July 1, 1958 R. G. LAUCHER 2,840,984

LONGITUDINALLY MOVABLE SHROUD AND VARIABLE AREA EXIT NOZZLE FOR JET ENGINE AFTERBURNER

Filed Aug. 15, 1952 3 Sheets-Sheet 1

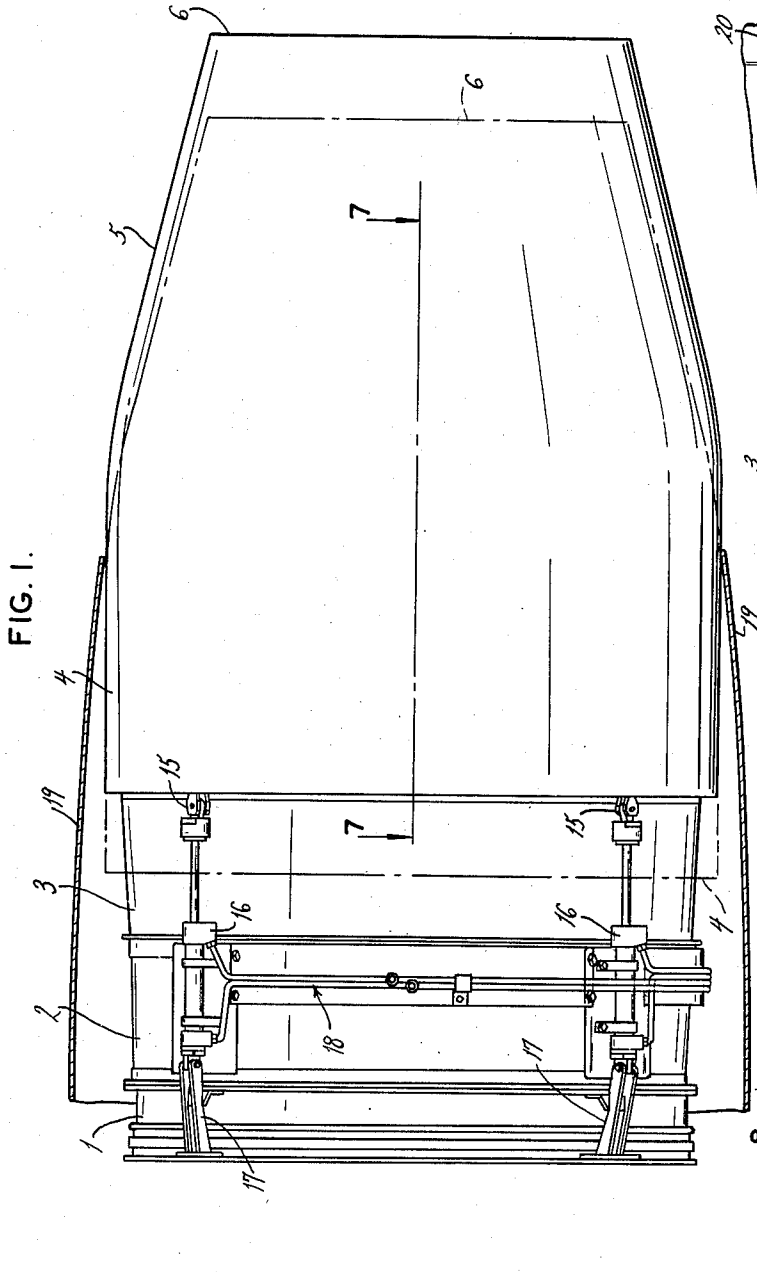


FIG. 1.

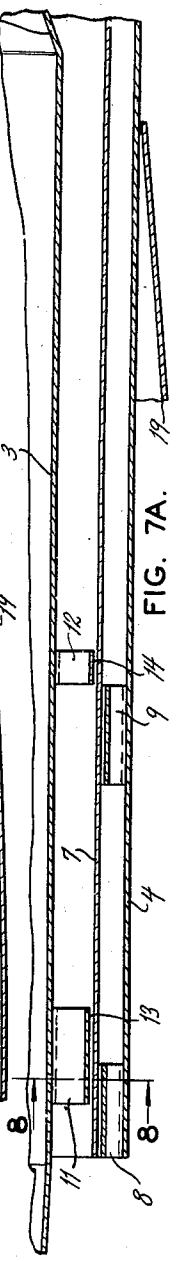


FIG. 7A.

INVENTOR.
RICHARD G. LAUCHER
BY
Gravely, Lieder & Woodruff & Dees
ATTORNEYS

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Filed Aug. 15, 1952 3 Sheets-Sheet 2

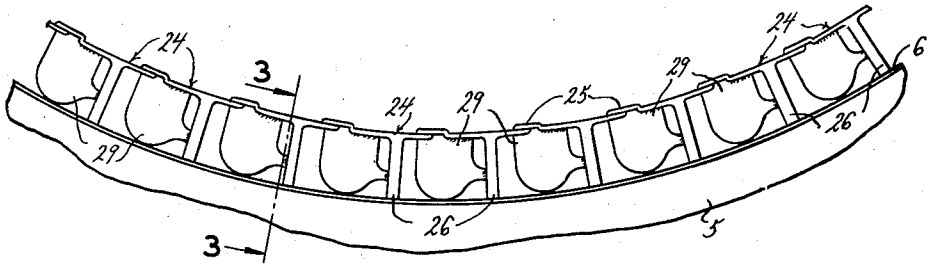


FIG. 2.

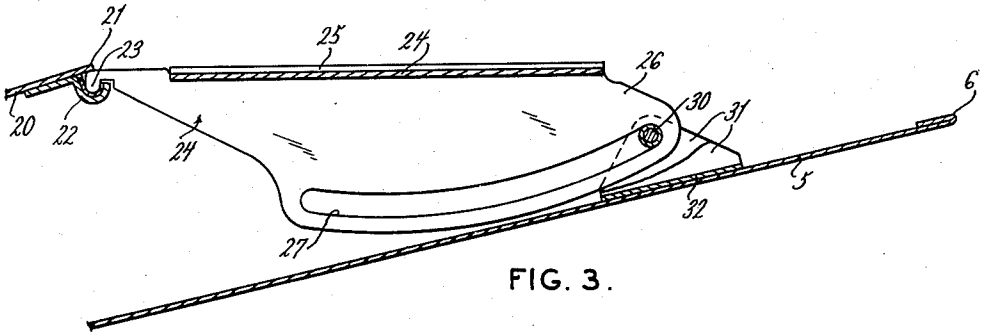


FIG. 3.

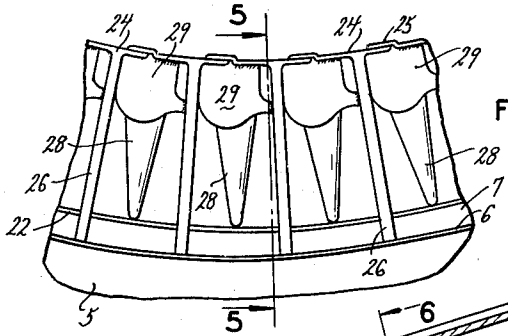


FIG. 4.

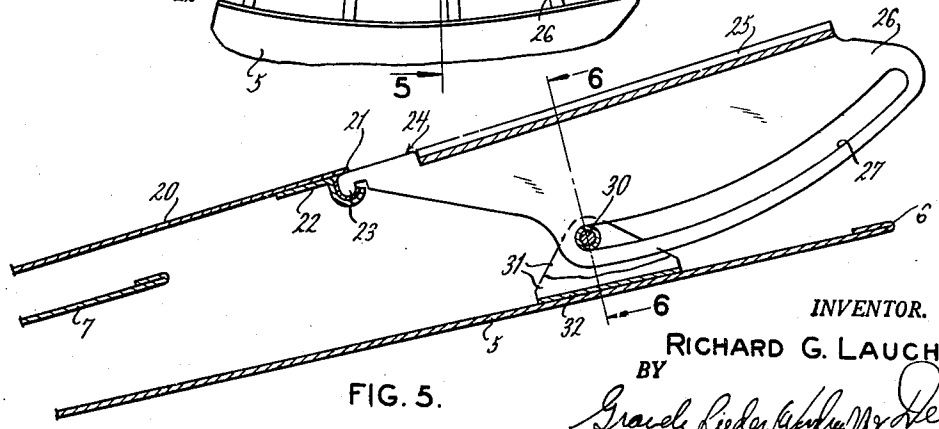


FIG. 5.

INVENTOR.
RICHARD G. LAUCHER
BY
Gravely, Lieder & Woodruff & Dees
ATTORNEYS

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Filed Aug. 15, 1952 3 Sheets-Sheet 3

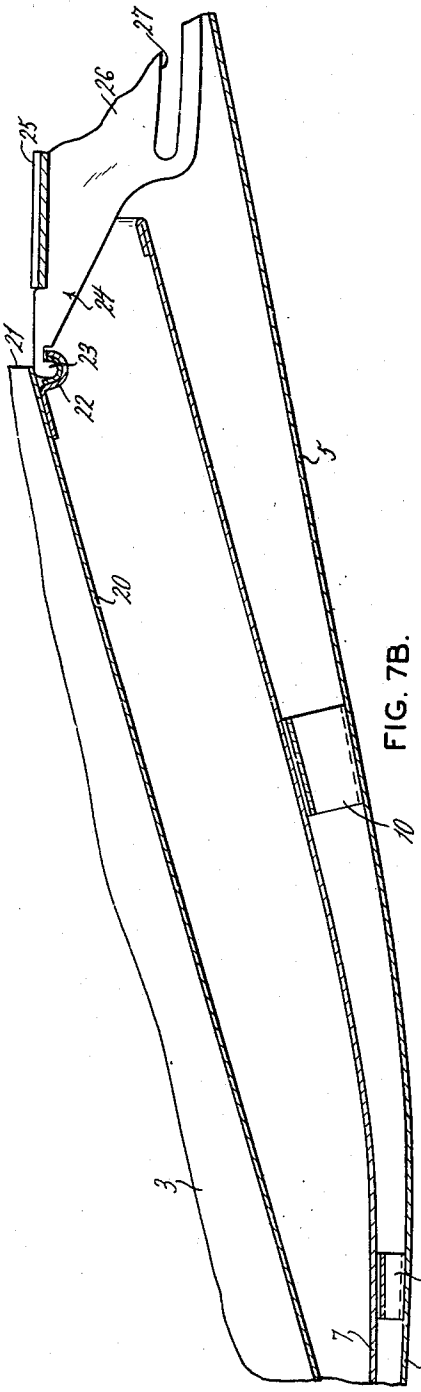


FIG. 7B.

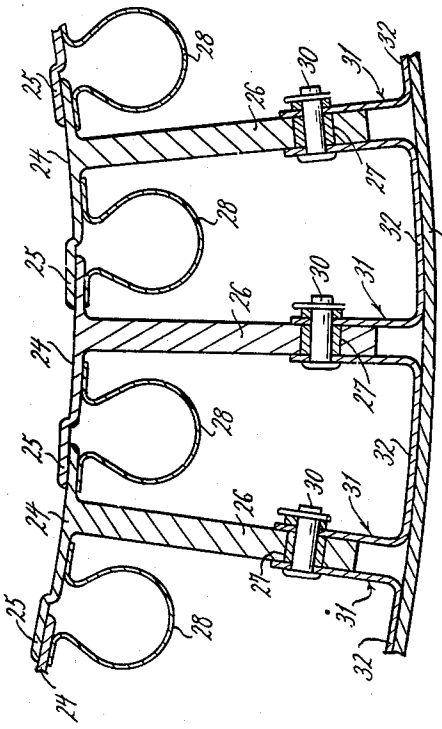


FIG. 6.

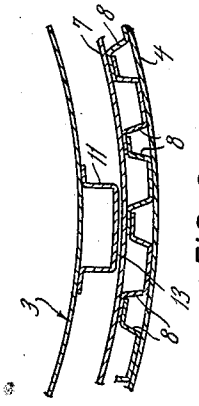


FIG. 8.

INVENTOR.
RICHARD G. LAUCHER
BY
Gravely, Lieder, Woodruff & Rees
ATTORNEYS

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LONGITUDINALLY MOVABLE SHROUD AND VARIABLE AREA EXIT NOZZLE FOR JET ENGINE AFTERBURNER

Richard G. Laucher, Van Nuys, Calif., assignor, by mesne assignments, to Westinghouse Electric Corporation, a corporation of Pennsylvania

Application August 15, 1952, Serial No. 304,600

5 Claims. (Cl. 60—35.6)

This invention relates to afterburners for jet engines, and particularly to shrouds for use with variable area afterburner exhaust nozzles.

Jet engines and afterburners are familiarly equipped with cooling shrouds. Such a shroud is, in effect, an annular cooling or air duct surrounding the combustion chamber and exhaust nozzle of the afterburner designed to induce the flow of cooling air and preventing disastrous overheating. Flow of cooling air is obtained in part by providing a cowling cooling opening to build up ram pressure upon forward flight, and in part by utilization of the augmentation or ejector effect of the exhaust gases. Augmentation or ejector effect is obtained by proper positioning of the rear opening of the shroud with respect to the concentric exhaust nozzle, so that the blast of gases from the exhaust nozzle will cause a reduction in relative pressure at the shroud rear opening thereby inducing the flow of the ducted cooling air between the shroud and the exhaust nozzle.

When an afterburner is added to the jet engine, a new cooling problem is presented. It is apparent that during afterburning operation, the cooling requirement will be greater than during non-afterburning operation. The present invention involves satisfying this requirement of increased cooling.

The principal object of the present invention is to provide an afterburner shroud which is movable to an aft position for increased ejector cooling while the engine is in afterburning operation, and to a forward position during non-afterburning operation.

A further object is to interrelate the operation of a longitudinally movable shroud with the operation of a variable diameter jet nozzle, so that they simultaneously assume their optimum relationships at any position between afterburning operation or non-afterburning operation.

An additional object of the present invention is to provide a simple mechanism to coordinate the positioning of an afterburner shroud for optimum ejector cooling with the enlargement of the jet nozzle for afterburning.

A still further object is to provide an exit nozzle having an annulus of convergible and divergible segments, adapted for use with a longitudinally movable shroud.

It is an additional object of the present invention to provide a jet nozzle adapted for enlargement and diminution by means of a tubular push-rod within which said nozzle is centered.

In the accompanying drawings:

Fig. 1 is an elevational view of the shroud and actuators therefor embodying the present invention, shown in afterburning position, the non-afterburning position being indicated by phantom lines;

Fig. 2 is a fragmentary rear end view of a jet nozzle embodying the present invention, shown in afterburning position;

Fig. 3 is a view partly in section taken along line 3—3 of Fig. 2;

Fig. 4 is a fragmentary rear end view of a jet nozzle similar to that shown in Fig. 2 but in nonafterburning position;

Fig. 5 is a partly sectional view taken along line 5—5 of Fig. 4;

Fig. 6 is a sectional view taken along line 6—6 of Fig. 5;

Figs. 7*a* and 7*b* taken together represent an enlarged sectional view taken along line 7—7 of Fig. 1; and

Fig. 8 is a sectional view taken along line 8—8 of Fig. 7*a*.

Referring now to the drawings by reference numerals and in greater detail, there is coupled to the aft end of a jet engine, not shown, an afterburner mounting ring **1**, secured to the throat **2** of an afterburner generally designated **3**. Included within the afterburner **3** and not shown on the drawing are the afterburning elements, fuel supply lines, fuel orifices, and flameholding means, as are presently well known.

Surrounding the afterburner **3** and held spacedly therefrom, as hereinafter set forth, is a generally tubular shroud **4** whose aft portion **5** converges in the formation of a hollow streamlined afterbody and terminates in an aft end opening **6**. Referring to Figs. 7*a*, 7*b*, and 8, stiffness is provided to the shroud **4** by means of an inner shroud wall **7**, mounted to the shroud **4** at its forward end by overlappingly spot-welded honeycomb spacing strips **8**. Similar intermediate spacing strips **9** and rear spacing strips **10** keep the inner shroud wall **7** in spaced alignment with the shroud **4** for the free passage of air. The inner shroud wall **7** is, in turn, kept spaced from the outer surface of the afterburner **3** by a plurality of forward spacer supports **11** and rear spacer supports **12**, having outwardly presented bearing surfaces **13**, **14**, respectively. The inner surface of the inner side wall **7** is adapted to bear slidingly on the bearing surfaces **13**, **14**, when the shroud **4** is longitudinally reciprocated thereon as hereafter described.

Secured to the forward end of the shroud **4** are a plurality of lugs **15** in which are pin-mounted the piston ends of hydraulic linear actuators **16**, each mounted at its forward end by an actuator bracket **17** to the afterburner mounting ring **1**. A harness of hydraulic lines **18** supplies the linear actuators **16** in parallel circuit with a source of hydraulic fluid under pressure, not shown.

The position of the aft end of the engine nacelle cowling **19** is shown in Figs. 1 and 7*a* in section.

Referring now to Fig. 7*b* and thence to Figs. 2, 3, 4, 5, and 6, the aft combustion chamber wall **20** of the afterburner **3**, converges to and terminates in the nozzle opening **21**, to the outer side of which is spot-welded an inwardly facing hinge ringe **22**, in which are mounted the forward lip portions **23** of nozzle segments generally designated **24**. These segments **24** are arranged in side-by-side relationship so as to form a hinged annulus having a sealed surface as will hereafter be more fully described.

Each of the nozzle segments **24** has a joggled side extension portion **25** which overlaps the adjacent nozzle segment **24** on the inner side of the nozzle. In addition, each nozzle segment **24** has an annular outward stem portion **26** arranged longitudinally and penetrated by an aft- and inward-extending cam slot **27**. Spring steel seals **28** shown in cross section in Fig. 6 in omega-shaped form and increasing in size from forward to aft ends, are secured, by spot-welding or otherwise, sealingly to and between adjacent nozzle segments **24**, as shown in Fig. 6, and are closed at their aft ends by seal caps **29**.

Cam-follower pins **30** penetrate the cam slots **27** and are mounted at both ends in the inward extending flanges of the adjacent aligned channel brackets **31**, whose webs **32** are spot-welded to the inner face of the aft portion **5** of the shroud **4**.

It will be observed from Figs. 1 and 3 that when the shroud 4 is in afterburning position, it is moved aft at such distance that the cam-follower pins 30 are at the extreme ends of the cam slots 27, and the linear actuators 16 are fully extended. In this position the aft end opening of the shroud 4 is substantially aft of the rear margins of the exhaust nozzle segments 24. This length is normally referred to as the "mixing length" and provides for cooling augmentation, or ejector action, on the flow of the cooling air, serving in effect to pump it through the shroud 4 at a rate sufficient for cooling during afterburning. In contrast, for non-afterburning operation, the shroud 4 is advanced forward so that the aft end opening 6 of said shroud is in the position shown in phantom lines in Fig. 1, or approximately adjacent the aft ends of the nozzle 24, as shown in Fig. 5. In this position, the augmentation of the cooling air is greatly reduced because of the lessened mixing length. The shroud is adjustable to any position between the two mechanical extremes in order to obtain the optimum performance in afterburning or non-afterburning position.

From a standpoint of function, it is to be noted that the shroud 4 serves in effect as a tubular push-rod actuating simultaneously all of the nozzle segments 24 for convergence and divergence. This brings about a positiveness of convergence and divergence of the nozzle segments not heretofore possible. In this way, the longitudinal positioning of the shroud 4 for optimum ejector cooling is mechanically coordinated with the enlargement of the jet nozzle area for afterburning operation, and the diminution of the jet nozzle area for non-afterburning operation accompanies the return forward of the shroud 4. In such forward position there is a lessened aerodynamic drag accompanying reduction in ejector pumping. It is to be noted that the shroud 4 fits closely within the end of the streamlined nacelle 19 and functions as the afterbody of said nacelle 19 between the forward and aft positions.

The invention has proved to be simple in construction, rugged and reliable in use, and highly effective in cooling under all conditions of operation.

It should be understood that changes and modifications in the form, construction, arrangement, and combination of the several parts of the longitudinally movable shroud for jet engine afterburners may be made and substituted for those herein shown and described without departing from the nature and principle of the present invention.

What I claim is:

1. In a jet engine afterburner, a variable area exit nozzle having a circumferentially enlarged position for afterburning operation and a circumferentially diminished position for non-afterburning operation, a generally tubular shroud surrounding the afterburner and converging to an aft end opening adjacent said variable area nozzle opening, said shroud having an open forward end for admission of cooling air, means for actuating and positioning said shroud longitudinally aft of said nozzle for increased flow of cooling air during afterburning and for returning said shroud to forward position for non-afterburning operation; and cam mechanism between the shroud and the variable area exit nozzle effective upon aft movement of the shroud to increase the nozzle exit area and effective upon forward movement of the shroud to diminish the nozzle exit area.

2. In a jet engine afterburner, a variable area exit nozzle having an enlarged diameter for afterburning operation and a diminished diameter for non-afterburning operation, a generally tubular shroud surrounding the afterburner and converging to an aft end opening adjacent said variable area nozzle opening, said shroud having an open forward end for admission of cooling air, means for actuating and positioning said shroud longitudinally aft of said nozzle for increased flow of cooling air during afterburning and for returning said shroud to forward position for non-afterburning operation; and cam mechanism coupling such longitudinal positioning of said shroud with the enlargement and diminution of said nozzle, whereby aft shroud movement enlarges and forward shroud movement diminishes the opening of said nozzle.

3. A variable area exit nozzle and shroud for jet engine afterburners comprising a shroud in the form of a hollow streamlined afterbody, converging to and terminating in an aft end opening, support structure adapted to permit longitudinal positioning of said shroud relative to said afterburner in a forward or non-afterburning position, and in an aft or afterburning position, a plurality of parallel linear actuators secured between said shroud and such afterburner for selecting and retaining such position, an exit nozzle within said streamlined afterbody movable into a position of circumferential enlargement for afterburning operation and into a position of circumferential diminution for non-afterburning operation; and cam means interconnecting said nozzle with said shroud so constructed and arranged as to relate the forward movement of said shroud into non-afterburning position with the diminution of said exit nozzle area and the aft movement thereof into afterburning position with the enlargement of said exit nozzle area.

4. In a jet engine afterburner, a variable diameter exit nozzle including a hinge ring and an annulus of nozzle segments hinged thereto, the said segments being of substantially T-shaped cross-section and being arranged with the stem portions of such T-sections radially outward from said nozzle, a cam slot in each said stem portion, and a tubular reciprocable actuator surrounding said nozzle to form a streamlined afterbody for the nozzle and engaging the said cam slots, so constructed and arranged that the forward movement of said actuator converges and the aft movement thereof diverges said nozzle segments.

5. For use with a jet engine afterburner, a generally tubular shroud converging to and terminating in an aft end opening, a variable diameter exit nozzle including a hinge ring and an annulus of nozzle segments hinged thereto, the said segments being of substantially T-shaped cross-section and being arranged with the stem portions of such T-sections radially outward from said nozzle, each stem portion having a cam slot therein, a plurality of cam slot-engaging means secured to the inner surface of said shroud in radial correspondence with the said stem portions of said nozzle segments; and actuator means adapted selectively to position said shroud in a forward position wherein the said aft end opening stands adjacent the aft margins of said nozzle segments and said nozzle segments are converged, and in an aft position wherein said shroud aft end opening projects behind the aft margins of said nozzle segments a length suitable for optimum ejector cooling and wherein said nozzle segments are diverged.

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