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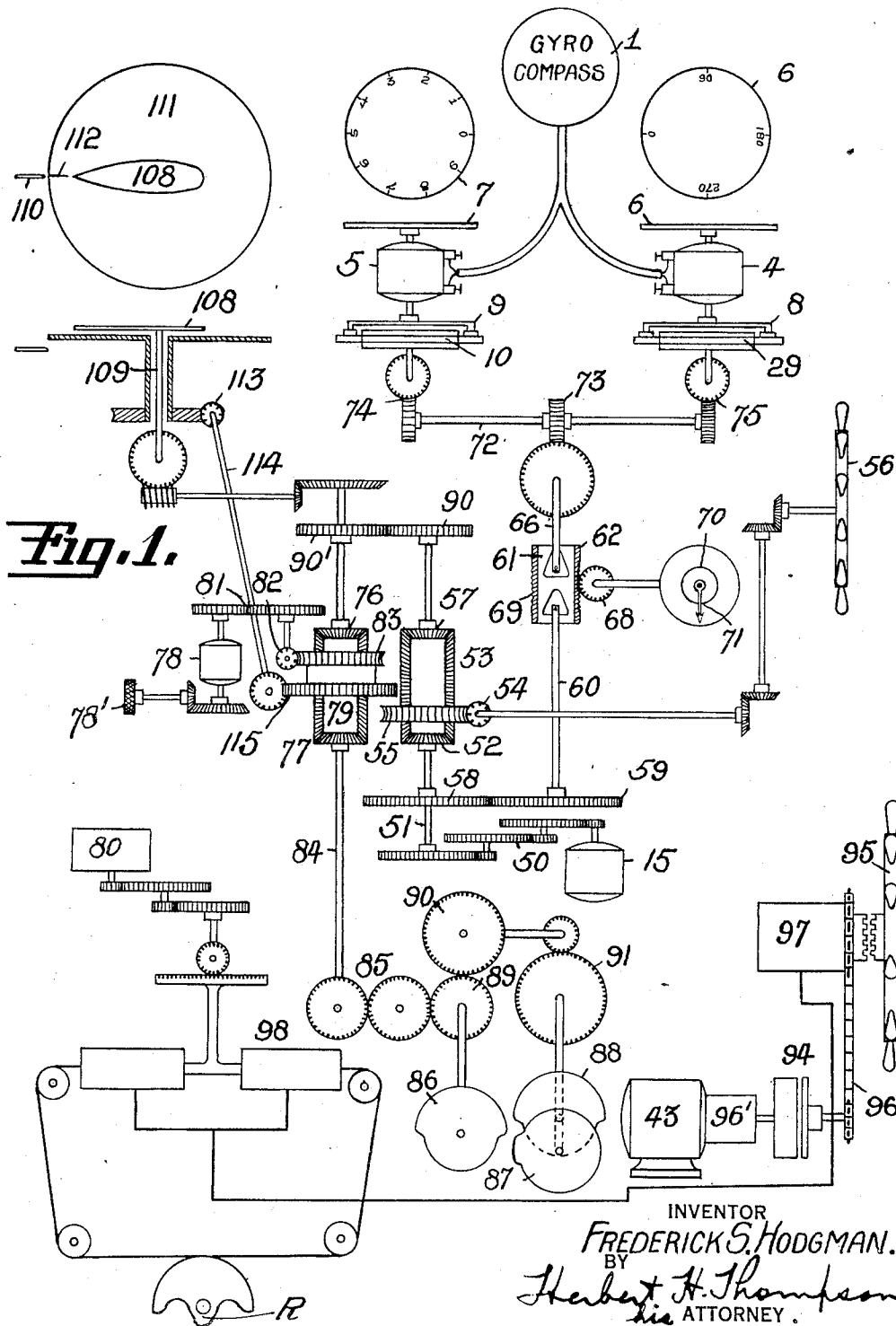
F. S. HODGMAN

2,015,183

SELF SYNCHRONOUS AUTOMATIC PILOT

Filed Oct. 27, 1931

4 Sheets-Sheet 1



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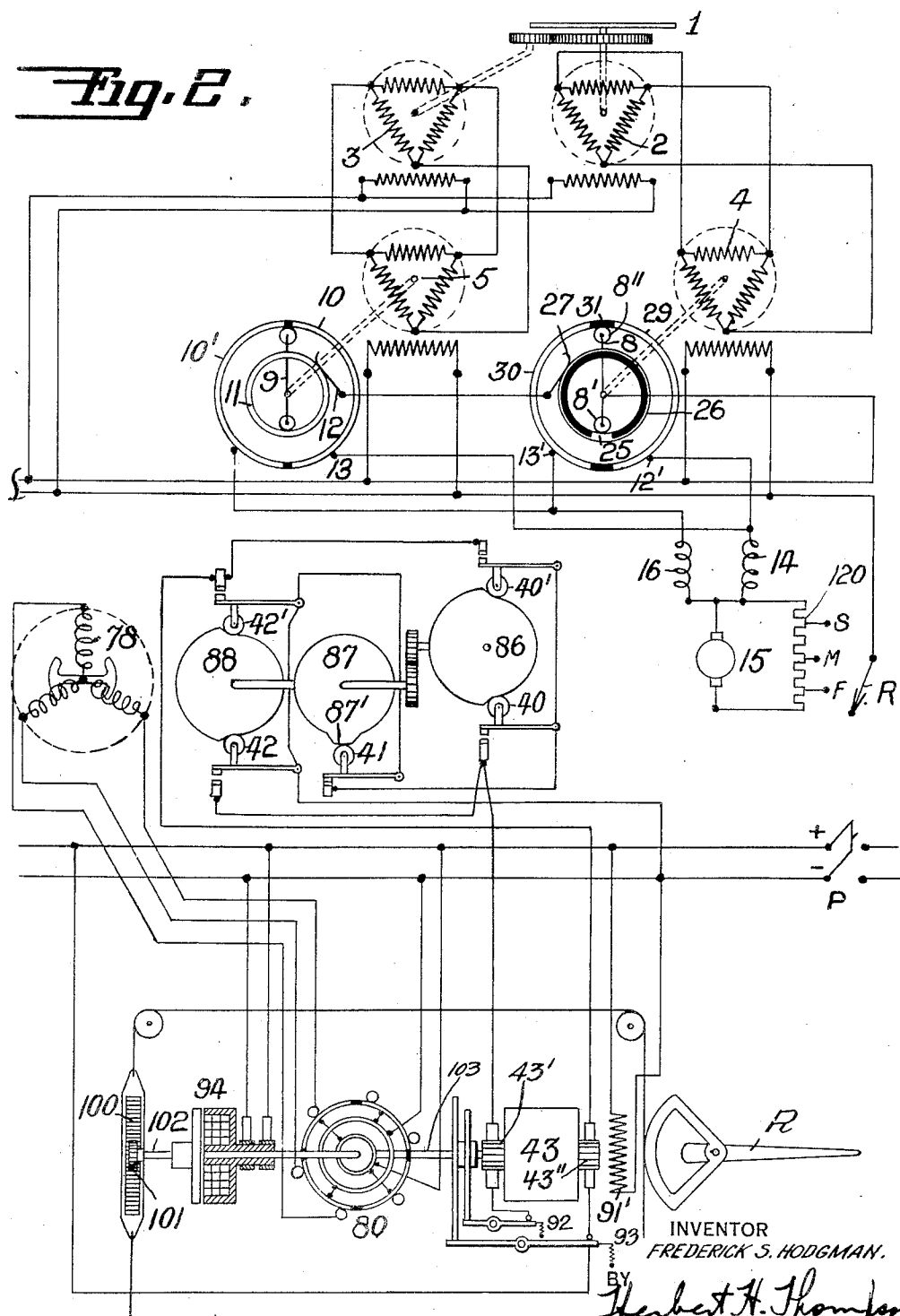
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SELF SYNCHRONOUS AUTOMATIC PILOT

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Fig. 2.



Sept. 24, 1935.

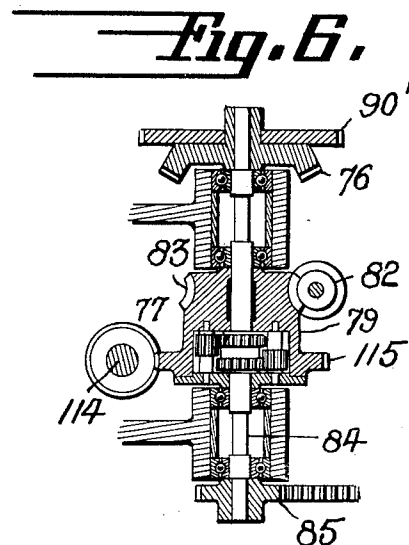
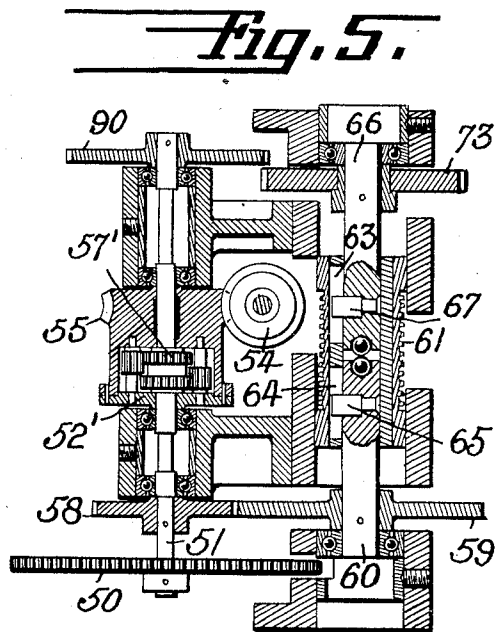
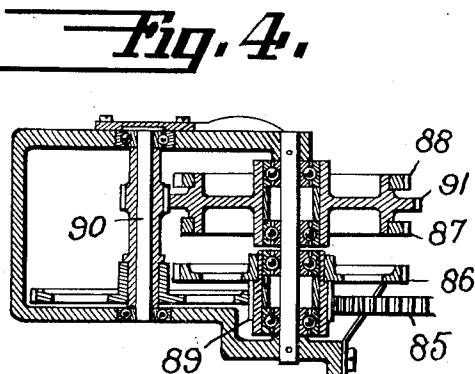
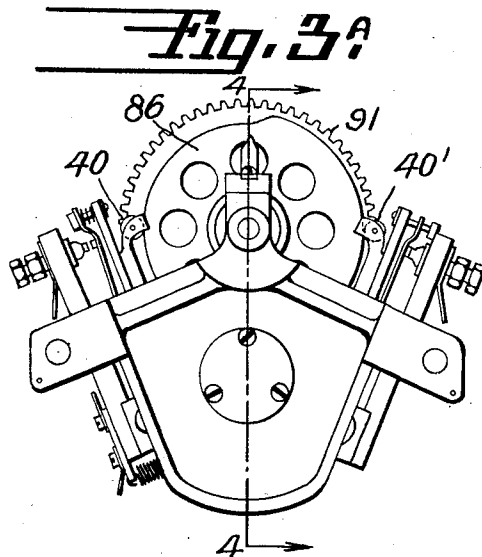
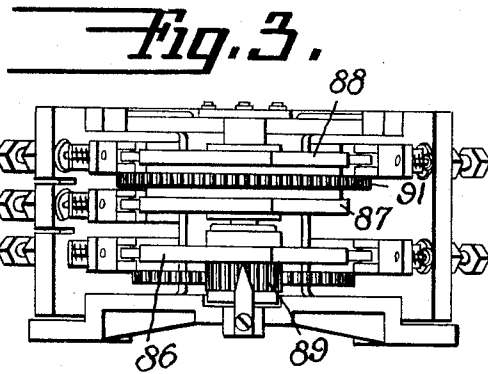
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SELF SYNCHRONOUS AUTOMATIC PILOT

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4 Sheets-Sheet 3



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SELF SYNCHRONOUS AUTOMATIC PILOT

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Fig. 7.

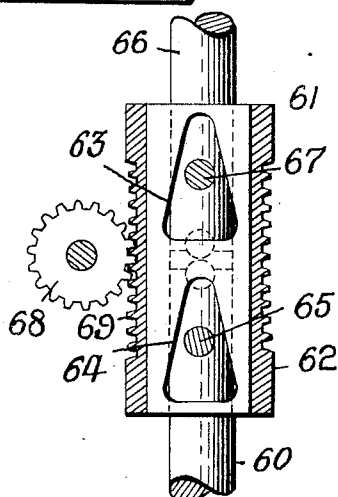


Fig. 8.

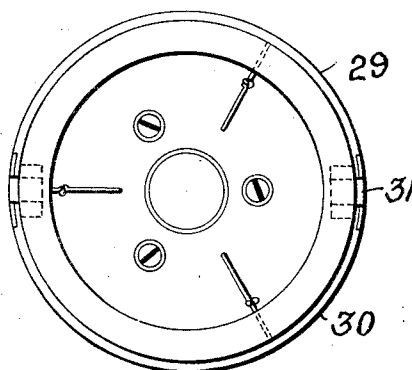


Fig. 9.

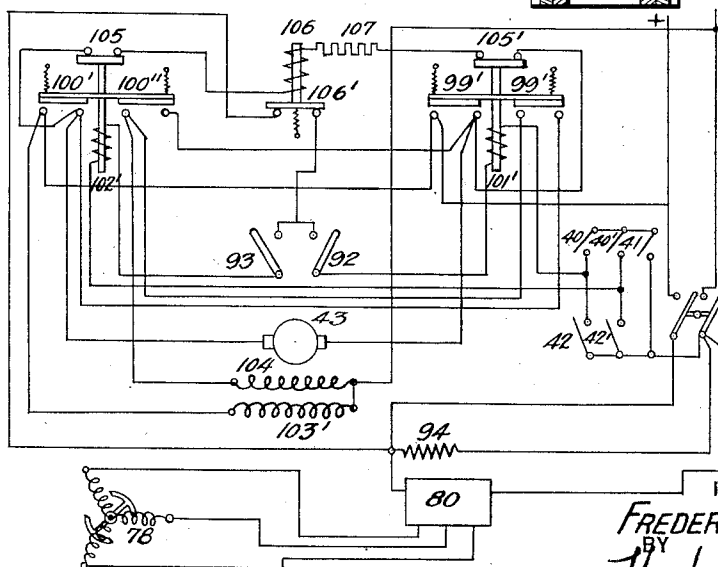
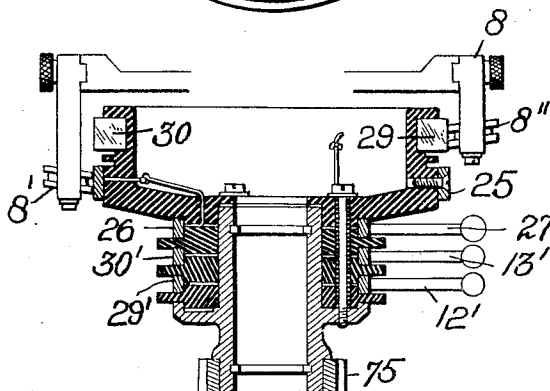


Fig. 10

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UNITED STATES PATENT OFFICE

2,015,183

SELF-SYNCHRONOUS AUTOMATIC PILOT

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Application October 27, 1931, Serial No. 571,475

7 Claims. (Cl. 172—282)

This invention relates to improvements in automatic steering devices for ships wherein the course controller is automatically maintained self-synchronous with the gyro compass. In the present automatic steering devices the controller is geared up to rotate many times for one rotation of the compass or ship in order to obtain accurate control. In case, however, there is a temporary circuit interruption between the controller and compass, or in case the controller is turned faster by hand than the ship can follow, synchronism may be lost and may only be reestablished by hand setting, if the ship's heading becomes displaced more than about 10° on either side of the indicated course. According to my present system, the controller is made self-synchronous so that no matter in what relative positions the controller and compass are at the time the circuit is thrown in, automatic synchronization is established and the rudder brought to the proper position to steer the ship on the predetermined course. My self-synchronous system, of course, has broader application than to the steering of ships and is adapted for any self-synchronous remote control system of a power motor. According to my invention, I prefer to insert an auxiliary controller or controllers and a small sensitive power motor between the compass controlled repeater motors and the main steering motor. By this means a much quicker and sensitive control of the ship is obtained for the reasons outlined in my prior application Serial No. 529,939 filed April 14, 1931 for Sensitive remote control system and automatic pilot.

Referring to the drawings,
Fig. 1 shows in diagrammatic form my system as applied to automatic steering for ships.

Fig. 2 is an elementary wiring diagram of the same.

Fig. 3 is a detailed plan view of the cam switches used to operate the main steering motor.

Fig. 3—A is a side elevation of the same.

Fig. 4 is a section taken approximately on line 4—4 of Fig. 3—A.

Fig. 5 is a vertical section through the primary differential and lost motion devices in the controller.

Fig. 6 is a vertical section of the secondary differential.

Fig. 7 is a detailed section of the lost motion device for introducing the telemotor adjustment.

Fig. 8 is a plan view of one of the annular contactors used in the controller.

Fig. 9 is a vertical section of the same also showing the brushes or trolleys.

Fig. 10 is a wiring diagram of a modified form of control for the steering motor.

In Fig. 2 the sending instrument, in this case a master compass, is represented at 1 and as usual in self-synchronous remote control systems the compass is provided with a course transmitter 2 connected at a 1 to 1 speed to the compass, and a fine transmitter 3 connected at multiple speed, such as a 36 to 1 to the compass. The course transmitter drives the coarse repeater motor 4 and the fine transmitter drives the fine repeater motor 5 at the controller. Each motor may be provided with a repeater card 6 and 7 if desired (Fig. 1). The motors and transmitters are preferably of the alternating current self-synchronous type (see Fig. 2) wherein the fields are continuously excited from an A. C. source S and the armatures are electrically connected.

It is well known that such motors are accurate only when little or no load is placed thereon. Therefore, I mount the power motor control contacts directly on the shaft of the motor. Also, instead of employing only a contactor on the fine motor, I prefer one on each motor in order to secure self-synchronism as hereinafter described. The course motor carries the trolley arm 8 and the fine motor the trolley arm 9, both arms being shown as having a trolley at each end. The fine controller may be of the usual form in which two trolleys bear respectively on upper ring 10 and lower slip ring 11, (Figs. 8 and 9). Said rings are shown in Fig. 2 as of different diameter for the sake of clearness. The upper ring is divided into two parts 10—10' by narrow strips of insulation and a lead-in brush 12 bears on the slip ring 11 to lead current into the trolleys. If, therefore, the trolleys 8 in Fig. 2 are turned clockwise or if the contact rings are turned counter-clockwise, the circuit will be completed from the trolleys to segment 10. Since no brush is in contact with the segment 10' at the time, the circuit will, therefore, be completed through the brush 13 which actually bears on a slip ring (not shown) in Fig. 2, and through one field winding 14 on the double wound field of the power motor 15 and thence back to the line through the armature. The actual construction of this contactor is quite similar to course contactor 8—22—26 shown in detail in Figs. 8 and 9 and hereinafter described. If, on the other hand, the trolleys are rotated counter-clockwise, the circuit is completed through the segment 10' to the other field winding 16 of the motor, thus driving the motor in the opposite direction.

The motor 15 may be made of sufficient size

to turn the rudder directly or through an auxiliary steering engine, but I prefer to make the motor 15 very small so as to respond very quickly to the controller and to use said motor only to operate additional cam-operated contacts 40—41—42, which in turn control the main steering motor 43, and to place a lost motion device between said motor and its controller as hereinafter described.

Except for this feature the system so far described is quite similar to the systems at present in use; but without a connection from the coarse or self-synchronous motor 4 the device would not be completely self-synchronous. I, therefore, also provide the controller 8 on motor 4 with means for causing the same to assume control of motor 15 when the ship is off course more than the angle of self-synchronism of controller 9, which, with a 36:1 ratio, would be about 5°. In order to effect this purpose, the lead-in current to the trolley 9 is led first to the trolley arm 8 and from thence, in order to reach the trolley 9, current must pass from the lower trolley 8' through the short contact segment 25 and thence through the annular external slip ring 26 connected to segment 25 and thence through the brush 27 to the trolley arm 9 (for actual construction see Figs. 8 and 9). It will be seen, however, that if the trolley 8' is rotated either to the right or left through an angle greater than the width of the segment 25, the current to the trolley 9 will be interrupted and the fine controller rendered inoperative. Under these conditions, however, the upper trolley 8'' is moved off the insulated sector 31 which is of about the same angular width as 25, bringing 8'' into contact with one of the live segments 29 or 30 which are connected through the slip rings 29' and 30' (Fig. 9) and brushes 12' and 13' to said field windings 14 and 16 respectively. Therefore, when the ship is off its course by an angle sufficient to move the trolley 8'' off the insulated segment 31 and the trolley 8' off the corresponding live segment 25, the coarse controller operates the motor to bring the ship around to within the predetermined degree of synchronism, i. e., within the limits of self-synchronism of the fine controller. At this point, however, the coarse controller becomes inoperative by engagement of the trolley 8'' with the dead section 31 and the fine controller becomes operative so that the fine controller alone will bring the ship on to exactly the right course.

There is, of course, provided a follow-back connection between the motor 15 and the controller contacts. The gear connections are diagrammatically shown in Fig. 1. Motor 15 is shown as connected to double reduction gearing 50 to a shaft 51 on which is mounted a gear 58 turning a gear 59 on shaft 60. In this shaft is interposed a lost motion device 61 for the purpose, among others, of eliminating the yaw of the ship. This device is shown as consisting of a sleeve 62 (see Fig. 7) having a pair of triangular slots 63 and 64 therein. The shaft 60 has a pin 65 thereon engaging slot 64, while a complementary shaft 66 has a pin 67 engaging slot 63. Sleeve 62, therefore, furnishes a loose adjustable lost motion connection between the shafts 60 and 66, the amount of lost motion being varied by adjusting the sleeve longitudinally on the shafts. This adjustment, as shown, is effected from a pinion 68, the teeth of which mesh with annular rack teeth 69 on the exterior of the sleeve, the pinion being adjustable from a knob 70 in accordance with the readings of cooperating pointer and scale 71.

The shaft 66 is shown as driving a cross shaft 72 through spiral gearing 73. Said cross shaft is shown as geared through one-to-one spiral gearing 74 to turn the contact rings 10 of the fine transmitter. The shaft 72 at its other end drives corresponding contact rings 26—29 of the coarse transmitter through suitable reduction worm gearing 75.

Shaft 51 also drives one arm 52 of a differential gear train 53. The central or planetary arm of said train is shown as revolved from a worm 54 turning a wormwheel 55 thereon. Said worm in turn is adjusted from the handwheel 56 by which course changes or corrections are introduced in the usual manner.

As above indicated I prefer to make the motor 15 very light so as to quickly respond to the controller on the repeater motors to actuate the main contacts for the main motor 43. The lost motion device above described cooperates to this end by causing motor 15 to turn through a large initial angle whenever it is first started, thus always closing the contacts on the main controller for a very small deviation of the ship (on the order of 5 minutes or less). For this purpose the third arm 57 of the differential drives one arm 76 of the second differential 77 through gears 90, 90'. The second arm 79 is driven from a follow-back repeater motor 78 actuated from a transmitter 80 connected with the motor 43 to furnish a follow-back connection from motor 43 to the main controller. A hand synchronizing knob 78' may be employed if the motor is not of the self-synchronous type. As shown, the repeater motor 78 is connected through gearing 81 to a worm 82 driving a wormwheel 83 forming a planetary arm of the gear train. The third arm of said train rotates a shaft 84 which rotates through suitable gearing 85 a plurality of cams 86—87—88 which operate the switches to control the motor. As shown, the cam 86 has a one-to-one connection to the shaft 84 while the other two cams are driven through a step-down gearing 89—90—91 so as to be rotated, say, at 1 to 18 speed. Cam 86, therefore, controls the fine contacts 40—40' (Fig. 2) while the other two cams control the coarse contacts 41, 42 and 42'. These contacts and motor 43 are preferably placed on the ship's main D. C. power circuit represented at P, while the motor 15 may be actuated from the lighter single phase circuit used to operate the repeater system of the compass and controller.

The fast and slow cam contacts may control the motor synchronously in a manner similar to the commutator contacts above described. Thus normally the fast contacts 40 and 40' are in control of the motor, the circuit to the same being closed by the switch 41, the roller of said switch resting on the raised portion 87' of the cam 87. In case, however, synchronism is lost, the roller of contact 41 will ride down on the lower portion of the cam 87 thus breaking the circuit to the contacts 40—40'. At the same time one of contacts 42—42' will be made to operate the motor from the slow or self-synchronous cam 88. In this case the motor is shown as having a double wound armature with two commutators 43'—43'' instead of a double wound field as in motor 15, although it is obvious that either form of winding may be employed in either case. The field 91' is shown as excited directly from the line. 92 and 93 are limit switches designed to be open when the rudder R approaches the limit of its movement in either direction. The rudder is shown diagram-

5 matically as turned from a rack bar 100 which is reciprocated by the rotation of pinion 101 on shaft 102. There is also shown an electro-magnetic clutch 94 between shaft 102 and the shaft 103 of motor 43. Said clutch remains closed only while the electric circuit to the servo motor is closed but which is disengaged when this circuit is broken, thus freeing the rudder from the load of the motor 43 when it is desired to steer by hand.

10 In Fig. 1 motor 43 is shown as driving the rudder R through the usual telemotor system, the motor being coupled to the main steering wheel 95 through gear box 96', sprocket and chain 96, and clutch 94, the handwheel operating the rudder through the telemotor or straight hydraulic servo-motor system represented generally at 97 and 98.

15 Fig. 10 shows a simplified wiring diagram of the control of the power motor 43 only. In this case the cam driven contacts 40, 40', 41, 42, 42' reverse the motor through auxiliary relay contacts 99, 99', 100', 100'' operated from windings 101' and 102' in circuit with cam contacts. In this case the motor is reversed by reversing the current through the armature while leaving the current through the shunt field 103' and series field 104 unchanged. Dynamic breaking may be provided, if desired, by contacts 105, 105', resistance 107 and coil 106 operating switch 106'.

20 I also prefer to provide at the controller an indication of the rudder movements as well as of the ship movements so that the pilot may observe promptly whether the helm has moved in response to the controller and also whether the ship is following the helm properly. For this purpose I have shown an upper dial 108 which may be the shape of the ship's hull and is driven from shaft 109 of gear 76, the movements of this shaft representing the differential of the compass movements and the handwheel 56 so that the dial 108 constitutes a course change indicator when read on the stationary index 110. Beneath the indicator 108 is a rotary dial 111 having index 112 thereon representing the position of the rudder. This dial is shown as rotated from a worm 113 on shaft 114 driven in turn from a gear spiral 115 on differential 79. Indicator 112, therefore, shows the rudder position being actuated from the rudder follow-up motor 78.

25 According to my present invention, I effect the adjustment known in the art as the weather adjustment in a different manner than heretofore accomplished. This adjustment is for the purpose of varying the sensitivity of control so that in calm weather very accurate steering may be obtained while in rough weather over-working of the steering engine may be avoided by lessening the sensitivity of the device. According to my present invention I effect this purpose by varying the normal speed of the motor 15 instead of varying the play in a lost motion connection between the compass and controller as heretofore generally done. This has the advantage that the sensitivity of the control is not sacrificed because a deviation of the ship from its course which persists longer than the normal period of weather yaw will always cause a rudder response. This motor, although operated from a single phase A. C. line may be of a commutator series wound type. I prefer to provide the speed control by placing a resistance 120 across the commutator and taking off taps therefrom to form rheostat contacts F, M and S. A rheostat arm 30 R is connected to one side of the A. C. line.

When the weather is bad and a non-sensitive control is desired the rheostat R is placed on the slow speed contact S. In this position, although the counter E. M. F. in the motor is small at slow speed, the major portion of the resistance 120 is in series therewith and the short end of the resistance in parallel therewith so that the armature current is greatly reduced. At the same time the strength of the field is increased on account of the low resistance in series therewith so that ample torque is retained. If a greater motor speed is desired, the arm R is placed on the contact M and if the most sensitive control is desired for fair weather steering, it is placed on contact F. In the latter position it will be seen that that portion of the resistance in series with the armature is reduced to a minimum, while that portion in shunt with the armature is increased to a maximum. The use of the shunt resistance also serves to steady the motor when operated on alternating current and improve the starting torque, especially at low speed.

35 In accordance with the provisions of the patent statutes, I have herein described the principle and operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means. Also, while it is designed to use the various features and elements in the combination and relations described, some of these may be altered and others omitted without interfering with the more general results outlined, and the invention extends to such use.

Having described my invention, what I claim and desire to secure by Letters Patent is:

1. In a self-synchronous receiver, the combination with a repeating device, of coarse and fine repeater motors, the former of which is adapted to be driven from a coarse transmitter having a one-to-one drive with the sending instrument and the latter to be driven from a fine transmitter having a multiple drive from said instrument, a power motor for driving said device, a pair of cam surfaces and cooperating contacts differentially rotated from said repeater motors and power motor at a one to one ratio, normally open circuit means for driving said power motor in one direction or the other as one or another of said contacts is closed by one of said cams, a third cam surface and cooperating contacts differentially rotated from said repeater motors and power motor at a multiple ratio, a circuit between said last-named contacts and the contact on the second of the first mentioned cams whereby said contacts are rendered inoperative when the receiver is out of synchronism more than a predetermined angle, and a circuit otherwise normally completed for normally driving said power motor in either direction as one or the other of said contacts is closed.

2. In a self-synchronous power means for turning a heavy object, a reversible power motor, a main contact device comprising a cam and a pair of reversing contacts operated thereby for normally operating said motor, an auxiliary contact device driven at a fractional speed of said main device and at a one to one ratio with said object, comprising a pair of cam surfaces, a contact on one surface for breaking the circuit to said pair of contacts when the angle between said surface and contact exceeds a predetermined value, and a pair of reversing contacts on the other surface adapted to assume control of said 75

motor as said circuit is broken, and follow-back connections from said motor to said cams and contacts.

3. In an automatic steering device, the combination with the controller and steering motor, of a follow-back connection between said motor and controller including a driving shaft, a driven shaft, and an adjustable lost motion connection between the same comprising a sleeve for connecting the ends of said shafts, said sleeve and shafts having cooperating pins and triangularly-shaped slots for said pins, and means for adjusting said sleeve longitudinally along said shafts to vary the amount of lost motion.

4. In an automatic steering device, the combination with the controller and steering motor, of a follow-back connection between said motor and controller including a driving shaft, a driven shaft, and an adjustable lost motion connection between the same comprising a sleeve for connecting the ends of said shafts, a pin on each of said shafts taking in a triangularly-shaped slot in said sleeve, and means for adjusting said sleeve longitudinally along said shafts to vary the amount of lost motion.

5. In an automatic steering device, a master compass actuated controller, a relay motor ex-

cited therefrom, relay contacts actuated by said motor, a main steering motor actuated from said contacts, and a weather adjustment for varying at will the speed at which said relay motor is actuated from said controller.

6. In an automatic steering device, a master compass controller, a relay motor excited therefrom, relay contacts actuated by said motor, a main steering motor actuated from said contacts, and means for varying at will the speed at which said relay motor is actuated from said controller as a weather adjustment including a resistance shunted across the armature but not the series field thereof, and means for tapping one side of the line into variable points therein to vary the proportion thereof in series with and in shunt with said armature.

7. In an automatic steering device, a master compass actuated controller, a relay motor excited therefrom, a follow-back connection from said motor to said controller including a lost motion device, relay contacts actuated by said motor, a main steering motor actuated from said contacts, and a weather adjustment for varying at will the speed at which said relay motor is actuated from said controller.

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