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(54) THROAT CONFIGURATION FOR AXISYMMETRIC NOZZLE

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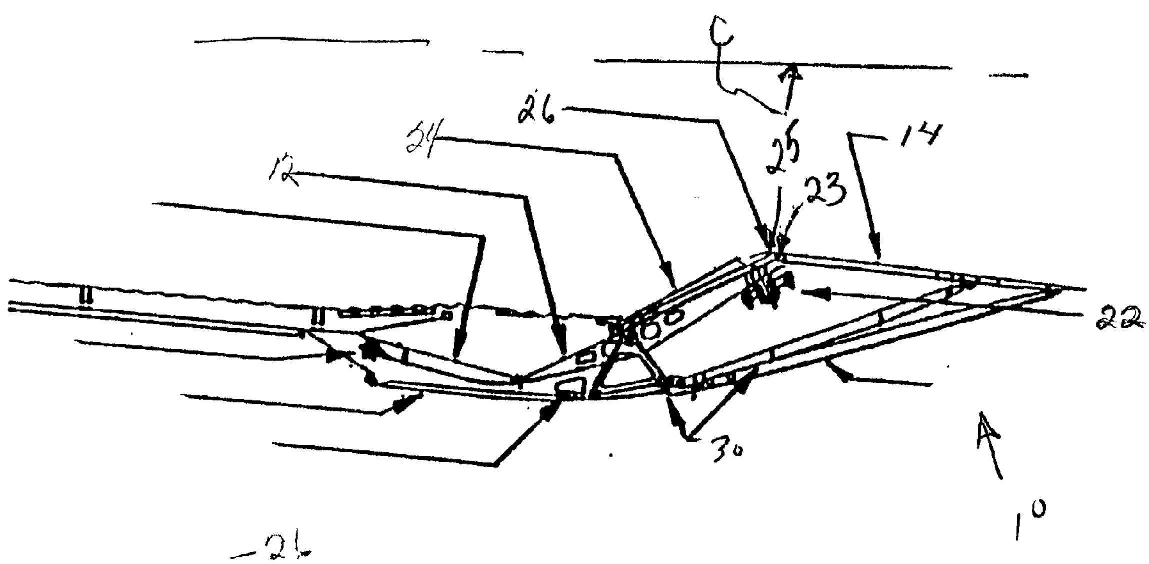
(57) ABSTRACT

The radius of the hinged portion of the convergent/divergent axisymmetrical exhaust nozzle of a gas turbine engine is configured at the surface seeing the flow to be contoured at a critical radius so to enhance the flow characteristics of the nozzle and improve the low observables. The liner normally associated with the convergent flap is cut back at the juncture adjacent the hinged point connecting the divergent flap to be below the radar sight at the tail of the engine.



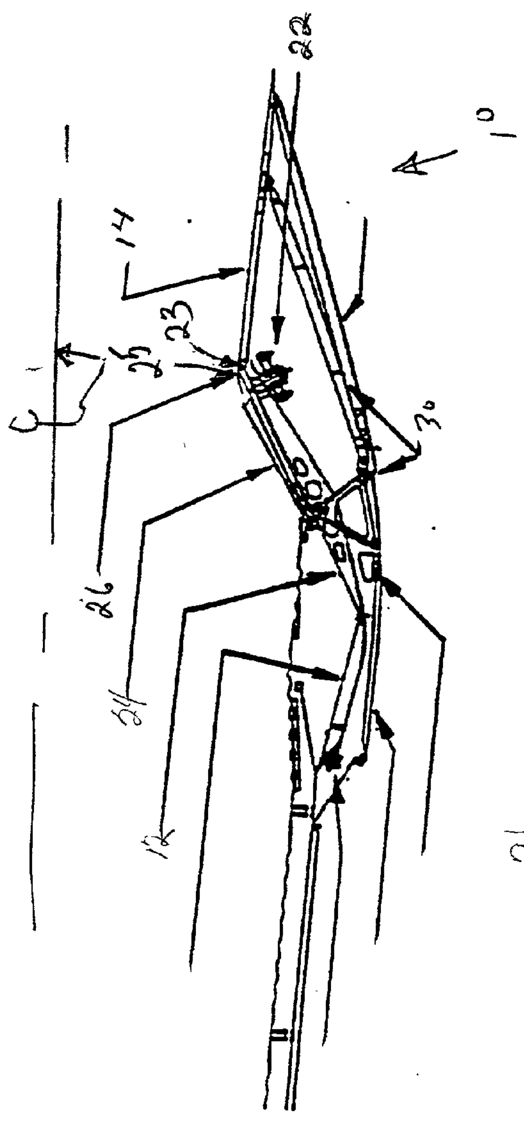


Fig 1

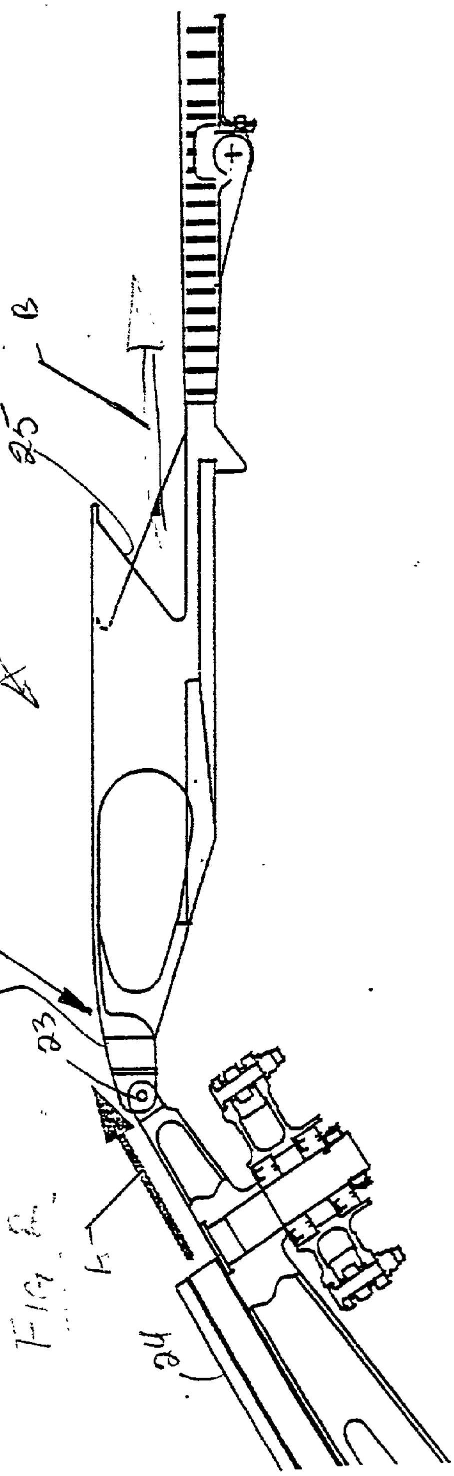


Fig 2

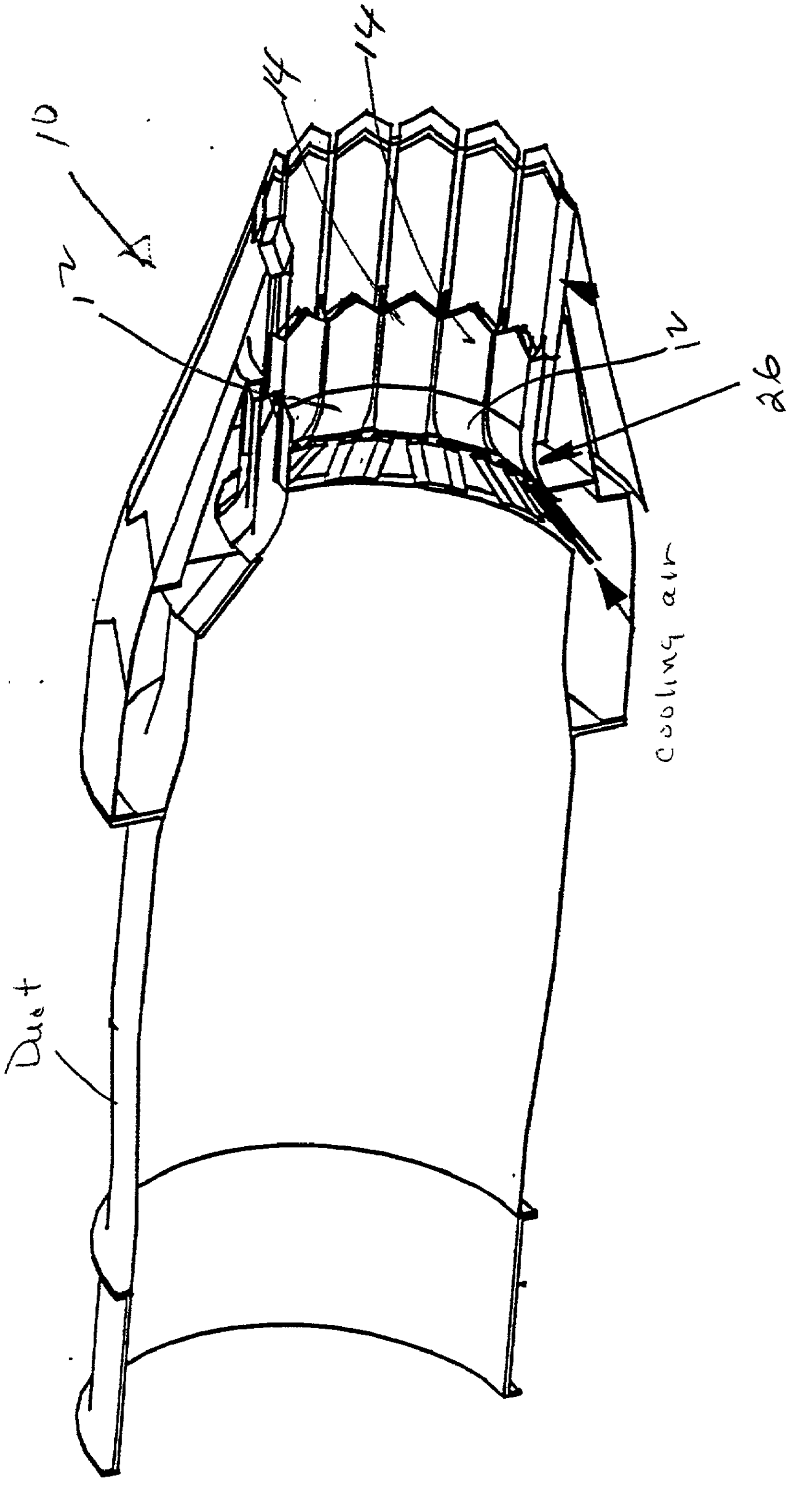


FIG 3

THROAT CONFIGURATION FOR AXISYMMETRIC NOZZLE

TECHNICAL FIELD

[0001] This invention relates to the exhaust nozzle of a gas turbine engine for powering aircraft and particularly to the configuration of the throat of a convergent/divergent nozzle of the exhaust of the gas turbine engine.

BACKGROUND OF THE INVENTION

[0002] As one skilled in this art will appreciate, the axisymmetrical nozzle of a gas turbine engine serves to adjust the throat of the nozzle be adjusted for different engine operating modes so as to give a different flow characteristics in the throat area. One of the problems with the heretofore known throat is that the interface between the convergent flap portion and divergent flap portion, particularly where the two portions are hinged, not only impairs the flow there over or fails to provide a streamlined flow stream adjacent the boundary layer, it presents itself in the sight of radar and hence, is radar reflective. Where it is desirable to minimize the radar reflectiveity of aircraft, particularly, military aircraft, this portion of the axisymmetrical exhaust nozzle presents is one of the more significant problems.

[0003] I have found that I can provide an improved streamlined flow over the hinged area of the convergent/divergent nozzle of a gas turbine engine designed for military aircraft by changing the hinge configuration. This change in configuration also improves the low observable characteristics of the nozzle. The invention is characterized as being capable of providing these improvements noted in the above, and is characterized as being simple in construction, inexpensive and capable of being used to retrofit existing axisymmetrical nozzles.

SUMMARY OF THE INVENTION

[0004] An object of this invention is to provide an improved convergent/divergent nozzle assembly for an axisymmetrical discharge nozzle for a gas turbine engine powering aircraft.

[0005] A feature of this invention is to provide a configuration of the flaps adjacent the hinge connection of the convergent and divergent portions of the discharge nozzle that enhance the flow characteristics adjacent thereto and the low radar observables..

[0006] The foregoing and other features of the present invention will become more apparent from the following description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] **FIG. 1** is a fragmentary view in elevation illustrating the convergent and divergent flap of a axisymmetrical nozzle utilizing this invention;

[0008] **FIG. 2** is an enlarged view illustrating the throat configuration of this invention; and

[0009] **FIG. 3** is a partial view in perspective illustrating this invention in the axisymmetrical exhaust nozzle of a gas turbine engine.

[0010] These figures merely serve to further clarify and illustrate the present invention and are not intended to limit the scope thereof

DETAILED DESCRIPTION OF THE INVENTION

[0011] This invention is an improvement over the exhaust nozzle described and claimed in U.S. Pat. No. 4,440,347 granted to Madden et al on Apr. 3, 1984 and commonly assigned to the assignee of this patent application and whose subject matter is incorporated herein by reference.

[0012] This invention can best be understood by referring to FIGS. **1-3** which shows the portion of the convergent/divergent nozzle generally illustrated as reference numeral **10** as having a plurality of circumferentially spaced axially extending convergent flaps **12** and a similar number of circumferentially spaced axially extending divergent flaps **14** that are hingedly connected at the throat **16** by the hinge connection **18**. These flaps **14** and **18** are articulated in a well known manner in order to change the throat area of he throat **16**.

[0013] The convergent/divergent flaps are suitably mounted in the transition duct **20** which interconnects with the afterburner (not shown) which in turn interconnects with the main engine. As is typical in the axisymmetrical exhaust nozzle the transition duct and convergent flap incorporate liner **22** to transport the heat away from the main components of the nozzle. The convergent flap likewise is provided with a suitable liner **24**. Also, typical in this construction is the use of cooling air as depicted by the arrows A and B taken from the compressor (not shown) which flows over the the components intended to be cooled and discharged from an ejector **25** . Articulation of the convergent/divergent flaps to change the throat area is suitably effectuated by the bellcrank lever **22** which pivots flaps **12** and **14** about the hinged pivot **23** to adjust the throat **25** at the radius throat **26**. The external flaps **28** consisting of a plurality of circumferentially spaced axial flap member is attached to the mode strut and bracket assembly **30** and articulate with the movement of the convergent/divergent flaps. A unison ring **32**, similar to the unison ring depicted in U.S. Pat. No. 4,440,347 is similarly used to move all of the individual flap elements synchronously. A balancing flap **36**, that is also a plurality of circumferentially spaced axial flap elements serves to minimize the load on the actuation members. The dogbone link **38** attached to the static structure **40** supports the convergent/divergent assembly through the static structure **40** that, in turn, is grounded to the transition duct.

[0014] Since the structural details of the axisymmetrical nozzle are well known a detailed description thereof is omitted here from for the sake of simplicity and for a more detailed description reference should be made to U.S. Pat. No. 4,440,347, supra. Suffice it to say that the convergent/divergent flaps serve to adjust the throat area (defined by the radius C) of the exhaust nozzle to provide the desired flow characteristics during certain operating conditions within the engine's operation envelope. The invention can best be seen in **FIG. 2** where the liner **24** is cut back from the pivot hinge **23** and the surface **40** adjacent the hinge **23** defines a smooth transition portion of the divergent flap and creates a smooth transition relative to the convergent flap (radius throat **26**). In accordance with this invention the range of radii of surface **40** or radius throat **26**, at this location is between 2 inches (") to 10" and preferably being at 7". This configuration of the radius throat **26** is critical and is applied to all the visible surfaces of the nozzle throat including, as required, the flaps and the seals adjacent to the flaps which serve to prevent the hot gases of the engine to escape and bypass the exhaust nozzle. By adhering to the critical radius as described above the throat **25** when articulated remains on a station line (a vertical plane passing through each location of the engine and nozzle) of the nozzle so that it does not alter the basic kinematics of the nozzle while providing a smooth transition for the radar energy and at the same time enhancing the aerodynamic performance of the nozzle.

[**0015**] What has been shown by this invention is a radius throat adapted for use on a well known axisymmetrical nozzle throat which serves to reduce the radial reflextivity characteristics of the nozzle while collaterally improving the aerodynamic performance of the nozzle. This invention has been tested and found to reduce the radar reflectivity from the typical axial station line throat design approach by three (3) to four (4) orders of magnitude.

[**0016**] Although this invention has been shown and described with respect to detailed embodiments thereof, it will be appreciated and understood by those skilled in the art that various changes in form and detail thereof may be made without departing from the spirit and scope of the claimed invention.

It is claimed:

1. A convergent/divergent nozzle of an axisymmetrical exhaust nozzle for a gas turbine engine including a hinged pivot at the juncture of where the convergent/divergent portion of said nozzle meet, said convergent nozzle comprising circumferentially spaced axially extending flaps and said divergent nozzle having circumferentially spaced axially extending flaps, a radius throat at the juncture of the hinged pivot, said radius throat being defined by a curvature formed on the flaps of the divergent nozzle and falling in the range of from 2 inch radius to 10 inch radius.

2. A convergent/divergent nozzle of an axisymmetrical exhaust nozzle for a gas turbine engine as claimed in claim 1 wherein said radius is substantially equal to 7.0 inches.

3. A convergent/divergent nozzle of an axisymmetrical exhaust nozzle for a gas turbine engine including a hinged pivot at the juncture of convergent portion and the divergent portion of said nozzle, said convergent nozzle comprising circumferentially spaced axially extending flaps and said divergent nozzle having circumferentially spaced axially extending flaps, a radius throat at the juncture of the hinged pivot, a liner attached to the surface of said convergent flaps exposed to the engine's working fluid for dissipating heat away from said convergent flaps, said liner extending along the length of said convergent flaps and terminating short of said hinged pivot and falling below the high point of said curvature and being out of the line of sight from the tail of the gas turbine engine.

4. A convergent/divergent nozzle of an axisymmetrical exhaust nozzle for a gas turbine engine as claimed in claim 3 wherein the radius of said radius radius throat being defined by a curvature formed on the flaps of the divergent nozzle and falling in the range of from 2 inch radius to 10 inch radius.

5. A convergent/divergent nozzle of an axisymmetrical exhaust nozzle for a gas turbine engine as claimed in claim 4 wherein said radius is substantially equal to 7.0 inches.

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