Nov. 4, 1969 R. ANGIER 3,475,912

PROPULSION UNITS

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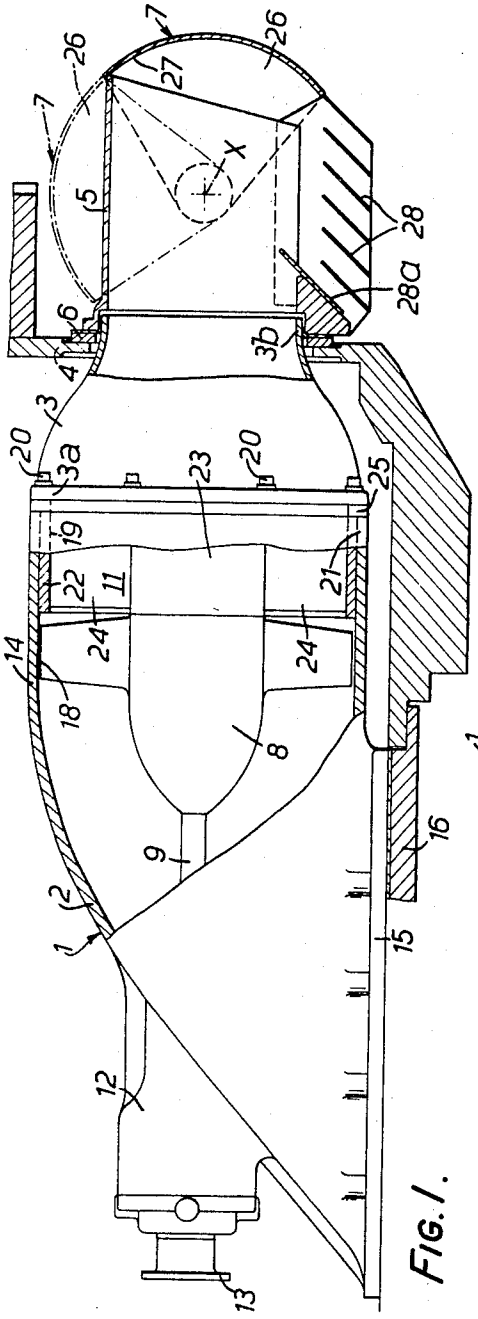


FIG. 1.

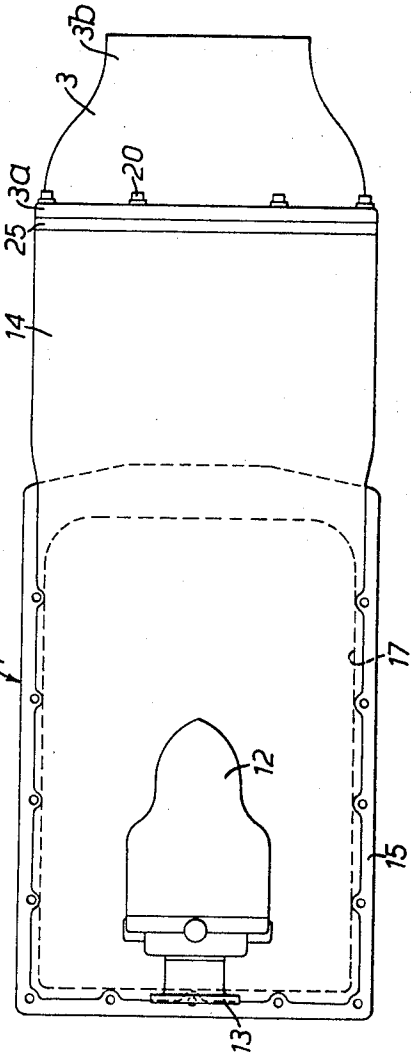


FIG. 2.

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PROPULSION UNITS

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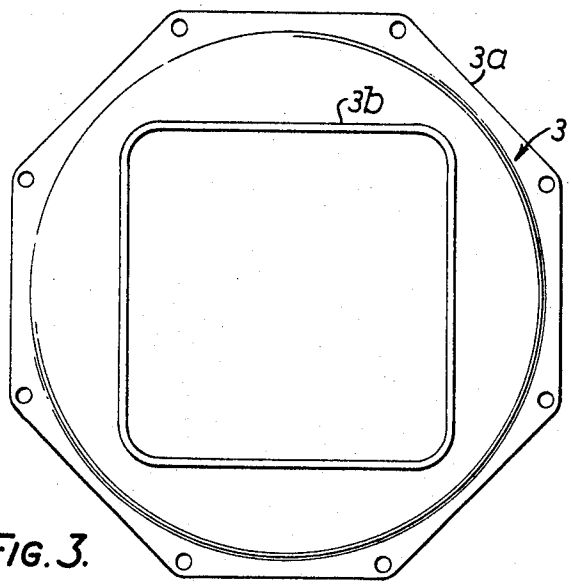


FIG. 3.

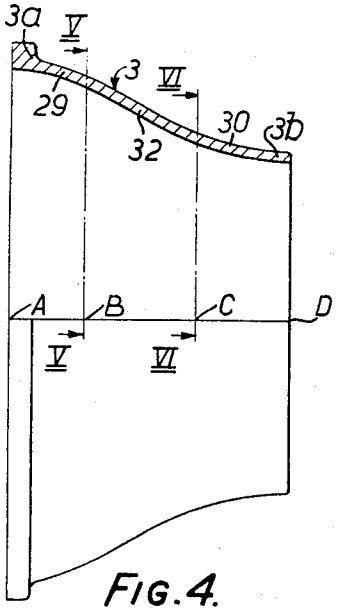


FIG. 4.

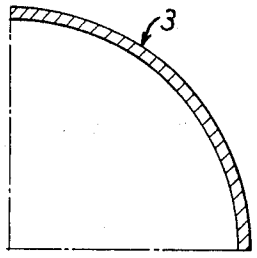


FIG. 5.

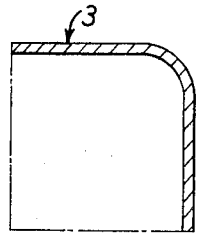


FIG. 6.

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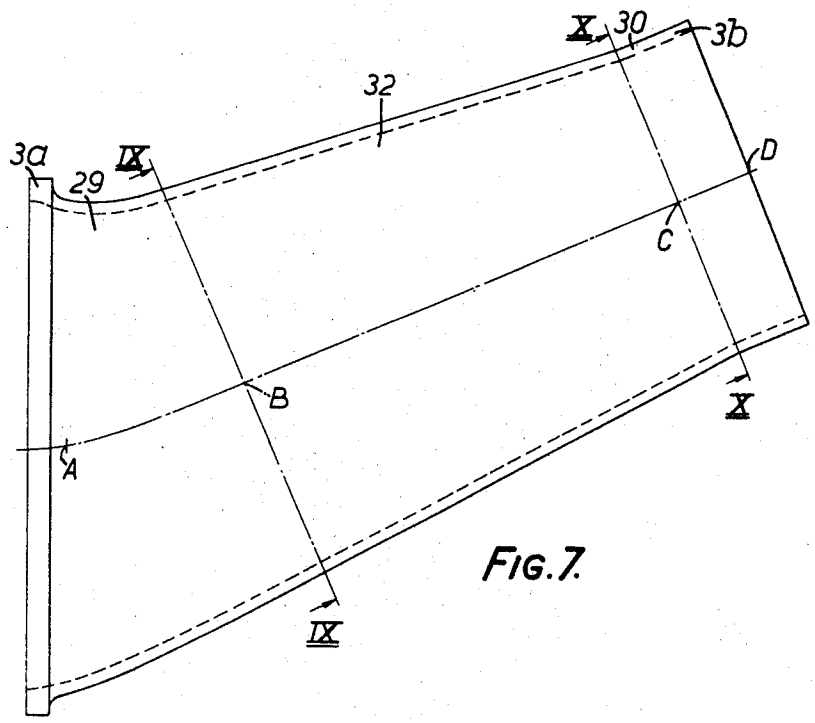


FIG. 7.

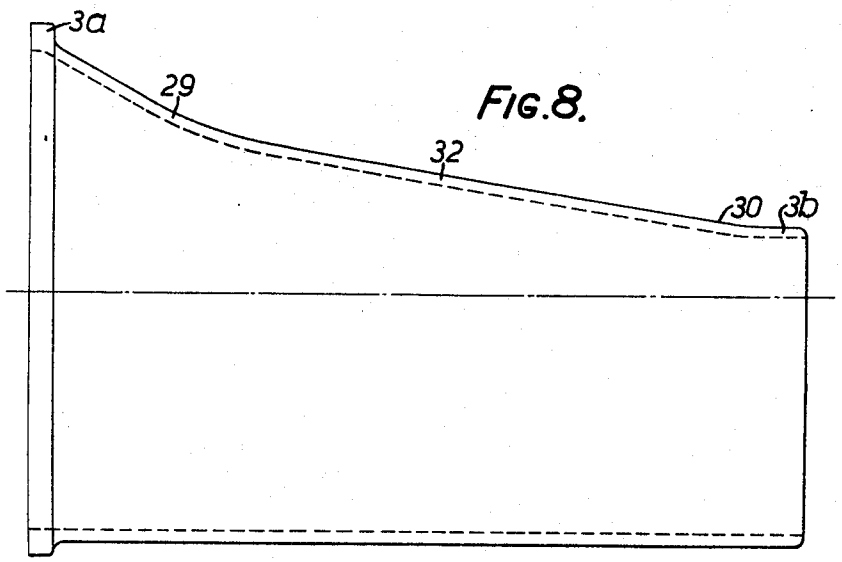


FIG. 8.

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PROPULSION UNITS

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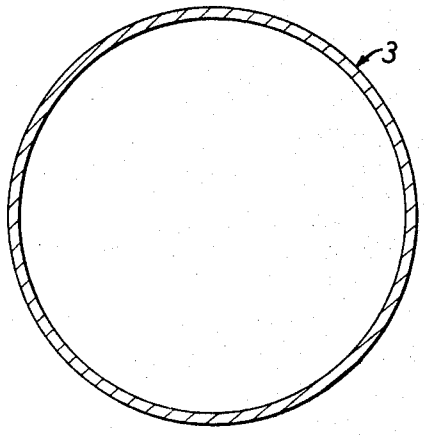


FIG. 9.

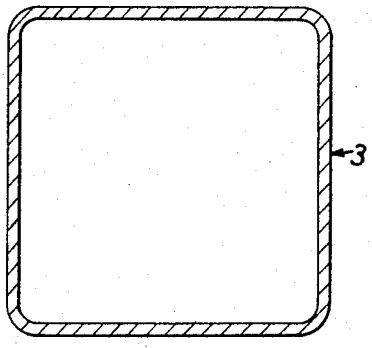


FIG. 10.

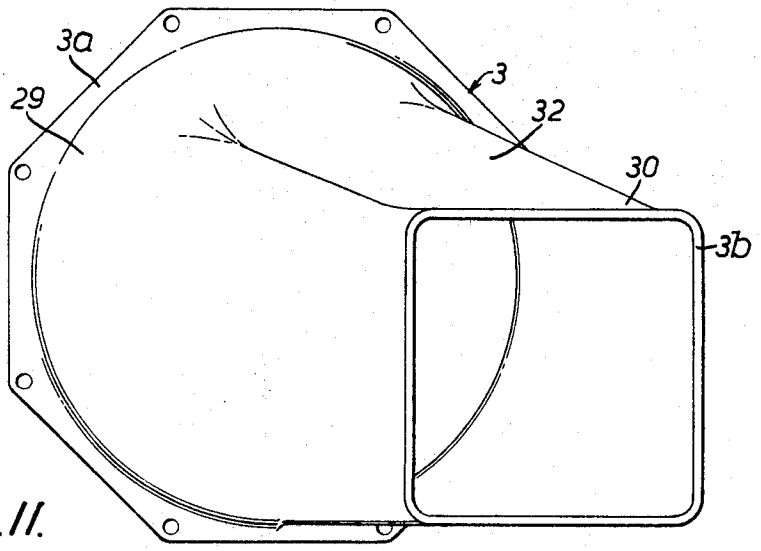


FIG. 11.

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United States Patent Office 3,475,912
Patented Nov. 4, 1969

3,475,912

PROPULSION UNITS

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Filed Oct. 2, 1967, Ser. No. 672,316
Int. Cl. B63h 25/46, 11/02; F02k 1/20
U.S. Cl. 60—222 8 Claims

ABSTRACT OF THE DISCLOSURE

A jet propulsion unit for a vehicle propulsion system, the unit having an outlet pipe with on opening at one end which is of substantially rectangular shape and from which in use the jet issues. The internal cross-section of the pipe merges smoothly from circular at the opposite end to square at said one end in a manner which provides a continuously decreasing flow cross-section along the length of the outlet pipe. The pipe at said one end communicates with a steering box having a jet deflector thereon, and a plate-like restrictor is positionable between the outlet of the pipe and the steering box.

This invention relates to hydraulic jet propulsion systems for waterborne vehicles, and in particular to jet propulsion units for use in such systems.

In a hydraulic jet propulsion system it is usual to have a steering mechanism which comprises a rectangular section, usually square, open-ended box positioned at the opening of an outlet pipe of the jet unit. A bucket-like or other deflector mounted on or in the box deflects the jet which issues from the pipe and passes through the box.

The outlet pipe is of round section, and when below water the effective flow cross-section varies as the jet leaves the outlet pipe and passes through the box. The effect is that of an increasing nozzle size with a tendency to cavitation in the pump section of the unit. In order to achieve acceptable flow conditions it is normal to bleed air to the corners of the steering box, and apart from the complication of this a phosphorescent wake results which is often undesirable. This is particularly the case with amphibious military vehicles which wish to avoid detection when travelling on water.

According to the invention a jet propulsion unit for a vehicle propulsion system has an outlet pipe with an end opening of substantially rectangular shape from which in use the jet issues.

The outlet pipe is conveniently attached to the casing of a pump section of the unit which contains a rotary impeller, and the internal section of the pipe preferably merges smoothly from circular at the outlet of the pump unit to the rectangular section at the outlet opening of the pipe in a manner which provides a substantially constant or continuously decreasing flow cross-section along the length of the outlet pipe. The outlet opening may be square for use with a square steering box of corresponding section.

The invention enables a steering box to be used of the same internal section as the outlet of the jet unit, and hence the steering box becomes in effect a continuation of the outlet pipe and the flow and cavitation problems of prior constructions are avoided. In particular there is no need to provide an air bleed to the box.

The casing of the pump section may have a polygonal external shape at the outlet end adjacent the outlet pipe which can then conveniently be flanged for attachment to the pump section, the flange bolts being threaded into the casing in the thickened regions at the corners of the polygonal shape. A straightening or guide vane assembly may have an external flange clamped between the pump casing and outlet pipe flanges, with the assembly located within the casing. Alternatively, and particularly when a short compact unit is required, the guide vanes may be housed or formed in the outlet pipe itself.

The invention will now be further described with reference to the accompanying drawings which show, by way of example, a jet propulsion unit and a modification thereof, each being in accordance with the invention and for use in the propulsion system of a waterborne vehicle.

In the drawings:

FIGURE 1 is a plan view, partly in longitudinal section, of the unit as mounted in the hull of the vehicle,

FIGURE 2 is a side view of the unit,

FIGURES 3 and 4 are respectively a rear end view and a half-sectional side view of an outlet pipe of the unit, to a larger scale,

FIGURES 5 and 6 are respectively sectional views on the lines V—V and VI—VI of FIGURE 4,

FIGURES 7 and 8 are respectively plan and side views of a modified form of outlet pipe,

FIGURES 9 and 10 are respectively sectional views on the lines IX—IX and X—X of FIGURE 7, and

FIGURE 11 is a rear end view of the outlet pipe of FIGURES 7 to 10.

The unit is shown in FIGURE 1 mounted at the left-hand side of the vehicle and towards the rear of the latter; a similar unit (not shown) is mounted at the right-hand side of the vehicle so that the two units are respectively symmetrically disposed on the two sides of the fore-and-aft axis of the vehicle.

The unit has a pump section **1** with a cast light alloy casing **2** to which is attached a jet outlet pipe **3** which is also in the form of a light alloy casting and flanged at one end **3***a* for attachment to the pump casing **2**. The other end **3***b* of the outlet pipe **3** is supported in a rear wall **4** of the vehicle and projects rearwardly through the wall **4** into a steering box **5**. The box **5** is separately supported on the wall **4**, being attached to an adaptor plate **6**, and has a bucket-like deflector **7** which is mounted for pivotal movement about a vertical axis X so that it can deflect the outlet jet stream passing through the box **5** to the side of the vehicle for steering purposes. The casing **2** houses a rotary impeller **8**, a drive shaft **9** on which the impeller is mounted and a straightening or guide vane assembly **11** which also supports an inner end bearing (not shown) for the shaft **9**. The front of the pump section **1** has an integrally formed bearing support **12** housing a further shaft bearing, and the projecting forward end of the shaft **9** terminates in an external drive flange **13**.

The pump components are housed in a rear end portion **14** of the casing **2** which is aligned with the drive shaft **9** with the latter disposed centrally within the portion **14**. Towards the forward end the casing **2** is cranked and terminates at a side flange **15** formed for bolting to the left-hand side wall **16** of the vehicle and which defines a rectangular inlet opening **17** of the unit. The inner wall surface of the casing **2** merges smoothly from the rectangular inlet opening **17** to a cylindrical bore **18** in the rear portion **14** which forms the pump chamber and continues to the outlet **19** of the casing **2**.

Externally the rear end portion **14** of the casing **2** is of octagonal shape, and flange bolts **20** attaching the outlet pipe **3** are threaded into the thickened portion of the wall **21** of the casing **2** at the octagon corners. The assembly **11** has a cylindrical outer rim **22** which fits closely within and is sealed (by resilient sealing rings which are not shown) relatively to the casing **2**. The rim **22** and central section **23** of the assembly, which section houses the rear end shaft bearing as described, are formed as an

integral casting in which they are joined by radially disposed straightener vanes **24**. An outwardly projecting flange **25** of the assembly is clamped between the rear end of the casing **2** and the outlet pipe mounting flange, utilising the flange bolts **20**.

The flow cross-section of the outlet pipe **3** changes smoothly from circular at the end **3***a* which is attached to the casing **2**, to match the pump bore **18** in the latter, to square at the open end **3***b*. This enables the unit to be used with the steering box **5** which provides substantially the same flow cross-section as the outlet pipe so that the box **5** is in effect a continuation of the outlet pipe **3** and flow problems do not occur; in particular there is no need to bleed air to the box **5**. Although the flow cross-section varies in shape throughout the length of the outlet pipe **3** it decreases progressively in area so that the problems of an increase in flow cross-section and resultant pump cavitation are also avoided.

In FIGURE 1 the steering box **5** and bucket **7** are shown in section, and the bucket consists of two parallel side plates **26** respectively disposed above and below the box **5** and which are joined by an arcuate plate **27** the arc of which is centred on the axis X. For travel straight ahead the bucket **7** occupies the position shown in broken lines in FIGURE 1, in which it lies inwardly of the box **5** and does not obstruct or deflect flow through the latter. A progressive steering action is obtained by movement of the bucket **7** into the jet stream, maximum sideways deflection being obtained in the position shown in FIGURE 1 in which the complete jet is deflected through a reverse cascade formed by parallel vanes **28** mounted in the outer side wall of the box **5**. With both the buckets **7** in this position a reverse thrust is obtained which propels the vehicle rearwardly.

The foremost vane **28***a* of the cascade of the vanes **28** takes the form of a plate which is bolted to the adjacent corner of the box **5**, the bolts passing through elongated slots (not shown) in the plate **28***a* which allow the position of the latter to be slidably adjusted so that the amount that it projects into the jet stream is variable. This enables the effective flow cross-sectional area of the steering box **5** to be readily adjusted.

In order to provide a smooth change from circular to square cross-section from the end **3***a* to the end **3***b* of the pipe **3**, the average rate of change of cross-sectional area with axial length is computed and this average change is produced over two spaced end portions **29** and **30**. The portion **29**, which lies between points A and B on the longitudinal axis of the pipe **3**, is of uniformly varying circular cross-section throughout its axial length and the portion **30**, between points C and D, is of uniformly varying square cross-section. The actual transition from circular to square is provided by a transition portion **32** which extends between points B and C and the internal bore of which is defined by a series of straight lines interconnecting the circular cross-section at B (FIGURE 5) and the square cross-section at C (FIGURE 6). The smooth and progressive reduction in cross-sectional area in the direction of the jet stream flow ensures that undue flow disturbance and cavitation do not occur.

It will be appreciated that the symmetrical shape of the outlet pipe **3** and pump unit **1** means that these two components are suitable for use on either the right- or left-hand side of the vehicle.

The modified outlet pipe **3** shown in FIGURES 7 to 11 is not symmetrical about its longitudinal axis but is cranked (as shown particularly in FIGURES 7 and 11) so that when it is fitted between a pump section **1** and steering box **5** of the form previously described, the jet stream leaving the pipe **3** and entering the steering box **5** has an outwardly directed lateral component in addition to the longitudinal propulsive component aligned with the fore-and-aft axis of the vehicle, assuming that the pump section **1** is arranged as in FIGURE 1. The pipe **3** shown in FIGURES 7 to 11 is designed for incorporation in the right-hand side propulsion unit.

The longitudinal axis of the end portion **29** between points A and B is of arcuate form as shown in FIGURE 7, the remaining length of the longitudinal axis between points B and D being rectilinear. As before, the change in cross-sectional area with axial distance is uniform between points A and B where the pipe is circular in cross-section, and over the end portion **30** between points C and D where the pipe is square in cross-section. The transition portion **32** interconnecting the circular cross-section at B (FIGURE 9) with the square cross-section at C (FIGURE 10) is defined by a series of interconnecting straight lines as previously described in connection with the pipe **3** shown in FIGURES 1 to 6. The pipe **3** of FIGURES 7 to 11 is of substantially constant cross-sectional area throughout its length, the small reduction in area which occurs from end **3***a* to end **3***b* being smooth and progressive.

I claim:

1. A jet propulsion unit for a vehicle propulsion system, the unit comprising a pump section with a casing which, at a downstream end thereof, is of circular cross-section and which surrounds a rotary impeller, an outlet pipe which merges smoothly with progressively decreasing internal cross-sectional area from a circular internal section at an upstream end of the pipe, which is connected to said downstream end of the casing, to a rectangular internal section at a downstream end opening which communicates with a steering box of corresponding rectangular internal section, a deflector pivotally mounted on the box and operative to deflect a hydraulic jet stream passing through the box for imparting a reverse thrust, and a plate-like member disposed upstream of the deflector and downstream of the outlet pipe and slidable into said rectangular internal section from one side thereof and secured thereto to vary the effective flow cross-sectional area while maintaining the latter of rectangular shape.

2. A jet propulsion unit according to claim **1**, wherein said plate-like member is adjustably bolted to the steering box to project into said rectangular section of the latter.

3. A jet propulsion unit according to claim **2**, wherein one side of the steering box has a cascade of vanes through which the jet stream is deflected by the deflector for reverse thrust, the upstream one of said vanes constituting said plate-like member.

4. A jet propulsion unit according to claim **1**, wherein said end opening is square in cross-section.

5. A jet propulsion unit according to claim **4**, wherein the outlet pipe has spaced end portions which are of continuously changing circular and square cross-sections respectively and which are interconnected by a transition portion defined by a series of straight lines drawn between adjacent ends of the end portion cross sections.

6. A jet propulsion unit according to claim **5**, wherein the rate of change of cross-sectional area with axial length over said two end portions is uniform and equal.

7. A jet propulsion unit according to claim **1**, wherein the outlet pipe has an upstream end flange and the downstream end of the casing of the pump section has an octagonal external shape with bolts threaded through said upstream end flange and into the casing in the region of the octagon corners.

8. A hydraulic jet propulsion unit for a vehicle propulsion system comprising a rotary impeller, a housing including a casing for said impeller and an outlet pipe portion, the internal shape of the housing being such that the internal cross-sectional area merges from a circular shape presented at the impeller to a rectangular shape presented at the downstream end of the outlet pipe, a steering box with a pivotable deflector for reverse thrust purposes positioned downstream of the outlet pipe and having an internal rectangular cross-section similar to that presented by the outlet pipe, and a jet restrictor member slidable into the rectangular cross-section from one side

thereof and secured thereto in order to vary the effective outlet jet section, the restrictor member being positioned between the downstream end of the outlet pipe and the pivotable deflector.

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AL LAWRENCE SMITH, Primary Examiner

U.S. Cl. X.R.

60—230; 115—14; 239—265