

CONTRA-ROTATING ROTOR UNIT**Field of the Invention**

THIS INVENTION relates primarily to a **type of** unit having an assembly providing contra-rotating, coaxial rotors. It is especially suited, although not exclusively so, to
5 facilitating the construction of a contra-rotating propeller assembly for a marine propulsion unit. Non-marine uses for the assembly are also possible, such as in the fields of commercial or private aviation and in the construction of liquid-pumping units. The term "propeller", as used in this specification is to be understood as covering a propeller having blades, such as a marine propeller, and also an impeller
10 having radially-projecting vanes rather than blades, which is also encountered in different types of marine propulsion systems, for example jet boat propulsion systems.

State of the Art

15 Proposals have been made for driving two contra-rotating propellers of a marine installation from a single drive shaft. For example, United States Patent Specification No. 4,540,369 (Caires) describes one such proposal for use with an outboard motor, and Canadian Patent No. 2,001,357 (Couture) describes another proposal. Although both proposals enable two propellers to be driven respectively in opposite directions
20 from a single shaft, they have draw-backs which militate against their use commercially.



The Caires proposal involves locating a set of static planetary gears between two opposed annular gears one of which is driven directly by a drive shaft in one direction, and the other of which is driven in the opposite direction indirectly from the drive shaft by way of the planetary gears. Exhaust gasses produced by outboard motor are fed through an annular tunnel which contains the static planetary gears and extends through the hubs of the propellers. The gases then discharge into the wake of the vessel astern of the propellers.

Caires partially overcomes the loss of efficiency of the assembly caused by discharging exhaust gases into the path of the propeller blades. However this is achieved at the price of allowing water and gas to flow through the meshing teeth of the planetary gears. The risk of water-borne, solid particles washing into the meshing zones of the planetary gears is considerable, as is the likelihood of heavy wear of the gears as there is no way of lubricating them. Thus Caires does not provide a commercially viable arrangement for driving two propellers from a common shaft in an efficient manner.

Couture seeks to overcome the lubrication problem by creating an annular closed chamber between contra-rotating hub-portions of two sets of propeller blades and stuffing the chamber with grease to keep the water out. Opposed, spaced bevel gears are formed respectively on the two propeller hubs and mesh with a ring of crown gears in the chamber. The crown gears rotate about axes which are radial with respect to the drive shaft, so that the rotation of one propeller is transmitted through the crown gears to rotate the other propeller in the opposite direction at the same speed.

The Couture proposal has a number of disadvantages which adversely affect the efficiency of the assembly. For example, the spacing between two contra-rotating propellers is critical and Couture does not allow any arrangement for changing this

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spacing in a given installation to achieve optimum efficiency. This can only be found empirically. Indeed it seems implicit in the Couture arrangement, for the two propellers to be sited very close to one another which is a very inefficient arrangement. Secondly, Couture does not provide any arrangement for maintaining the
5 grease pressure above that of the outside water so that there is always a risk, which grows with time, of sea water entering the chamber and damaging the gears.

For a contra-rotating propeller assembly to be commercially acceptable, due regard must be paid to a number of different features which affect its efficiency. Firstly, the axial spacing of the two sets of propeller blades can be a critical feature which can only
10 be determined by model testing. Secondly, the thrust of the two propellers, particularly when the vessel is going astern, must be acceptable and this can be varied by designing the propellers to operate at different relative rotational speeds. Thirdly, the gearing is preferably so arranged that there is no risk of sea water contaminating the gears. Fourthly, the bending moment produced on a drive shaft by the weight of the
15 propellers is preferably kept as low as possible.

Object of the invention

An object of this invention is to provide an improved contra-rotating rotor assembly.

The invention

In accordance with the present invention, a unit comprises two, axially-aligned and
20 contra-rotating rotors one of which is attached to a drive shaft and drives the other rotor through a positionally-held planetary gear mounted on a static support sleeve through which the drive shaft passes and which extends axially through one of

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the rotors; the planetary gear having its rotational axis extending parallel to the shaft and meshing with gearing of the rotors to transmit a reversing drive between them, and being located inside an oil-filled cylindrical gearbox arranged around the drive shaft and extending coaxially between the two rotors so as to space them apart.

5 Preferred features of the invention

Preferably the gear box has three, coaxial cylindrical sections of which the outer two sections are respectively formed by annular hubs of two contra-rotating rotors, and the intermediate cylindrical section supports a set of axially-parallel planetary gears which are circumferentially equi-spaced around the axis of the shaft. Each planetary
10 gear is provided at its opposite ends with respective pinions which mesh with geared surfaces of the two hubs. The three cylindrical sections are preferably spaced by seals which allow the outer two sections to rotate in opposite directions with respect to one another while preventing water from entering the gear box.

The design of the assembly of the invention is particularly well-suited to a marine
15 propulsion unit as it is of robust construction and enables the intermediate cylindrical section of the gearbox to serve one or more of the following four functions: It enables a bearing for supporting one of the outer cylindrical sections to be mounted on an axially-extending portion of the intermediate section which can also carry the weight of one of the propellers. Secondly, it enables radial, fluid-straightening blades to be
20 mounted between contra-rotating marine propellers and this can be useful to enhance the efficiency of operation of the assembly. Thirdly, if used in an outboard motor, it enables a gas exhaust passage to be formed through the intermediate section and the straightening blades, to convey exhaust gases from the outboard motor radially outwards to a position beyond the swept cylindrical volume of the propellers. This



avoids the risk of the exhaust gas bubbles spoiling the efficiency of operation of the assembly. Fourthly, by arranging the axes of the individual planetary gears parallel to that of the drift shaft, the axial length of the planetary gears can be chosen to suit the spacing between the propellers, and use can then be made of stepped planetary
5 gears having differently sized pinions at opposite ends, so that the rotational speeds of respective propellers can have a ratio other than 1:1.

The intermediate cylindrical section of the gearbox may also be used to support a cylindrical coaxially-arranged shroud around the outside of the volume swept by the rotating propellers. This shroud may be attached to the ends of the straightening
10 vanes.

Introduction to the Drawings

The invention will now be described in more detail, by way of example, with reference to accompanying partly diagrammatic drawings, in which:

In the Drawings

15 FIGURE 1 is an artistic representation of the under-water stern portion end of a hull of a vessel to which a contra-rotating propeller assembly is fitted;

FIGURE 2 is an exploded and partly-diagrammatic perspective view, partially cut away, of an assembly similar to that shown in figure 1 but modified for use as part of an outboard motor and, for convenience the same reference numerals as
20 used in figure 1 have been used in figures 2 and 3 to denote like parts; and

FIGURE 3 is a sectional side elevation of the assembly of figure 2.

Description of Preferred Embodiment

Figure 1 shows the stern portion 1 of a ship having a hull 2 through the after-end of which extends a propeller shaft 3. A contra-rotating propeller assembly 4 is rigidly
5 attached to the after end of the hull 2 by a ring of bolts, such as that referenced 22 in the modification of the assembly illustrated in figure 2 and 3.

Figure 2 shows the parts from which the propeller assembly 4 is constructed. They comprise a gearbox 10 formed with three coaxial cylindrical sections 12, 13, and 14. The outer two sections 12 and 14 comprise annular rotatable propeller hubs from
10 which respective sets of propeller blades 15 and 16 extend. The intermediate cylindrical section 13 is stationary and is formed with a central sleeve portion 19 which projects axially through the hub 14 and is held against rotation by the ring of bolts 22 connecting the section 13 either to the hull 2 in the arrangement shown in figure 1, or to the submerged tail-portion of an outboard motor in the arrangement
15 shown in figures 2 and 3.

A set of flow straightening vanes 18 project radially outwards from the section 13 between the blades 15, 16 of the propellers, and supports a cylindrical shroud 17 which is coaxial with the gearbox, and is arranged radially outwards of the propeller blades 15 and 16. A gas exhaust passage 28 extends internally lengthwise of each
20 blade and opens through the outside of the shroud 17, as is shown in figure 3, by way of a tear-drop shaped depression 29 which is shaped so that water flowing past it, generates a suction effect to facilitate the discharge of gas from the passage 28 when the shroud is travelling through the water. The passage 28 extends radially inwards

through the interior of the intermediate section 13 and then axially forwards through the sleeve portion 19 to connect with a gas duct (not shown) through which exhaust gases from an internal combustion engine (also not shown) are discharged. A tapered roller bearing 23 is carried by the portion 19 within the gearbox 10, to carry the weight of the propeller hub 14 and its blades.

The propellers are turned in opposite directions by drive provided by a shaft 25 driven by the engine and extending axially through the centre of the intermediate section 13 of the gearbox. The after-end of the shaft 25 projects beyond the intermediate section 13, and is splined at 26 to the interior of an annular drive gear 30. The hub 12, which surrounds the gear 30, is provided with a conical shell 37 for the assembly, and is attached rigidly by bolts 31 to one end of the drive gear 30. A rubber annular pressure seal 32 is located between the hub 12 and the intermediate section 13 to prevent sea water entering the gearbox while allowing rotation of the hub 12. A second annular seal 34 is located between the intermediate section 13 and the other propeller hub 14. A third annular seal 35 is provided at the forward end of the hub 14 to complete the sealing of the gearbox.

Drive from the shaft 25 is transmitted by the gear 30 to a set of three, equi-angularly spaced, static, stepped, planetary driving gears 40 of which only one is illustrated in the drawings. Each gear 40 has a central shaft 41 passing through a lubricated, axial bore 39 in the intermediate section 13 which thus serves as a static carrier for the planetary gears. Two differently-sized pinions 42 and 43 are respectively provided at opposite ends of the gear 40. The smaller pinion 42 meshes with the gear 30 and the larger pinion 43 meshes with an internal gear 44 provided in the hub 14. Such an arrangement enables the two propellers to rotate at different speeds, in opposite directions.

The gearbox 10 is supplied with lubrication oil under pressure from a duct (not shown) opening into a chamber 51 at the forward-end of the roller bearing 23, as shown in figure 3. The lubrication oil flows through the bearing 23 and through channels 52 extending along the bores 39 to lubricate the shafts 41 of the planetary gears 40. The oil then flows inwardly between the gear 30 and the section 13 to a further lubrication channel 53 which extends forwardly along the drive shaft 25 to lubricate it also.

Operation of Preferred Embodiment

The above-described assembly operates as follows:

10 Drive to the propellers is provided by the shaft 25 which rotates the gear 30. This turns the planetary gears 41 by way of the pinions 42 which mesh with the gear 30, and also the propeller 15 by way of the hub 12 which is bolted to the end of the gear 30.

15 The planetary gears 40 are individually rotated in the opposite direction of rotation to the shaft 25, and cause rotation of the propeller 16 in the same direction as the gears 40 by the meshing of the pinion 43 with the internal gear 44 of the hub 14. However, the hub 14 rotates more slowly than the hub 12 as a result of the difference in the diameters of the pinions 42 and 43.

The blades 16 drive water through the interior of the shroud 17 and impart to it a twisting motion which is straightened by the vanes 18 before the water encounters the

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set of propeller blades 15. These rotate at a higher speed than the blades 16 and propel the water out of the rear of the shroud 17.

Exhaust gas from the outboard motor engine pass through the axial portion of the duct 28 located in the projecting portion 19, and then through the radial portions of the
5 duct 28 to the outside of the shroud 17. The gas then dissipates in the stern wash of the vessel without encountering the propellers.

Lubrication oil is circulated through the gearbox from the chamber 51 and flows, as already described, through the tapered roller bearing 23 which supports the weight of the hub 14, through the bores 39 containing the shafts of the planetary gears 40, and
10 then back along the channel 53 extending along the drive shaft 25. The lubrication oil is supplied at a pressure above that of the surrounding sea water, and is retained in the gearbox by the seals 32,34 and 35.

It will be observed from figure 3 that the propeller shaft 25 is freed of the weight of the hub 14, and the length of the shaft 25 supported in the intermediate cylindrical
15 section 13, together with close proximity of the gear 30 and hub 12 to the section 13, ensure that only a very small portion of a the drive shaft 25 is subjected to bending movement when the propeller is in use.

Modification of the Invention

It is preferred to use a symmetrically arranged set of planetary gears to transmit
20 drive between the two propeller blade hubs. However, there are circumstances when a single planetary gear will suffice.

Also, it is not essential for the two propellers to be driven at different speeds, and there are circumstances at which the contra-rotation of the two propellers at the same speed will be required, for example when it is required that the torques produced by the propellers shall be self-cancelling as is desired in some torpedo drive units.

**CLAIMS**

1. A unit comprising two, axially-aligned and contra-rotating rotors one of which is attached to a drive shaft and drives the other rotor through a positionally-held planetary gear mounted on a static support sleeve through which the drive shaft
5 passes and which extends axially through one of the rotors; the planetary gear having its rotational axis extending parallel to the shaft and meshing with gearing of the rotors to transmit a reversing drive between them, and being located inside an oil-filled cylindrical gearbox arranged around the drive shaft and extending coaxially between the two rotors.
- 10 2. A unit as claimed in claim 1, in which the gearbox has three, coaxial cylindrical sections of which the outer two sections are respectively formed by annular hubs of two contra-rotating rotors, and the intermediate cylindrical section supports a set of planetary gears which are circumferentially equi-spaced around the
15 its opposite ends with respective pinions which mesh with geared surfaces of the two hubs, the three cylindrical sections being provided with seals which allow the outer two sections to rotate in opposite directions with respect to the intermediate section while preventing water from entering the gearbox.
3. A unit as claimed in claim 2, in which the intermediate section has the
20 sleeve extending axially from one side and providing a support for a bearing which supports the weight of one of the rotors.
4. A unit as claimed in claim 2 or claim 3, in which the intermediate section is provided with radially projection, flow-straightening vanes.



5. A unit as claimed in claim 4, in which the rotors respectively comprise marine propellers and a cylindrical shroud coaxially surrounds both of them and is fixed to the outer-ends of the vanes.

6. A unit as claimed in claim 4 or claim 5, forming part of a marine outboard motor which has an exhaust gas venting duct extending through the sleeve of the intermediate section and through at least one of the vanes, the duct being arranged to discharge gas outside of the swept volume of the propeller blades.

7. A unit as claimed in claim 6, in which the outer-end of the duct opens into a tear-drop shaped depression which induces suction in the outer-end of the duct when water is travelling past it.



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