July 30, 1957 R. T. FRENCH ET AL 2,800,765

MOVABLE FLAME HOLDER FOR COMBUSTION APPARATUS

Filed Aug. 27, 1947 2 Sheets-Sheet 1

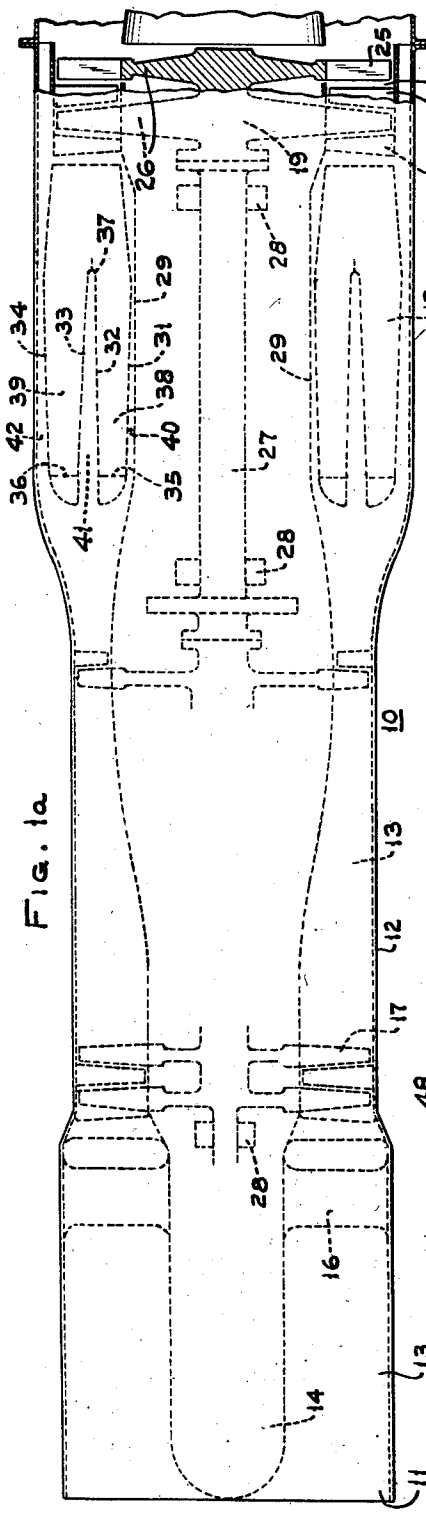


Fig. 1a

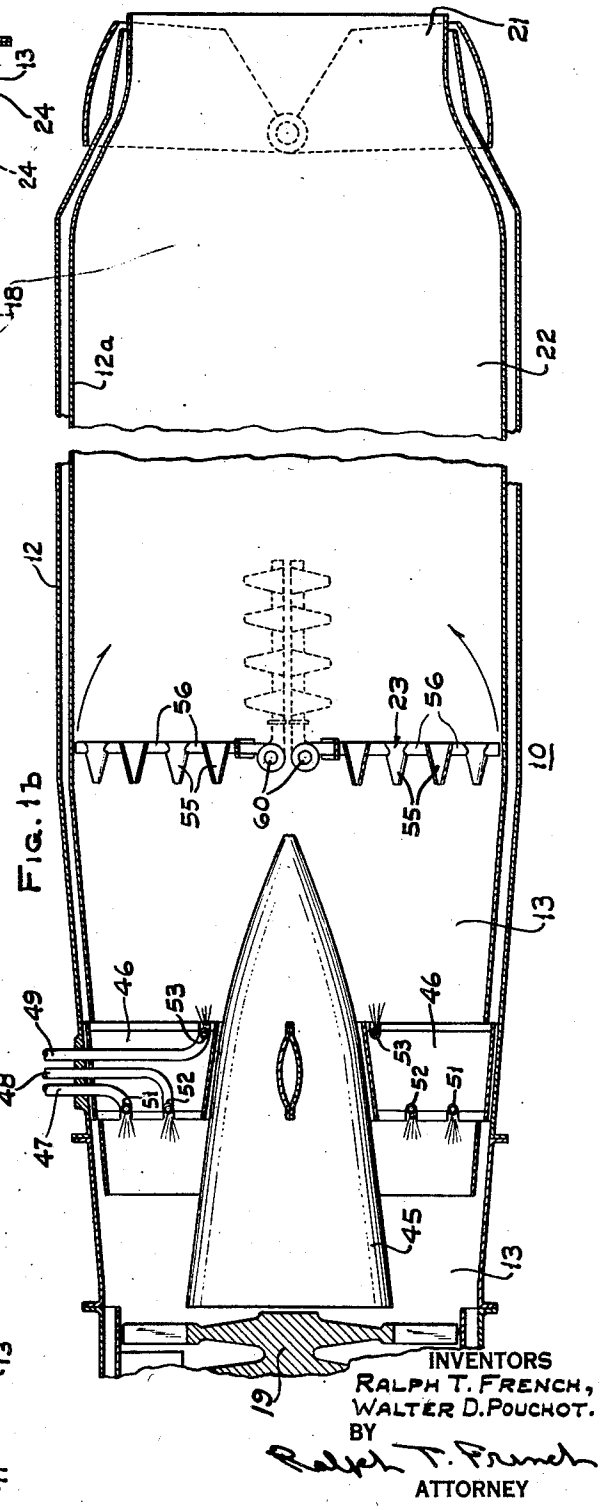


Fig. 1b

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FIG. 2.

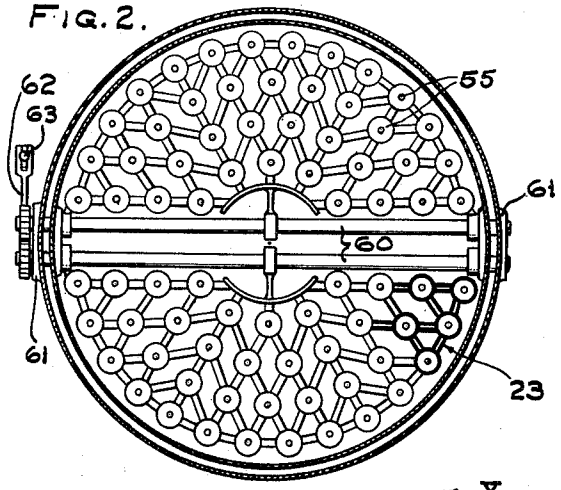
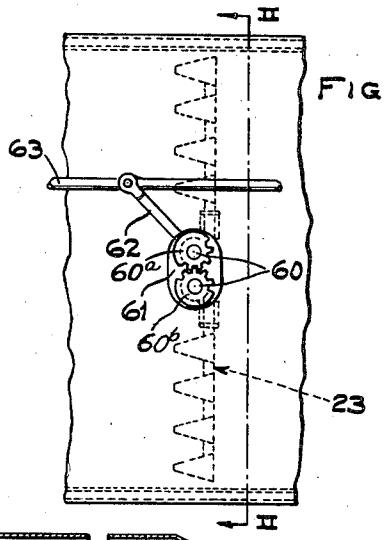


FIG. 3.



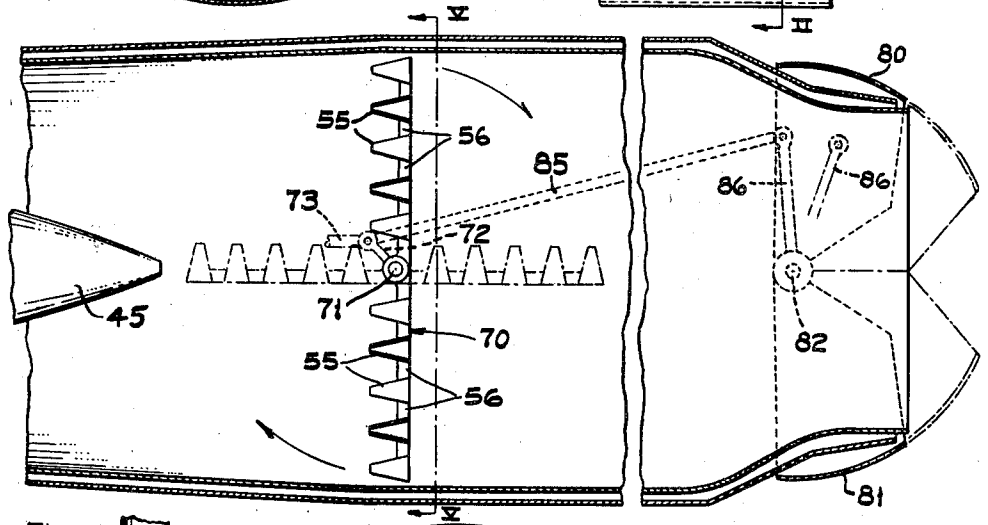


FIG. 4.

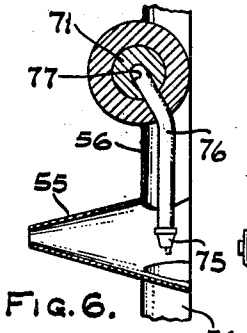


FIG. 6.

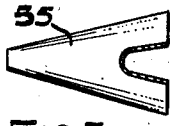


FIG. 7.

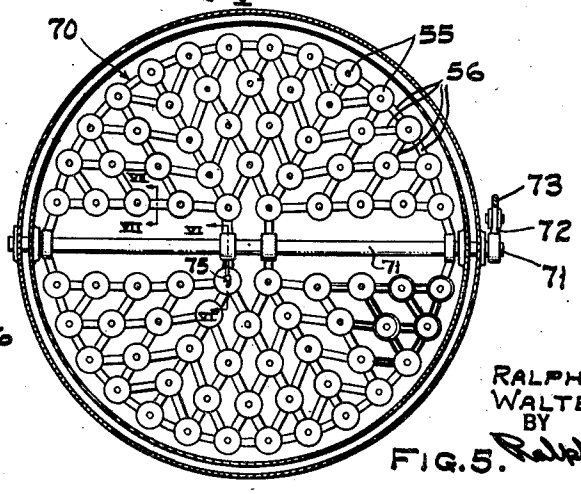


FIG. 5.

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MOVABLE FLAME HOLDER FOR COMBUSTION APPARATUS

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Application August 27, 1947, Serial No. 770,800

1 Claim. (Cl. 60—35.6)

This invention relates to combustion apparatus, more particularly to flame holders therefor, and has for an object to provide improved apparatus of this character.

In combustion apparatus where the gases to support combustion flow through the combustion chamber at velocities in excess of fifty feet per second, it is likely to be difficult to maintain a suitable flame formation. In some cases the flame may be entirely extinguished and in other cases it may be forced a considerable distance downstream of the location where burning is desired.

To avoid these and other difficulties resulting from high velocities of gases through combustion chambers, it has heretofore been proposed to provide, in the combustion chamber and at a point upstream of the desired flame location, a flame holder. Such flame holder usually extends generally transversely of the stream of gases and serves to produce in the stream a degree of stagnancy sufficient to permit retention of the flame at the desired location.

Such flame holders, while performing a very necessary function, have certain disadvantages, not the least of which is that they seriously obstruct the normal flow path through the combustion chambers, and may reduce the effective cross sectional area thereof as much as 43 percent.

One of the most common uses of flame holders is in "tail burners" or "after burners" for aviation gas turbine power plants, where the exhaust gases from the turbine are reheated before passing through an exhaust nozzle as an aircraft-propelling jet. Such tail burners customarily are used only a small portion of the total operating time of the gas turbine power plant, as, for example, when rapid climbs or short bursts of excess speed are desired. The remainder of the time, when the tail burner is not in operation, maximum efficiency of the power plant is seriously impaired, due to the excessive pressure drop resulting from reduction in effective flow area by the flame holder.

The present invention substantially eliminates this primary drawback of existing flame holders by so constructing and mounting the same that when the tail burner or other combustion apparatus with which the flame holder is associated is not in use the flame holder can be moved by the pilot to a position where its obstructing effect is substantially eliminated or at least materially reduced.

Accordingly, another object of the invention is to provide a flame holder which is adjustable between an operative position when it produces a degree of stagnancy accompanied by a material pressure drop and an inoperative position where the pressure drop is materially reduced.

Yet another object of the invention is to mount a flame holder for pivotal movement between operative and inoperative positions.

A further object of the invention is to provide, in a gas turbine power plant having an exhaust nozzle and a tail burner between the turbine and said nozzle, means for throttling the nozzle when the tail burner is inoperative and a flame holder adjustable between operative and inoperative positions, together with mechanism for simultaneously moving the nozzle throttling means to operative position and the flame holder to inoperative position, and vice versa.

These and other objects are effected by the invention as will be apparent from the following description and claim taken in connection with the accompanying drawings, forming a part of this application, in which:

Figs. 1*a* and 1*b*, taken together, constitute a longitudinal sectional view through an aviation gas turbine power plant constructed in accordance with the present invention;

Fig. 2 is a sectional view, taken along the line II—II of Fig. 3, looking in the direction indicated by the arrows;

Fig. 3 is a fragmentary side elevational view of a portion of the structure shown in Fig. 1*b*;

Fig. 4 is a view similar to Fig. 1*b*, but showing a modified flame holder;

Fig. 5 is a sectional view, taken along the line V—V of Fig. 4, looking in the direction indicated by the arrows;

Fig. 6 is a sectional view, taken along the line VI—VI of Fig. 5, looking in the direction indicated by the arrows; and

Fig. 7 is a sectional view, taken along the line VII—VII of Fig. 5, looking in the direction indicated by the arrows.

As previously indicated, the present invention, while not limited thereto, is particularly adapted for use with a gas turbine power plant of the type employed on aircraft to drive the propeller or an electric generator and/or to supply motive fluid for jet propulsion of the aircraft. Such a plant preferably comprises a streamlined tubular casing having mounted axially therein a compressor adjacent the forward or inlet end, a turbine in the rearward half of the power plant, and combustion apparatus located between the compressor and the turbine for heating the compressed air and which discharges the hot gases at suitable temperature and pressure to the turbine. The gases on leaving the turbine are discharged through a nozzle provided at the rear of the casing and may aid in propelling the aircraft.

Referring now to the drawings more in detail, the power plant shown in Figs. 1*a* and 1*b* and indicated in its entirety by the reference character **10**, is adapted to be mounted in or on the fuselage or wing of an aircraft with the left end or intake **11**, as viewed in Fig. 1*a*, pointed in the direction of flight.

The plant comprises an outer shell or casing structure **12—12*a*** providing an annular air duct or passage **13** extending fore and aft with respect to the aircraft. This casing has mounted therein, along its longitudinal axis, a fairing cone **14** adapted to house gearing connecting through a hollow guide vane **16** with auxiliaries (not shown), an axial flow compressor **17**, combustion apparatus generally indicated **18**, a turbine **19** which drives the compressor, and a nozzle **21** defined by the rear end of the casing **12*a***. Additionally, the passage **13** provides a tail burner combustion space **22** between the turbine **19** and the exhaust nozzle **21**, and in which combustion space is positioned the flame holder **23** constituting the primary element of the present invention.

Air enters at the intake **11** and flows substantially straight through the plant, passing through the compres-

sor **17** where its pressure is raised, and into the combustion apparatus **18** where it is heated. The hot gases, comprising the products of combustion and excess air heated by the combustion, on leaving the combustion apparatus are directed by suitable guide vanes or nozzles **24** against the blades **25** of the turbine discs **26** and then are discharged through the nozzle **21** to propel the aircraft.

By reference to Fig. 1*a* it will be seen that the compressor and turbine rotors are interconnected by means of a shaft **27** supported by suitable bearings **28** and enclosed by an inner wall structure, generally indicated **29**, which protects the shaft and bearings from high temperatures and also defines a portion of the annular air flow passage **13** in which the combustion apparatus **18** is located.

The combustion apparatus comprises annular walls **31**, **32**, **33** and **34**, the walls **31** and **32** being joined at their upstream ends by an end wall **35** and the walls **33** and **34** similarly being joined at their upstream ends by the wall **36**. The walls **32** and **33** are joined at their downstream ends, as at **37**, whereby there are provided annular burner spaces **38** and **39** overlapped by annular air spaces **40**, **41** and **42**. Fuel is supplied to the burner spaces **38** and **39** by annular series of nozzles (not shown) carried by the end walls **35** and **36**.

Referring now to Fig. 1*b* for a description of the tail burner, it will be seen that a fairing cone **45**, positioned with its base in close proximity to the downstream end of the turbine **19**, provides for gradual divergence of the annular passage **13** from the turbine outlet to the point of the fairing cone, where the passage becomes cylindrical in cross section. Preferably, the fairing cone **45** is supported by a plurality of radial struts **46**, one of which is hollow and houses fuel supply conduits **47**, **48** and **49** terminating in annular fuel manifolds **51**, **52** and **53**, respectively. The manifolds **51** and **52** have circumferentially-spaced fuel emission openings for directing sprays of fuel upstream, while the manifold **53** has similar openings for directing fuel sprays downstream.

The flame holder **23** is disposed within the tail burner combustion space **22** at a point slightly downstream of the fairing cone **45** and serves to produce in the stream of gases flowing therepast a degree of stagnancy sufficient to maintain a flame formation in the combustion space **22** slightly downstream of the flame holder.

The particular shape of the baffle or shield elements making up the flame holder is not critical to the present invention, but has been illustrated as having the form of a hollow cone **55** pointed upstream, and each such cone is connected to adjacent cones by bridge members **56** which are concave at their downstream sides to promote spreading of the flame transversely of the combustion space, from cone to cone.

As best shown in Fig. 2, the flame holder **23** is divided into two separate semi-circular halves, each such half being mounted on a shaft **60**, journaled in bearings **61** carried by the casing walls **12—12***a*. One of the shafts **60** is adapted to be oscillated through an angle of 90 degrees by means of the arm **62** secured thereon at one end, and whose other end is connected to a longitudinally-reciprocable rod **63**, operable at the will of the pilot.

That end of the arm **62** which is secured to its shaft **60** is provided with a gear segment **60***a* meshing with a corresponding gear segment **60***b* secured to the other shaft **60**, whereby rotation of the first shaft **60** produces opposite rotation of the other shaft, with the result that reciprocation of the rod **63** effects movement of the flame holder halves between the operative position shown in full lines (Fig. 1*b*) and the inoperative position shown by dot-dash lines.

In Figs. 4, 5, 6 and 7 there is shown a modified flame holder **70**, which is constructed as a single unitary element and fixedly mounted on a single shaft **71** operated through arm **72** by rod **73** under control of the pilot.

The flame holder moves between an operative position where it extends generally transversely of the tail burner combustion chamber, as shown in full lines (Fig. 4) and an inoperative position where it extends axially of the combustion chamber, parallel to the direction of flow of turbine exhaust gases therethrough and shown in dot-dash lines.

After the flame holder (either form) has been moved to operative position and fuel supplied to the gas stream through one or more of the fuel manifolds **51**, **52** or **53** upstream thereof, the fuel must be ignited, preferably at a relatively sheltered point in the gas stream, and to this end ignition means, such as the spark plug **75**, is positioned at the downstream side of one of the inverted cones **55** (Figs. 5 and 6) with its cable **76** passing through a bore **77** in the shaft **71**. While not illustrated, it will be obvious that a similar ignition means would be provided with a flame holder such as shown in Figs. 1 to 3.

Inasmuch as a far larger volume of heated gases exhaust through the nozzle **21** when the tail burner is in operation than when it is inoperative, it is desirable to be able to enlarge the nozzle, and this is accomplished by the adjustable sections **80** and **81**, pivoted at **82** and movable between the full line and dot-dash line positions indicated in Fig. 4.

The details of this nozzle adjusting means form no part of the present invention, being separately disclosed and claimed in copending application by Carl F. Koenig III, Robert E. Weiler and James D. Brown, Serial No. 770,836, filed August 27, 1947, now abandoned, abstract published November 1, 1949 in 628 O. G. 256, and assigned to the assignee of the present application. However, the present invention does include the novel cooperation between the flame holder and the adjustable nozzle, for when the tail burner is to be used the nozzle usually would be opened and the flame holder moved to operative position, and when the tail burner is out of use the nozzle usually would be closed and the flame holder moved to inoperative position. To this end, a rod **85** extends from the arm **72** to the arm **86** on the nozzle pivot **82**, so that the flame holder and nozzle sections are moved simultaneously and by a single operation of the pilot.

It will be apparent that a similar interconnecting operating mechanism for the flame holder and nozzle could be provided for flame holding apparatus such as shown in Fig. 1*a*, but a showing thereof has been omitted for the sake of clearness of disclosure.

While the invention has been shown in several forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications without departing from the spirit thereof.

What is claimed is:

In a power plant, structure defining a combustion chamber having an inlet and an outlet and adapted for flow of gases therethrough at velocities exceeding 50 feet per second, a flame-holder for effecting a degree of stagnancy in the stream of gases flowing through the chamber such that a flame formation may be maintained within the chamber, means supporting the flame-holder for movement between an operative position where it produces a material pressure drop in the gas stream and an inoperative position where the pressure drop produced thereby is materially reduced, adjustable means associated with the outlet of the combustion chamber and movable between an operative position where it throttles the gas stream leaving the combustion chamber and inoperative position where its throttling action is materially reduced, and means for moving the flame holder to operative position upon movement of the throttling means to inoperative position and for moving the flame holder to inoperative position upon movement of the throttling means to operative position.

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