

IMPROVEMENTS IN MULTIPLE RUDDER SYSTEMS

This invention relates to multiple rudder systems for marine vessels.

A considerable number of marine vessels are equipped with propulsion ducts and many of these are fitted with a proprietary system embodying three shutter rudders across the end of the duct. The three rudders are linked together so they go over to similar angles and are of high aspect ratio and act in cascade. The system is extremely efficient for normal steering purposes and benefits from a low steering gear torque as well.

In order to obtain very high levels of low speed manoeuvrability it is necessary for a steering device to reduce any fore and aft forces to a minimum and produce a high level of transverse force.

When standard shutter rudders are put over to a large angle, as when, for example, the rudders are set to thrust the stern of the vessel to port, i.e. the trailing edges of the rudders are to starboard, then, if the leading edges of the rudders are straight, there will be a gap between the leading edge of the port rudder and the periphery of the duct through which a considerable amount of water from the propeller escapes in a fore and aft direction.

This leakage can be restricted by providing convexly arcuate leading edge extensions to the wing rudders such that at a large angle of deflection the forward extension of the wing rudder which is turned towards the duct inner wall

substantially closes off the gap that would otherwise exist and considerably reduces the fore and aft component of flow from the propeller. Our G.B. Patent Specification - 2079231 describes such a system.

5 However, it has been discovered there is a limit to the angle through which such rudders can be turned, because as the angle approaches about 80 degrees the rudders effectively throttle the flow from the nozzle and little or no steering force is developed. The aforementioned Patent
10 Specification 2079231 indicates a maximum rudder angle of 75 degrees port and starboard at which angle we have found that the outflow from the rudders can be of the order of 65°.

Thus there remains the hitherto unsolved problem of how to increase the angle of flow from the rudders without
15 excessive restriction to the flow from the propeller.

According to the present invention, there is provided a combined propulsion and steering system for a marine vessel comprising:

20 a fixed propulsion duct to closely surround a propeller of the vessel said duct having a water flow entry plane forward of the propeller and a water flow exit plane aft of the propeller;

25 at least three side by side shutter rudders mounted at the aft end of the duct to operate in the duct outflow and coupled to turn in unison about respective vertical axes lying side by side in a transverse plane a short distance aft of said exit plane of the duct, the horizontal distance separating the axes of the outer or wing shutter rudders

being significantly less than the diameter of the duct in said exit plane;

the rudder or each rudder intermediate said wing rudders extending, when the rudders are straight ahead, substantially no farther forward than said exit plane of the duct;

said wing rudders being provided with forward extensions that, when the rudders are straight ahead, extend forwardly of said exit plane of the duct into the confines of the duct and have leading edges that are convexly arcuately curved such that when the rudders are put over to a maximum rudder angle in the order of 75° the forward extension of the wing rudder on the outside of the turn substantially closes the gap for water flow between itself and the duct wall at that side;

whereby the flow turning effect of the wing rudder on the outside of the turn and of the intermediate rudder or rudders achieves a water outflow angle in the order of 65° ;

and said wing rudders being further provided with trailing edge flaps each fixed at an angle on its respective wing rudder to give, in the straight ahead position of the rudders, an outboard inclination relatively to the duct axis of said trailing edge flaps at a preselected toe-out angle such that, when the rudders are over at maximum rudder angle, the wing rudder on the inside of the turn deflects a respective portion of the water outflow from the duct through an angle so much greater than the rudder angle as to be almost at right angles to the axis of the duct whereby the

total duct outflow has an effective or mean angle of deflection that is greater than the rudder angle. The toe-out angle of the trailing edge flaps can be chosen to suit particular installations but is typically of the order of 15 degrees.

When the rudders are over, say, with the trailing edges to starboard the rudders form a cascade with the water flow from the propeller leaving the duct through the slots between the rudders and the gap between the trailing edge of the starboard rudder and the trailing edge of the duct at that side. The water exiting the duct through the slots between the rudders will have an outflow angle that is somewhat less than the rudder angle. The water exiting the duct through the gap between the starboard rudder and the trailing edge of the duct will be deflected by the trailing edge flap through an angle greater than the rudder angle. We have discovered that the overall effect is equivalent to deflection of the total water flow through an angle greater than the rudder angle, of the order of 5 degrees greater.

The use of the invention can therefore increase the angle of flow from the rudders by an angle of the order of 15 degrees compared to rudders not so fitted. For a rudder angle of 75 degrees the outflow angle will be of the order of 80 degrees, which is getting close to giving a purely transverse force on the vessel and much better than 65°.

The fixed trailing edge flaps combine synergistically with the arcuate leading edge extensions of G.B. - Patent Specification - 2079231. Thus, it could be thought that the

angled flap on the port rudder, when the rudders are over with the trailing edges to starboard, would deflect the water in that region to a lesser angle than the rudder angle thus counteracting the effect of the flap on the starboard rudder.

5 However, at maximum rudder angles there is substantially no flow over the outer side of the port rudder and therefore that flap has no adverse effect on the flow exiting the duct.

10 The length and angle of the trailing edge flaps can be selected to suit varying performance requirements. A larger flap and/or angle will increase the water outflow angle but with a resulting increase in rudder drag under normal operating conditions.

One embodiment of the invention is shown by way of example in the accompanying diagrammatic drawings, in which:

15 Figure 1 is a side elevation, in longitudinal section, of a ship's propulsion duct with an arrangement of three aft shutter rudders.

Figure 2 is a sectional plan view.

20 Figure 3 is an aft end elevation of the duct showing the rudders put over to starboard.

Figure 4 is a view similar to Figure 2 showing the rudders put over to starboard.

25 A ship's propulsion duct 11 closely surrounds a propeller 12. Just beyond the aft end of the duct are three vertical pintles 14, spaced transversely in a common vertical plane at right angles to the axis 15 of the duct and propeller and carrying three vertical shutter rudders 16, 17, 18 that are coupled to turn in unison. The transverse

spacing of the rudders is such that, in the straight ahead position, the wing rudders 16, 18 lie well inboard of the side extremities of the duct wall.

The central rudder 17, which is in line, in the straight ahead position, with the axis 15 of the duct and propeller, has a nose portion, ahead of its pintle, that projects only as far as the plane of the aft end of the duct. The rudder as a whole is of symmetrical aerofoil section. The wing rudders 16, 18 have nose portions 20 of convexly arcuate form which extend forward into the aft end of the duct. The wing rudders have fixed flaps 19 at their aft extremities angled outboard relative to the duct axis.

Figure 4 is a sectional plan view with the rudders turned to an angle of 70 degrees. The arrows indicate the direction of water flow exiting the duct. The effect of the starboard rudder trailing edge flap 19 in redirecting the flow past the outside of this rudder to an angle greater than the rudder angle can be seen.

Without the use of the trailing edge flaps 19 it is not possible for a propulsion duct fitted with three shutter rudders to deflect the flow from the nozzle through more than about 65 degrees without excessively throttling the flow. The use of the arrangement shown at the deflection angle illustrated increases this angle to about 80 degrees and consequently increases the manoeuvrability of a vessel so fitted.

CLAIMS:

1. A combined propulsion and steering system for a marine vessel comprising:

a fixed propulsion duct to closely surround a propeller of the vessel said duct having a water flow entry plane forward of the propeller and a water flow exit plane aft of the propeller;

at least three side by side shutter rudders mounted at the aft end of the duct to operate in the duct outflow and coupled to turn in unison about respective vertical axes lying side by side in a transverse plane a short distance aft of said exit plane of the duct, the horizontal distance separating the axes of the outer or wing shutter rudders being significantly less than the diameter of the duct in said exit plane;

the rudder or each rudder intermediate said wing rudders extending, when the rudders are straight ahead, substantially no farther forward than said exit plane of the duct;

said wing rudders being provided with forward extensions that, when the rudders are straight ahead, extend forwardly of said exit plane of the duct into the confines of the duct and have leading edges that are convexly arcuately curved such that when the rudders are put over to a maximum rudder angle in the order of 75° the forward extension of the wing rudder on the outside of the turn substantially closes



the gap for water flow between itself and the duct wall at that side;

whereby the flow turning effect of the wing rudder on the outside of the turn and of the intermediate rudder or rudders achieves a water outflow angle in the order of 65°;

and said wing rudders being further provided with trailing edge flaps each fixed at an angle on its respective wing rudder to give, in the straight ahead position of the rudders, an outboard inclination relatively to the duct axis of said trailing edge flaps at a preselected toe-out angle such that, when the rudders are over at maximum rudder angle, the wing rudder on the inside of the turn deflects a respective portion of the water outflow from the duct through an angle so much greater than the rudder angle as to be almost at right angles to the axis of the duct whereby the total duct outflow has an effective or mean angle of deflection that is greater than the rudder angle.

2. A system according to Claim 1, wherein the toe-out angle of said trailing edge flaps is in the order of 15° and the effective angle of deflection of the total duct outflow is in the order of 80°.

3. A propulsion duct system for a marine vessel according to Claim 1 and substantially as described with reference to the accompanying drawings.

