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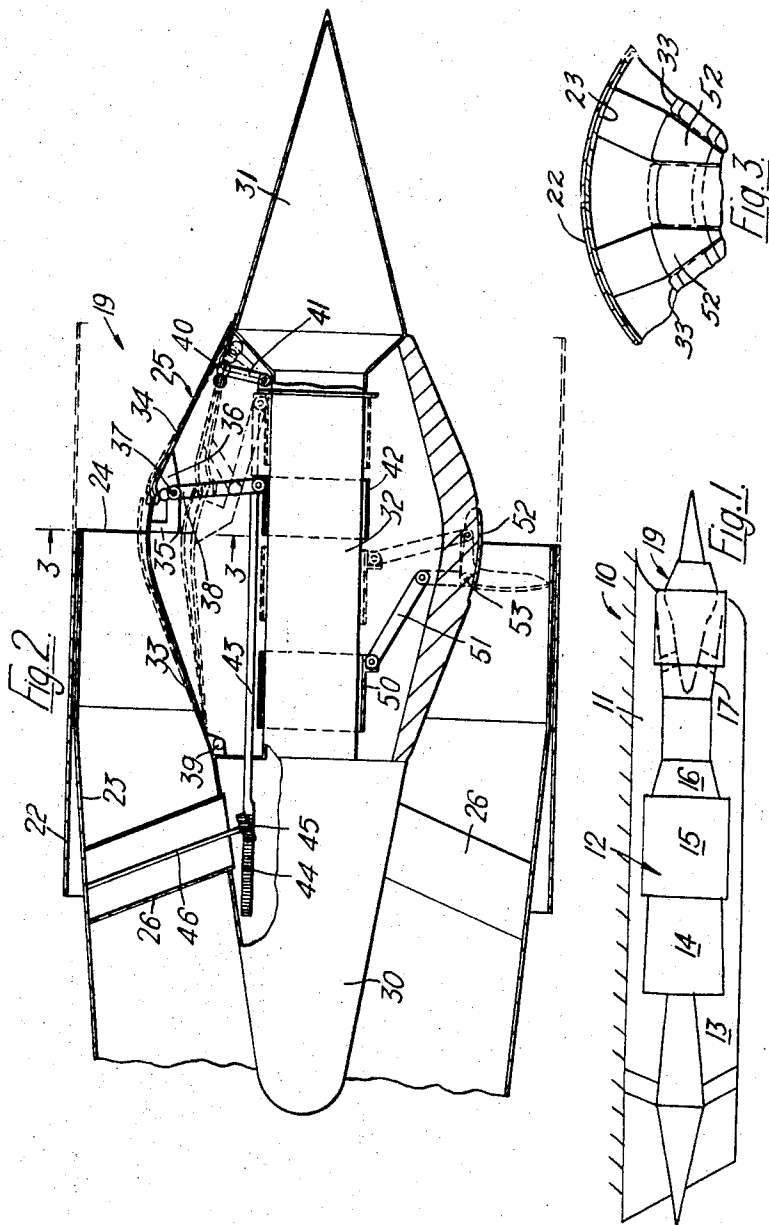
F. J. COLVILLE ET AL

3,352,494

SUPERSONIC JET PROPULSION NOZZLE

Filed July 26, 1965

3 Sheets-Sheet 1



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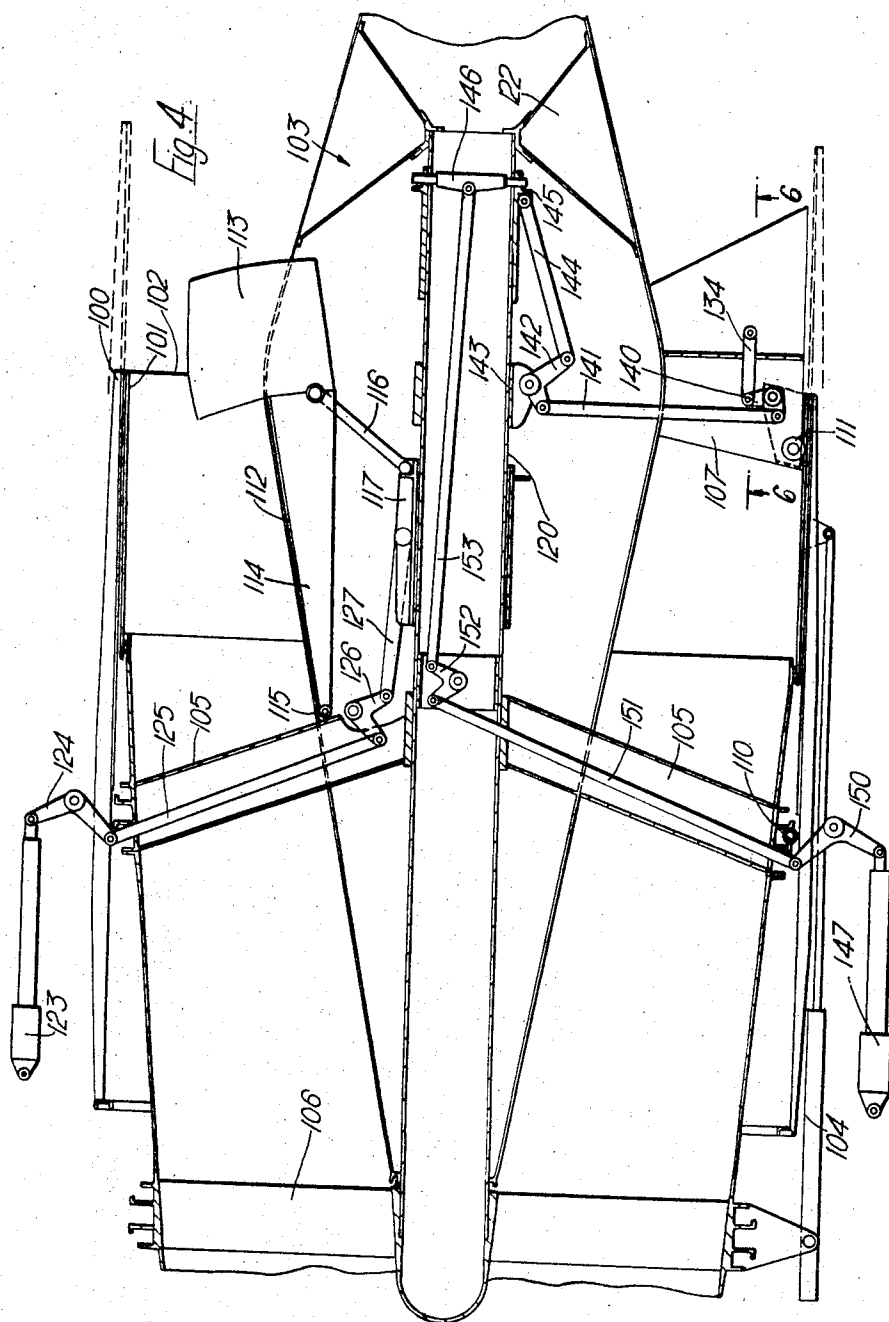
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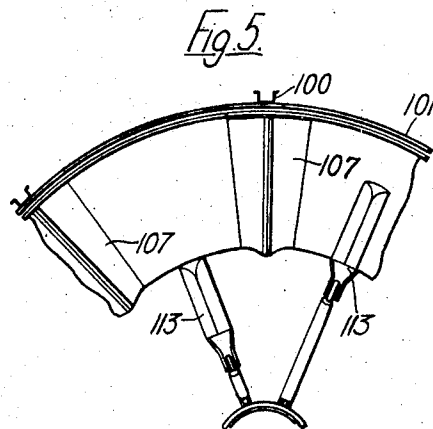
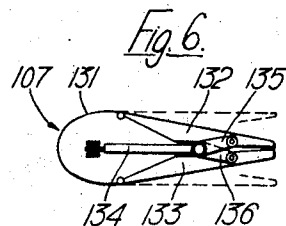
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SUPERSONIC JET PROPULSION NOZZLE

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6 Claims. (Cl. 239—265.13)

ABSTRACT OF THE DISCLOSURE

A supersonic jet propulsion nozzle having a relatively movable outer casing and central plug for defining at least two positions, one position in which a convergent nozzle is defined and a second position in which a convergent-divergent nozzle is defined. Means, e.g. hinged flaps, are provided for increasing the peripheral area of the exhaust gas stream to reduce the noise of the jet gases when required. Movable plug portions may be provided to permit the throat area to be varied in either said position.

This invention concerns a supersonic jet propulsion nozzle.

According to the present invention, there is provided a supersonic jet propulsion nozzle having a substantially cylindrical nozzle casing (or casing assembly) and a bulbous plug mounted therein, the plug and the casing (or casing assembly) being relatively movable axially to permit the throat of the nozzle to be disposed as required either in a position at the downstream end of the casing (or casing assembly) or in a position upstream of said downstream end, whereby the nozzle may be employed either as a convergent or as a convergent-divergent nozzle, and silencing means for substantially increasing the peripheral area over which the said jet gases mix with the ambient air to substantially reduce the noise created by jet gases passing through the nozzle.

The silencing means may accordingly comprise a plurality of angularly spaced apart movable parts which are carried by the plug adjacent the said throat, the said parts being movable into and out of a position in which they prevent jet flow through corresponding portions of the throat.

The said movable parts may comprise a plurality of flaps each of which is connected by a linkage to a common actuating member. Thus the actuating member may comprise a sleeve which is axially movable over a tube which is mounted centrally of said plug.

There may be a second axially movable sleeve mounted on said tube, the plug being made up of a plurality of pairs of fingers each pair of which comprise fingers mounted on a common pivot connected to the second sleeve for radial movement thereby.

Alternatively, the silencing means may comprise a plurality of angularly spaced apart members which are connected to the plug adjacent the said throat, each said member having a downstream portion made up of separable parts which may be moved between a closed position, in which they are closed up against each other, and an open position, in which they are moved apart to permit a flow of ambient air to pass therebetween.

Thus each angularly spaced apart member may be an aerofoil-shaped vane having a fixed upstream portion, the downstream portion being made up of two pivoted separable parts. The said separable parts may be arranged to be moved by a mechanical linkage.

The casing assembly may have an outer portion which

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is slidable over an inner portion so as to alter as required the position of the downstream end of the casing assembly.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:

FIGURE 1 is a diagrammatic view of a gas turbine engine provided with a supersonic nozzle according to the present invention,

FIGURE 2 is a broken away cross sectional view of the supersonic nozzle of the engine of FIGURE 1,

FIGURE 3 is a section taken on the line 3—3 of FIGURE 2,

FIGURE 4 is a broken away sectional view of another supersonic nozzle which may be employed in the engine of FIGURE 1,

FIGURE 5 is an end view of the nozzle of FIGURE 4, and

FIGURE 6 is a diagrammatic section taken on the line 6—6 of FIGURE 4.

Referring first to FIGURE 1, an aircraft 10 is provided with a pod 11 in which is mounted a supersonic gas turbine engine 12. The engine 12 comprises, in flow series, a supersonic intake 13, one or more compressors 14, combustion equipment 15, one or more turbines 16, and a jet pipe 17 which is provided with a thrust reverser (not shown) and with a supersonic nozzle 19.

The nozzle 19 has a substantially cylindrical nozzle casing provided with an outer casing portion 22 (FIG. 2) which is slidable over an inner casing portion 23. Within the inner casing portion 23, and spaced therefrom by a throat 24, is a bulbous plug 25. The outer casing portion 22 may be moved (by power means, not shown) between the full line and dotted line positions shown in FIGURE 2. When the outer casing portion 22 is disposed in the full line position, and throat 24 is aligned with the downstream end of the outer casing portion 22, whereby to form the nozzle into a convergent nozzle. When, however, the outer casing portion 22 is moved axially to the dotted line position, the throat 24 will be disposed upstream of the downstream end of the outer casing portion 22, whereby the nozzle will be a convergent/divergent nozzle.

The plug 25 is supported within the inner casing portion 23 by means of a plurality of angularly spaced apart struts 26 each of which is arranged tangentially of the plug 25 so as to help to prevent buckling on differential expansion and contraction.

The plug 25 consists of a substantially conical upstream portion 30 and a conical downstream portion 31, the portions 30, 31 being interconnected by a tube 32 which is mounted centrally of the plug 25.

The central portion of the plug 25 has an outer casing which is made up of a plurality of pairs of fingers 33, 34, whose ends slightly overlap. The fingers 33, 34 of each said pair are connected by knuckle joints 35, 36 to a common pivot 37 on a link 38, the pivots 37 being disposed adjacent the throat 24. Each of the fingers 33 is mounted at its upstream end on a pivot 39, while each of the fingers 34 is mounted adjacent its downstream end on a pivot 40 carried by a link 41.

The various links 38 are connected to a common sleeve 42 which is axially movable, by means of a push rod 43, between the full line and the dotted line positions shown in FIGURE 2. The push rod 43 is provided with a rack 44 which meshes with a pinion 45, the pinion 45 being mounted on a shaft 46 which extends through one of the struts 26. Power means (not shown) are provided for rotating the shaft 46.

Accordingly, by appropriate movement of the push rod 43, the fingers 33, 34 may be disposed either in the full line position shown, or in one of a number of other positions indicated by dotted lines. Thus, as will be appreciated, the ability to move the fingers 33, 34 radially, and

thus to adjust the peripheral shape of the central portion of the plug 25, enables the area of flow through the throat 24 to be adjusted both when the outer casing portion 22 is in the full line and when it is in the dotted line position.

Thus the outer casing portion 22 may be moved either to form a convergent-divergent nozzle or a convergent nozzle so as to suit the aerodynamic air flow conditions. However, for high Mach numbers, it may be necessary to alter the area of the throat 24 so as to ensure satisfactory operation of the engine, and the provision of the fingers 33, 34 accordingly enables this to be done.

Thus, for example, at take-off, the outer casing portion 22 will be disposed in the full line position, whilst the fingers 33, 34 will be in their outermost position. Just after take-off, however, the fingers 33, 34 are radially retracted so as to permit the throat 24 to have its maximum area.

Slidably mounted on the tube 32 is a sleeve 50 which is connected by linkages 51 to a plurality of angularly spaced flaps 52 which are disposed adjacent the throat 24. Each of the flaps 52 is pivoted at 53 in the casing of the central portion of the plug 25. The flaps 52 are movable between a position, shown in dotted lines, in which they prevent jet flow through certain parts of the throat 24, and a position, shown in full lines, in which they form part of the casing of the said central portion.

It will be appreciated that when the flaps 52 are in the dotted line position, they substantially increase the peripheral area over which the jet gases mix with the ambient air. This assists in substantially reducing the noise created by the jet gases passing through the nozzle. Furthermore, when the flaps 52 are in the dotted line position, a depression is formed downstream of them which has the effect of drawing in ambient air. This promotes mixing of the ambient air with the jet gases and hence promotes still further jet silencing.

In order to compensate for the reduction in the effective area of the throat 24 when the flaps 52 are in the dotted line position, the fingers 33, 34 may be moved radially inwardly e.g. from the outermost dotted line position to the position of the innermost dotted line.

The sleeve 50 is movable between the full line and dotted line positions by means not shown. If desired, the sleeve 50 could be moved axially by means connected to the push rod 43, or to an additional separately actuated push rod (not shown).

In FIGURES 4-6 there is shown a modified supersonic nozzle which may be used on the engine 12. The said nozzle has a substantially cylindrical nozzle casing provided with an outer casing portion 100 which is slidable over an inner casing portion 101.

Within the inner casing portion 101, and spaced therefrom by a throat 102, is a bulbous plug 103. The outer casing portion 100 may be moved by a pneumatically operated ram 104 between the full line and dotted line positions shown in FIGURE 4. When the outer casing portion 100 is disposed in the full line position, the throat 102 is aligned with the downstream end of the outer casing portion 100, whereby to form the nozzle into a convergent nozzle. When, however, the outer casing portion 100 is moved axially by the ram 104 to the dotted line position, the throat 102 will be disposed upstream of the downstream end of the outer casing portion 100, whereby the nozzle will be a convergent-divergent nozzle.

The plug 103 is supported within the inner casing portion 101 by means of a plurality of angularly spaced apart aerofoil-shaped struts 105, 106 each of which is arranged tangentially of the plug 103. The plug 103 is also provided with a plurality of angularly spaced apart aerofoil-shaped vanes 107 which are connected to the plug 103 adjacent the throat 102. The struts 105 and vanes 107 are respectively provided with rollers 110, 111 for engagement by the outer casing portion 100.

The plug 103 has an outer casing 112 in which are mounted a plurality of angularly spaced apart aerofoil-shaped members 113 each of which is mounted at the

downstream end of an arm 114 whose upstream end is pivoted at 115.

Each of the members 113 is radially movable between an inoperative position in which it lies within the confines of the outer casing 112 and an operative position (indicated in full lines) in which it extends outwardly thereof.

Each of the members 113 is connected by a link 116 to a sleeve 117. The sleeve 117 is slidable over an axially extending tube 120 which is disposed within the plug 103. The upstream end of the tube 120 is supported by the struts 106, while the downstream end of the tube 120 is supported from the outer casing 112 by a casing 122.

A pneumatically actuated ram 123 is arranged to move the sleeve 117, and hence the members 113, by way of a mechanical linkage comprising a bell crank lever 124, a link 125 passing through a strut 105, a bell crank lever 126, and a link 127.

The members 113 may thus be moved by the ram 123 so as to adjust the area of flow through the throat 102 both when the nozzle is in its convergent and when it is in its convergent-divergent position. Thus the outer casing portion 100 may be moved by the ram 104 either to form a convergent-divergent nozzle or a convergent nozzle so as to suit the aerodynamic air flow conditions. However, for high Mach numbers it may be necessary to alter the area of the throat 102 so as to ensure satisfactory operation of the engine, and the provision of the members 113 enables this to be done. The fact that the members 113 are, moreover, moved by a mechanical linkage renders the construction particularly suitable for the high temperatures which will be experienced in operation.

Each of the vanes 107 has a fixed upstream portion 131 (see FIG. 6) and a downstream portion which is made up of two pivoted separable parts 132, 133. The parts 132, 133 are connected to a common push rod 134 by links 135, 136 respectively. Thus by movement of the push rod 134 the parts 132, 133 may be moved between a closed position (shown in full lines) in which they are closed up against each other, and an open position (shown in dotted lines) in which they are disposed apart to permit a flow of ambient air therebetween. When the parts 132, 133 are, therefore, in their open position, a flow of air will be drawn between them and will reduce the noise created by the jet gases passing through the nozzle, by virtue of increasing the peripheral area over which the jet gases mix with the ambient air.

The push rod 134 of each vane 107 is connected by a bell crank lever 140 and link 141 to a bell crank lever 142. The latter is mounted on a fixed sleeve 143 secured on the tube 120.

The bell crank lever 142 is connected by a link 144 to a sleeve 145 which is slidable along the tube 120. The sleeve 145 is provided with a diametrically extending plate 146 which passes through a slot in the tube 120. The plate 146 is connected to a pneumatically operated ram 147 by way of a mechanical linkage comprising a bell crank lever 150, a link 151 extending through a strut 105, a bell crank lever 152 and a link 153.

We claim:

1. A supersonic jet propulsion nozzle having a substantially cylindrical nozzle casing and a bulbous plug mounted therein, the plug and the casing being relatively movable axially to permit the throat of the nozzle to be disposed as required either in a position at the downstream end of the casing or in a position upstream of said downstream end, whereby the nozzle may be employed either as a convergent or as a convergent-divergent nozzle, and a plurality of angularly spaced apart aerofoil shaped vanes which are connected to the plug adjacent the said throat, each said member having a fixed upstream portion and a downstream portion made up of two pivoted separable parts which may be moved between a closed position, in which they are closed up against each other, and an open position, in which they are moved apart to permit

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a flow of ambient air to pass therebetween thereby substantially increasing the peripheral area over which the said jet gases mix with the ambient air to substantially reduce the noise created by jet gases passing through the nozzle.

2. A supersonic jet propulsion nozzle comprising: a substantially cylindrical nozzle casing having a downstream end; a bulbous plug mounted in said casing and defining with said casing a throat; said plug and said casing being movable axially relative to each other as desired between at least two positions, one position in which said throat is at the downstream end of said casing and defines a convergent nozzle and the other position in which said throat is upstream of said downstream end of said casing and defines a convergent-divergent nozzle; transversely movable portions on said plug for varying the area of said throat in each of said one and said other positions of said plug relative to said casing; and silencing means, independent of and angularly spaced relative to said movable portions, for substantially increasing peripheral area over which jet gases mix with ambient air to substantially reduce the noise created by jet gases passing through said nozzle.

3. A supersonic jet propulsion nozzle as claimed in claim 2 in which said silencing means comprise a plurality of angularly spaced apart movable parts carried by said plug adjacent said throat, said movable parts being movable into and out of a position in which said parts prevent jet flow through corresponding portions of said throat.

4. A supersonic jet propulsion nozzle as claimed in claim 2 in which said silencing means comprise a plurality of angularly spaced apart movable flaps carried by the plug adjacent said throat, a common actuating member and a linkage connecting each flap to said actuating member for movement into and out of a position in which said flaps prevent jet flow through corresponding portions of the throat.

5. A supersonic jet propulsion nozzle as claimed in claim 2 in which said substantially cylindrical nozzle casing comprises a fixed inner portion and a movable outer portion, said outer portion being movable axially

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relative to the bulbous plug to permit the throat of the nozzle to be disposed as required in either of said positions.

6. A supersonic jet propulsion nozzle comprising: a substantially cylindrical nozzle casing having a downstream end; a bulbous plug mounted in said casing and defining with said casing a throat; said plug and said casing being movable axially relative to each other as desired between at least two positions, one position in which said throat is at the downstream end of said casing and defines a convergent nozzle and the other position in which said throat is upstream of said downstream end of said casing and defines a convergent-divergent nozzle; movable portions on said plug for varying the area of said throat in each of said one and said other positions of said plug relative to said casing; and silencing means, independent of said movable portions, for substantially increasing peripheral area over which jet gases mix with ambient air to substantially reduce the noise created by jet gases passing through said nozzle, said silencing means including a plurality of angularly spaced apart fixed members connected to said plug adjacent said throat, said fixed members extending radially across said throat, and each of said members having a downstream portion made up of separable parts which are movable between a closed position, in which the separable parts are closed up against each other, and an open position, in which the separable parts are moved apart to permit a flow of ambient air to pass therebetween thereby substantially increasing peripheral area over which jet gases mix with the ambient air.

References Cited

UNITED STATES PATENTS

35	2,570,629	10/1951	Anxionnaz	-----	239-265.33
	2,938,335	5/1960	Cook	-----	239-265.13

FOREIGN PATENTS

40	950,288	2/1964	Great Britain.
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