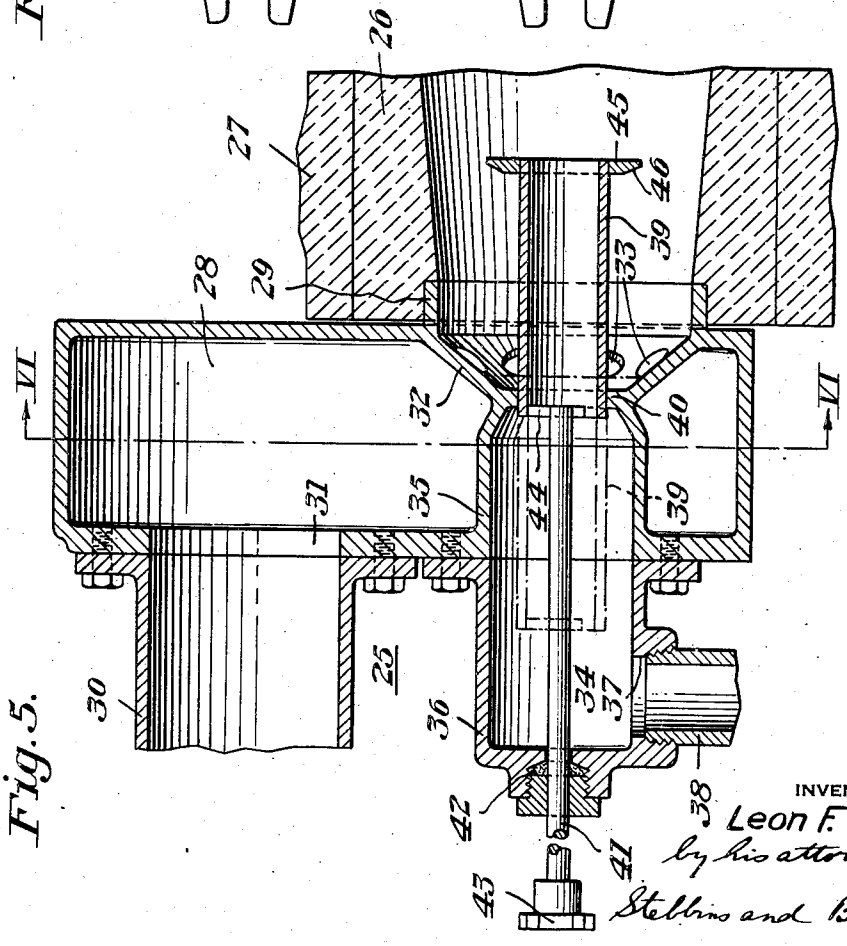


Fig. 5.

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UNITED STATES PATENT OFFICE

2,360,548

COMBUSTION METHOD

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Original application December 27, 1940, Serial No. 371,862. Divided and this application February 5, 1942, Serial No. 429,643

4 Claims. (Cl. 158—117.5)

This invention relates to the combustion of fluid fuel, and, particularly, to a method for producing the combustion of hydrocarbon gas such as natural gas with a luminous flame.

This is a division from my application Serial No. 371,862 filed December 27, 1940, for Combustion apparatus and method.

Luminous-flame burners have been known heretofore but have been characterized by a limited thermal capacity compared to burners producing a non-luminous or clear flame. It is generally accepted that the production of a luminous flame necessitates cracking of the carbon from hydrocarbon fuel by a slow burning process so that the heat generated by the combustion which occurs initially cracks at least a portion of the remaining hydrocarbon fuel producing hydrogen and atomic carbon which thereafter burns slowly. This form of combustion has heretofore been generally obtained by introducing gas and air streams along parallel lines at equal low velocities so that they mix slowly over the area of contact of the two streams and combustion starts in that area. Known types of luminous-flame burners, however, have been limited in their application to large furnaces in which the amount of heat liberated per cubic foot of furnace volume is relatively low, i. e., less than 35,000 B. t. u. per hour.

I have invented a novel method and apparatus for the combustion of hydrocarbon fuel with a luminous flame, adaptable to furnaces requiring a heat input in excess of the figure above mentioned, e. g., up to 70,000 B. t. u. per hour per cubic foot of combustion space. In a preferred practice of the invention, I discharge a fuel jet substantially centrally of an annular air stream and impart only sufficient turbulence to the adjacent layers of fuel and air near the plane of their initial contact to cause rapid mixing of such layers without materially affecting the central core of the fuel stream or the outer layers of the air stream. The air is introduced at a velocity higher than that of the gas and the condition of turbulence at the zone of initial contact may conveniently be obtained by creating a low-pressure or partial-vacuum condition in said zone. The rapid mixing of the adjacent layers of fuel and air creates an annular column of combustion gases, the heat from which cracks the remaining fuel, releasing the carbon to produce a luminous flame. The cracked fuel and the remaining air are then mixed gradually on continued flow and combustion spreads quickly over the entire section of the stream of air and fuel mixture.

The apparatus for producing combustion according to my method may take various forms and is claimed in my copending application identified above. In its simplest form, the apparatus may comprise a fuel tube having a wall thickness such that an annular stream of air flowing past the end thereof creates a partial-vacuum condition adjacent the end. This causes the outer layer of fuel to be pulled outwardly and the inner layer of air to be drawn inwardly, without materially affecting the remaining portions of the fuel and air streams. In another form, the fuel tube may have a thickened end portion tapering rearwardly to increase the velocity of the air as it sweeps around the end of the fuel tube. In a further form, an annular baffle is mounted on the fuel tube adjacent the discharge end.

Further novel features and advantages of the invention will become apparent during the following detailed description of the apparatus and method briefly outlined above, with reference to the accompanying drawings illustrating the method diagrammatically and showing a preferred embodiment of the apparatus and certain modifications. In the drawings,

Figure 1 is a diagrammatic view illustrating the flow of fuel and air which I produce in order to obtain combustion with a luminous flame of high thermal capacity, and the simplest form of apparatus for achieving this mode of operation;

Figure 2 is a diagrammatic sectional view taken substantially along the plane of line II—II of Figure 1;

Figure 3 is a partial central longitudinal sectional view taken through a burner operating according to the method of my invention showing another form of apparatus;

Figure 4 is a similar view showing a further modification;

Figure 5 is a central vertical longitudinal section through a complete burner embodying the principles of my invention; and

Figure 6 is a transverse sectional view taken substantially along the plane of line VI—VI of Figure 5.

Referring now in detail to the drawings and, for the present, to Figures 1 and 2, I have there illustrated a stream of hydrocarbon fuel 10 being discharged substantially centrally of an annular air stream 11. Throughout the drawings the light arrows indicate fuel and the heavy arrows air.

The air stream 11 may be conceived of as flowing along any suitable duct or passage indicated at 12, e. g., through the wall of a furnace,

toward a combustion space therein indicated generally at 13. The fuel stream 10 flows through a nozzle or supply tube 14. I maintain a pressure on the air supply such that the velocity of the air as it sweeps around the end of the tube 14 is somewhat greater than the velocity of the fuel flowing through the tube 14. As illustrated, the radial thickness of the air stream is only slightly less than the diameter of the fuel stream. In other words, the fuel stream has a diameter less than one-half the outside diameter of the air stream.

The tube 14 has a wall thickness such that a condition of partial vacuum or low pressure is created in an annular zone 15 adjacent the end of the tube. This condition of low pressure causes the outer layer of the fuel stream to be pulled outwardly and the inner layer of the air stream to be drawn inwardly, as indicated by the arrows in Figure 1, without materially affecting the central core of the fuel stream or the outer layers of the air stream. This condition is also illustrated in Figure 2 where I have adopted the conventional symbol, i. e., a cross, indicating the tail of an ongoing arrow to indicate flow toward and through the plane of the paper. As clearly shown in Figure 2, the heads of the arrows in the outer layer of the fuel stream 10 are deflected outwardly, and the heads of the inner arrows of the air stream are deflected inwardly.

The above described diversion of portions of the fuel and air streams results in rapid mixing of these portions in the zone 15 adjacent the point of initial contact, i. e., the end of the tube 14. This partial mixture of the fuel and air causes combustion to be initiated in an annular column, as indicated by the dotted arrows, commencing close to the zone 15, assuming previous ignition of the ongoing stream of fuel and air at a point somewhere in the combustion space 13. The exact point at which combustion begins depends, of course, on the relative proportions of fuel and air, the velocity of the two streams and other conditions with which those skilled in the art are well acquainted. This initial combustion furnishes sufficient heat to crack the fuel in the central core of the stream 10, releasing carbon which imparts a high degree of luminosity to the flame. Thereafter, the remainder of the fuel becomes mixed with the remainder of the air and combustion spreads inwardly and outwardly from the aforesaid annular column until it is substantially continuous over the entire section of the ongoing stream of mixed fuel and air, or throughout the combustion space 13.

Referring now to Figure 3 showing an embodiment of the invention as applied to a furnace burner, a port block 16 has a flaring throat 17 opening into a combustion chamber which may be the interior of a furnace or other space to be heated. An air pipe or duct 18 extends into the opening through the port block from the exterior thereof and is connected by any suitable means to a convenient source of air under appropriate pressure. A fuel tube or nozzle 19 extends through the air pipe 16 substantially centrally thereof and is connected to a suitable source of hydrocarbon fuel. The wall of the tube 19 is thickened adjacent the discharge end as indicated at 20 and decreases in thickness away from the extreme end rearwardly thereof. This construction provides an annular Venturi throat 21 which increases the velocity of the air flowing through the pipe 18 as it passes the extreme end of the tube 19.

The thickened end 20 of the tube 19 produces an even more marked condition of low pressure or partial vacuum at the point of initial contact between the air and fuel than the fuel tube 14 of Figure 1. An even more rapid mixing of the inner layer of air and the outer layer of fuel is thereby effected with the initiation of combustion in an annular column as illustrated by the dotted arrows. It will be evident that the apparatus shown in Figure 3 operates on precisely the same principle as explained with reference to Figures 1 and 2, the only difference being that already pointed out.

Figure 4 illustrates a further modification in which a fuel tube 22 extends coaxially into an air pipe or duct 23. The fuel tube 22 and air pipe 23 are associated with a port block such as that shown at 16 in the same manner as the air pipe 18 and fuel tube 19, although the port block is not shown in Figure 4. An annular baffle 24 is secured to the fuel tube 22 adjacent the end thereof. This baffle, as will be readily understood, creates considerable turbulence in the inner layers of the air stream flowing through the pipe 23. As a matter of fact, the turbulence results from a partial-vacuum or low-pressure condition just beyond the baffle. It is evident, therefore, that the structure shown in Figure 4 will be effective to produce combustion according to my method which has already been fully explained with reference to Figures 1 and 2.

Referring now more particularly to Figures 5 and 6, I have there shown a complete burner indicated generally at 25 associated with a port block 26 which may be assumed to form part of a furnace wall 27. The burner 25 comprises generally an air chamber 28 having a flange 29 on one side thereof projecting into the port formed in the block 26. An air-supply pipe 30 communicates with the chamber 28 through an opening 31 in the rear wall thereof. A frusto-conical wall 32 extends inwardly into the chamber 28 from the flange 29 and is provided with holes 33 uniformly distributed circumferentially thereof. It will be apparent that this construction, when air is supplied through the pipe 30, will deliver air to the port block in uniformly distributed condition.

A fuel chamber 34 is formed by an annular wall 35 extending inwardly from the rear of the air chamber to the frusto-conical wall 32 and a cup shaped casting 36 secured to the rear wall of the air chamber. The casting 36 has a hole 37 therein tapped to receive a fuel pipe 38. A fuel tube 39 is slidable through an opening in a wall 40 extending inwardly from the annular wall 35 and the frusto-conical wall 32. An adjusting rod 41 extends through the rear wall of the casting 36 having a gland 42 therein. The outer end of the rod has a knob 43 thereon while the inner end is secured to a spider 44 in the inner end of the tube 39. The tube 39 is provided with an annular baffle 45 secured thereto adjacent the discharge end thereof. The rear outer edge of the baffle is beveled as at 46.

With the fuel tube 39 in the position illustrated in solid lines it will be apparent that air supplied to the chamber 28 through the pipe 30 will flow into the port in the block 26 through the holes 33 and be distributed uniformly over the annular area of the section of the port between the tube 39 and the block. Fuel supplied through the pipe 38 flows into the chamber 34 and the tube 39 and is thereby introduced centrally of the annular air stream. The baffle 45 creates the condition

of turbulence in the inner lays of the air stream caused by the partial vacuum or low pressure condition beyond the baffle which results in partial mixing of the fuel and air adjacent their point of initial contact in the manner already explained. This initial combustion cracks at least a portion of the remaining fuel and thereby imparts a high degree of luminosity to the flame. The remainder of the fuel and air become rapidly mixed and combustion proceeds to completion.

If combustion with a clear non-luminous flame is desired, it is only necessary to pull back on the knob 43. When the tube 39 and baffle 45 are in the positions indicated in chain lines, the baffle does not affect the flow of the air stream. Instead of an annular stream of air coaxial with the port in the block 26, the holes 33 create a plurality of air jets directed inwardly into a central fuel stream issuing from the tube 39. The angularity of the air jets relative to the fuel stream causes immediate mixture of all the gas and air so that rapid combustion with a clear flame ensues.

It will be apparent from the foregoing description and explanation that the invention is characterized by numerous advantages over combustion methods known heretofore. In the first place, the burner of my invention permits the production of a luminous flame with higher fuel and air velocities than have been possible heretofore whereby I am able to obtain a greater heat input per minute per cubic foot of combustion space. This is possible because I effect quick mixing of a portion of the fuel and air for combustion to effect the cracking of the remainder of the fuel. This is accomplished by producing the turbulence which results from the low-pressure or partial-vacuum condition created adjacent the point of initial contact between the fuel and air. After the initial combustion and cracking, the remaining fuel and air mix rapidly because the turbulence at the point of initial contact carries over into the latter stages of combustion, so that combustion proceeds to completion with a highly luminous flame. By the method and apparatus disclosed, it is possible to obtain a heat liberation per cubic foot of combustion space of about 70,000 B. t. u. per hour which is comparable to that obtained with conventional non-luminous burners.

Although I have illustrated and described but a preferred practice and certain variations of the method of my invention it will be understood that changes may be made in the procedure disclosed without departing from the spirit of the invention or the scope of the appended claims.

I claim:

1. In a method of producing a luminous flame, the steps including supplying an annular air stream in which the air is substantially uniformly distributed over the sectional area of the stream, discharging a gaseous fuel jet substantially centrally of the air stream, at a velocity lower than that of the latter, and generally parallel thereto, creating a partial vacuum around the zone of contact between fuel and air at the point where they initially come in contact, and thereby producing turbulence in the adjacent layers only of fuel and air and causing rapid partial mixing thereof so that combustion of the mixed portions of fuel and air, on ignition thereof, furnishes sufficient heat to crack the remaining fuel and produce a luminous flame on complete combustion thereof.

2. In a method of producing a luminous flame, the steps including supplying a stream of air under pressure supplying a jet of gaseous hydrocarbon fuel adjacent the center of the stream of air, deflecting the inner layer of the air stream outwardly adjacent the point of initial contact thereof with the fuel, to produce turbulence in only the adjacent layers of fuel and air and cause rapid mixing of said layers only thereof adjacent said point, whereby ignition of the mixed fuel and air results in partial combustion and release of carbon, followed by complete combustion with a luminous flame on gradual mixture of the remainder of the fuel with the remainder of the air.

3. In a method of producing a luminous flame, the steps including supplying a stream of air under pressure supplying a jet of gaseous hydrocarbon fuel adjacent the center of the stream of air, accelerating the air stream adjacent the point of initial contact thereof with the fuel, producing turbulence of the contacting layers only of air and fuel adjacent said point, thereby causing rapid mixing thereof so that ignition of said mixed fuel and air results in partial combustion and release of carbon, followed by complete combustion with a luminous flame on gradual mixture of the remainder of the fuel with the remainder of the air.

4. In a method of producing a luminous flame, the steps including supplying an air stream, delivering a jet of gaseous fuel substantially centrally of the air stream but at a velocity lower than that of the air stream, imparting turbulence to the adjacent layers only of fuel and air at their point of initial contact and thereby effecting rapid partial mixing thereof so that combustion of the mixed portions of fuel and air, on ignition thereof, provides sufficient heat to crack the remaining fuel and produce a luminous flame on complete combustion thereof.

LEON F. CONWAY.