April 8, 1952 L. E. BERGGREN ET AL 2,592,110

OFFICE TYPE FLAME HOLDER CONSTRUCTION

Filed May 21, 1949

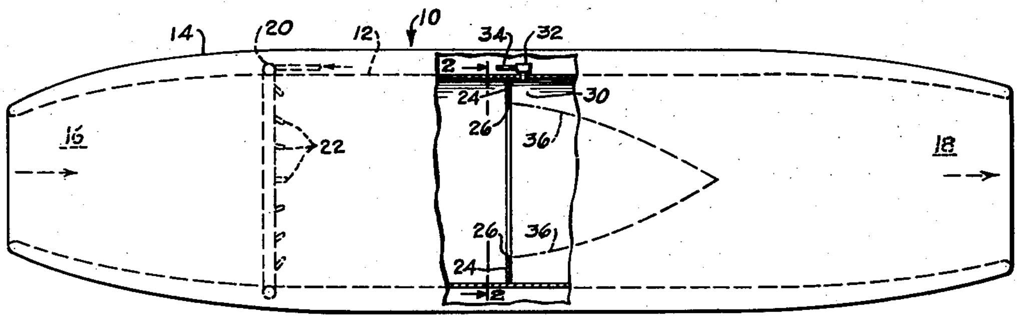

Fig_1

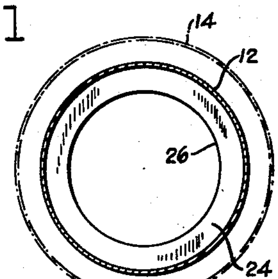

Fig_2

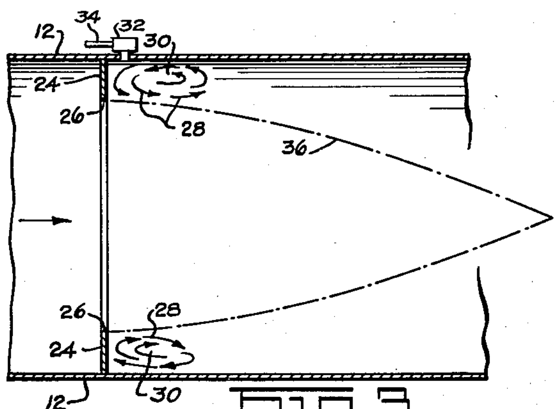

Fig_3

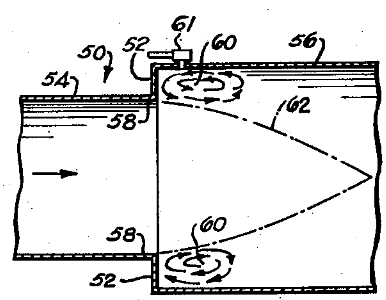

Fig_4

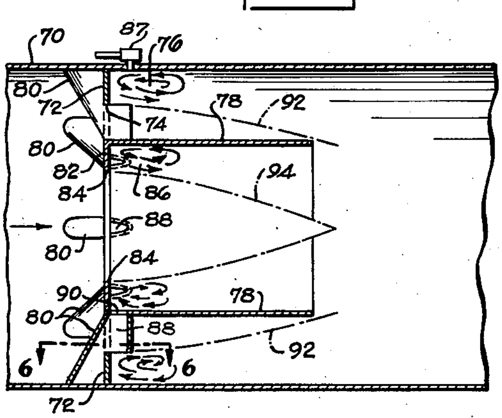

Fig_5

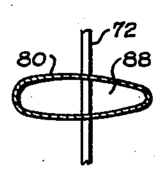

Fig_6

INVENTORS
LLOYD E. BERGGREN.
ALAN A. KURTIS.
BY *Victor D. Behn*

ATTORNEY

Patented Apr. 8, 1952 2,592,110

UNITED STATES PATENT OFFICE

2,592,110

ORIFICE TYPE FLAME HOLDER CONSTRUCTION

Lloyd E. Berggren, Verona, N. J., and Alan A. Kurtis, New York, N. Y., assignors to Curtiss-Wright Corporation, a corporation of Delaware

Application May 21, 1949, Serial No. 94,575

2 Claims. (Cl. 60—39.65)

1

This invention relates to means for stabilizing or holding a flame and is particularly directed to flame holding or stabilizing means for jet engines.

If the velocity of the combustion gases through a combustion chamber is greater than the flame speed the flame will blow out. In jet engines, combustion takes place in a chamber in which the velocity of the gases is quite large. For example, in the combustion chamber of a gas turbine engine, the velocity range of the combustion gases in said chamber is approximately 60 to 120 feet per second. In a ram jet engine this velocity range is approximately 100 to 350 feet per second while in an after burner construction in the exhaust duct of a gas turbine this velocity range may be as high as 350 to 550 feet per second. Accordingly in jet engines some means must be provided for stabilizing and holding the combustion flame in a desired location within the engine.

If a non-streamlined object or other obstruction is placed in a duct through which a stream of combustible gas is flowing, eddies or vortices are formed in the gas stream on the downstream side of the object. A flame initiated in this eddy region may become stabilized in said region even though the velocity of the main stream of the gases is greater than the flame speed. A flame stabilized in this eddy region will act as a continuous igniter for the main stream of unburned gases. The combustion chamber or chambers of jet engines are generally provided with non-streamlined object type flame holders of various configurations in which a non-streamlined object is disposed in the flow path of the combustible mixture, so that said mixture flows between at least two opposite sides of said object and the adjacent walls of the combustion chamber. The eddies behind a non-streamlined object so disposed are not very stable in position and they may even continually blow away and reform again behind said object. As a result, the position and shape of a flame held by such a flame holder may fluctuate considerably. This instability of the flame results in inefficient combustion. In addition with such a non-streamlined object flame holder, the flame front diverges, in a downstream direction, from the sides of the flame holder to the walls of the duct. At the duct walls the gas velocity generally is relatively low and if sufficiently low the flame front will flash back upstream along said walls thereby adding to the instability of the flame.

An object of the invention comprises the provision of a simple and improved flame holder structure for a combustion chamber whereby combustion is smooth and stable over a wide velocity range of flow through the combustion chamber. The flame holder structure of the invention comprises a member having an orifice disposed across the flow path of the combustion mixture for flow of said mixture through said orifice, said orifice member forming an internal annular flange on a tubular member extending downstream from said orifice member. This tubular member may form part of the wall of the combustion chamber or it may be disposed within the combustion chamber in the directon of the gas flow through said chamber. With this arrangement, the orifice member or internal flange on said tubular member forms a non-streamlined object in the stream of the combustible mixture and the tubular member forms a sheltered region behind said orifice member or flange in which said mixture will eddy. Thus, said tubular member provides a fixed surface behind said orifice member or flange against which the combustion mixture eddies thereby stabilizing the eddying in this region. In addition, with this flame holder construction the flame front converges, in a downstream direction, from the inner periphery of the orifice member. An igniter is provided for initially igniting the mixture in said sheltered eddy region whereupon the burning gases in said region act as a continuous source of ignition for the stream of the unburned gases flowing through said orifice.

2

Other objects of the invention will become apparent upon reading the annexed detailed description in connection with the drawing, in which:

Figure 1 is a diagrammatic view of a ram jet engine embodying the invention;

Figure 2 is a sectional view taken along line 2—2 of Figure 1;

Figure 3 is an enlarged view of a portion of Figure 1;

Figure 4 is an axial sectional view of a modified form of the invention;

Figure 5 is an axial sectional view of a further modification of the invention; and

Figure 6 is a sectional view taken along lines 6—6 of Figure 5.

Referring first to Figures 1 to 3 of the drawing, a ram jet engine is schematically indicated at 10 and comprises an open-ended duct 12 disposed within an outer casing 14. The duct 12 has a forwardly directed air entrance opening 16 and a rearwardly directed discharge opening

18. Fuel is introduced into the duct 12 from a manifold 20 and a plurality of fuel nozzles 22 for forming a combustible mixture within said duct 12. This much of the structure of the ram jet engine is conventional.

A flame holder structure is disposed a sufficient distance downstream of the fuel nozzles 22 to permit the formation of a substantially uniform combustible mixture in the duct 12 prior to combustion therein. This flame holder structure comprises a flat plate-like member 24 secured to the wall of the duct 12 and extending inwardly therefrom. This plate-like member has an opening 26 therethrough comprising an orifice within the duct 12. Thus the plate-like or orifice member 24 in effect constitutes an internal flange on the tubular wall of the duct 12, said flange extending around the entire periphery of said wall. The orifice 26 is symmetrically disposed within the duct 12 for flow of the combustible mixture through said orifice.

With this flame holder structure, as best seen in Figure 3 eddies 28 are formed in the sheltered region 30 downstream of the flange or orifice member 24 and against the adjacent downstream surface of the tubular wall of the duct 12. This adjacent fixed surface of the tubular wall of the duct 12 stabilizes eddying of the combustible mixture in the region 30. Means are provided for initially igniting the combustible mixture in the sheltered eddying region 30. As illustrated, a pilot burner 32 is supplied with fuel from a conduit 34, said pilot burner being disposed so that it can ignite the eddying combustible mixture in the region 30 behind the flange or orifice member 24. This pilot burner 32 is equipped with its own igniter (not shown) such as a spark plug. If desired, however, a spark plug may be used for directly igniting the combustible mixture in the eddying region 30.

Upon ignition, the region 30 becomes filled with burning and eddying combustion gases which continually ignite the unburned combustible mixture flowing through the orifice 26 thereby forming a stable combustion flame which has a substantially conical front, as approximately indicated by the dot-and-dash line 36. Accordingly combustion is confined to the area downstream of the flange or orifice member 24 and the dot-and-dash line 36.

The cross-sectional area of the orifice 26 is not particularly critical. This orifice should, however, be as large as possible so as not to unnecessarily restrict the flow of gases through the duct 12. If the orifice is made too large, however, the sheltered region 30 becomes too small and the flame will blow out. In the case of the duct 12 having a 6″ internal diameter, an orifice 26 having a diameter between 4½″ and 5¼″ has been found to provide a satisfactory flame holder. In general the cross-sectional area of the orifice should at least be equal to one-half the cross-sectional area of the duct immediately downstream of said orifice.

The orifice member 24 has been described as a flat plate-like member with an opening therethrough to form an orifice within the duct 12. This is the preferred construction because the orifice member then has a simple construction which is easy to fabricate. Obviously, however, said orifice member need not be flat.

The primary purpose of the plate-like orifice member 24 is to provide the sheltered region 30 on its downstream side. Obviously, such a sheltered region may also be formed by providing a step in the diameter of the duct. Such an arrangement is illustrated in Figure 4 in which a duct 50 may constitute part of the duct of a ram jet engine. Air enters the duct 50 at its left end, Figure 4, and fuel is discharged therein, as in Figure 1, to form a combustible mixture within said duct. The duct 50 has a step 52 in its cross-sectional area forming a portion 54 of relatively small cross-section area and a portion 56 of relatively large cross-section area downstream from said small cross-section area portion. The discharge end of the small cross-section area portion 54 constitutes an orifice 58 through which the combustible mixture discharges into the large diameter discharge portion 56. With this construction the combustible mixture will eddy in the region 60 behind the flange or step 52 in much the same manner that the combustion mixture eddies behind the orifice member or flange 24 in Figure 1. Since, however, the orifice member 24 projects out into the flowing stream of combustible gases, it is more effective in causing eddies on its downstream side than is the step 52. Accordingly the radial dimension of the step 52 in Figure 4 would have to be larger than the corresponding radial dimension of the orifice member 24 in Figure 1 in order to obtain an equivalent flame holder action. As in Figs. 1–3, in Fig. 4 an igniter 61 similar to the igniter 32 is provided for igniting the combustion mixture in the region 60. Upon ignition of the combustible mixture in the region 60 in Figure 4 the eddying of the burning combustion gases in this region will act as a continuous source of ignition for the unburned gases flowing through the orifice 58. The resulting combustion has a substantially conical flame front as approximately indicated by the dot-and-dash line 62.

When a single orifice flame holder construction, such as illustrated in Figures 1 and 3 or in Figure 4, is used in a combustion chamber of large cross-sectional area, the conical flame front may become so long in axial direction as to require an excessively long combustion chamber. The axial length of the flame front may be reduced, however, by using a plurality of co-axial orifice members in the manner illustrated in Figure 5.

In Figure 5, a combustion mixture is supplied to a duct 70 for combustion therein. As in Figures 1 to 4, the duct 70 may constitute the duct of a ram jet engine. A plate-like member 72 has an opening 74 therethrough co-axial with the duct 70 thereby forming an orifice within said duct through which the combustion mixture flows in the direction indicated by the arrow. The member 72 in effect constitutes an internal flange for the tubular wall of the duct 70 thereby forming a sheltered region 76 corresponding to the sheltered region 30 of Figures 1 to 3. In addition a tubular member 78 is co-axially supported within the duct 70 by streamlined struts 80. The upstream end of the tubular member 78 has an internal flange 82 around its entire periphery with an opening 84 therethrough. The internal flange 82 constitutes a second orifice member within the duct 50. Thus a second sheltered region 86 is formed between the orifice member or flange 82 and the adjacent downstream surface portion of the tubular member 78 in which the combustible mixture will eddy. As illustrated, the orifice members 72 and 82 are substantially co-planar. Preferably the axial separation, if any, of the planes of the orifice members 72 and 82 is no greater than the effective diameter of the smaller orifice 84. By "effective diameter" of a cross-sectional area of any shape is meant the diameter of a circle of the same cross-sectional area.

The combustible mixture eddying in one of the sheltered regions 76 or 86 is initially ignited. Thus as illustrated an igniter 87 which may be similar to the igniter structure described in connection with Figure 1, has been provided for igniting the mixture in the sheltered region 76. The struts 80 have passages 88 therethrough alined with holes 90 in the tubular member 78. The passages 88 and the alined holes 90 constitute flame cross-over tubes for igniting the combustible mixture eddying in the other of the regions 76 or 86 from the hot combustion gases previously ignited in the region 76 or 86. With this construction the orifice member 72 and the adjacent downstream portion of the duct 70 constitute a flame holder for combustion of the mixture flowing between the duct 70 and the tubular member 78 while the orifice member 82 and the tubular member 78 constitute a flame holder for combustion of the mixture flowing through said tubular member. The tubular member 78 should be long enough to form a sufficiently large sheltered region 86 but should not be so long as to extend into the flame front of the combustion between said tube and the wall of the duct 70. Preferably the tubular member 78 is at least as long as the effective diameter of its orifice 84.

With the flame holder structure of Figures 5 and 6, the flame front of the combustible mixture ignited by the hot gases in the region 76 has a substantially frusto-conical shape indicated approximately by the dot-and-dash line 92. The flame front of the combustible mixture ignited by the hot gases in the region 86 has a substantial conical shape indicated approximately by the dot-and-dash line 94. In the absence of the flame holder structure comprising the tubular member 78 and its orifice member 82, the flame front portion 94 would constitute the apex of the frusto-conical flame front 92. Thus in the absence of the flame holder structure 78 and 82, the flame front would be approximately twice as long. Obviously, the flame front may be further reduced in axial length by providing additional orifice members, for example by increasing the diameter of the orifice member 82 and its tubular member 78 and by co-axially supporting a smaller tubular member and orifice member therewithin.

In lieu of the plate-like orifice member 72 the sheltered region 76 obviously could be formed by a step in the cross-sectional area of the duct 70 just as in Figure 4.

The invention has been described in connection with the combustion chamber of a ram jet engine. Obviously, however, the invention is not so limited and may be used in other jet engines as well as in any combustion chamber where a flame holder structure is needed to prevent the combustion flame from being blown out because

of the high velocity of the gases flowing through the combustion chamber.

While we have described our invention in detail in its present preferred embodiment, it will be obvious to those skilled in the art, after understanding our invention, that various changes and modifications may be made therein without departing from the spirit or scope thereof. We aim in the appended claims to cover all such modifications.

We claim as our invention:

1. In a jet engine; combustion apparatus including a tubular duct and having means for supplying a combustible mixture to said duct; a flame holder structure for said combustion apparatus comprising means providing an orifice within said duct for flow of said mixture through said orifice; a tubular member co-axially supported within said duct for flow of a portion of said mixture through said member, said tubular member having a cross-sectional area smaller than that of said orifice and having an inturned flange at a point upstream of the downstream end of said member, said flange forming a second but smaller orifice within said duct; and means for igniting the combustible mixture in said duct downstream of said orifices.

2. In a jet engine; combustion apparatus including a tubular duct and having means for supplying a combustible mixture to said duct; a flame holder structure for said combustion apparatus comprising means providing an orifice within said duct for flow of said mixture through said orifice; a tubular member; a plurality of struts co-axially supporting said tubular member within said duct, said tubular member having a cross-sectional area smaller than that of said orifice and having an inturned flange at its upstream end forming a second but smaller orifice within said duct, the axial separation of the planes of said orifices being no greater than the effective diameter of the smaller of said orifices; means for igniting the combustible mixture in the region immediately downstream of one of said orifices; and passageways through said struts providing flame cross-over passages establishing communication between said ignited region and the region immediately downstream of the other of said orifices for ignition of the combustible mixture in said latter region.

LLOYD E. BERGGREN.
ALAN A. KURTIS.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,814,910	Ensign et al.	July 14, 1931
1,907,734	Butz	May 9, 1933
2,332,736	Martin	Oct. 26, 1943
2,385,833	Nahigyan	Oct. 2, 1945
2,508,420	Redding	May 23, 1950
2,543,033	Little	Feb. 27, 1951