United States Patent [19]

Swavely et al.

[11] **3,792,815**

[45] **Feb. 19, 1974**

[54] **BALANCED FLAP CONVERGING/DIVERGING NOZZLE**

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[73] Assignee: **United Aircraft Corporation,** East Hartford, Conn.

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[21] Appl. No.: **309,567**

Related U.S. Application Data

[63] Continuation of Ser. No. 209,665, Dec. 20, 1971, abandoned.

[52] **U.S. Cl.** **239/265.39,** 6/242

[51] **Int. Cl.** **B64c 15/08**

[58] **Field of Search**..... 239/265.33, 265.37, 265.39; 60/242

[56] **References Cited**

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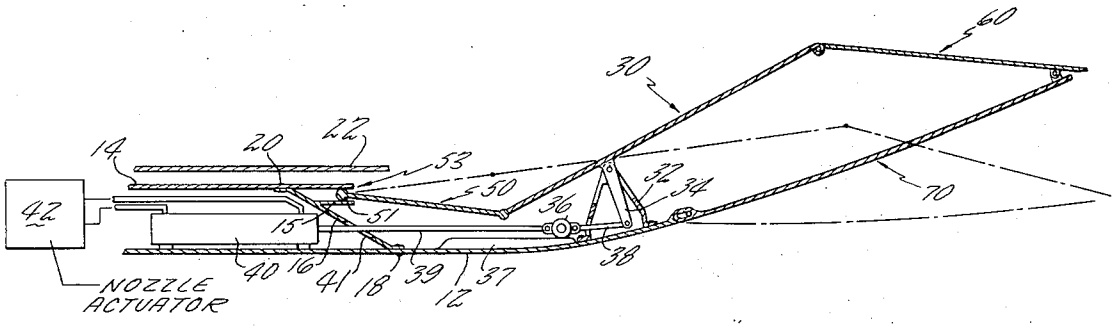
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Assistant Examiner—Michael Y. Mar
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[57] **ABSTRACT**

A nozzle having four sets of flaps is formed on the exhaust end of a turbojet engine. One set of main flaps is pivotally located downstream of an exhaust opening with a second set of balance flaps pivotally connected between said main flaps and the rear end of the engine. A third set of diverging flaps are pivotally mounted to the main flaps and extend downstream thereof with the downstream end of said diverging flaps being pivotally connected at their rearward end to a fourth set of external flaps which are pivotally mounted at their forward end to the outer housing of the engine by a lost-motion connection. The nozzle actuating system is connected to a plurality of levers on the main flaps by a unison ring which pivots the main flaps about their pivot means to obtain the desired nozzle opening. All of the flaps move in unison with the main flaps.

11 Claims, 3 Drawing Figures



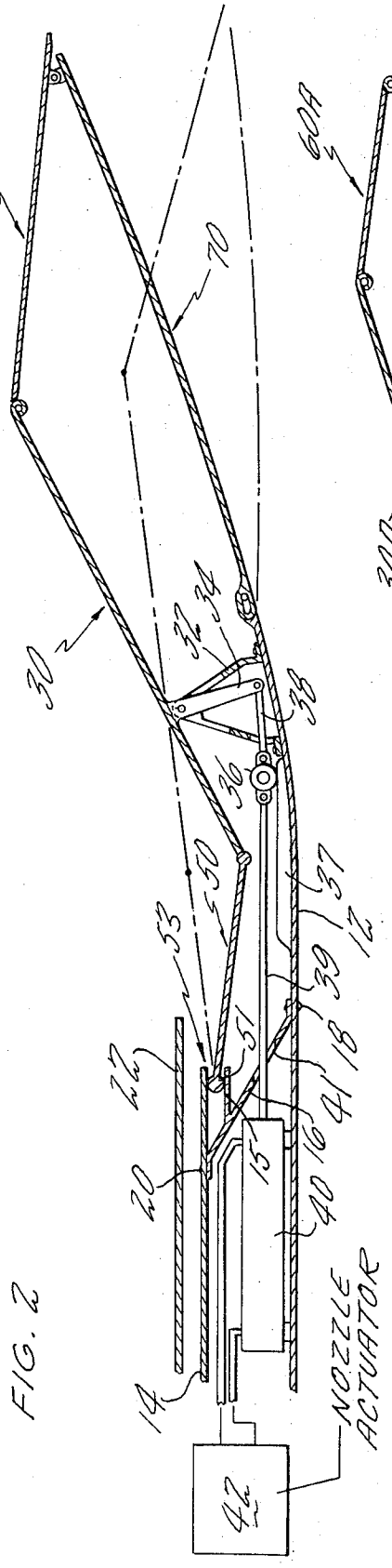


FIG. 2

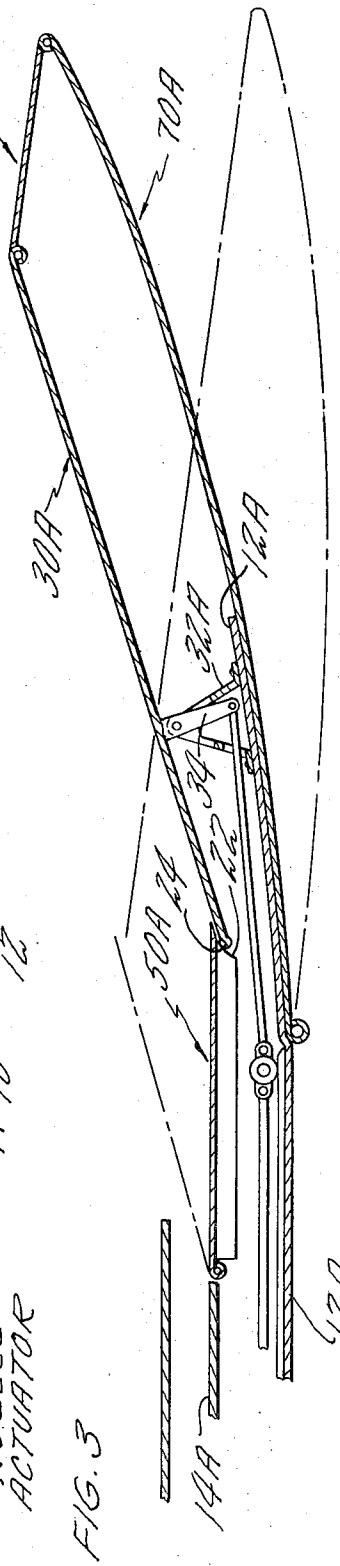


FIG. 3

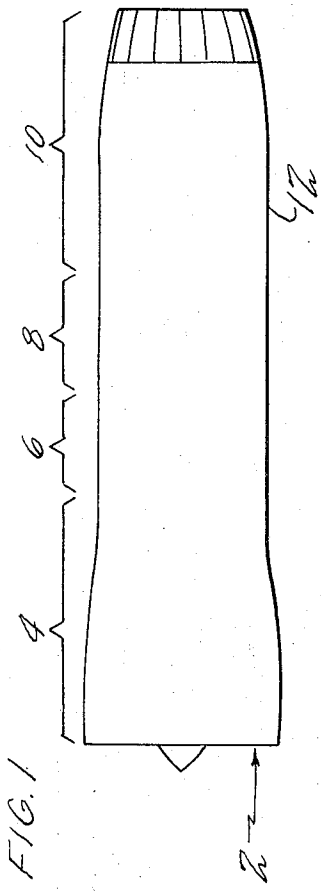


FIG. 1

BALANCED FLAP CONVERGING/DIVERGING NOZZLE

This is a continuation, of application Ser. No. 209,665 filed Dec. 20, 1971 now abandoned.

The invention disclosed herein was made in the course of or under a contract with the Department of the Air Force.

BACKGROUND OF THE INVENTION

This invention relates to variable area nozzles for turbojet engines and while many nozzles are in the prior art, none appear to provide the cooperating movement between diverging and converging flaps along with a balance flap and external flap such as set forth herein. Several prior art nozzle patents are identified in the specification.

SUMMARY OF THE INVENTION

A primary object of the present invention is to provide a balanced flap convergent/divergent nozzle system having a contiguous variable divergent section.

In accordance with the present invention, a long flap system is provided having low external drag, high internal performance, and without the need for high actuation forces.

A stable nozzle system is set forth that can provide internal geometry variation for complete integration with the airframe for subsonic and supersonic flight conditions. This nozzle is capable of attaining the correct area ratios and divergence angles for high internal performance and the external geometry has a minimum of projected area for drag to act upon.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view illustrating the application of the invention to a turbojet engine.

FIG. 2 is an enlarged sectional schematic view taken through the nozzle and the rear portion of the engine showing the maximum area and minimum area position of the flaps of the nozzle.

FIG. 3 is an enlarged sectional schematic view of a modification of the nozzle shown in FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, the engine 2 shown includes the conventional compressor section 4, the burner section 6, turbine section 8, and exhaust duct and nozzle section 10. In FIG. 2, the inner case 14 is shown fixed to the outer housing structure 12 by a conical shaped connecting member 16. This member is attached to the outer housing by bolts 18 and extends forwardly to a point where it is connected to the inner casing by bolts 20, forming the section of a cone. An inner liner 22 is positioned around and fixedly spaced from the inner side of inner case 14.

A plurality of main flaps 30 are mounted for pivotal movement at the rear end of the outer housing structure 12. These flaps are each pivotally mounted on a bracket member 32 which extends inwardly from the end of the structure 12. An actuating arm 34 extends outwardly from each flap and movement of the arm actuates the attached main flap 30 about its pivotal mounting. Each flap 30 is pivotally mounted at a desired balance point. In one nozzle design, this location was made approximately one-third of the distance from its forward edge. Each pivotal mounting is substantially in axial alignment with the inner liner 22.

So that all the main flaps 30 are moved in unison the free end of each of the arms 34 is connected to a unison ring 36 by connecting link 38. A plurality of actuating cylinder and piston units 40 are mounted in the space between the housing structure 12 and the inner case 14 in front of the connecting member 16. An actuating rod 39 extends from each of the cylinder and piston units 40 and is attached to the unison ring 36. The unison ring 36 is centered within and slides on track members 37. Each actuating rod 39 extends through an opening 41 in the connecting member 16. A nozzle actuator 42 connects one side of the cylinder and piston unit to an actuating pressure while opening the opposite side to drain thereby movably positioning the main flaps 30. An arrangement of this type is shown in U. S. Pat. No. 2,815,643.

A plurality of balance flaps 50 extend forwardly of the main flaps 30. Each flap 50 has its rearward end pivotally connected to the forward end of a main flap 30 while its forward end has cylindrical means 51 thereon which is mounted for axial movement in a track means 53. Each track means 53 is formed between a rearward extension of the inner case 14 and a rearward extending flange 15 on the connecting member 16. While a simple cylinder and track means has been shown, any type of device permitting axial movement along with a change in angular position of the balance flap 50 can be used.

A plurality of divergent flaps 60 extend rearwardly of the main flaps 30. Each flap 60 has its forward end pivotally connected to the rearward end of a main flap 30 while its rearward end is pivotally connected to the rear end of an external flap 70. Each external flap 70 has its forward end pivotally mounted at the rear end of the housing structure 12, just rearwardly of the bracket members 32. Each of these pivotal connections can include a lost-motion movement.

Each of the annular set of flaps, the balance flaps 50, the main flaps 30, the divergent flaps 60, and the external flaps 70, can have seal means positioned along adjacent side edges of cooperating flaps to prevent an excessive amount of leakage therebetween. Seal means are shown in U. S. Pat. No. 2,972,226; U. S. Pat. No. 3,004,385; U. S. Pat. No. 2,697,907; and U. S. Pat. No. 2,910,828.

In operation, it can be seen that when the nozzle actuator 42 directs an actuating pressure to the forward side of the cylinder and piston unit 40, the actuating rod 39 will place the unison ring 36 in its rearward position (as shown in solid in FIG. 2) with the flaps positioned so as to form the minimum throat portion at the hinge location between flaps 30 and 60. When the nozzle actuator 42 directs an actuating pressure to the rearward side of the cylinder and piston unit 40, the actuating rod 39 will be moved forwardly placing the unison ring 36 in a more forward position with the flaps positioned differently. In FIG. 2, the phantom lines show the flaps 50, 30, and 60 in a position where the flaps 50 and 30 form a long converging surface while the flap 60 continues to be the diverging portion.

Referring to FIG. 3, a plurality of main flaps 30A are mounted for pivotal movement at the rear end of the outer housing structure 12A. These flaps are each pivotally mounted on a bracket member 32A which extends inwardly from the end of the structure 12A. An

actuating arm 34A extends from the flap 30A in the same manner as in FIG. 2 with the actuating mechanism also being the same. In FIG. 3, each balance flap 50A is pivotally mounted at its front end to the rear of the inner case 14A and has a cam surface 22 at the rear end which rides on a cam follower 24 positioned on the forward end of its cooperating flap 30A. The flaps 30A, 60A, and 70A are each connected in the same manner as the corresponding flaps in FIG. 2. However, flap 70A has its forward end pivotally mounted on the housing structure 12A at a point forwardly of the bracket member 32A. The nozzle shown in FIG. 3 permits the formation of a different configuration than that of FIG. 2, without varying from the spirit of the invention.

In operation, it can be seen that when the nozzle actuator 42 directs an actuating pressure to the forward side of the cylinder and piston unit 40, the flaps will be positioned so as to form the minimum throat portion at the hinge location between flaps 30A and 60A. As before, when the nozzle actuator 42 directs an actuating pressure to the rearward side of a cylinder and piston unit 40, the valve flaps will be positioned differently with the unison rings 36 in a more forward position. In FIG. 3, the phantom lines show the flaps 50A forming the converging portion with the flaps 30A and 60A forming a long diverging surface. It is noted that the minimum throat area has now moved upstream to the hinged location between the flaps 50A and 30A. Further, approximately the same shallow divergence angle is maintained in both positions shown of the nozzle in FIG. 2 thereby providing high performance at both subsonic and supersonic pressure ratios.

Stop means can be located in the cylinder and piston unit 40 or between the bracket members 32 and arms 34 to predetermine the range of movement of the main flaps 30 and 30A, and therefore the remaining associated flaps, to arrive at the desired limit positions of the flaps.

An actuating system for a nozzle such as shown in this application, is disclosed in co-pending application Ser. No. 209,664 Filed Dec. 20, 1971, now U.S. Pat. No. 3,730,436 for SYNCHRONIZED EXHAUST NOZZLE ACTUATING SYSTEM to William M. Madden et al. Further, an exit area schedule selector system for a nozzle such as disclosed herein is disclosed in co-pending application Ser. No. 209,803, Filed Dec. 20, 1971, for EXIT AREA SCHEDULE SELECTOR SYSTEM by Kenneth E. Harmon. A seal means for a nozzle such as disclosed herein is set forth in co-pending application Ser. No. 210,017, Filed Dec. 20, 1971, for SEAL CENTERING AND RETENTION MEANS by Connie W. McMath.

We claim:

1. In combination with jet engine fixed structure, an exhaust nozzle mounted on said fixed structure, said nozzle comprising a circumferential row of first main flaps pivotally mounted on said fixed structure for controlling the flow area therethrough, second balance flaps located between the forward edge of said first main flaps and a point on said fixed structure forwardly of the forward edge of said first main flaps, third divergent flaps, fourth external flaps, said third divergent flaps having their forward ends pivotally mounted to the rearward ends of said first main flaps, said fourth external flaps having their forward ends pivotally mounted to said fixed structure radially outwardly from the pivotal mounting of the first main flaps, the rear ends of said third divergent flaps and said fourth external flaps being pivotally connected together, and an actuating means for variably positioning said first main flaps.

2. In combination with jet engine fixed structure, an exhaust nozzle mounted on said fixed structure, said nozzle comprising a circumferential row of first main flaps, means pivotally mounting said first main flaps on said fixed structure for controlling the flow area therethrough, second balance flaps being positioned between the forward edge of said first main flaps and a point on said fixed structure forwardly of the forward edge of said first main flaps, third divergent flaps, said third divergent flaps having their forward ends pivotally mounted to the rearward ends of said first main flaps, first flap connecting means for connecting each third divergent flap rearwardly of its forward end to fixed structure radially outwardly from the pivotal mounting of the first main flaps, said first flap connecting means having its forward end pivotally mounted to said fixed structure radially outwardly from the pivotal mounting of the first main flaps, said first flap connecting means having its rear end pivotally mounted to a third divergent flap rearwardly of its forward end, and an actuating means for variably positioning said first main flaps.

3. A combination as set forth in claim 2 wherein said first flap connecting means comprises external flaps.

4. A combination as set forth in claim 2 wherein said engine fixed structure includes an exhaust duct located forwardly of said exhaust nozzle, each main flap is pivotally mounted at a point downstream of said exhaust duct and substantially in axial alignment therewith.

5. A combination as set forth in claim 4 wherein the forward end of said second balance flaps are mounted around the rear end of the exhaust duct.

6. A combination as set forth in claim 2 wherein each main flap is pivotally mounted at a point one-third of its distance from its forward end.

7. A combination as set forth in claim 2 wherein the nozzle throat can vary between the location where the first main flaps and second balance flaps meet and the location where the first main flaps and third divergent flaps meet.

8. A combination as set forth in claim 2 wherein said engine fixed structure includes an outer duct forming an external nacelle, said first flap connecting means having their forward ends pivotally mounted to the rear end of said nacelle.

9. A combination as set forth in claim 8 wherein said first main flaps are mounted on brackets fixed to the inner side of said external nacelle.

10. A combination as set forth in claim 9 wherein said first flap connecting means has its forward end mounted forwardly of the pivotal mounting of said first main flaps, said first flap connecting means engaging said outer casing along a portion of their length when the nozzle throat is at its minumum diameter.

11. A combination as set forth in claim 5 wherein a mounting means is provided for the forward end of the second balance flaps around the rear end of the exhaust duct, said mounting means permitting the balance flaps to move with the first main flaps while providing a balancing action due to the forces acting on the balance flaps.

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