

PATENT SPECIFICATION

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(54) IMPROVEMENTS IN OR RELATING TO SHIPS' HELMS

(71) We, SPERRY CORPORATION formerly SPERRY RAND CORPORATION, a Corporation organised and existing under the laws of the State of Delaware, United States of America, of 1290 Avenue of the Americas, New York, New York 10019, United States of America do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to ships' helms (or steering systems) and is concerned with a variable ratio helm in which the ratio of rudder rotation to helm rotation is non-linear.

Traditionally, a ship's helm has required a plurality of complete (360°) rotations of a wheel of the helm to effect the hardover rudder rotation, i.e., a full rudder rotation of about 45°. This insensitivity of rudder rotation or movement to helm wheel rotation is an effect which grew out of the mechanical advantage of block and tackle coupling of the helm to the rudder which permitted a seaman to generate enough force at the helm to effect a change of heading of a large ship by substantial displacement of the rudder, which is subjected to extremely large forces. This insensitivity of rudder rotation to helm rotation, however, made heading keeping, (i.e. maintaining the ship aligned on course) much easier because large helm rotations, as large as 60°, in either direction resulted in minor repositioning of the rudder of the order of 5° in either direction. Accordingly, less stringent control of the helm was required to keep the ship on course. It is to be noted that hardover rudder varies from ship to ship but is of the order of 45° rudder rotation from midship. Accordingly, as various mechanical and electrical systems eventually replaced the manual-pulley arrangement for opera-

tion of the rudder, the insensitivity of the rudder to helm rotation remained, i.e., a plurality of helm rotations were necessary for hardover to hardover rudder, in order that rudder rotation during heading keeping remained insensitive to large wheel rotations as in the previous known pulley arrangements. However, for change of heading the insensitivity of the rudder to the rotation of the ship's steering system required a plurality, generally three, complete rotations of the helm from hardover to hardover rudder which can be a troublesome manoeuvre and which in an emergency requires additional time to order. Furthermore, during an emergency the seaman at the helm would order a hardover rudder, which as stated above takes some time to achieve, and if no response is forthcoming would then have to generate an emergency or Non Follow Up (NFU) operation to rotate the rudder in the required direction.

Therefore, there is a need to provide a helm which is insensitive to large rotations about midships for heading keeping but is also highly responsive to helm rotation for change of heading. Furthermore, during an emergency the instinctive reaction of the seaman at the helm to continue turning the wheel towards and past the hardover rudder position renders it desirable to provide an emergency Non Follow Up system incorporated in the helm order device at the hardover rudder position.

According to the invention there is provided a ship's helm for use with marine craft of a type in which the steering apparatus produces an electrical command signal that controls rudder angle through an electrical network and including manual steering means displaceable between respective hardover stop positions, the helm comprising signal generating means responsive to the manual steering means and operable to produce an electrical rudder command sig-

8 MAY 1981

nal having a linear variation with displacement of the steering means over a central portion of the displacement of the steering means between limits, centred about midships, and a non-linear variation with respect to the remaining displacement of the steering means from each of the limits to the respective hardover stop positions, whereby displacement in rudder angle which is linear with respect to the central portion of the displacement and non-linear with respect to the remaining displacement of the steering means.

A ship's helm according to the invention may be capable of ordering hardover to hardover rudder in less than one complete rotation, (360°) of the wheel and, in addition, may provide a relatively insensitive signal about midships to the rudder such that a much greater wheel rotation for each degree of rudder rotation about midships is required in order to make heading keeping easier.

A variable ratio ship's helm forming a preferred embodiment of the invention includes a desensitised control about midships such that for a sector of the wheel rotation fine hand control is possible which prevents 'over steering' about a desired heading. Furthermore, the variable ratio ship's helm also includes a more responsive control for the remaining sector of the wheel rotation which requires less wheel rotation for each degree of rudder rotation such that large helm or rudder orders for changing ship's heading, between the range of hardover to hardover rudder, are possible in less than one revolution of the helm.

The helm may include variable signal means, such as a variable ratio potentiometer, for converting movement of the helm into a variable ratio helm order signal to the rudder. In particular, the preferred embodiment of the variable ratio helm of this invention comprises a non-linear potentiometer which is coupled to the wheel and which provides a helm output signal which is linear in the region from 5° left rudder to 5° right rudder, in which the helm has a gradient of approximately 9° of helm per degree of rudder, and which is logarithmic thereafter, so that about 150° of helm (left or right) is equal to about 45° hardover rudder (left or right) respectively. The helm may also include adjustable stops to provide various hardover rudder settings, other than 45°, corresponding to the hardover rudder setting of the particular ship; centring means for returning the helm to midships; helm adjustment means for providing an offset rudder angle, other than midships, for heading keeping; and overriding emergency steering or non follow control selectable at both hardover rudder positions, which directly applies power to the rudder in the

appropriate direction.

A ship's helm according to the invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a block circuit diagram illustrating the helm-rudder electrical connection and the helm-non followup-rudder connection of the ship's helm.

Figure 2 is a sectional side view of the ship's helm.

Figure 3 is a rear view of the helm.

Figure 4 is a front view of the helm, partially cut away to show a dial of the helm.

Figure 5 is a sectional view taken on the line 5-5 of Figure 2.

Figure 6 is a sectional view taken on the line 6-6 of Figure 3.

Figure 7 shows a hardover rudder position stop of the helm without the emergency steering system switch shown in Figure 6, and

Figure 8 is a view of spring centring means of the helm, as seen on the line 8-8 of Figure 2.

Figure 1 is a block diagram showing the helm-rudder electrical connection 10 of the ship's steering system. The helm-rudder connection 10 includes a helm 11 whose signal is applied to the rudder 12 through a control amplifier 13, a power unit 14, a mechanical differential 15, a steering gear 16 and a repeatback loop 17 having a power unit position detector 18 coupled between the power unit 14 and the amplifier 13 for a feedback of the power unit position thereto. Also indicated in Figure 1 is a non-followup circuit 19 which is connected to the helm 11.

The ship's steering system or helm 11 is shown in Figure 2 and comprises a housing 21, a wheel 22, a shaft 23 connecting the wheel 22 to compound signal generating means 24 disposed within the housing 21. The shaft 23 extends through a bore 25 in the housing 21 and a bore 26 in the wheel 22 and incorporates retaining rings 27 and a key 28 to retain the shaft 23 in the wheel, in a conventional manner. Attached to the shaft 23 and rotatable therewith via an irregularly shaped disc 29 is a dial 30 which, when viewed through an opening 31 in the housing 21, indicates helm order angle with reference to a pointer or indicator 32 attached to the housing 21. The compound signal generating means 24 comprises a non-linear potentiometer 34 including rotatable means 35 coupled to the shaft 23 for providing a signal output to the rudder 12. Furthermore, as shown in Figures 2 and 3, the potentiometer 34 is attached to a plate 36 having a slot 37 receiving a pin 38 which is secured to a plate 39 attached to the housing 21, enabling the rotating means 35 to rotate with the wheel 22 while preventing rotation of the potentiometer 34. The non-

(9)

linear potentiometer 34 provides a linear signal to the rudder corresponding to 1° of rudder rotation for every 9° of a first portion of rotation of the wheel 22 from a null point 0° or midships to 5° of rudder in 1° increments, for both left and right rudder, as shown on the matching curve on the dial 30 as viewed in Figure 4. Furthermore, for 5° rudder to hardover rudder (substantially 45°) the output signal from the potentiometer 34 to the rudder varies antilogarithmically with the rotation of the wheel 22. That is, rotation of the rudder from midships or 0° (in either direction) to 5° rudder is accomplished in 45° rotation of the wheel 22 in a corresponding direction, and rudder rotation from 5° to hardover rudder (substantially 45° rudder) is accomplished in the remaining 105° of wheel rotation for the desired direction. Thus, hardover rudder is accomplished in about 150° rotation of the wheel 22, i.e., less than one-half of a complete revolution of wheel rotation from midships to hardover rudder and less than one complete revolution of wheel rotation for hardover rudder to hardover rudder.

Referring now to Figures 2 and 5, the dial 30 is shaped in the form of a truncated cone having a lip portion 40 which extends radially inwardly towards the irregularly shaped disc 29 and which is fastened thereto. The face of the dial 30 is shown in Figure 4 having numerals disposed thereon for indication of rudder angle. As shown, the numerals extend linearly from a null point, marked 0°, to 5° and thereafter extend logarithmically to 45° hardover rudder for both left and right rudder, as explained above.

The disc 29 includes a cylindrically flared portion 41 (Figure 2 and Figure 5) extending axially of the shaft 23 and including adjustable stops 42 (Figure 5) which may also include pins to ensure the desired position or location of the adjustable stops. The adjustable stops 42 are set at the desired hardover rudder angle position specified by the particular ship to which the helm 11 is to be fitted. Rotation of the wheel 22 rotates the disc 29 and the accompanying adjustable stops 42, one of which, at the hardover rudder position, left or right, strikes a T-shaped pin member 43 attached to the plate 39 and extending outwardly therefrom, as shown in Figures 2, 6 and 7. In the modification of Figure 7, the T-shaped member 43 is the hardover rudder 'stop' which the adjustable stops 42 engage at the hardover rudder position and which prevent further rotation of the wheel 22 in the appropriate direction.

In the preferred embodiment of Figure 6, however, wherein both adjustable stops 42 are shown in their respective hardover positions, the T-shaped member 43 forms

part of a switching means 44 which extend outwardly from the opposite side of the plate 39 and which are connected by respective actuators 45 to a pair of micro-switches 46. Each microswitch 46, when tripped, activates the non followup circuit 19 for applying power directly to the rudder 12 in the corresponding direction ordered by the wheel 22 of the helm 11. In this manner, if hardover rudder is reached and no response of the rudder is experienced, the emergency non followup circuit 19 may be immediately and instinctively activated, by the application of an additional turning force to the wheel 22 which trips the switching means 44 and trips the corresponding microswitch 46.

The switching means 44 comprise a threaded stud attached to the T-shaped member 43, a pair of washers 47, belleville or spring washers 48 disposed between the washers 47, spacer means 49 and a nut for holding the washers and spacers on the stud. The belleville washers or spring washers 48 compress under an applied force such as an additional force or torque applied to the helm 11 which, in turn, is transmitted from the appropriate adjustable stop 42 to its corresponding T-shaped member 43. The switching means 44 then tilts into engagement with the appropriate actuator 45, actuating the appropriate microswitch 46 and the non followup circuit 19. In the embodiment shown in Figure 7, the T-shaped member 43 is fixedly attached to plate 39 and resists any additional force or torque (from the helm 11) which tends to rotate the rudder further than the hardover position dictated by the ship and defined by the adjustable stops 42 and the T-shaped member 43.

Referring to Figure 8, a spring return 50 is coupled via the shaft 23 to the wheel 22 and the housing 21. The spring return 50 comprises a coiled spring 51 having opposite leg portions 52 and 53 coupled to the shaft 23 by means of a pin 54 which may be fixedly attached to the shaft 23 but is shown attached to a disc 57 coupled to the shaft 23 as described below. The opposite leg portions 52 and 53, which are axially spaced from each other, cross one another (as shown in Figure 8) and removably engage stops 55 and 56, respectively fixedly attached to the housing 21 and the pin 54, which is shown in this embodiment attached to a disc 57 encircling the shaft 23. The stop pin 55 is eccentric and may be adjusted to remove lost motion of the spring return device 50. The pin 54, moreover, engages the legs 52 and 53 such that movement of the wheel 22 in either direction (right or left) engages one of the legs (52 or 53) respectively, the other leg being fixedly engaged by its stop (56 or 55) respectively, and deflects the spring 51 by rotation

thereof such that upon release of the force of torque affecting the movement of the wheel the deflected spring 51 engages the pin 54, returning the wheel 22 and dial 30 to midships or the 'O' position which appropriately signals the rudder to return to the midship position.

Also incorporated in this embodiment of the invention is a 'Weather Helm' adjustment 60 (Figure 2) which may be used to establish a new 'O' position for the rudder, i.e., rudder offset or bias, to compensate for any long time moments caused by wind, sea and hydrodynamic forces, which may be affecting the heading of the ship. The 'Weather Helm' adjustment 60 includes a knob 61 coupled to the dial 30 and the shaft 23 via an adjustment shaft 62 which extends into a bore 63 in the shaft 23. The 'Weather Helm' adjustment 60 further includes a plurality of frictionally engaging key like members 64 (one of which is shown) disposed in the shaft 23. The members 64 are disposed within the bore 63 and are engaged by the adjustment shaft 62 when the knob 61 is rotated to cause axial movement of the shaft 62 into the bore 63. The engagement of the adjustment shaft 62 with the members 64 forces them into frictional, clutching, engagement with the disc 57 such that the disc 57 is adjustably attached to the shaft 23.

Rotation of the knob 61 in an opposite direction backs off the adjustable shaft 62 from the position shown in Figure 2, which releases the key like members 64 and declutches the disc 57 such that the wheel 22 may be turned to an alternative rudder position or offset angle, to compensate for the deviation forces affecting the heading of the ship, without deflecting the spring return 50. Accordingly, upon a counter rotation of the adjustment 60 and engagement of the members 64 with the disc 57 a new zero-torque position is established at the selected offset angle, that is, at the new zero-torque position of the spring return 50. Thus, the spring return 50 will return the wheel upon release thereof from a heading to the new zero-torque selected offset angle. It will be noted from Figures 2 and 8 that the disc 57 may be formed with a wedge shape 57w in which is situated a pin 57p attached to the shaft 23. The pin 57p limits the setting of the new zero-torque position to an angle no greater than the half angle of the wedge shape 57w, if the pin 57p is disposed at the zero-torque-null position of the spring return 50 and the dial 30.

Further features of the embodiment include a light 70 adjustable by a dimmer knob 71 (Figure 2) for illumination of the dial 30 and a friction device 80 (or drag or braking means) such as a spring washer to prevent free wheeling of the shaft 23. The friction device 80 provides the necessary

restraint, i.e. force or torque feedback, to the helmsman to enable him accurately to position and hold the helm steady. In addition, the helm 11 includes mounting means 86 (Figure 2) for securing the helm 11 to a console panel 88 by means of mounting studs 90 each of which has a frusto-conical head 91 which fits into a recess 92 located at the rear of the housing 21. The studs 90 are securely fastened to the console panel 88 and extend axially therefrom, and the helm 11 is fastened to the studs 90 by set screws 93 (Figure 3) which enter the recess 92 from the sides of the housing 21 and substantially radially to the studs and engage the conical heads 91 such that a wedging action therebetween forces the housing 21 and its associated gasket 95 into locking and sealing engagement with the console panel 88. Accordingly, the mounting means 86 is of a clean, neat and modern appearance and accommodates all console panel thicknesses or materials capable of supporting the helm 11 and provides 'front removal' for ease of servicing of the helm.

In operation, rotation of the wheel 22 is converted to a non-linear signal from hardover to hardover rudder by the signal generating means 24 such that for 9° rotational increments of the wheel 22, in either direction (left or right rudder), the rudder will linearly displace in 1° increments accordingly, and for a rotation of the wheel 22 beyond the 5° rudder position to hardover rudder, in either direction, the rudder will rotate to an angle in antilogarithmic proportion of the angular rotation of the wheel 22. That is, rotation of the wheel from 45° as measured from the null or midships position to 150° will rotate the rudder from 5° to 45° rudder or hardover rudder in antilogarithmic proportion to the wheel rotation. Thus, fine control in the 'null' or central region and hardover-to-hardover rudder control requires less than one full turn of the wheel, which allows use of an aircraft type wheel 22 (Figure 4). The aircraft type wheel, moreover, provides a visual indication of helm order.

Furthermore, if for some reason, the rudder fails to respond to the rotation of the helm as the helmsman orders rudder rotation there is engendered a natural instinct in the helmsman to turn the wheel further in the appropriate direction and to hardover rudder and further if no response is forthcoming. Sufficient force or torque at the hardover stop condition due to a 'panic' type reaction, however, will trip or close the switching means 44 and activate one of the microswitches 46 which energizes the emergency system or non followup circuit 19 such that rudder rotation is ordered at maximum rudder speed until the non followup loop is disconnected, for example, by

releasing the force on the wheel opening the switch 44 which deactivates the non follow-up circuit.

It will be noted that the dial 30 shown in Figure 4 includes direction indicators 100, each in the shape of an arrow head or a plan view of a ship, disposed thereon in relative relation to the angular position indicating numerals. Further, the direction indicators 100 are presented in two sets, one set of which is arranged heading right to left (counterclockwise) and the other set is arranged heading left to right (clockwise). The direction indicators 100 present a visual indication to the helmsman of the direction of the ship's heading, the rudder angle thereof being indicated by the numeral adjacent the fixed pointer 32, because the dial 30 of the helm 11 rotates with the shaft 23, in contrast to a fixed dial in a rotating pointer in the prior art. Accordingly, a helmsman accustomed to the dial of the prior art could be confused by the dial 30 of the helm 11 if the direction indicators 100 were not arranged as shown.

WHAT WE CLAIM IS:-

1. A ship's helm for use with marine craft of a type in which the steering apparatus produces an electrical command signal that controls rudder angle through an electrical network and including manual steering means displaceable between respective hardover stop positions, the helm comprising signal generating means responsive to the manual steering means and operable to produce an electrical rudder command signal having a linear variation with displacement of the steering means over a central portion of the displacement of the steering means between limits, centred about midships, and a non-linear variation with respect to the remaining displacement of the steering means from each of the limits to the respective hardover stop positions, whereby displacement of the steering means produces a displacement in rudder angle which is linear with respect to the central portion of the displacement and non-linear with respect to the remaining displacement of the steering means.

2. A ship's helm according to claim 1, wherein the non-linear signal from the signal generating means produces a signal which is anti-logarithmic with respect to the steering means displacement.

3. A ship's helm according to claim 1 or 2, wherein said linear variation is one degree for every nine degrees of the displacement of the steering means over said central portion.

4. A ship's helm according to any of the preceding claims and further including stops on the steering means and stop pins fixed to the helm to engage the stops to prevent further displacement of the steering means

beyond the predetermined hardover stop positions.

5. A ship's helm according to claim 4, wherein the stops are adjustable such that the hardover position can be altered.

6. A ship's helm according to any of the preceding claims and further including an emergency signal generating means coupled to the steering means.

7. A ship's helm according to claim 6, wherein the emergency generating means include switching means activated at the hardover position of the steering means.

8. A ship's helm according to claim 1 and further including a dial for indicating the angle of displacement of the ship's rudder and wherein the dial includes indicator means pointing towards the direction of the displacement.

9. A ship's helm according to any of the preceding claims and further including spring return means for returning the displaced steering means to its null position.

10. A ship's helm according to claim 9, wherein the spring return means include frictional clutch means responsive to the steering means and disengageably attached to the steering means, whereby upon disengagement of the frictional clutch means the null position of the steering means can be altered.

11. A ship's helm according to any of the preceding claims and further including frictional drag means which are coupled to the steering means and which are adjustable during installation, whereby the braking force of the drag means provides the necessary restraint to the steering means for accurate positioning thereof.

12. A ship's helm according to any of the preceding claims and mounted on a panel, including mounting means comprising mounting studs each of which has a frusto-conical head, the mounting studs being securely fastened to the panel and extending longitudinally outwardly therefrom, and having their heads disposed in a recess within the helm, and set screws which enter the recess radially of the mounting studs and engage the conical heads for securely holding the helm to the panel.

13. A ship's helm according to any of the preceding claims, wherein the signal generating means are a non-linear potentiometer.

14. A ship's helm according to claim 1, wherein the steering means are rotatably displaceable and the respective hardover stop positions are angularly displaced less than 360°.



releasing the force on the wheel opening the switch 44 which deactivates the non follow-up circuit.

It will be noted that the dial 30 shown in Figure 4 includes direction indicators 100, each in the shape of an arrow head or a plan view of a ship, disposed thereon in relative relation to the angular position indicating numerals. Further, the direction indicators 100 are presented in two sets, one set of which is arranged heading right to left (counterclockwise) and the other set is arranged heading left to right (clockwise). The direction indicators 100 present a visual indication to the helmsman of the direction of the ship's heading, the rudder angle thereof being indicated by the numeral adjacent the fixed pointer 32, because the dial 30 of the helm 11 rotates with the shaft 23, in contrast to a fixed dial in a rotating pointer in the prior art. Accordingly, a helmsman accustomed to the dial of the prior art could be confused by the dial 30 of the helm 11 if the direction indicators 100 were not arranged as shown.

WHAT WE CLAIM IS:-

1. A ship's helm for use with marine craft of a type in which the steering apparatus produces an electrical command signal that controls rudder angle through an electrical network and including manual steering means displaceable between respective hardover stop positions, the helm comprising signal generating means responsive to the manual steering means and operable to produce an electrical rudder command signal having a linear variation with displacement of the steering means over a central portion of the displacement of the steering means between limits, centred about midships, and a non-linear variation with respect to the remaining displacement of the steering means from each of the limits to the respective hardover stop positions, whereby displacement of the steering means produces a displacement in rudder angle which is linear with respect to the central portion of the displacement and non-linear with respect to the remaining displacement of the steering means.

2. A ship's helm according to claim 1, wherein the non-linear signal from the signal generating means produces a signal which is anti-logarithmic with respect to the steering means displacement.

3. A ship's helm according to claim 1 or 2, wherein said linear variation is one degree for every nine degrees of the displacement of the steering means over said central portion.

4. A ship's helm according to any of the preceding claims and further including stops on the steering means and stop pins fixed to the helm to engage the stops to prevent further displacement of the steering means

beyond the predetermined hardover stop positions.

5. A ship's helm according to claim 4, wherein the stops are adjustable such that the hardover position can be altered.

6. A ship's helm according to any of the preceding claims and further including an emergency signal generating means coupled to the steering means.

7. A ship's helm according to claim 6, wherein the emergency generating means include switching means activated at the hardover position of the steering means.

8. A ship's helm according to claim 1 and further including a dial for indicating the angle of displacement of the ship's rudder and wherein the dial includes indicator means pointing towards the direction of the displacement.

9. A ship's helm according to any of the preceding claims and further including spring return means for returning the displaced steering means to its null position.

10. A ship's helm according to claim 9, wherein the spring return means include frictional clutch means responsive to the steering means and disengageably attached to the steering means, whereby upon disengagement of the frictional clutch means the null position of the steering means can be altered.

11. A ship's helm according to any of the preceding claims and further including frictional drag means which are coupled to the steering means and which are adjustable during installation, whereby the braking force of the drag means provides the necessary restraint to the steering means for accurate positioning thereof.

12. A ship's helm according to any of the preceding claims and mounted on a panel, including mounting means comprising mounting studs each of which has a frusto-conical head, the mounting studs being securely fastened to the panel and extending longitudinally outwardly therefrom, and having their heads disposed in a recess within the helm, and set screws which enter the recess radially of the mounting studs and engage the conical heads for securely holding the helm to the panel.

13. A ship's helm according to any of the preceding claims, wherein the signal generating means are a non-linear potentiometer.

14. A ship's helm according to claim 1, wherein the steering means are rotatably displaceable and the respective hardover stop positions are angularly displaced less than 360°.

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15. A ship's helm for navigable craft constructed and arranged substantially as herein particularly described with reference to the accompanying drawings.

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