Aug. 29, 1961 G. OULIANOFF 2,997,845

JET PROPULSION NOZZLE ADJUSTABLE TO GIVE FORWARD AND REVERSE THRUSTS

Filed March 19, 1958 3 Sheets-Sheet 1

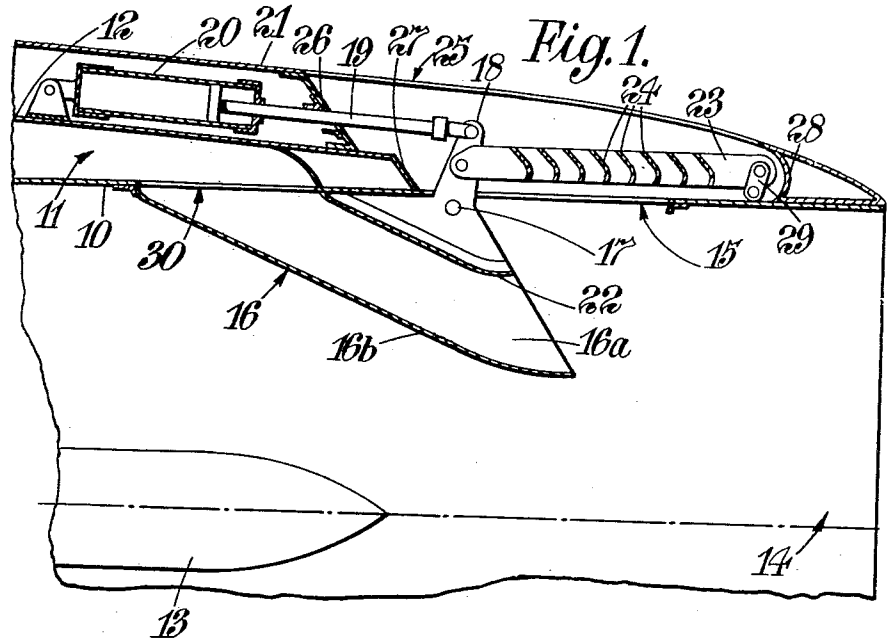


Fig. 1.

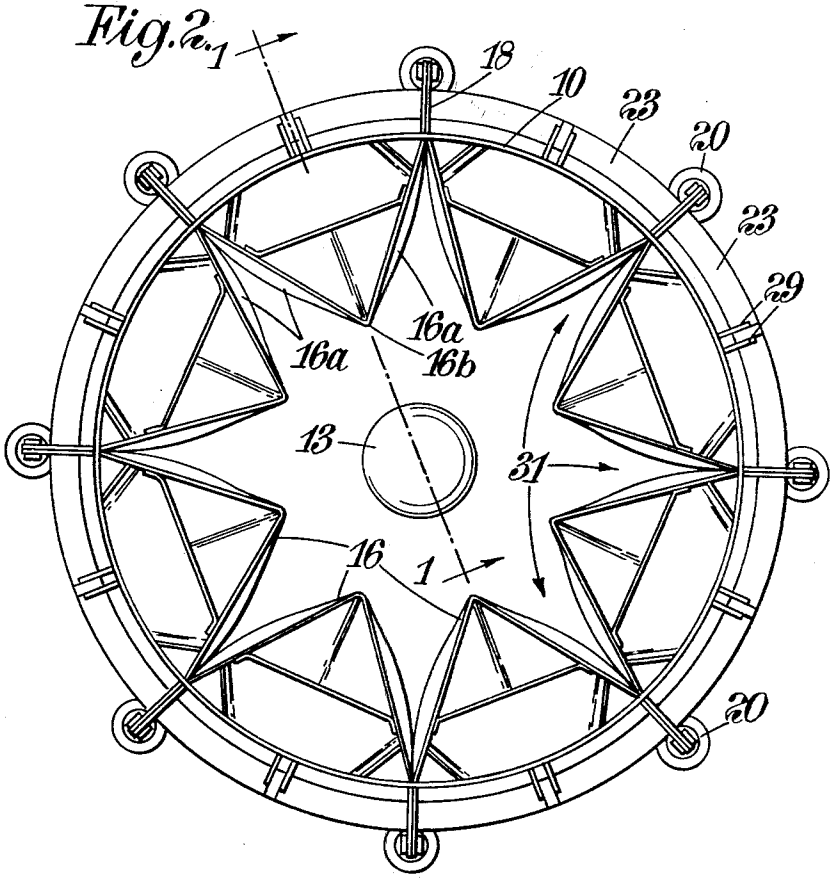


Fig. 2.

Aug. 29, 1961 G. OULIANOFF 2,997,845

JET PROPULSION NOZZLE ADJUSTABLE TO GIVE FORWARD AND REVERSE THRUSTS

Filed March 19, 1958 3 Sheets-Sheet 2

Fig. 3.

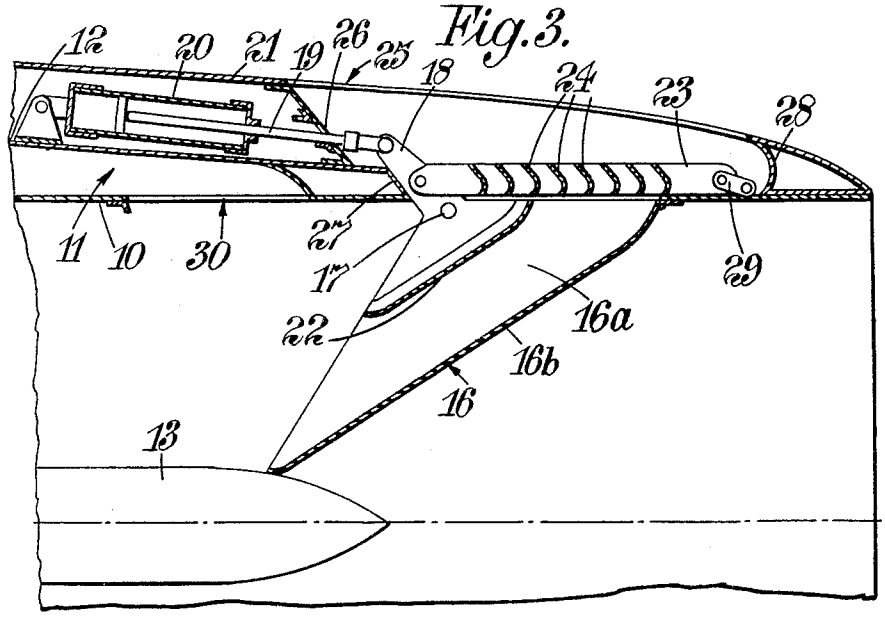
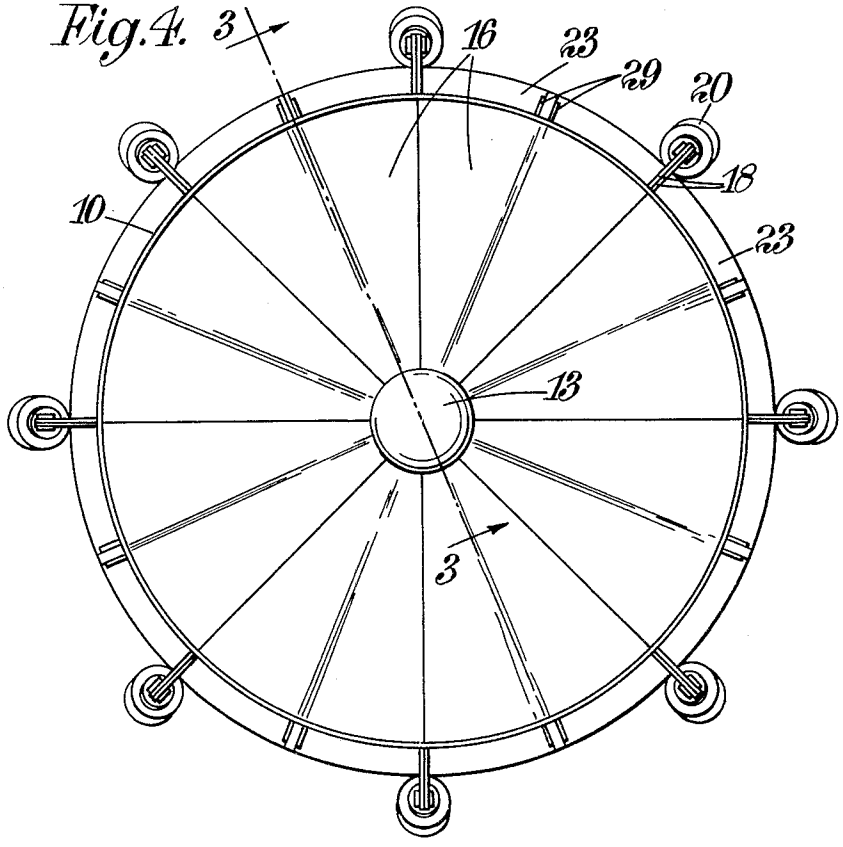


Fig. 4.



Aug. 29, 1961 G. OULIANOFF 2,997,845

JET PROPULSION NOZZLE ADJUSTABLE TO GIVE FORWARD AND REVERSE THRUSTS

Filed March 19, 1958 3 Sheets-Sheet 3

Fig. 5.

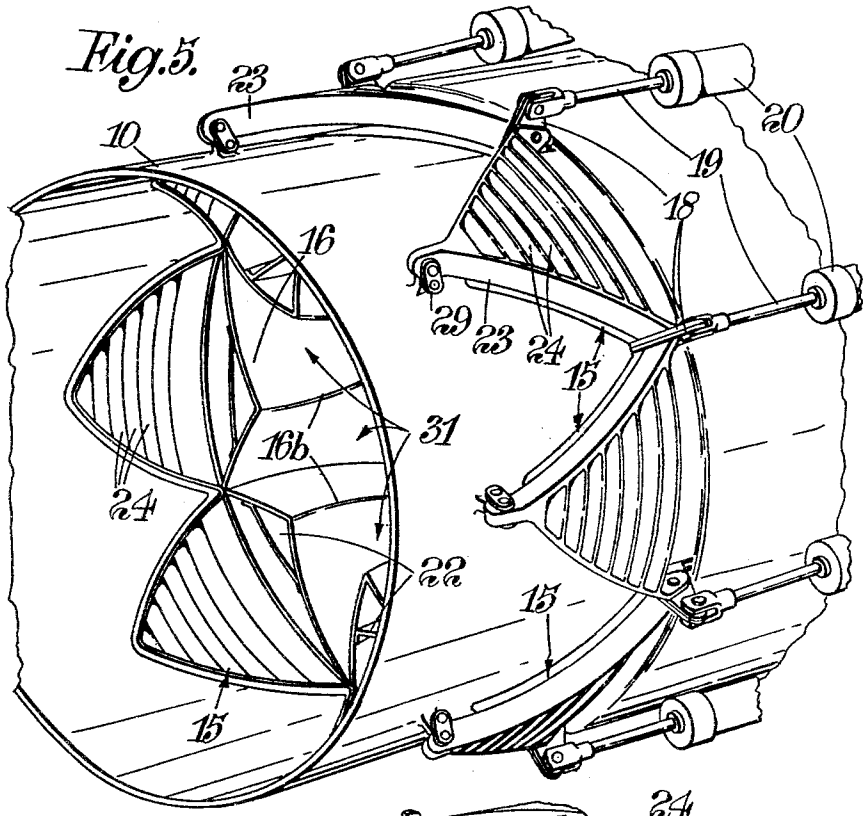
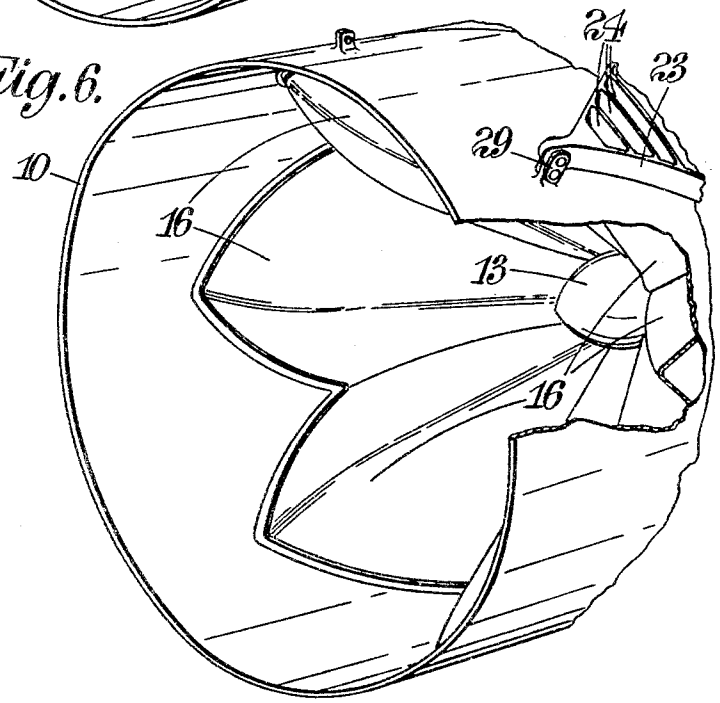


Fig. 6.



United States Patent Office 2,997,845 Patented Aug. 29, 1961

2,997,845

JET PROPULSION NOZZLE ADJUSTABLE TO GIVE FORWARD AND REVERSE THRUSTS

George Oulianoff, Allestree, England, assignor to Rolls-Royce Limited, Derby, England, a company of Great Britain

Filed Mar. 19, 1958, Ser. No. 722,580
Claims priority, application Great Britain Mar. 22, 1957
8 Claims. (Cl. 60—35.54)

This invention comprises improvements in or relating to nozzles for jet propulsion purposes.

This invention has for an object to provide a simple construction of silenced nozzle with which a reverse thrust may be obtained when it is desired, for instance, to produce a braking effect on an aircraft.

In patent application Serial No. 466,167 there is described and claimed the combination with a jet propulsion engine of a propelling nozzle comprising a rigid tubular structure through which exhaust gas from the engine flows, and from the downstream end of which said exhaust gas is discharged to atmosphere to provide propulsive thrust, said tubular structure providing internally thereof for the flow of exhaust gas a cross-sectional area which decreases from the upstream end of the nozzle towards the downstream end thereof over at least part of the axial length of the nozzle, and providing also a selected number of circumferentially-spaced channels having a fixed configuration which extend in an axial direction from adjacent the upstream end of the nozzle to the downstream end thereof, exhaust gas flowing through the channels and emerging therefrom in a number of circumferentially-spaced streams between which mixing of the exhaust gas with air takes place, whereby in operation of the engine the intensity of audible noise is reduced substantially as compared with a plain frusto-conical nozzle. The number of such channels may vary, but about six channels are preferred since thereby a maximum reduction of intensity is obtained in the range of audible frequencies.

The present invention provides a nozzle construction having a tubular wall and a series of structures adjustably mounted therein which structures in one position of adjustment co-operate with the wall to define a "silenced" nozzle and in a second position of adjustment act as scoops to direct exhaust gas flowing in the nozzle to porting in the tubular wall, from which porting the gas is caused to emerge to atmosphere with a component of velocity in the forward direction thereby to produce a reverse thrust.

According to a preferred feature of this invention, each of the structures defines ducting having open ends contained substantially in intersecting planes and the structure is pivoted to the tubular wall about an axis substantially tangential to the tubular wall so that in the first position of adjustment the periphery of one open end of the channel lies against the tubular wall and the other open end faces downstream, and in the second position of adjustment the one end faces upstream and the second end registers with the porting. Each such structure may comprise a pair of circumferentially-facing triangular walls which meet along a common edge and diverge from the edge and the structure has its pivotal axis extending across it adjacent the corners of the walls opposite the common edge. The structure may have internal partitioning to form a number of ducts leading between the open ends.

According to yet another preferred feature of the invention, vaned grids are provided in association with the porting to assist in directing the exhaust gas forwardly, and the grids are linked to the structures so that when the structures are approaching or moving from their second positions of adjustment the gas loads on the structures and vaned grids oppose one another, thereby rendering more uniform the operating loads required to be applied by motor means provided for moving the structures.

According to another preferred feature of this invention, it is arranged that, when the structures are in the first position, air is permitted to flow through them to emerge therefrom between the streams of exhaust gas issuing from the exhaust gas channels formed between the structures. In the case of a nozzle for a by-pass gas-turbine engine, the air may be derived from the by-pass air passage, and in the case of non-by-pass engines or by-pass engines in which the by-pass air is mixed with the exhaust gas upstream of the nozzle, the air may be derived from an annular space between the jet pipe leading to the nozzle and a surrounding fairing. When the structures are in the first position, mixing air may also be allowed to flow to between the exhaust gas streams through the reverse thrust porting.

One construction of nozzle of this invention suitable for use with a by-pass gas turbine engine will now be described by way of example, the description referring to the accompanying drawings, in which—

FIGURE 1 is an axial section through the nozzle with the moving parts adjusted to give a silencing effect,

FIGURE 2 is a view on the outlet end of the nozzle with parts removed to show details of construction, and shows the section line **1—1** of FIGURE 1,

FIGURES 3 and 4 are views corresponding to FIGURES 1 and 2 showing the nozzle adjusted to give a reverse thrust, FIGURE 3 being a section on the line **3—3** of FIGURE 4,

FIGURE 5 is a perspective view of the "silenced" nozzle, parts being removed to show details of construction, and

FIGURE 6 is a corresponding view showing the nozzle adjusted to give reverse thrust.

The arrangement illustrated in the drawings is suitable for use with a by-pass gas-turbine engine. The exhaust gas from the engine flows to the nozzle through a jet-pipe **10**, and the by-pass air from the engine flows to the nozzle in an annular channel **11** defined between the jet-pipe **10** and an outer wall **12**.

The jet-pipe **10** is cylindrical and is extended to form the tubular wall of the nozzle at the outlet from the jet-pipe. Alternatively the tubular wall may be a separate cylindrical piece of the same diameter as the jet pipe and attached thereto.

A bullet-ended centre body **13** is provided centrally of the jet-pipe and it terminates upstream of the outlet **14** from the nozzle.

The jet-pipe **10** is formed adjacent the outlet with a series of six angularly-spaced triangular ports **15**, the ports being axially downstream of the end of the centre body **13**.

Each port **15** has associated with it a structure **16** which is adjustable so that the nozzle may be operated as a silenced nozzle giving a normal rearwardly issuing jet or as a nozzle giving reverse thrust.

Each structure **16** has a pair of triangular circumferentially-facing walls **16***a* which meet at a common edge **16***b* and diverge from the common edge. Each structure **16** is pivoted to the jet-pipe **10** to swing about pivots **17** which are arranged to be substantially tangential to the jet-pipe adjacent the upstream end of the associated port **15**, and are adjacent the corners of the triangular walls **16***a* opposite the edge **16***b*. Each wall **16***a* has an integral lug **18** projecting outwards through the port **15** to be connected to a piston rod **19** of a ram **20** mounted externally of the outer wall **12** of the by-pass duct **11** and within a cowling **21** which extends axially to the outlet **14**. The structure **16** is divided internally by an internal partition **22** to form a pair of ducts extending through the structure parallel

to the edge 16*b*. The structures 16 are interconnected at the lugs 18 by means of the piston rods 19 in order to synchronize the movement of the structures.

Also, with this arrangement, the pressure supplied to one piston rod 18 can fail without a failure of the reverser as a whole since each structure 16 is connected to two piston rods 18.

Each port 15 also has associated with it a triangular grid 23 comprising a series of vanes 24, which grid is accommodated in a duct extending outwardly from the port 15 to a corresponding port 25 in the cowling 21 and defined between annular walls 26, 27 upstream of the port 15 and wall 28 downstream of the port 15. At its forward end the grid 23 is pivoted to the lugs 18 on the side of the pivots 17 remote from the structure 16 and at its rearward end the grid is supported by swinging links 29.

The jet-pipe 10 is also provided with ports 30 through which air can flow from the by-pass duct 11.

In use of the nozzle, with the parts in the positions shown in FIGURES 1, 2 and 5, a silencing effect is obtained, since the exhaust gas, in flowing through the nozzle, flows through a series of circumferentially-spaced channels 31 defined between the structures 16 and issues from the channels 31 (FIGURE 2) as spaced streams into the spaces between which mixing air flows partly from the by-pass duct 11 through ports 30 and the structures 16 and partly from atmosphere through ports 25 and ports 15. The structures 16 are dimensioned so that in this position the total cross-sectional area available for exhaust gas flow decreases from the upstream ends of the structures 16 to the plane of the pivots 17 so that a throat is formed in this plane. It is to be noted that the throat is downstream of the end of the centre body 13.

With the parts in the position shown in FIGURES 3, 4 and 6, the nozzle acts to give a reverse thrust. In this position, the structures 16 have been swung by the rams 20 so that the downstream-facing ends of the ducts through the structures register with the ports 15 and the upstream ends of the ducts face upstream so that the structures act as scoops directing the exhaust gas and by-pass air flowing from ports 30 through the ports 15. The exhaust gas then flows to atmosphere through ports 25 with a component of velocity in the forward direction giving a reverse thrust. This component of velocity is in part imparted by the vanes 24. It will be noted that in this position, the structures 16 meet on the centre body 13, which acts as a limiting stop, and they act to block the rearward flow of the whole of the exhaust gas and by-pass air. The centre body 13 is not essential as a small aperture could be left where the structures 16 meet.

During the latter part at least of the swinging movement of the structures 16 from the first to the second position and during the initial part of the return swinging movement, the gas loads on the grids 23 oppose those on the structures 16, and thus the operating loads required are made more uniform.

In an alternative construction, the downstream ends of the structures 16 may, in the first position, be contained in the plane of the pivots 17 and in this case the tapering downstream portions of the structures provided in the illustrated construction will be omitted.

In certain applications of the invention, it may be necessary to blank off certain of the outlets 15, 25 so as to prevent hot gases impinging on parts of the aircraft in which the engine and nozzle is employed. This may be necessary for example when the engine is in a pod mounting.

In an alternative arrangement, e.g. where the engine is not of the by-pass type or the by-pass air is mixed with the exhaust gases upstream of the nozzle, the duct 11 may open to atmosphere through suitable air intakes from which mixing air is conveyed to the nozzle and in this case reverse flow of the exhaust gases along duct 11 and to atmosphere through the intakes will occur when the structures 16 are in the position shown in FIGURE 3, thus assisting in production of reverse thrust.

I claim:

1. A nozzle for jet propulsion purposes having a tubular wall having a gas passage with an outlet at one end and a first series of angularly spaced peripheral ports upstream of the outlet, such ports placing the gas passage in communication with atmosphere, a source of air, said wall also having therein a second series of angularly spaced peripheral ports upstream of said first series of ports and communicating said source of air with said gas passage, and a corresponding series of angularly spaced structures adjustably mounted within said wall, each said structure having upstream and downstream open ends and ducting connecting the open ends, the open ends being contained in intersecting planes, and each said structure being pivotally mounted between a corresponding one of the first series of ports and a corresponding one of the second series of ports to swing about an axis substantially tangential to the wall between a first position and a second position, in said first position the periphery of the upstream open end lies against said wall in register with the corresponding one of the second series of ports whereby air from said source of air is fed through the ducting in the structure into the gas passage, and in which the downstream open end of the structure faces the outlet of said wall, the structures when in said first position defining between them a series of gas channels leading towards the outlet and circumferentially alternating with the air-streams emerging from said structures, whereby noise attenuation is obtained when the structures are in the first position, in said second position the downstream open end of each structure registers with the corresponding one of the first series of ports and the upstream open end thereof faces upstream in the gas passage so that said structures act as scoops to direct exhaust gas from the gas passage through the ports of the first series of ports, power means connected to the structures to effect swinging between said first and second positions, and means acting on the gas flowing through the first series of ports to atmosphere to impart to the gas a component of velocity in the upstream direction to produce a braking effect.

2. A nozzle according to claim 1, wherein each structure comprises a pair of circumferentially-facing triangular walls which meet along a common edge and diverge from the edge and the structure has its pivotal axis extending across it adjacent the corners of the walls opposite the common edge.

3. A nozzle according to claim 1 wherein each structure has internal partitioning to form a number of ducts leading between the open ends.

4. A nozzle according to claim 1, wherein the means imparting to the gas a forward component of velocity comprises vaned grids at each port, and the grids are linked to parts of the structures extending beyond their swinging axes so that when the structures are approaching or moving from their second positions of adjustment the gas loads on the structures and vaned grids oppose one another, thereby rendering more uniform the operating loads required to be applied by motor means provided for moving the structures.

5. A nozzle according to claim 4, wherein the structures have lugs projecting therefrom through the first porting in the tubular wall, the lugs being on the sides of the pivotal axes remote from the structure, and the grids are externally of the tubular wall are pivoted at the upstream ends to the lugs and at the downstream ends to swinging links, there also being rams externally of the tubular wall, the rams being connected to the lugs to effect swinging of the structures.

6. A nozzle according to claim 1, wherein the structures when in their second positions of adjustment completely block rearward flow of gas through the nozzle.

7. A nozzle for jet propulsion purposes having a tubular wall, said tubular wall defining a gas passage with an

outlet at one end and said tubular wall having therein upstream of the outlet a first series of angularly-spaced peripheral ports placing the gas passage in communication with atmosphere and also having therein a second series of angularly-spaced peripheral ports longitudinally aligned with and upstream of said first series of angularly-spaced peripheral ports, a source of air, said second series of angularly-spaced peripheral ports placing said source of air in communication with the gas passage, and a corresponding series of angularly-spaced structures adjustably mounted within the tubular wall, each said structure having upstream and downstream open ends and ducting connecting the open ends, the open ends being contained in intersecting planes, and each said structure being pivotally mounted between a corresponding one of the first series of ports and a corresponding one of the second series of ports to swing about an axis substantially tangential to the wall between a first position in which the periphery of the upstream open end lies against the tubular wall in register with the corresponding one of the second series of ports whereby air is fed to the duct through the structure, and in which the downstream open end faces the outlet of the tubular wall and the corresponding one of the first series of ports is uncovered to admit air from atmosphere to the gas passage behind the pivoted structure, and a second position in which the downstream open end registers with the corresponding port of the first series of ports and the upstream open end faces upstream in the gas passage, the structures when in said first position defining between them a series of gas channels leading towards the outlet and circumferentially alternating with the airstreams emerging from said structures whereby noise attenuation is obtained and in the second position acting as scoops directing exhaust gas to the first series of ports, power means connected to the structures to effect swinging between the first and second positions, and means acting on the gas flowing through the first series of ports to atmosphere to impart to the gas a component of velocity in the upstream direction.

8. In combination a jet pipe, means defining an air passage surrounding said jet pipe and a nozzle for jet propulsion purposes mounted at an end of said jet pipe, said nozzle having a tubular wall, said tubular wall defining a gas passage with an outlet at one end and said tubular wall having therein upstream of the outlet a first series of angularly-spaced peripheral ports placing the gas passage in communication with atmosphere, a corresponding series of ports in said jet pipe in alignment with the series of ports in the tubular wall, said second series of ports placing the air passage in communication with the interior of the jet pipe, and a corresponding series of angularly-spaced structures adjustably mounted within the tubular wall, each said structure having upstream and downstream open ends and ducting connecting the open ends, the open ends being contained in intersecting planes, and each said structure being pivotally mounted on said tubular wall between a corresponding one of the ports therein and a corresponding one of the ports in the jet pipe to swing about an axis substantially tangential to the wall between a first position in which the periphery of the upstream open end lies against the jet pipe in register with the corresponding one of the ports in the jet pipe, whereby air flows from the air passage into the duct through the structure, and the downstream open end faces the outlet of the tubular wall and the port in the tubular wall is uncovered to admit air from atmosphere to the gas passage behind the pivoted structure, and a second position in which the downstream open end registers with the corresponding port in the tubular wall and the upstream open end faces upstream in the gas passage, the structures when in said first position defining between them a series of gas channels leading towards the outlet and circumferentially alternating with the airstreams emerging from said structures whereby noise attenuation is obtained and in the second position acting as scoops directing exhaust gas to the ports in the tubular wall, power means connected to the structures to effect swinging between the first and second positions, and means acting on the gas flowing through the ports in the tubular wall to atmosphere to impart to the gas a component of velocity in the upstream direction.

References Cited in the file of this patent

UNITED STATES PATENTS

2,838,909	Meulien	June 17, 1958
2,841,956	Gunson et al.	July 8, 1958
2,847,822	Hausmann	Aug. 19, 1958
2,848,867	Hausmann	Aug. 26, 1958
2,940,252	Reinhart	June 14, 1960

FOREIGN PATENTS

733,931	Great Britain	July 20, 1955
739,500	Great Britain	Nov. 2, 1955