March 14, 1961 W. F. EGBERT ET AL 2,974,477

VARIABLE JET NOZZLE AND SHROUD

Filed Jan. 29, 1953 2 Sheets-Sheet 1

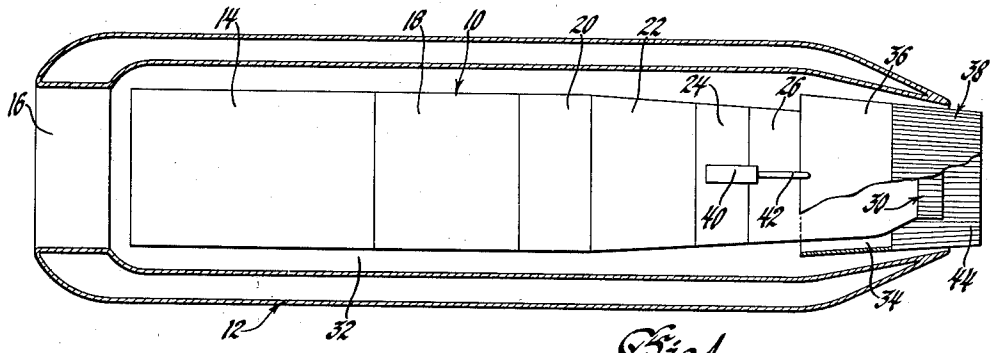


Fig. 1

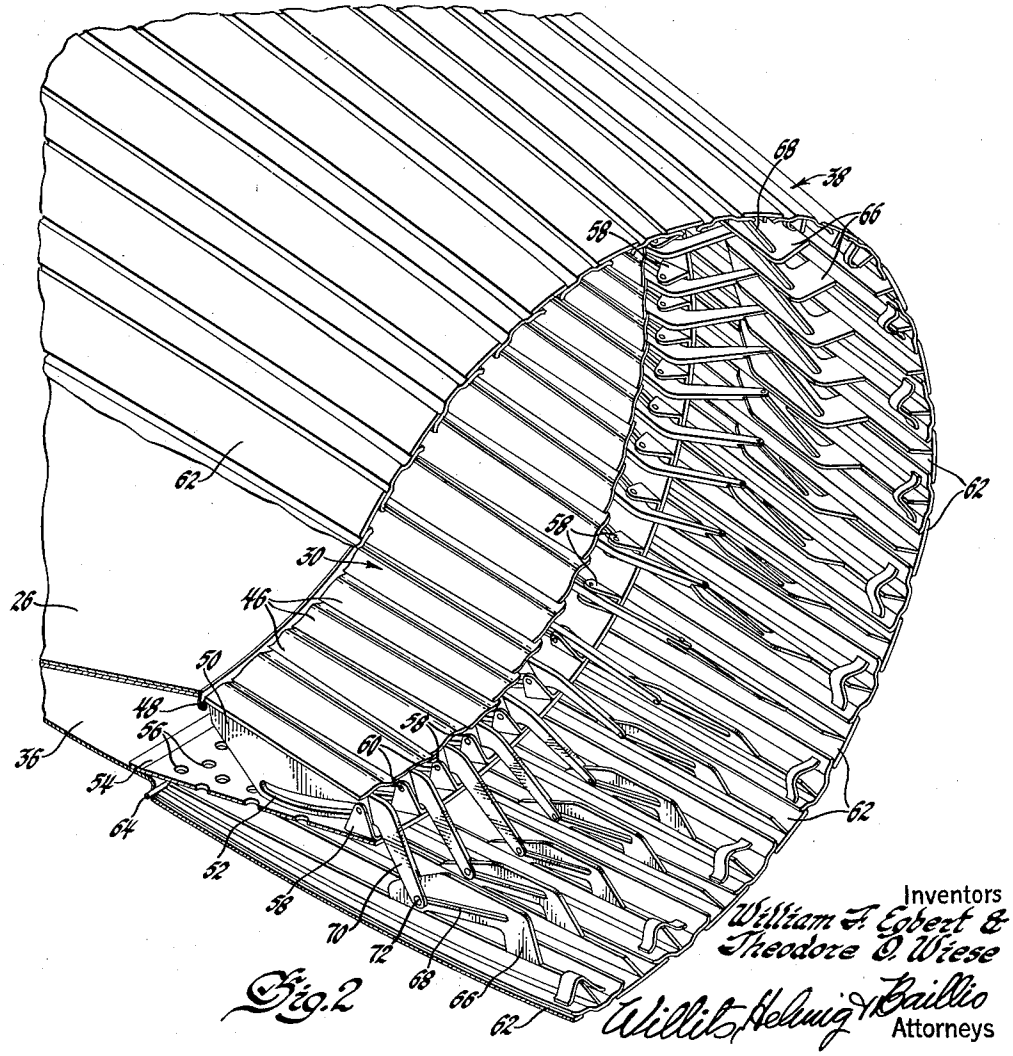


Fig. 2

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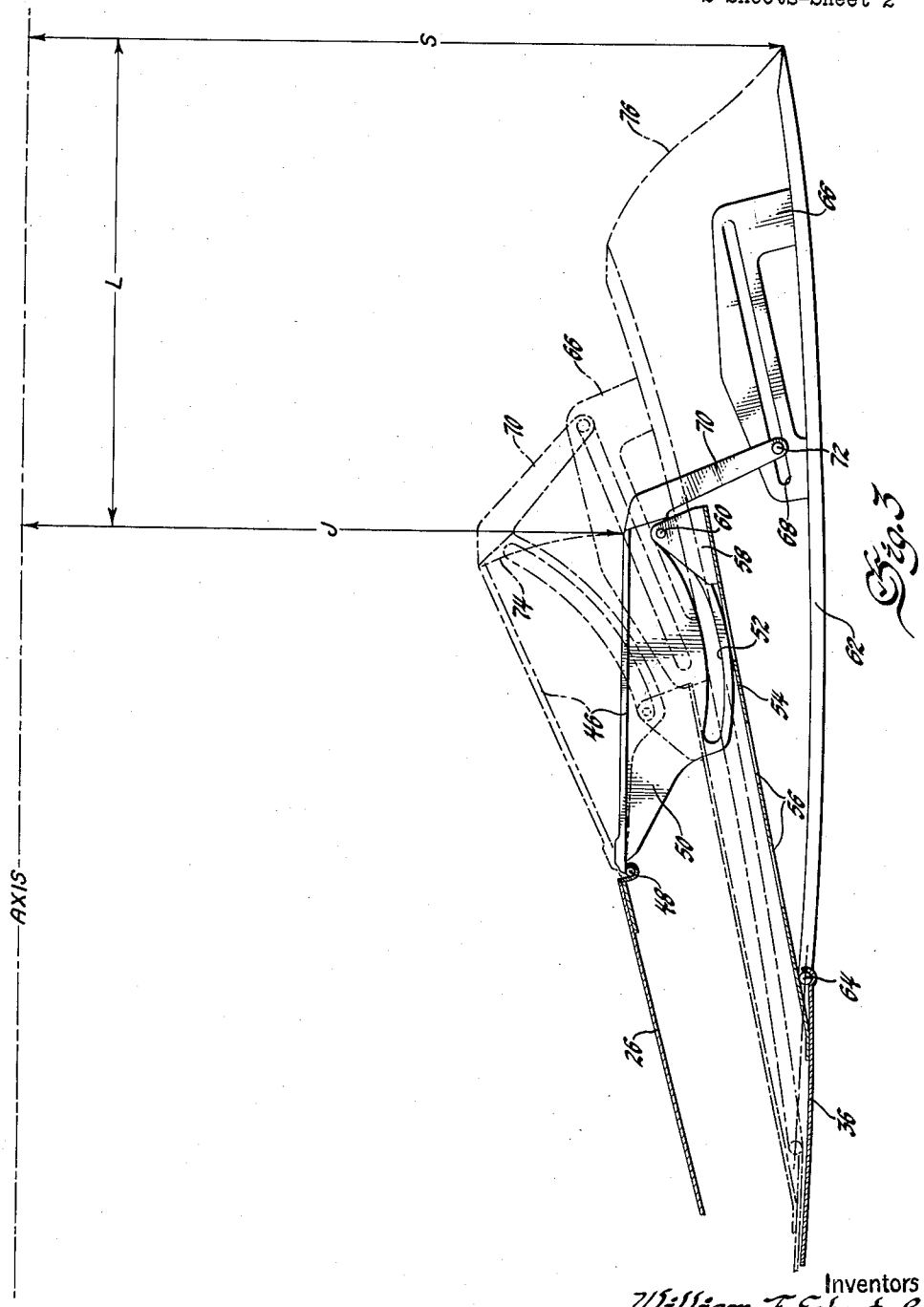


Fig. 3

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VARIABLE JET NOZZLE AND SHROUD

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5 Claims. (Cl. 60—35.6)

This invention relates to the exhaust system of a turbojet aircraft engine.

The invention is particularly applicable to turbojet engines having variable area jet nozzles such as are usually provided for turbojet engines equipped with afterburners. A variable area jet nozzle is necessary in an afterburner equipped engine because the optimum jet nozzle area with afterburning is greater than the optimum jet nozzle area without afterburning, and the high fuel rates associated with afterburning preclude its use except for take-offs and climbs and for attaining maximum speeds for short periods of time. A shroud pipe may be placed in closely spaced surrounding relationship with the exhaust tail pipe of the turbojet engine so that cooling air will be drawn between the shroud pipe and the tail pipe by the ejector action of the exhaust gases flowing through the tail pipe.

In the application of the ejector principle to a turbojet engine, the outlet of a shroud nozzle is placed in closely spaced relation with the outlet of the jet nozzle of the engine to form a mixing or entrainment chamber therewith. The engine exhaust stream issues from the jet nozzle and flows across the mixing chamber entraining cooling air supplied thereto by the shroud nozzle. With a jet nozzle of variable area type, it is desirable to have a variable area shroud nozzle to provide the desired degree of aspiration for all flight conditions, as it is impossible to design a non-variable area shroud nozzle that will provide correct aspiration for all flight conditions. For example, a fixed area shroud nozzle designed to aspirate properly for large area jet nozzle operations will over-aspirate at low area jet nozzle operations. Conversely, a fixed area shroud nozzle designed for low area jet nozzle operations will provide inadequate aspiration at large area jet nozzle operations.

The use of variable area shroud nozzles with high pressure ratio turbojet engines that may operate at supersonic speeds is particularly desirable, for choking and reverse flow in the shroud may occur if fixed area shroud nozzles designed for subsonic speeds are used. The cooling air flow is usually small with respect to the engine exhaust flow, for example three or four percent thereof. The degree of aspiration of an ejector of the type described is primarily dependent on two ratios; namely, the ratio of the jet nozzle outlet area to the shroud nozzle outlet area and the ratio of the distance between the boundary edges of the nozzle outlets to the square root of the jet nozzle outlet area.

The invention provides an arrangement whereby the jet nozzle outlet area may be varied with the shroud nozzle outlet area in a predetermined manner and wherein the distance between the boundary edges of the nozzle outlets may likewise be varied with the square root of the jet nozzle outlet area in a predetermined manner. The arrangement includes an axially movable shroud duct that actuates the jet nozzle through cam means to vary its outlet area and additional cam means connecting the jet nozzle to the shroud nozzle for concurrent variation of the outlet area of the shroud nozzle. The aforementioned ratios may vary for different operating conditions, but either one or both of the ratios is preferably maintained substantially constant for all operating conditions. As a result, the nozzle configuration accommodates to various operating conditions so as to achieve the desired operating effect. The accomplishment of this result is the principal object of the invention.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred form of the present invention is clearly shown.

In the drawings:

Fig. 1 is a longitudinal view of an aircraft turbojet engine installation, partially broken away.

Fig. 2 is a partial perspective, partially broken away, of the exhaust portion of the engine, and

Fig. 3 is a partial longitudinal section of the exhaust portion of the engine illustrating the coordinated movement between the jet and shroud nozzles in accordance with the invention.

Referring now to Fig. 1, a substantially annular turbojet engine **10** of known design is suitably supported in spaced relation in the annular interior of an aircraft nacelle **12**. The turbojet engine includes a compressor **14** which receives air from the nacelle inlet **16** and delivers it to the combustor **18** for expansion through a turbine **20** that drives the compressor. The high velocity exhaust gases from the turbine pass through an annular diffused casing **22** and an afterburner which includes an annular fuel injection and flameholder casing **24** and an annular combustion casing **26**. The high velocity, high temperature exhaust gases are emitted from the combustion casing **26** through a variable area jet nozzle **30** to drive the aircraft. An annular chamber **32** is formed between the turbojet engine **10** and the aircraft nacelle **12** and an annular chamber **34** is formed between an annular shroud duct **36** and the exhaust duct **26**. The shroud duct **36** is provided with a variable area shroud nozzle **38** and is slidably supported for axial movement with respect to the exhaust duct **26**. A number of suitable actuating cylinders **40** are secured to the engine to impart axial movement to the shroud duct **36** through the piston rods **42**. Cam means, to be described, interconnect the shroud duct and the nozzles **30** and **38** to vary concurrently their outlet areas and the spacing between the boundary edges of their outlets on axial movement of the shroud duct. An annular ejector mixing or entrainment chamber **44** is formed by the nozzles **30** and **38** to aspirate air from the inlet **16** through the chambers **32** and **34** to cool the outer surface of the jet engine **10**, especially the afterburner portion thereof.

Referring to Figs. 2 and 3, the jet nozzle **30** is defined by a plurality of overlapping flaps or staves **46** each pivotally secured to the end of the exhaust duct **26** at **48**. Each flap **46** includes an actuating plate **50** having a cam slot **52** therein. A conical member **54**, provided with cooling air passages **56**, is secured to the shroud duct **36** and a number of U-shaped brackets **58** are secured thereto. Each bracket **58** mounts a cross pin **60** slidably received in a respective jet nozzle flap cam slot **52** so that axial shifting of the shroud duct **36** will rotate the flaps **46** about their hinge axes **48** and thus vary the outlet area (πJ^2) of the jet nozzle **30**.

The shroud nozzle **38** is formed by a plurality of overlapping flaps **62** each pivotally secured to the shroud duct **36** at **64**. Each flap **62** includes an actuating plate **66** having a cam slot **68** therein. Each jet nozzle flap **46** carries a forked arm **70** and each arm has a cross pin **72** slidably received in a respective shroud nozzle flap cam slot **68**, so that axial movement of the shroud duct

36 will also vary the outlet area (πS^2) of the shroud nozzle 38. The distance L between the boundary edges of the outlets of the nozzles 30 and 38 is also varied by axial movement of the shroud duct 36. The ratio of the outlet areas of the exhaust and shroud nozzles (J^2/S^2) and the ratio of the axial distance between the boundary edges of the nozzle's outlets to the square root of the outlet area of the exhaust nozzle ($L/J\sqrt{\pi}$) may be varied in any desired fashion during axial movement of the shroud duct by suitably proportioning the nozzles and cam slots. The J^2/S^2 ratio and the $L/J\sqrt{\pi}$ ratio are preferably maintained substantially constant at all positions of the nozzles. Figs. 3 illustrates an arrangement that achieves these constant ratios. Dash-dot lines 74 and 76 trace the paths of the boundary edges of the jet and shroud nozzles during axial shifting of the shroud duct. Forward shifting of the shroud duct 36 effects pivotal movement of the nozzle flaps 46 and 62 from the open throttle solid-line position to the reduced throttle dash-dot position. The exhaust nozzle flaps 46 are swung towards the turbine axis about their fixed pivots 48 by the forward shifting of the camming pins 60. The shroud nozzle flaps 62 are swung towards the turbine axis about their forwardly shifting pivots 64 by the axially directed swinging movement of the camming pins 72. The shroud nozzle outlet area is thus reduced as a predetermined function of exhaust nozzle outlet area reduction and the spacing between the outlets is reduced likewise. The nozzles are so proportioned that substantially constant ratios are achieved with a cam slot 52 of circular configuration and a cam slot 68 of straight configuration, thereby simplifying the machining of the cam slots. Other nozzle proportions and cam configurations or other kinematic arrangements may be used to achieve a desired functional relation between the exhaust and shroud outlets.

While the preferred embodiment of the invention has been described fully in order to explain the principles of the invention, it is to be understood that modifications in structure may be made by the exercise of skill in the art within the scope of the invention, which is not to be regarded as limited by the detailed description of the preferred embodiment.

We claim:

1. A combination fluid nozzle and shroud construction comprising a plurality of nozzle flaps, support means having a direct pivot connection with said nozzle flaps adjacent their upstream ends to provide a nozzle outlet of variable area, a plurality of shroud flaps spaced from and about said nozzle flaps, longitudinally shiftable actuator means having a direct pivot connection with said shroud flaps adjacent their upstream ends to provide a shroud outlet of variable area, cam means interconnecting said nozzle flaps and said actuator means to swing said nozzle flaps about their pivot connection to vary the area of said nozzle outlet on longitudinal shifting of said actuator means, and cam means interconnecting said shroud flaps and said nozzle flaps to swing said shroud flaps about their pivot connection to vary the area of said shroud outlet with area variations of said nozzle outlet.

2. A combination fluid nozzle and shroud construction comprising a plurality of circumferentially overlapping nozzle members disposed to form a substantially annular nozzle surface; means pivotally supporting said nozzle members adjacent to their upstream ends for pivotal movement to vary the nozzle fluid flow area downstream of said pivotal supports; a plurality of circumferentially overlapping shroud members forming a substantially annular shroud co-axial with and about said nozzle members; axially moveable annular means co-axial with said nozzle and disposed adjacent to the upstream end of said shroud; means pivotally connecting the upstream ends of said shroud members to said annular means; and cam means operatively interconnecting said shroud members and nozzle members so that axial movement of said annular means is operative to pivotally move the downstream ends of said nozzle and shroud members inwardly and outwardly in the same direction.

3. A turbojet engine comprising an exhaust duct, a shroud duct around said exhaust duct in spaced relation thereto forming an air passage therewith, means for longitudinally shifting said shroud duct with respect to said exhaust duct, an exhaust nozzle comprising a plurality of flaps pivotally secured to said exhaust duct to provide an exhaust outlet of variable area, a shroud nozzle comprising a plurality of flaps pivotally secured to said shroud duct to provide a shroud outlet of variable area, the boundary edge of said shroud outlet being spaced from the boundary edge of said exhaust outlet to form an ejector therewith so that air will be aspirated from said air passage by the propulsive exhaust jet emerging from said exhaust outlet, cam means interconnecting said exhaust flaps and said shroud duct to vary the area of said exhaust outlet on longitudinal shifting of said shroud duct, and cam means interconnecting said shroud flaps and said exhaust flaps to vary the area of said shroud outlet on longitudinal shifting of said shroud duct, said nozzles and interconnecting cam means being proportioned to vary the area of said shroud outlet and the spacing between the boundary edges of said outlets as a predetermined function of the area variation of said exhaust outlet.

4. A turbojet engine comprising an exhaust duct, a shroud duct around said exhaust duct in spaced relation thereto forming an air passage therewith, means for longitudinally shifting said shroud duct with respect to said exhaust duct, an exhaust nozzle comprising a plurality of flaps pivotally secured to said exhaust duct to provide an exhaust outlet of variable area, a shroud nozzle comprising a plurality of flaps pivotally secured to said shroud duct to provide a shroud outlet of variable area, the boundary edge of said shroud outlet being spaced from the boundary edge of said exhaust outlet to form an ejector therewith so that air will be aspirated from said air passage by the propulsive exhaust jet emerging from said exhaust outlet, cam means interconnecting said exhaust flaps and said shroud duct to vary the area of said exhaust outlet on longitudinal shifting of said shroud duct, and cam means interconnecting said shroud flaps and said exhaust flaps to vary the area of said shroud outlet on longitudinal shifting of said shroud duct, said nozzles and interconnecting cam means being so proportioned that the ratio of the area of said exhaust outlet to the area of said shroud outlet is maintained substantially constant during longitudinal shifting of said shroud duct and the ratio of the distance between the boundary edges of said shroud and exhaust outlets to the square root of the area of said exhaust outlet is maintained substantially constant during longitudinal shifting of said shroud duct.

5. An aircraft turbojet engine installation comprising a nacelle, a turbojet engine housed in spaced relation in said nacelle and forming an air chamber therewith, said engine comprising an annular exhaust duct, an annular shroud duct around said exhaust duct in spaced relation thereto forming an annular air passage therewith, means for axially shifting said shroud duct with respect to said exhaust duct, an annular exhaust nozzle comprising a plurality of overlapping flaps pivotally secured to said exhaust duct to provide an annular exhaust outlet of variable area, an annular shroud nozzle comprising a plurality of overlapping flaps pivotally secured to said shroud duct to provide an annular shroud outlet of variable area, the annular boundary edge of said shroud outlet being spaced downstream and radially outward of the annular boundary edge of said exhaust outlet to form an ejector therewith so that air will be aspirated from said air passage and chamber by the propulsive exhaust jet emerging

from said exhaust outlet, cam means interconnecting said exhaust flaps and said shroud duct to vary the area of said exhaust outlet on axial shifting of said shroud duct, and cam means interconnecting said shroud flaps and said exhaust flaps to vary the area of said shroud outlet on axial shifting of said shroud duct, said nozzles and interconnecting cam means being so proportioned that the ratio of the area of said exhaust outlet to the area of said shroud outlet is maintained substantially constant during axial shifting of said shroud duct and the ratio of the distance between the boundary edges of said shroud and exhaust outlets to the square root of the area of said exhaust outlet is maintained substantially constant during axial shifting of said shroud duct.

References Cited in the file of this patent

UNITED STATES PATENTS

2,597,253 Melchior ---------- May 20, 1952

FOREIGN PATENTS

998,358 France ---------- Sept. 19, 1951