May 3, 1960 M. KADOSCH ET AL 2,934,896

VARIABLE-AREA PROPELLING NOZZLE COMBINED WITH A THRUST SPOILER

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Fig. 2

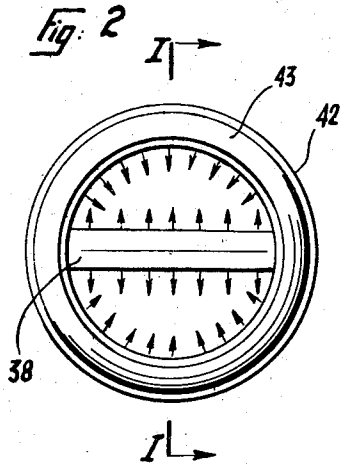


Fig. 1.

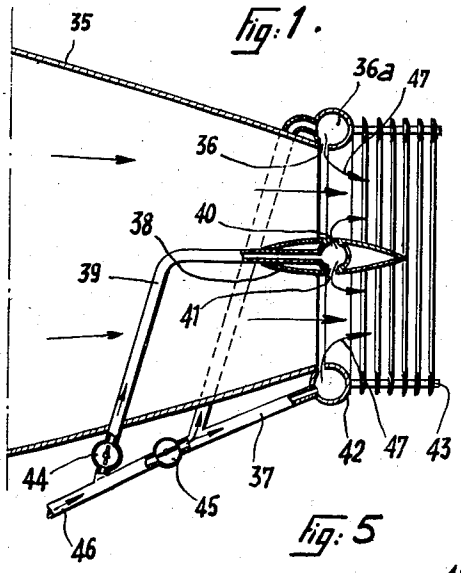


Fig. 3

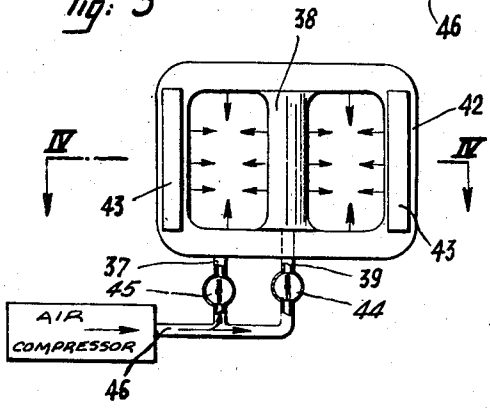


Fig. 5

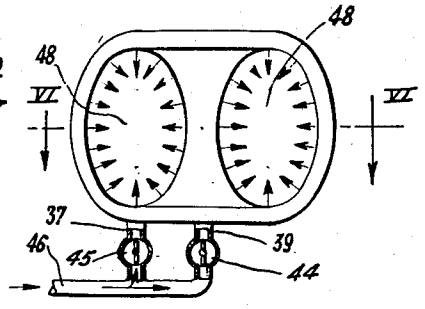


Fig. 6

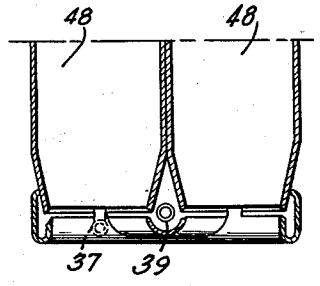
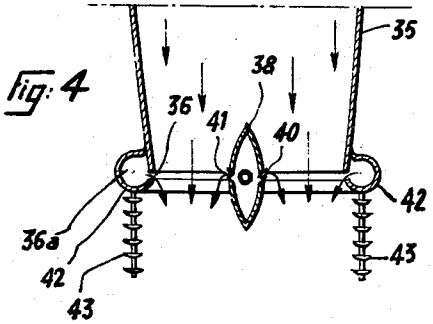


Fig. 4



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VARIABLE-AREA PROPELLING NOZZLE COMBINED WITH A THRUST SPOILER

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Application June 1, 1953, Serial No. 358,668

Claims priority, application France June 5, 1952

3 Claims. (Cl. 60—35.54)

U.S. patent application Serial No. 263,666, filed December 27, 1951, discloses a flow control device for a jet propulsion nozzle allowing of varying the available area of the nozzle by means of a screen-like fluid jet formed about said nozzle in a general transverse direction with respect thereto.

The object of the present invention is to combine such a nozzle area control device with a thrust spoiling device for laterally deflecting the propulsive jet when a reduction in thrust is desired.

A further object of this invention is to so combine these two devices that they may act separately or simultaneously in order to obtain an improvement of the operation during the periods when the jet deflection or thrust spoiling device is not in operation, or the maximum reduction of the area of the discharge nozzle, or other useful effects which will be indicated below.

The description which follows below with reference to the attached drawings (which are given by way of example only and not in any sense by way of limitation) will make it quite clear how the invention is to be carried into effect, the special features which are referred to, either in the text or in the drawings, forming, naturally, a part of the said invention.

Figure 1 is a diagrammatic axial cross-section of the discharge nozzle of a reaction unit provided with a combined arrangement for the contraction and the deflection of the jet.

Figure 2 is a rear view of the same discharge nozzle.

Figure 3 is a rear view of a rectangular discharge nozzle provided with a combined arrangement analogous to that of Figure 1.

Figure 4 is a horizontal cross-section through the line IV—IV of Figure 3.

Figure 5 is a rear view of a double discharge nozzle having two elliptical openings.

Figure 6 is a section taken along line VI—VI of Figure 5.

Figures 1 and 2 show the discharge nozzle 35 of a reaction unit of any particular kind, of a turbo-jet unit for example, which is provided with a hollow annular chamber 36*a*, of circular cross-section, which has an annular slot 36, the direction of which is approximately at right angles to the axis of the discharge nozzle and which is adapted to produce a jet of auxiliary fluid 47 enabling the area of the outlet of the discharge nozzle 35 to be varied, as described in the above-mentioned patent application. This fluid is supplied by a source at a total head which is higher than the static pressure of the flow through the discharge nozzle 35; this source of pressure fluid may be the compressor of the reaction unit or an auxiliary compressor. The slot 36 can be given a profile so as to expand the auxiliary fluid which passes through it and to increase its speed, thereby producing a jet having a high dynamic pressure. The slot may have a shape of the convergent-divergent type and its axis may be inclined towards the front of the nozzle 35.

This exhaust nozzle 35 is, in addition, provided with

an arrangement for deflecting the jet, similar to that which has been described in the U.S. patent application Serial No. 229,772 filed June 4, 1951, now Patent No. 2,793,494. This arrangement includes, as shown in the drawings, a hollow streamlined body 38 of airfoil cross-section, disposed along a diameter of the discharge nozzle. The streamlined body could also be a body of revolution about the axis of the discharge nozzle.

The internal volume of this body 38, as well as the chamber 36*a*, is adapted to receive a gas under pressure constituted, for example, by air taken from the compressor of the reaction unit and which may be previously heated to increase its internal energy. On its opposite faces, the body 38 comprises two slots 40 and 41 extending over the whole of the length of the said body and inclined upstream of the main flow in the discharge nozzle 35. In this way, the thin auxiliary jets ejected from the slots 40 and 41 have a tendency to force back the gases flowing through the discharge nozzle 35 and to deflect them from their normal direction of flow, laterally of the diametrical plane occupied by the streamlined body 38. The gases which are deflected in this way tend to adhere to the rounded edge or convex extension 42 of the discharge nozzle, formed by the external wall of the chamber 36*a*. There may thus be obtained a reduction in propulsive thrust or even a negative thrust if the deflection exceeds 90°. A series of curved blades 43 with their concavity facing upstream and which are disposed beyond the convex extension 42, facilitate the obtaining of a large deflection by guiding portions of the jet once the deflection has been started.

When the contraction and deflection arrangements i.e. the nozzle area and thrust varying devices, are not in operation, the gases escaping freely from the nozzle of the reaction unit into the atmosphere have a generally divergent shape by virtue of the flow which they induce in the surrounding atmosphere and also due to the fact that the gases mix with the air. As a consequence of this, the set of blades 43 can intercept a small part of the gases, which has the effect of reducing the thrust as compared with a reaction unit which is not provided with such blades.

The effect of the blowing of air through the peripheral slot 36, during periods when the jet is not being deflected, is to eliminate this disadvantage by forcing the flow inwards to a certain distance from the blades 43 as indicated by the arrows 47. This constitutes a first method of use of the arrangement shown in Figures 1 and 2.

On the other hand, in the embodiment shown, the slots 40 and 41 of the deflection or thrust spoiling device and the annular slot 36 of the contraction or area varying device are practically in opposition. If therefore these two devices are put in action simultaneously by opening the two valves 44 and 45 which supply them through a common feed pipe 46 connected to the source of gas under pressure such as, for example, the air compressor of the reaction unit or an auxiliary compressor, the auxiliary jets are ejected towards each other in the one case from the slot 36, and in the other case from the slots 40 and 41 and tend to squeeze between them the main jet in the discharge nozzle. In this way, they give to this jet a convergent form, the neck of which constitutes the effective area of the nozzle and which may be varied by adjusting the two auxiliary jets, by means of the valves 44 and 45. This constitutes a second method of use of the arrangement illustrated. It will be noted that, in this case, there is obtained a supplementary advantage which consists in the elimination of the bad effect of the angles which exist in the geometric section of the gas outlet between the diametrical body 38 and the discharge nozzle (see Figure 2). At these points, the gases have a tendency to be slowed down with the production of eddy

currents in the transverse planes, which results in a loss of energy of the gases and, in consequence, of axial thrust. This disadvantage is overcome by putting into simultaneous operation the auxiliary jets ejected from the slot **36** and the slots **40** and **41**. Reference to Figure 2 and the arrows which have been drawn to show the two systems of auxiliary jets, will show that the main jet is thus accelerated just as much in the angles as in the other portions of the area, and the detrimental effect of the angles is thus eliminated.

When it is desired to vary the area of the outlet, the output of the auxiliary jets is adjusted, as has already been explained above, by operating the valves **44** and **45**, the valve **44** of the jet deflecting device being closed when it is desired to increase the area of the outlet opening.

When it is desired to deflect the gases in order to reduce the thrust, the blowing action through the slot **36** is stopped by closing the valve **45** so that the auxiliary jets which escape from the slots **40** and **41** act alone in repelling the gases towards the blades **43**. This constitutes a third method of use of the device.

The stopping of the blowing action through the slot **36** has the effect of increasing the effective area of outlet for the gases, of reducing their kinetic energy and in a general way of reducing the temperatures along the whole of the reaction unit, all of which are features which are clearly favourable to the efficiency and the safety of the transition to operation with deflection.

The arrangement described is applicable to discharge nozzles having outlet openings of any shape whatever.

Figures 3 and 4 show an application to a discharge nozzle having a rectangular cross-section. The streamlined body **38**, provided with slots **40** and **41** for the auxiliary deflection jets, is arranged along an axis of symmetry of the rectangle whilst the slot **36** which provides the contraction or area control jet extends over the periphery of the rectangle which is not occupied by the body **38**. With such an arrangement, there is the advantage that the blades **43** are arranged on the sides of the rectangle parallel to the body **38** and are thus cylindrical instead of being tore-shaped as in the case of Figures 1 and 2.

Figures 5 and 6 show an arrangement of a similar kind

applied to a double discharge nozzle comprising two separate orifices **48** of approximately elliptical shape. This form of discharge nozzle has the advantage that it avoids corner parts having a very small radius of curvature.

What we claim is:

1. In a jet propulsion unit having a propulsive nozzle designed for forming an axially-issuing propulsive jet, an auxiliary slot-like nozzle extending along the outlet periphery of said propulsive nozzle and directed inwardly, piping means for supplying pressure gas to said auxiliary nozzle whereby an auxiliary jet issues therefrom inwardly across a peripheral portion of said stream to exert a throttling action thereon and constrict the same, and valve means in said piping means for cutting off the supply of pressure gas whereby said stream resumes its full cross-section, the provision of a plurality of deflector blades extending in cascade formation downstream of the propulsive nozzle and said slot-like nozzle, outside but adjacent the periphery of the constricted stream issuing therefrom when said valve means is opened and within the peripheral part of the unconstricted stream issuing from said propulsive nozzle when said valve means is closed.

2. The combination of claim 1, further comprising controllable means positioned within the jet for forming an inner obstacle projecting thereinto to urge the streamlines of said jet outwardly from the axis of the nozzle.

3. The combination of claim 2, wherein the obstacle forming means extends transversely of the nozzle, substantially opposite to the throttling means.

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