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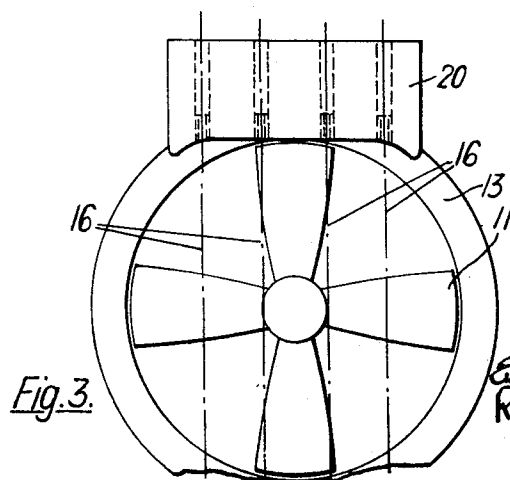
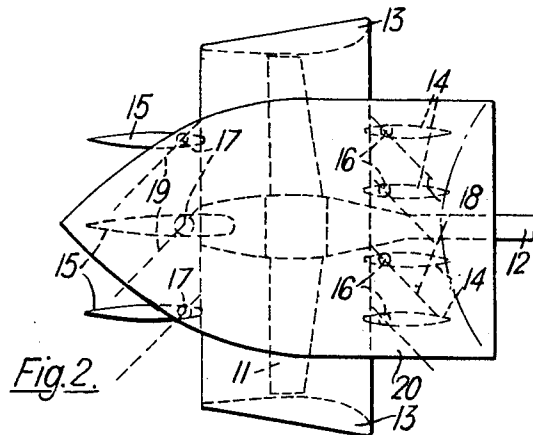
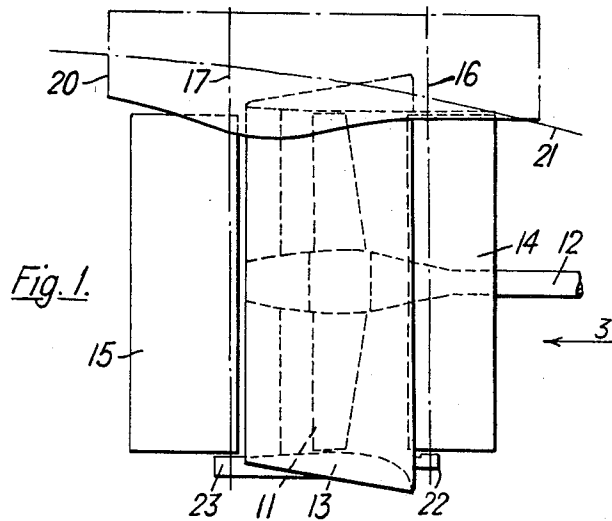
R. CLARK ET AL

3,412,703

STEERING OF VESSELS FITTED WITH PROPULSIVE NOZZLES

Filed Jan. 19, 1967

2 Sheets-Sheet 1



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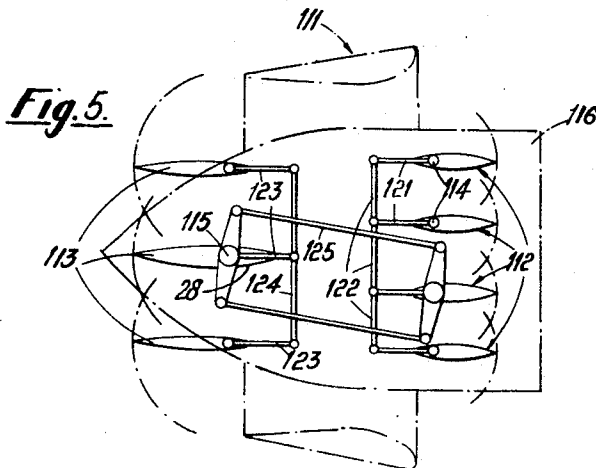
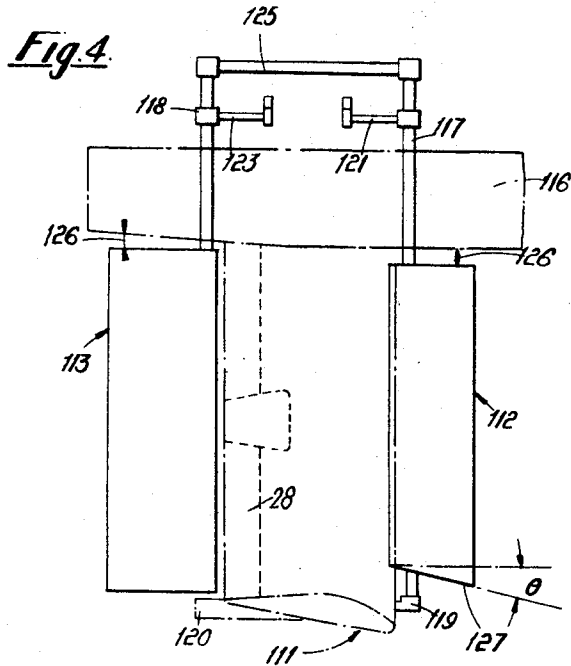
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1

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STEERING OF VESSELS FITTED WITH PROPULSIVE NOZZLES

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Continuation-in-part of application Ser. No. 597,283,
Nov. 28, 1966. This application Jan. 19, 1967, Ser.
No. 610,404

Claims priority, application Great Britain, Jan. 20, 1966,
2,710/66

5 Claims. (Cl. 114—163)

ABSTRACT OF THE DISCLOSURE

A propulsion and steering assembly for a marine vessel, comprising a propeller operating within a fixed propulsion nozzle and having a forward set of multiple rudders or vertical shutters working at the nozzle entry and a second set of multiple rudders or vertical shutters at the nozzle exit, and wherein the two sets of rudders are linked together so that when the trailing edges of the aft rudders are put to port the leading edges of the forward rudders are simultaneously put to starboard and vice versa.

This application is a continuation-in-part of application No. 597,283, filed Nov. 28, 1966.

This invention relates to the steering of marine vessels fitted with propulsion nozzles.

The propulsion nozzle is a thrust augmenting device commonly fitted to screw-propelled vessels with screws operating under conditions of high loading. With such nozzles, steering may be effected by rotating the entire nozzle, which has the disadvantage of increasing the clearance from the screw to the nozzle and thereby reducing thrust; or by a normal rudder system, which has the disadvantage that it gives no steering when going astern; or by a normal rudder at exit of the nozzle for ahead steering and two flanking rudders, one on either side of the propeller shaft forward of the nozzle for astern steering.

In vessels which operate under high conditions of slip, i.e. tugs, it is generally desirable to fit large propellers and hence large nozzles where these are installed. With a single rudder or twin flanking rudders, even at large angles of helm, such as 60°, full blanking off of the nozzle and diversion of flow is not easy without having recourse to rudders of very large chord. As a result there is a tendency for a compromise to be effected between the propeller diameter and the rudder size, making the rudder rather larger than would otherwise be chosen and the propeller rather smaller, thereby limiting the performance of the vessel.

Furthermore, in the race from a propeller, especially under conditions of high slip, there is a considerable rotation component in the wake from the propeller and this store of energy is wasted in the overall propulsion of the vessel.

An object of the invention is to improve the steering of fixed nozzle vessels and at the same time reduce the steering torque, as compared with conventional installations, and extract hitherto wasted energy from the propeller.

According to the present invention, there is provided a propulsion and steering assembly for a marine vessel, comprising a propeller operating within a fixed propulsion nozzle, and having a set of multiple rudders or vertical shutters working at the entry and/or the exit of the nozzle.

It is a feature of such a system that the total torque for a given effect varies inversely as the square root of the number of rudder fins or blades and hence such an ar-

2

angement allows of considerably reduced steering gear torque.

Any number of rudder blades may be employed but it is desirable that when they are turned to port or starboard, the nose of one should be covered in a fore and aft direction by the tail of another, thereby allowing no straight-through flow and forcing the entire flow through the cascade formed by the rudder blades and discharging it in the direction of the blade chord. By so doing a very high efficiency of steering is obtained, impact losses are lessened compared with using a single or double blade, and the blades themselves can be of very simple construction with relatively light bearings at top and bottom compared with those of a normal rudder.

In one embodiment, the bending moment produced by the "lift" of each of the blades may be reduced by a horizontal strut fitted across the entrance or exit of the nozzle and containing bearings for the blades thereby effectively halving their span. In another embodiment, the stocks of the multiple rudders may be taken above the top of the nozzle into a sponson box where they may be coupled to one another thereby forming a self-contained steering nozzle system which may be constructed and added separately to a vessel without affecting rudder alignment.

As a further development of the invention, it has been found that if the two sets of rudders are linked together so that, for example, when the vessel is going ahead the trailing edges of the aft rudders are put to port and the leading edges of the leading rudders are put to starboard the vessel will turn to port much more effectively than when only the after system is used. It is not necessary that the forward rudder system and the after rudder system turn to the same angle when they are put over; the same or different angles may be used as may be desired. The converse applies when going astern and hence it is desirable and effective to link the two rudder systems together so they may be operated by one steering gear, which is in itself a considerable saving in cost and complexity.

It is advantageous when arranging the system in this way to make the forward rudders of approximately symmetrical construction, that is with the rudder stocks at or near the centre of the chord of the rudder, in order to minimise the torque when going ahead. By so doing and judiciously arranging the balance of the after rudders as well, it is possible to balance the torque from one system against the other and to produce a very small resultant steering gear torque which is a further advantage of the combined system.

It is desirable also to adjust the balance of the two flanking trailing rudders, and overall the preferred system is to operate the steering gear directly on to the stock of the centre after rudder with side linkages to the flanking rudders and with a direct link to one of the forward rudders which in turn will have side linkages to the others. It has been found that this system is most effective both ahead and astern and in association with this arrangement it may be that it is desirable to "toe out" the two outer forward shutter rudders to a suitable angle to approximate to the water in-flow angle to the nozzle. The inner flanking rudders on the forward shutter system on either side of the propeller may, however, be left fore and aft, or may be "toed out" or even if necessary "toed in," as may be desired. The same will apply to the after rudders.

In order to effect propeller withdrawal, the exit blades may be carried in a ring forming the tail or exit of a nozzle which may be detachable from the nozzle complete with the cross-strut, if fitted, and with the blades of the multiple rudders in their bearings.

A further aspect is that the ends of each of the forward shutter rudders, i.e. the top and bottom edges, may be cut back a certain distance, the amount of which distance can be of the order of one-third or one-quarter of the chord

of the rudder, and the bottom or top or both angled suitably so as to prevent interference drag from the flow entering the nozzle. This is particularly advantageous.

Two forms of propulsion unit for a tug will now be described by way of example, reference being had to the accompanying diagrammatic drawings, in which:

FIGURE 1 is a side elevation of one embodiment,

FIGURE 2 is a plan view of the embodiment of FIGURE 1,

FIGURE 3 is an end elevation looking in the direction of the arrow 3 of FIGURE 1,

FIGURE 4 is a side elevation of a second embodiment, and

FIGURE 5 is a plan of the arrangement of FIGURE 4.

Referring firstly to FIGURES 1 to 3 of the drawings, a propeller 11 driven by a propeller shaft 12 works in a propulsion nozzle 13. At the nozzle entry are fitted four equidistantly-spaced vertical rudder blades or shutters 14; three further equidistant blades 15 are fitted at the nozzle exit. The entry blades 14 are each mounted to turn about a respective vertical pivot 16 near the aft edge of the blade, while the exit blades 15 have pivots 17 near their forward edges. It will be observed that the spacing and dimensions of the blades are such that, both in the case of the entry blades and the exit blades, each multiple rudder can be turned until the nose of one blade is covered, in the fore and aft direction, by the tail of the blade next to it, as illustrated by the sets of broken lines 18, 19 in FIGURE 2.

A head box 20 overlies the nozzle 13, projecting beyond it both forward and aft, and serves as the means of securing the unit to the ship's hull 21. Pintles for the multiple rudder blades 14, 15 are journaled at their upper ends in the head box 20 and at their lower ends in bearing brackets 22, 23 projecting forward and aft from the bottom of the nozzle 13. Within the head box the blade pintles of each multiple rudder may be coupled together so that the blades turn in unison.

The blades may be so designed that they extract most or all of the rotational component of the race from the screw, thereby increasing the thrust of the nozzle and propeller assembly by a considerable amount which may be as much as 15%. This is effected, anyway, by the blades even if of symmetrical aerofoil section with zero incidence normally fore and aft due to the fact that the inflow velocity to them from the propeller is at an angle of incidence which results in their generating lift. However, they may be suitably angled or twisted so that the top half and the bottom half have opposite incidence and therefore may be more nearly suited to the inflow angles from the propeller wake and furthermore they may be twisted so that they have a progressive increase in angle of incidence to enable exact matching to the wake of the propeller.

When going ahead, the forward blades 14 are kept fore and aft and steering is effected by the after blades 15. When going astern, the reverse is the case, the forward blades 14 being used for steering and the after blades 15 being kept fore and aft.

Referring now to FIGURES 4 and 5 of the drawings, a propeller (not shown) works in a propulsion nozzle 111. At the nozzle entry are fitted equidistantly-spaced vertical rudder blades or shutters 112; three further equidistant blades 113 are fitted at the nozzle exit. The entry blades 112 are each mounted to turn about a respective vertical pivot 114 nearer the aft edge of the blade, while the exit blades 113 have pivots 115 nearer their forward edges. It will be observed that, as in the first embodiment described, the spacing and dimensions of the blades are such that, both in the case of the entry blades and the exit blades, each multiple rudder can be turned until the nose of one blade is covered, in the fore and aft direction, by the tail of the blade next to it.

A head box 116 overlies the nozzle 111, projecting beyond it both forward and aft, and serves as the means of securing the unit to the ship's hull. Pintles 117, 118 for the multiple rudder blades 112, 113 are journaled at their upper ends in the head box 116 and at their lower ends in bearing brackets 119, 120 projecting forward and aft from the bottom of the nozzle 111.

Above the head box 116 the pintles 117 of the forward rudders 112 have rearwardly-extending arms 121 that are all connected by links 122 so that the forward rudder blades turn in unison. Similarly, the pintles 118 of the aft rudders 113 have forwardly-extending arms 123 connected by links 124, whereby the aft rudder blades turn in unison. The steering gear is coupled directly to the stock or pintle of the aft centre rudder and this stock is in turn coupled to the stock or pintle of one of the inner forward rudders 112 by means of a linkage 125. Thus when the steering gear is operated all the rudder blades turn simultaneously, the forward blades to port and the aft blades to starboard or vice versa.

Both the forward and the aft rudder blades are cut back somewhat at their tops away from the head box and the line of the inner wall of the nozzle, as at 126. The bottom ends of the forward blades are also cut back, as at 127, and are given a slope so that the bottom edges are inclined upwardly, in the rearward direction, at an angle θ to the horizontal.

It will be noted that the aft centre blade is of thicker section than the aft flanking rudders; its forward portion 28 is non-moving and separate from the remainder, constituting a fixed vertical strut spanning the nozzle exit. The purpose of this strut is, as before, to carry a support bearing for the aft end of the propeller shaft. However, this arrangement is not obligatory and the propeller shaft support bracket may be located either forward or aft of the propeller and may be of vertical post form, cantilever post form, of the conventional A type, or of Y type with a bottom support arm.

We claim:

1. A propulsion and steering assembly for a marine vessel, comprising a propeller operating within a fixed propulsion nozzle and having a forward set of multiple-rudders or vertical shutters working at the nozzle entry and a second set of multiple rudders or vertical shutters at the nozzle exit, and wherein the two sets of rudders are linked together so that when the trailing edges of the aft rudders are put to port the leading edges of the forward rudders are simultaneously put to starboard and vice versa.

2. An assembly according to claim 1, wherein the aft rudders are linked to turn in unison, the forward rudders are likewise linked to turn in unison, and the steering gear is coupled to an inner rudder of one set which in turn is coupled to an inner rudder of the other set.

3. An assembly according to claim 2, wherein there are three aft rudders and the steering gear is coupled to the aft centre rudder.

4. An assembly according to claim 3, wherein there are four forward rudders and the outer two are "toed out."

5. An assembly according to claim 1, wherein the torques on the forward and aft rudder sets are opposed and substantially balanced.

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