Jan. 13, 1925. 1,522,883

J. H. HAMMOND, JR

POLYPULSE SYSTEM OF CONTROL

Filed June 16, 1917 6 Sheets-Sheet 1

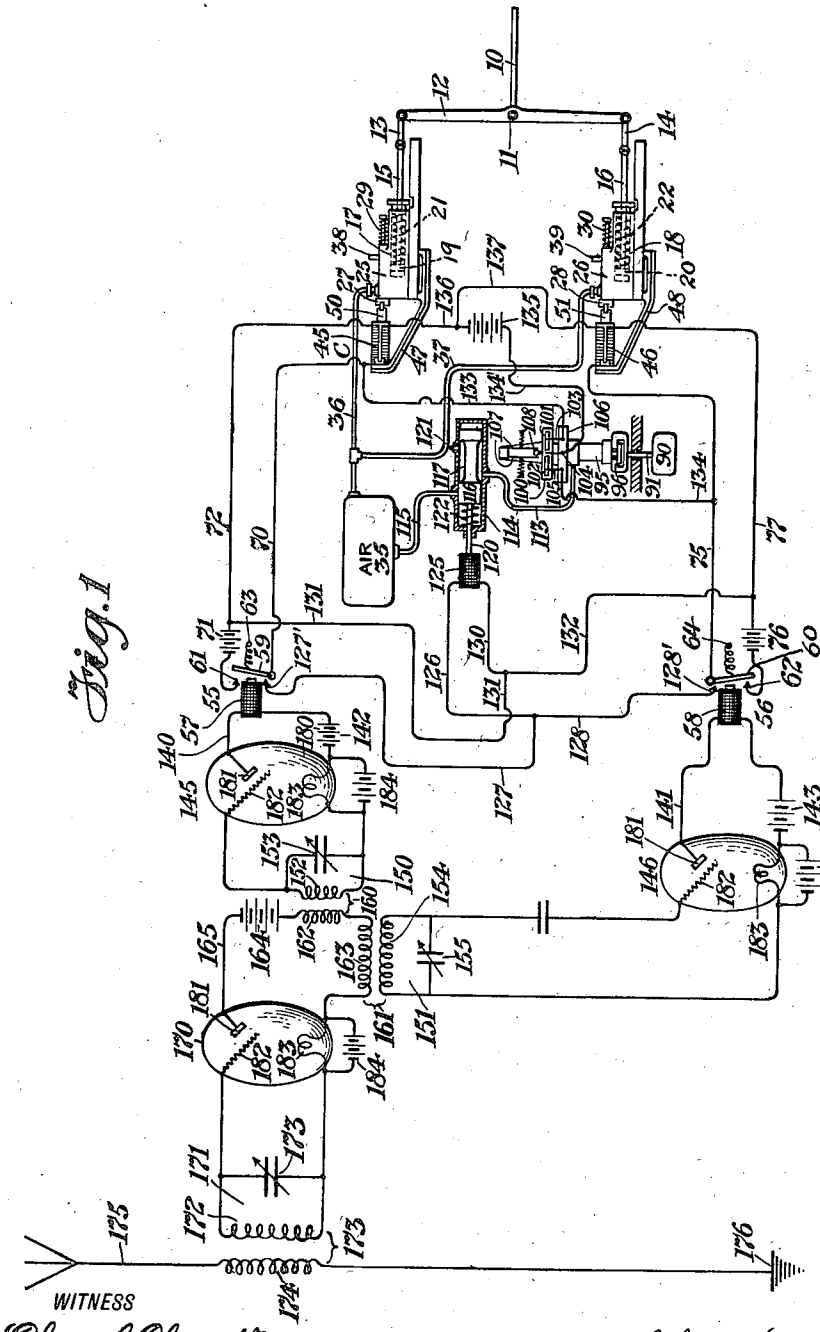


Fig. 1

WITNESS
Chas. J. Clagett

INVENTOR
John Hays Hammond Jr.
BY
A. D. Gardner
HIS ATTORNEY

Jan. 13, 1925. 1,522,883

J. H. HAMMOND, JR

POLYPULSE SYSTEM OF CONTROL

Filed June 16, 1917 6 Sheets-Sheet 2

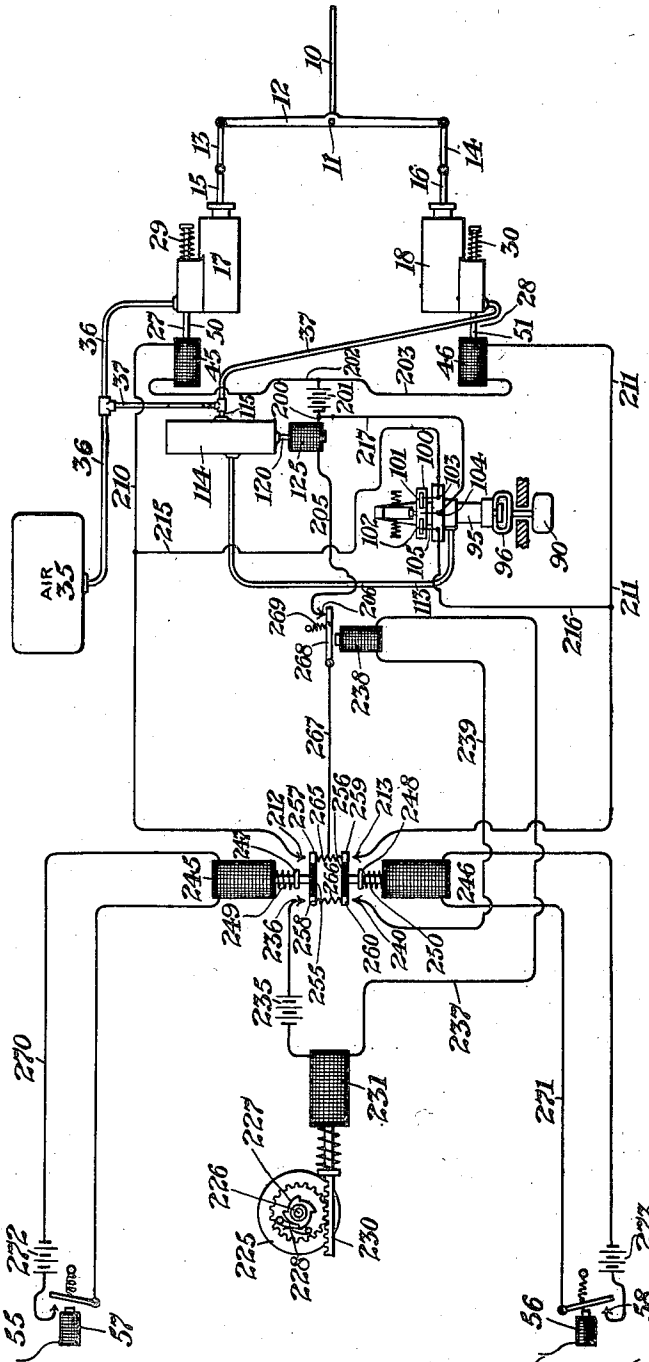


Fig. 2

WITNESS
Chas. J. Clagett

INVENTOR
John Hays Hammond Jr.
BY
A. J. Gardner
HIS ATTORNEY

Jan. 13, 1925. 1,522,883

J. H. HAMMOND, JR

POLYPULSE SYSTEM OF CONTROL

Filed June 16, 1917 6 Sheets-Sheet 3

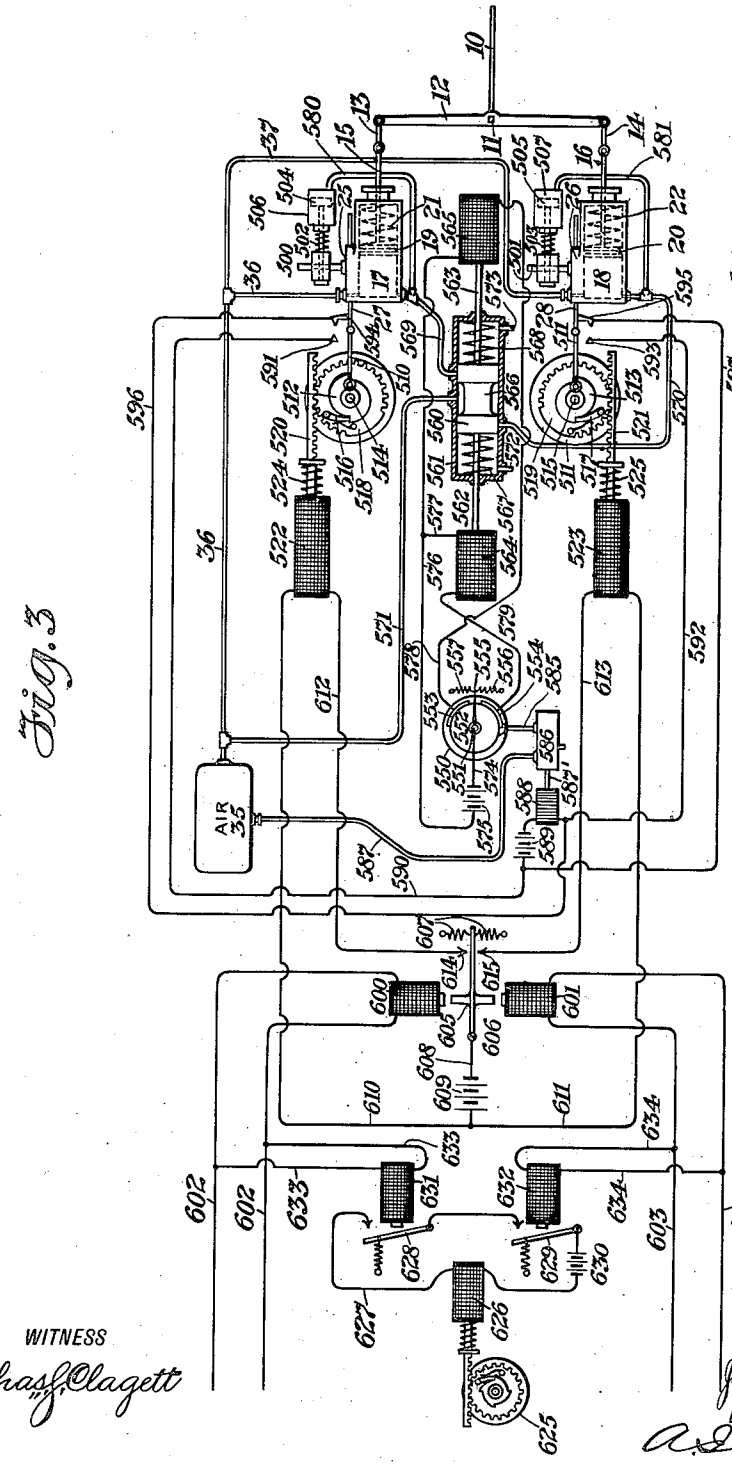


Fig. 3

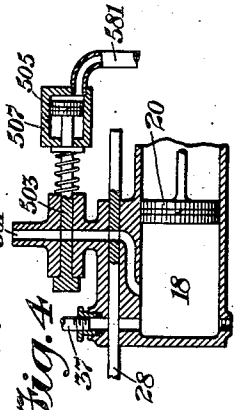


Fig. 4

WITNESS
Chas. J. Clagett

INVENTOR
John Hays Hammond Jr.
BY
A. D. Gardner
HIS ATTORNEY

Jan. 13, 1925. 1,522,883

J. H. HAMMOND, JR

POLYPULSE SYSTEM OF CONTROL

Filed June 16, 1917 6 Sheets-Sheet 4

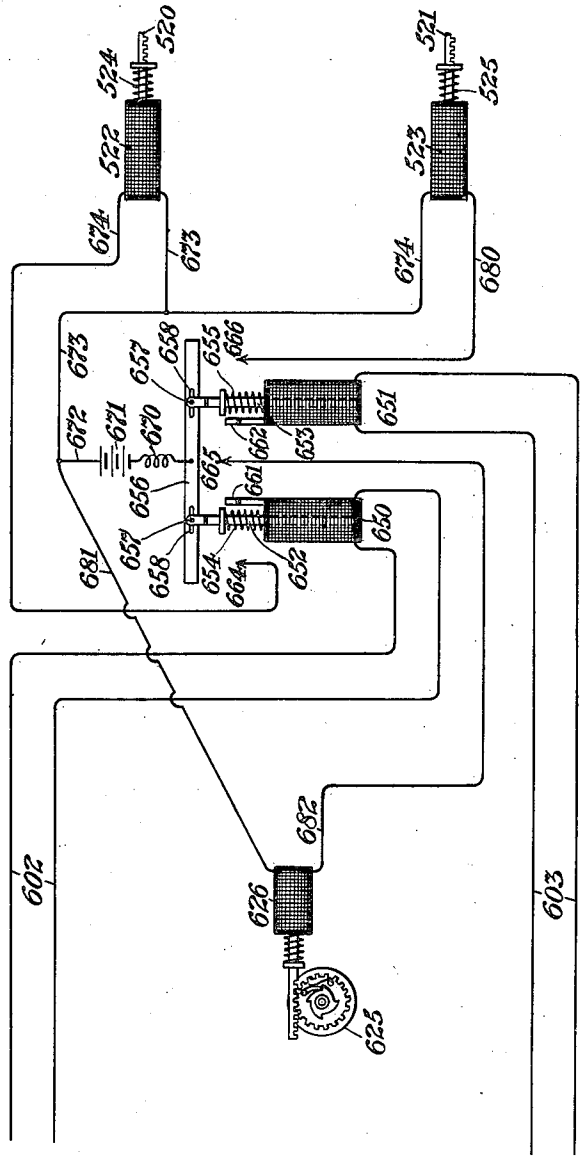


Fig. 5

INVENTOR
John Hays Hammond Jr.
BY
A. G. Gardner
HIS ATTORNEY

Jan. 13, 1925. 1,522,883

J. H. HAMMOND, JR

POLYPULSE SYSTEM OF CONTROL

Filed June 16, 1917 6 Sheets-Sheet 5

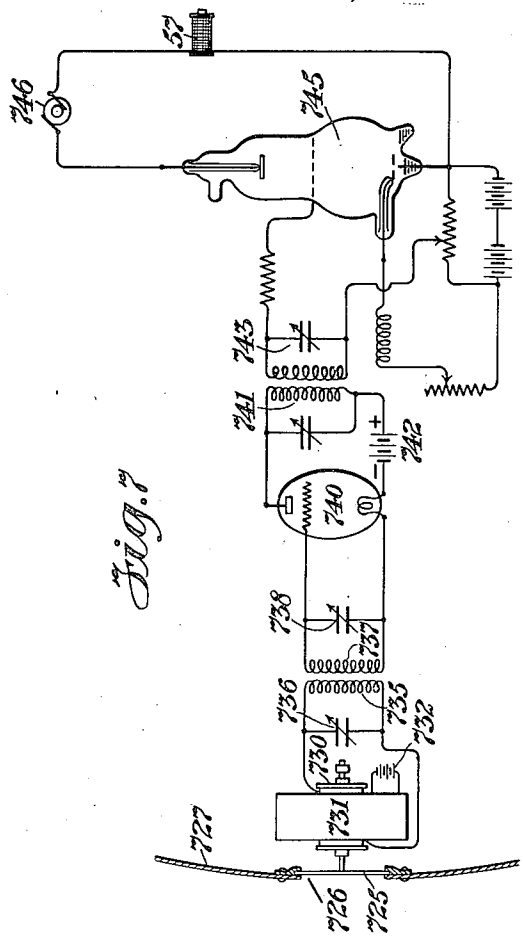


Fig. 7

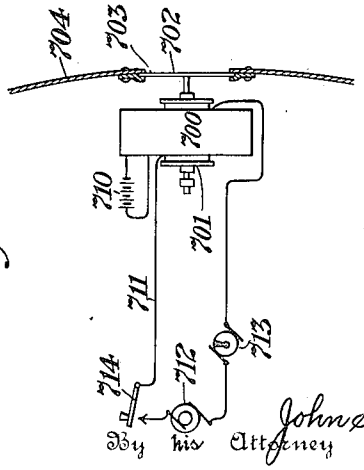


Fig. 6

Inventor
John Hays Hammond Jr.
By his Attorney
A. D. Gardner

Jan. 13, 1925. 1,522,883

J. H. HAMMOND, JR

POLYPULSE SYSTEM OF CONTROL

Filed June 16, 1917 6 Sheets-Sheet 6

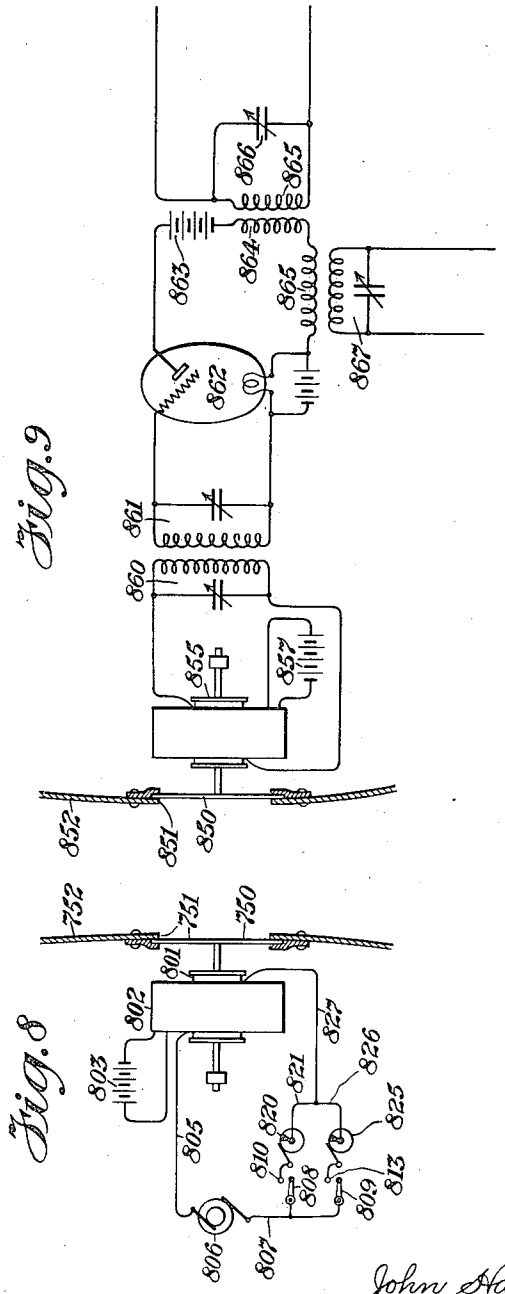


Fig. 9

Fig. 8

INVENTOR

John Hays Hammond Jr.

By

A. D. Gardner

HIS ATTORNEY

Patented Jan. 13, 1925. 1,522,883

UNITED STATES PATENT OFFICE.

JOHN HAYS HAMMOND, JR., OF GLOUCESTER, MASSACHUSETTS.

POLYPULSE SYSTEM OF CONTROL.

Application filed June 16, 1917. Serial No. 175,134.

To all whom it may concern:

Be it known that I, JOHN HAYS HAMMOND, Jr., a citizen of the United States, and a resident of the city of Gloucester, county of Essex and State of Massachusetts, have invented certain new and useful Improvements in Polypulse Systems of Control, of which the following is a specification.

Some of the objects of this invention are to provide an improved polypulse system of control for movable bodies; to provide an improved system for the control of a movable body in response to radiant energy; to provide an improved receiving system for radiant energy; and to provide other improvements as will appear hereinafter.

In the accompanying drawings, Figs. 1, 2 and 3 are diagrammatic plan views of different forms of receiving systems constructed in accordance with this invention; Fig. 4 is an enlarged fragmentary longitudinal section of a portion of the system shown in Fig. 3; Fig. 5 a further modified form of the receiving system constructed in accordance with this invention; Figs. 6 and 7 are diagrammatic views of a sound transmitting system and a sound receiving system which may be utilized in connection with this invention; and Figs. 8 and 9 are diagrammatic views of a multiplex sound transmitting system and a corresponding receiving system constructed in accordance with this invention.

Referring to the drawings, and more particularly to Fig. 1, one embodiment of this invention comprises a receiving system for radiant energy which is shown as mounted upon a movable body, such for instance, as a marine vessel or other movable body, to control the direction of movement of the movable body through the action of a rudder 10, which is rigidly secured to a rudder post 11 which is arranged to rotate about an axis fixed with respect to the movable body, the axis being for instance in the case of a marine vessel, normally vertical, and the rudder 10 being arranged in a well known manner in a normally substantially vertical plane to steer or direct the vessel in any desired direction. Rigidly secured to the rudder post 11 and arranged in a plane substantially perpendicular thereto, is a rigid lever 12, the opposite ends of which are pivotally connected to the outer ends of two connecting rods 13 and 14, the inner ends of which are pivotally connected respectively to two piston rods 15 and 16 which are arranged to reciprocate in two fixed cylinders 17 and 18. Arranged to reciprocate within the two cylinders 17 and 18 respectively, are two pistons 19 and 20 which are secured respectively to the inner ends of the piston rods 15 and 16, and which are pressed inwardly by normally balanced spiral springs 21 and 22 respectively. The two cylinders 17 and 18 are provided respectively with valve casings 25 and 26, in which are arranged respectively two reciprocatory valves controlled respectively by two valve stems 27 and 28, which are normally held in predetermined positions by spiral springs 29 and 30. A tank 35 or other source of compressed air is connected by a pipe 36 and a branch pipe 37 to the two valve casings 25 and 26 in a well known manner, to supply compressed air for reciprocating the piston rods 15 and 16. The two valve casings 25 and 26 are also provided with two outlets or exhaust pipes 38 and 39. The valve stems 27 and 28 control the inlet of compressed air into and the exhaust of compressed air from the inner ends of the cylinders 17 and 18.

For reciprocating the two valve stems 27 and 28, two solenoids 45 and 46 are arranged in alinement with the valve stems 27 and 28 respectively, and are held in fixed positions respectively by brackets 47 and 48. These solenoids 45 and 46 are provided respectively with reciprocatory cores 50 and 51, the outer ends of which are rigidly connected to the valve stems 27 and 28 respectively. These two solenoids 45 and 46 are arranged to be controlled by relays 55 and 56, comprising two fixed electro-magnets 57 and 58, two armatures or switches 59 and 60 arranged to swing about fixed axes respectively, and two fixed contacts 61 and 62 arranged in the path of the switches 59 and 60, the switches 59 and 60 being normally held open and out of contact with the corresponding fixed contacts 61 and 62 by spiral springs 63 and 64. The switch 59 of one of the relays is connected by a conductor 70 to one end of the winding of the corresponding solenoid 45, and the corresponding fixed contact 61 is connected through a battery 71 and conductor 72 to the other end of the sole-

noid 45. The switch 60 of the other relay is connected by a conductor 75 to one end of the winding of the corresponding solenoid 46, and the corresponding fixed contact 62 is connected through a battery 76 and conductor 77 with the other end of the solenoid 46. When either of the relays 55 or 56 is energized, the corresponding switch 59 or 60 will be drawn into engagement with its corresponding contact 61 or 62 to close the circuit through the corresponding solenoid 45 or 46, and to cause the rudder 10 to be oscillated accordingly either in one direction or in the opposite direction, as the case may be, as hereinafter described.

For automatically controlling the rudder 10 to direct the movable body or vessel upon a predetermined course when both relays 55 and 56 are deenergized, a gyroscope 90 is mounted upon the movable body or vessel, and is provided with a normally vertical stem 91 which is arranged to rotate with respect to the movable body or vessel about a normally vertical axis which is coincident with its longitudinal axis, and which is fixed with respect to the movable body or vessel. This stem 91 is held by the gyroscope 90 against rotation in space, and is arranged in a well known manner to be connected or disconnected from a rotary spindle 95 in longitudinal alinement therewith, by means of a pneumatic clutch 96. A commutator 100 is fixed upon the spindle 95 and is provided with two segmental contacts 101 and 102, which are arranged to co-operate with three brushes 103, 104 and 105, which are fixed upon a stationary collar 106 loosely surrounding the spindle 95. The commutator 100 is arranged to be returned to an initial position by spring pressed pivoted flat arms 107 which engage rollers 108 carried by the upper end of the commutator.

The pneumatic clutch 96 for rendering the gyroscope 90 either operative or inoperative, is controlled by compressed air entering the clutch through a pipe 113 which leads from a cylindrical valve casing 114, which is connected by a pipe 115 with the tank 35 or source of supply of compressed air. Within the cylindrical valve casing 114, is a reciprocatory piston valve 116, which is provided with an annular recess 117 and which is arranged to be actuated by a valve stem 120 which is rigid with the valve 116, and which extends slidably through one end of the valve casing 114. The valve casing 114 is also provided with an exhaust port or outlet 121, and a spiral spring 122 surrounding the valve stem 120 and within the valve casing 114, normally holds the valve 116 in such a position that the inlet of air from the tank 35 into the valve casing 114 is prevented, and the outlet of air from the pneumatic clutch 96 through the pipe 113, valve casing 114, and outlet 121 is permitted. The valve 116 is controlled by a fixed solenoid 125 which surrounds the valve stem 120. One end of the winding of the solenoid 125 is connected by a conductor 126 and two branch conductors 127 and 128 with two fixed contacts 127′ and 128′ which are controlled by the two switches 59 and 60 respectively. The other end of the winding of the solenoid 125. is connected by the conductor 130 and two branch conductors 131 and 132 with the conductors 72 and 77 of the relay circuits. The arrangement is such that when either of the relays 55 and 56 is energized separately to steer the boat selectively either in one direction or in an opposite direction, as the case may be, the corresponding circuit through the solenoid 125 and corresponding battery 71 or 76 will be closed and the solenoid 125 will be energized and will act to draw the valve 116 towards the left to close the exhaust 121 and to permit the compressed air to flow from the tank 35 through the pipe 115, valve casing 114, pipe 113, and into the pneumatic clutch 96, to release the spindle 95 from the gyroscope stem 91, and thus render the gyroscope temporarily inoperative to control the movement of the rudder 10. But when neither of the relays 55 and 56 is energized, or when both of the relays 55 and 56 are simultaneously energized, the solenoid 125 will be practically unaffected, and the valve 116 will be returned into or held in a closed position, as shown in Fig. 1, in which position the compressed air will be released from the pneumatic clutch 96, thus permitting the clutch to clamp the gyroscope stem 91 to the spindle 95 to steer the boat automatically in a fixed direction under the action of the gyroscope as will appear hereinafter.

To permit the boat to be steered by the gyroscope 90, the outer brushes 103 and 105 are connected respectively by conductors 133 and 134 with the conductors 70 and 75 respectively, which lead to the inner ends of the two solenoids 45 and 46 respectively for controlling the rudder. The central brush 104 is connected by a conductor 134′ to one pole of a battery 135, the other pole of which is connected by a conductor 136 and a branch conductor 137 to the conductors 72 and 77 respectively which lead to the outer ends of the solenoids 45 and 46 which control the rudder. When the right hand brush 103 and the central brush 104 are both upon the segmental contact 101, the circuit will be closed through the battery 135 and upper solenoid 45, and the circuit through the lower solenoid 46 will be open, thus causing the rudder 10 to be swung in a clockwise direction, as viewed in Fig. 1. When the central brush 104 and the left hand brush 105 are both upon the left hand segment 102, the circuit will be closed through the battery 135 and the lower solenoid 46, and will be

opened through the upper solenoid 45, thus causing the rudder 10 to be swung in a counterclockwise direction.

For selectively energizing the relays 55 and 56 to control the movement of the rudder 10 either selectively or in an automatic manner, the two electromagnets 57 and 58 of the two relays are respectively in two circuits 140 and 141 which contain respectively batteries 142 and 143 or other sources of electric energy, and which are controlled by two secondary detectors 145 and 146, of any well known or suitable construction, and which are operatively connected to and arranged to be controlled in a well known manner by two secondary closed oscillatory circuits 150 and 151 which include respectively a coil 152 and a variable condenser 153 and a coil 154 and a variable condenser 155. The closed circuits 150 and 151 are tuned to different predetermined frequencies, for instance, the closed circuit 150 is tuned to 15,000 oscillations per second, and the other closed circuit 151 is tuned to 20,000 oscillations per second. The two coils 152 and 154 form the secondaries of two transformers 160 and 161, the primary coils 162 and 163 of which are in series with a battery 164 in a circuit 165 controlled in a well known manner by a primary detector 170 of any well known or suitable construction. The primary detector 170 is operatively connected to and controlled by a primary closed oscillatory circuit 171 including a coil 172 and a variable condenser 173. The coil 172 forms the secondary of a transformer 173, the primary coil 174 of which is in series with an antenna or open aerial circuit 175, which is grounded through the primary coil 174 in any suitable manner, as at 176. The closed oscillatory circuit 171 is preferably tuned to the the natural frequency of oscillation of the open aerial circuit 174, 175, which may be for instance, 100,000 oscillations per second. Each of the detectors 145, 146 and 170 may be in the form of an evacuated glass bulb or container 180, in which is arranged in a well known manner a terminal 181, grid 182 and a filament 183, the filament being heated by a battery 184, but any other suitable form of detector may be used.

In the operation of the form of this invention shown in Fig. 1, a transmission system is utilized, which is arranged to transmit a series of radiant oscillations having a wave frequency equal to the frequency of the receiving antenna 175, and having imposed thereon either one or both of two series of periodic variations having frequencies equal respectively to the two frequencies of the secondary closed oscillatory circuits 150 and 151, which are controlled through the action of the primary detector 170, and which control the secondary detectors 145 and 146.

When it is desired to rotate the rudder 10 in a clockwise direction, as viewed in Fig. 1, to steer the movable body or vessel towards the left, an impulse of radiant energy is transmitted which has a wave frequency corresponding to the frequency of the receiving antenna 175, and which has imposed thereon a periodic variations equal in frequency to the frequency of the corresponding secondary closed oscillatory circuit 150, and this impulse energizes the primary closed oscillatory circuit 171 and causes oscillations to be set up in the controlled circuit 165 having a frequency equal to the frequency of the secondary closed circuit 150, and these oscillations set up corresponding oscillations in the secondary closed circuit 150 which causes the operation of the corresponding secondary detector 145 which acts to cause a current to flow through the controlled circuit 140 and electromagnet 57, thus closing the switch 59, and causing a current to flow through the battery 71, conductor 72, solenoid 45 and conductor 70. By thus energizing the solenoid 45, the valve stem 27 is drawn towards the left thus admitting compressed air from the tank 35, through the pipe 36 and into the inner end of the cylinder 17, which pushes the piston therein outwardly and causes the piston rod 15 to swing the rudder 10 in a clockwise direction to steer the movable body or vessel towards the left. This closing of the switch 59 also closes the shunt circuit through the battery 71, branch conductor 131, conductor 130, solenoid 125, conductor 126, branch conductor 127, and contact 127′, thus energizing the solenoid 125 and consequently drawing the valve 116 towards the left to open the valve and to permit compressed air to enter from the tank 35 into the pneumatic clutch 96, thus disconnecting the spindle 95 from the gyroscope 90 and rendering the gyroscope temporarily inoperative to control the rudder.

When it is desired to rotate the rudder 10 in a counterclockwise direction to steer the movable body or vessel towards the right, a series of waves of radiant energy having a wave frequency equal to the natural frequency of oscillation of the antenna 175, and having impressed thereon a series of periodic variations of a frequency equal to the frequency of the corresponding secondary closed circuit 151, for instance, a frequency of 20,000 per second, is transmitted to the antenna 175, and the consequent oscillations set up in the antenna 175 act upon the primary closed circuit 171 to operate the detector 170, and to cause unidirectional oscillations in the controlled circuit 165 having a frequency equal to the corresponding frequency of the periodic variations received by the antenna 175, for instance, 20,000 oscillations per second, and these oscillations act

upon the secondary closed circuit 151 to cause the operation of the secondary detector 146, and to set up a flow of current in the controlled circuit 141, and thus energize the electromagnet 58 to close the switch 60, and cause the current to flow from the battery 76 through the conductor 77, solenoid 46 and conductor 75, thus causing the corresponding valve stem 28 to be drawn towards the left to admit compressed air from the tank 35, through the pipe 36 and branch pipe 37, and into the inner end of the cylinder 18, to force the piston rod 16 outwardly and thus swing the rudder 10 counterclockwise to steer the movable body or vessel towards the right. This closing of the switch 60 also acts to close the shunt circuit through the branch conductor 132, conductor 130, solenoid 125, conductor 126, branch conductor 128 and contact 128′, thus energizing the solenoid 125, and consequently rendering the gyroscope 90 temporarily inoperative to control the movement of the rudder 10, is hereinbefore described.

When it is desired to have the rudder 10 controlled automatically by the gyroscope 90 to direct the boat upon a fixed course, it is necessary only to discontinue transmitting any radiant energy, and when no radiant energy is received by the antenna 174, both of the switches 59 and 60 will remain open, and consequently the circuits through the batteries 71 and 76 will remain open, and the solenoid 125 will consequently be deenergized, and will permit the valve 116 to be moved into a closed position, as shown in Fig. 1, in which the pneumatic clutch 96 will be free to exhaust through the pipe 113, annular recess 117 and exhaust port 121, thus permitting the clutch 96 to clamp the spindle 95 to the gyroscope stem 91 to permit the commutator 100 to be controlled by the gyroscope 90. When the commutator 100 is in a central position, as shown in Fig. 1, both of the circuits through the battery 135 will be open, and the rudder 10 will be unaffected by the gyroscope 90, but when the boat is turned either in one direction or in the opposite direction, or in other words, rotated about a vertical axis either in one direction or in the opposite direction through the action of the tide or of the wind or from any other cause to cause a relative rotation between the commutator 100 and the brushes 103, 104, 105, then the circuit will be closed through the battery 135, and one or the other of the solenoids 45 and 46, depending upon the direction in which the boat has been diverted from its course to cause the boat to be returned to its original course, and to continue substantially upon that course.

In the form of this invention shown in Fig. 2, the construction is similar to that shown in Fig. 1, as hereinbefore described, but is arranged to control not only the rudder 10 but also one or more other functioning devices, as will appear hereinafter.

This modified form of the invention shown in Fig. 2, comprises, as hereinbefore described, a rudder 10 controlled by two piston rods 15 and 16, actuated by pistons arranged in cylinders 17 and 18 controlled by valve stems 27 and 28 arranged to be controlled by solenoids 45 and 46 respectively, the cylinders 17 and 18 being arranged to receive compressed air from a tank 35 through a pipe 36 and branch pipe 37, as hereinbefore described. This modified form is also provided, as hereinbefore described, with a gyroscope 90 arranged to control a spindle 95, through the action of a pneumatic clutch 96 to control the rudder 10 automatically, the pneumatic clutch 96 being arranged to receive compressed air through a pipe 113, controlled by a valve 114 which has an inlet pipe 115 communicating through the pipes 37 and 36 with the air tank 35. The valve 114 is controlled, as hereinbefore described, by a valve stem 120, which is arranged to be controlled by a solenoid 125, one end of which is connected by a conductor 200 with one pole of a battery 201, the other pole of which is connected by conductors 202 and 203 with the inner ends of the two solenoids 45 and 46. The other end of the solenoid 125 is connected by a conductor 205 with a fixed contact 206. The inner ends of the solenoids 45 and 46 are connected by conductors 210 and 211 with two fixed contacts 212 and 213 respectively. The brushes 103 and 105 of the commutator 100 are connected by conductors 215 and 216 with the conductors 210 and 211 respectively, leading to the outer ends of the two solenoids 45 and 46 respectively. The central brush 104 is connected by conductor 217 with the conductor 200 leading to the battery 201.

For controlling one or more subsidiary prime movers or devices, a commutator 225 of any well known or suitable construction is provided which may be either an electric commutator or a pneumatic commutator or valve. This commutator 225 is fixed upon a rotary spindle 226 which has fixed thereon a ratchet 227 which is arranged to be rotated step by step by a spring pressed pawl 228 which is pivotally secured to a gear 229 which is loosely mounted upon the spindle 226. This gear 229 engages a spring pressed rack 230 which is arranged to be reciprocated by a solenoid 231. One end of the winding of the solenoid 231 is connected through a battery 235 with a fixed contact 236, and the other end of the winding of the solenoid 231 is connected by a conductor 237 to one end of a fixed electromagnet 238, the other end of which is connected by a conductor 239 with a fixed contact 240.

For simultaneously connecting the fixed contact 236 electrically with the fixed contact 240, and the fixed contact 212 electrically with the fixed contact 213, two fixed solenoids 245 and 246 are provided and are arranged to control two reciprocatory cores 247 and 248 which are normally pressed inwardly by spiral springs 249 and 250. These cores have fixed to their outer ends respectively, two transversely extending parallel bars 255 and 256 of insulating material, upon which are terminally secured respectively two pairs of conductors or contacts 257, 258 and 259, 260. The two inner contacts 257 and 259 are connected by an extensible conductor 265, and the two outer contacts 258 and 260 are connected by an extensible conductor 266. The two contacts 257 and 258 are normally out of engagement with the two fixed contacts 212 and 236, but are arranged to be moved into engagement therewith when the corresponding solenoid 245 is energized. The other two movable contacts 259 and 260 are normally out of engagement with the corresponding fixed contacts 213 and 240, but are arranged to be moved into engagement therewith when the corresponding solenoid 246 is energized. The inner extensible conductor 265 is connected by a conductor 267 with a normally closed pivoted switch 268 which is arranged to cooperate with the fixed contact 206 and to be controlled by the electromagnet 238. The switch 268 is normally closed against the contact 206 by a spring 269. The two solenoids 245 and 246 are in normally open circuits 270 and 271, containing batteries 272 and 273 respectively, and arranged to be controlled by relays 55 and 56 respectively, corresponding to the relays 55 and 56 of Fig. 1, and controlled in the same manner in response to electroradiant energy having a wave frequency equal to the natural frequency of the receiving antenna 175, and having superimposed thereon a predetermined secondary frequency to control the relay 55, or a different predetermined secondary frequency to control the relay 56, as hereinbefore described.

In the operation of the modified form of this invention shown in Fig. 2, when it is desired to swing the rudder 10 in a clockwise direction to turn the boat towards the left, suitable radiant energy is transmitted to energize the relay 55, as hereinbefore described, and consequently, the solenoid 245 which acts to move the two movable contacts 257 and 258 into engagement with the two stationary contacts 212 and 236. This does not affect the solenoid 231, but closes the circuit through the movable contact 257, extensible conductor 265, conductor 267, switch 268, contact 206, conductor 205, solenoid 125, battery 201, conductor 202, upper solenoid 45, conductor 210 and contact 212, thus causing the gyroscope 90 to be rendered temporarily ineffective to control the boat, and simultaneously causing the rudder 10 to be swung in a clockwise direction, as hereinbefore described.

When it is desired to swing the rudder 10 in a counterclockwise direction, the relay 56 is energized, as hereinbefore described, thus energizing the solenoid 246 and drawing the two movable contacts 259 and 260 into engagement with the two stationary contacts 213 and 240. This does not influence the solenoid 231, but completes the circuit through the switch 268, solenoid 125, battery 201 and solenoid 46, to temporarily render the gyroscope 90 ineffective to control the rudder and to simultaneously swing the rudder 10 in a counterclockwise direction.

When it is desired to rotate the commutator 225 through one or more steps to control one or more subsidiary prime movers or devices, the two relays 55 and 56 are simultaneously energized, thus energizing the two solenoids 245 and 246, and causing the two movable contacts 257 and 258 to be drawn into engagement with the two stationary contacts 212 and 236, and the two movable contacts 259 and 260 to be drawn into engagement with the two stationary contacts 213 and 240. This action closes the circuit through the battery 235, solenoid 231 and solenoid 238, thus drawing in the rack 230 to move the commutator 225 through one step in a counterclockwise direction, and at the same time, drawing the switch 268 away from the fixed contact 206, and thus breaking the circuit through the solenoid 125, and permitting the gyroscope 90 to be automatically clamped to the spindle 95 by the pneumatic clutch 96 to render the gyroscope 90 effective to control the rudder 10, as hereinbefore described. The commutator 225 may be rotated step by step through any number of steps by repeating this operation.

When the impulses of radiant energy which have energized the two relays 55 and 56 are discontinued, the two circuits through the two solenoids 245 and 246 are consequently broken, and the movable contacts 257, 258 and 259, 260 are moved inwardly away from the corresponding fixed contacts 212, 236, 213 and 240 respectively, thus breaking the circuit through the solenoids 231 and 238 to permit the rack 230 to be returned into its initial position without affecting the commutator 225 and to permit the switch 268 to be drawn into engagement with its fixed contact 206 without closing the circuit through the solenoid 125. When the parts are thus arranged, the rudder 10 will be under the control of the gyroscope 90, as hereinbefore described.

In the modified form of this invention

shown in Fig. 3, the rudder 10 is arranged to be actuated by two spring pressed pistons 19 and 20, which are arranged in cylinders 17 and 18 controlled by valve stems 27 and 28, controlling the supply of compressed air from the tank 35 through the pipe 36 and branch pipe 37 into the cylinders, as hereinbefore described.

In this form of the invention, the cylinders 17 and 18 are provided respectively with exhaust pipes 500, and 501, which are controlled by normally open springs pressed slide valves 502 and 503, which are arranged to be controlled by pistons 504 and 505 mounted in stationary auxiliary cylinders 506 and 507. The purpose of these auxiliary valves 502 and 503, will appear hereinafter.

For actuating the valve stems 27 and 28, these stems are pivotally connected to the inner ends of two connecting rods 510 and 511 respectively, the outer ends of which are pivotally connected respectively with a pair of ratchets 512 and 513 which are fixedly secured respectively upon two rotary shafts 514 and 516 which are arranged to rotate about fixed axes. The two ratchets 512 and 513 are each provided with a pair of diametrically opposed teeth, and the two pairs of teeth are arranged to be engaged respectively by two spring pressed pawls 516 and 517 which are pivotally secured respectively to two segmental gears 518 and 519, which are loosely mounted respectively upon the two shafts 514 and 515. The two gears 518 and 519 are engaged respectively by two racks 520 and 521 which are arranged to be reciprocated in fixed paths by two fixed solenoids 522 and 523, the racks being held in their outermost positions by springs 524 and 525.

For automatically controlling the rudder 10 to cause the boat to be directed upon a predetermined course a gyroscope 550 is provided, and is connected to a spindle 551 and to a pneumatic clutch, as hereinbefore described. Surrounding the spindle 551 and fixedly secured to the boat is a commutator 552 provided with two segments 553 and 554 arranged to be engaged alternately by a movable contact 555, which is fixedly secured to the spindle 551, and which is normally yieldingly held in a given position by the springs 556 and 557. A piston valve 560 is arranged to reciprocate in a fixed valve casing 561, and is provided with two coaxial valve stems 562 and 563 extending in opposite directions from the valve, and forming the cores of two solenoids 564 and 565 whereby the valve 560 is controlled. The valve 560 is provided with a central annular recess 566, and is held in a central position by two opposed springs 567 and 568. The valve casing 561 is connected by two pipes 569 and 570 with the inner ends of the two cylinders 17 and 18 respectively, and is connected by a pipe 571 with the pipe 36 which leads from the air tank 35. The valve casing 561 is provided at its opposite ends with two exhaust pipes 572 and 573 opening into the surrounding air. The contact arm 555 of the gyroscope 550 is connected by a conductor 574 with one pole of a battery 575, the other pole of which is connected by a conductor 576 and branch conductor 577 to the inner ends of the two solenoids 565 and 564, and the two segmental contacts 553 and 554 are connected by conductors 578 and 579 to the outer ends of the two solenoids 565 and 564 respectively. The outer ends of the auxiliary cylinders 506 and 507 are connected by pipes 580 and 581 to the pipes 569 and 570 respectively, which lead from the main cylinders 17 and 18 to the valve casing 561. The pneumatic clutch of the gyroscope 550 is connected by a pipe 585 to the outlet of a valve casing 586, which is arranged to receive compressed air from the tank 35 through a pipe 587. The passage of air from the air tank 35 through the valve casing 586 and pipe 585 is controlled by a valve having a valve stem 587′ which is controlled by a fixed solenoid 588, one end of which is connected to one pole of a battery 589, the other pole of which is connected by a conductor 590 with a fixed contact 591. The other end of the solenoid 588 is connected by a conductor 592 to a fixed contact 593. The two fixed contacts 591 and 593 are arranged to be engaged by two movable contacts 594 and 595, which are rigidly secured to the valve stems 27 and 28 respectively, and which are connected by conductors 596 and 597 to the conductors 592 and 590 respectively, the movable contacts 594 and 595 being so arranged that when the valve stems 27 and 28 are in their outermost positions, the movable contacts 594 and 595 will engage with the stationary contacts 591 and 593 respectively, to control the solenoid 588 controlling the gyroscope 550, as will appear hereinafter.

For selectively energizing the two solenoids 522 and 523 to control the rudder 10, two stationary electromagnets 600 and 601 are provided and are arranged in two separate circuits 602 and 603, which are arranged to be controlled, as hereinbefore described, by two separately operative relays controlled by radiant energy having different predetermined frequencies. Between the electromagnets 600 and 601 is arranged an armature 605 which is pivotally supported at one end 606 to swing about a fixed axis, and is normally held in a central position by opposed springs 607 secured to the free end of the armature 605. The armature 605 is connected by a conductor 608 to one pole of a battery 609, the other pole of

which is connected by two branch conductors 610 and 611 to the inner ends of the solenoids 522 and 523 respectively, and through the windings of these solenoids and conductors 612 and 613 to two fixed contacts 614 and 615 spaced upon opposite sides of the armature 605 when the armature is in a central position.

For controlling one or more auxiliary prime movers or devices, a rotary commutator or valve 625 of any well known or suitable construction, is provided, which is mounted as hereinbefore described, to be controlled by a solenoid 626 which is arranged in a normally open circuit 627 controlled by two normally open switches 628 and 629 and containing a battery 630. The two switches 628 and 629 are arranged to be controlled respectively by two fixed electromagnets 631 and 632 which are connected by conductors 633 and 634 to the two circuits 602 and 603 respectively in parallel with the two electromagnets 600 and 601, so that whenever either of the magnets 600 or 601 is energized, the corresponding magnet 631 or 632 will be simultaneously energized.

In the operation of the system shown in Fig. 3, when it is desired to turn the rudder 10 clockwise, an impulse of radiant energy having the predetermined high and secondary frequencies, is transmitted to energize the electromagnet 600, whereupon the armature 605 will be drawn into engagement with the fixed contact 614, and will thus close the circuit through the battery 609 and solenoid 522, to rotate the ratchet 512 in a counterclockwise direction through half a revolution, thus opening the inner end of the cylinder 17 to receive air from the tank 35, and at the same time closing the exhaust pipe 500 through the action of the valve stem 27. This forces the piston 19 outwardly, and turns the rudder 10 in a clockwise direction. At the same time, this movement of the valve stem 27 brings the movable contact 594 into engagement with the fixed contact 591, and closes the circuit through these contacts, the battery 589 and the solenoid 588, which renders the gyroscope 550 ineffective to control the rudder 10, as hereinbefore described. The radiant impulse for effecting this result may be discontinued immediately, after the solenoid 522 has been energized for a sufficient period of time to perform its function, and the valve stem 27 will then be held in its outermost position by the ratchet 512.

Now if it should be desired to cause the rudder 10 to swing back into a central position, a second similar impulse of radiant energy is transmitted to energize the electromagnet 600, and thus reenergize the solenoid 522 thereupon again drawing the rack 520 towards the solenoid, and thus rotating the ratchet in a counterclockwise direction through half a revolution into its initial position, as shown in Fig. 3, thus closing the inlet from the tank 35 into the cylinder 17, and opening the exhaust pipe 500, whereupon the rudder 10 will be returned to a central position by the two springs 21 and 22.

If now it should be desired to turn the rudder 10 in a counterclockwise direction from a central position, a corresponding impulse of radiant energy having the required frequencies is transmitted to energize the electromagnet 601, and this acts to close the circuit through the battery 609 and lower solenoid 523 to rotate the ratchet 573 through half of a revolution in a clockwise direction to swing the rudder 10 in a counterclockwise direction, and at the same time to close the circuit through the contacts 595 and 593 and the battery 589 and solenoid 588 to render the gyroscope ineffective to control the rudder 10.

Now if it should be desired to permit the boat to be controlled automatically by the gyroscope 550, a second suitable impulse of radiant energy is transmitted to reenergize the solenoid 523 and to rotate the ratchet 573 through a half revolution in a clockwise direction and into its initial position, as shown in Fig. 3, thus permitting the rudder 10 to be returned to its central position, and at the same time breaking the circuit through the solenoid 588 and battery 589, thus rendering the gyroscope 550 operative to control the rudder 10.

In order to have the rudder 10 controlled by the gyroscope 550, both valve stems 27 and 28 should be in their initial positions, as shown in Fig. 3, in which both circuits through the solenoid 568 will be open and consequently the contact arm 555 will be clutched to the stem 551 of the gyroscope 500. If now the boat should be diverted in either direction, the contact arm 555 would make contact either with the segment 553 or the segment 554 to close the circuit either through the solenoid 565 or the solenoid 564, and to move the valve 560 either towards the left or towards the right as the case may be. When the valve 560 is moved towards the left the air from the tank 35 will be permitted to flow from the pipe 571 through the annular recess 566 and pipe 570 into the inner end of the lower cylinder 18 to push the piston 20 outwardly and thus to turn the rudder 10 in a counterclockwise direction. At the same time, the air will pass through the branch pipe 581, and into the corresponding auxiliary cylinder 507 to close the corresponding exhaust pipe 501. When the valve 560 is moved towards the right, the air from the tank 35 will flow through the pipe 571, annular passage 566 and pipe 569 into the inner end of the upper cylinder 17 to swing the rudder 10 in a clockwise direction. At the same time, the

air will flow through the branch pipe 580 and auxiliary cylinder 506 to close the exhaust pipe 500, the other exhaust pipe 501 being meanwhile opened as a result of the exhaust of the air through the branch pipe 581 and pipe 570, valve casing 561 and exhaust 572. If now the contact arm 555 should swing away from the segment 553 and engage the segment 554, the operation would be reversed, and the valve 502 would be permitted to open the exhaust pipe 500 by the exhaust of air through the branch pipe 580, pipe 569, valve casing 561 and exhaust pipe 573. The gyroscope 550 would thus act to control the steering mechanism of the boat in such a manner as to automatically steer the boat upon a substantially fixed straight course.

When it is desired to rotate the commutator or valve 625 through one or more steps to selectively control one or more prime movers or other devices, two suitable impulses of radiant energy having the required frequencies respectively are transmitted simultaneously to energize the electromagnets 600 and 601, and the electromagnets 631 and 632 simultaneously. The armature 605 will now be acted upon by opposed balanced forces, and will remain in a central position without effecting the operation of the rudder which should be under the control of the gyroscope 550. The simultaneous energization of the two electromagnets 631 and 632 simultaneously closes the two switches 628 and 629, thus closing the circuit through the battery 630 and the solenoid 626, and consequently rotating the commutator 625 through a single step, as hereinbefore described. The commutator 625 may be thus rotated through any number of steps by repeating this operation to selectively control any one of a plurality of prime movers or other devices, as fully described in several of applicant's co-pending applications.

In the modified form of this invention shown in Fig. 5, the construction is similar to that shown in Fig. 3, but instead of having the system controlled, as shown in Fig. 3, this modified system shown in Fig. 5 is controlled by two fixed parallel solenoids 650 and 651, which are controlled respectively by electroradiant energy having different secondary frequencies, as hereinbefore described, and in a manner the same as the manner in which the electromagnets 600 and 601 of Fig. 3 are controlled. These solenoids 650 and 651 are provided with cores 652 and 653 respectively, which are normally held in their outermost positions by spiral springs 654 and 655. An elongated movable contact or conducting bar 656 is slidably connected to the outer ends of the two cores 652 and 653 by means of two pivots 657 rigid with the outer ends of the cores respectively, and snugly but slidably engaging respectively in two elongated slots 658 provided therefor in the bar 656 and extending longitudinally thereof. The outer ends of the cores 652 and 653 are insulated from the main portions of the cores so that the bar 656 will be held normally in an insulated condition. Between the bar 656 and the solenoid 650, 651, are two fixed insulated stops 661 and 662, and three fixed contacts 664, 665 and 666. This bar 656 is connected by an extensible conductor 670 to one pole of a battery 671, the other pole of which is connected by a conductor 672, and branch conductor 673 to one end of the hereinbefore described upper solenoid 522 of Fig. 3. The other end of this solenoid 522 is connected by a conductor 674 with the corresponding fixed contact 664. The battery 671 is also connected through the conductor 672, branch conductor 673 and a branch conductor 674' with one end of the hereinbefore described lower solenoid 523 of Fig. 3. The other end of this latter solenoid is connected by a conductor 680 with the corresponding fixed contact 666. The battery 671 is also connected through the conductor 672, and a branch conductor 681 with one end of the hereinbefore described solenoid 626 of Fig. 3. The other end of this latter solenoid is connected by a conductor 682 with the central fixed contact 665.

In the operation of the system shown in Fig. 5, the rudder 10 is normally controlled by the gyroscope 550, as hereinbefore described in connection with Fig. 3, but when it is desired to swing the rudder 10 in a clockwise direction, a suitable impulse of radiant energy is transmitted to cause the energization of the solenoid 650 which causes the core 652 to be drawn inwardly, thus swinging the bar 656 into engagement with the corresponding contact 664, thus closing a circuit through the battery 671, conductor 670, bar 656, contact 664, conductor 674, upper solenoid 522, branch conductor 673 and conductor 672. This energizes the upper solenoid 522, temporarily terminates the control of the rudder by the gyroscope 550, and causes the rudder 10 to be turned in a clockwise direction, as hereinbefore described. When it is desired to turn the rudder in a counterclockwise direction, a suitable impulse of radiant energy is transmitted to energize the solenoid 651, and this swings the bar 656 about the upper end of the opposite core 652 and into engagement with the corresponding contact 666, thus closing the circuit through the battery 671, conductor 670, bar 656, contact 666, conductor 680, lower solenoid 523 and conductors 674', 673 and 672, thus energizing the lower solenoid 523, and consequently temporarily terminating the control of the rudder 10 by the gyroscope 550, and causing

the rudder 10 to be swung in a counterclockwise direction, as hereinbefore described.

When it is desired to rotate the commutator 625 of Fig. 5, step by step, through one or more steps, the two solenoids 650 and 651 are simultaneously energized, as hereinbefore described, thus drawing the bar 656 downwardly and into engagement with the central fixed contact 665, the bar 656 in this position being prevented by the stops 661 and 662 from being rocked into engagement with either of the other contacts 664 or 666. When the bar 656 is in engagement with the central contact 665, the circuit is closed through the battery 671, conductor 670, bar 656, contact 665, conductor 682, solenoid 626, conductor 681 and conductor 672, thus energizing the solenoid 626 and rotating the commutator 625 through one step. This action has no effect upon the rudder 10, as the circuits through the contacts 664 and 666 are left open, and consequently the rudder 10 remains under the control of the gyroscope 550 while the commutator 625 is thus being rotated step by step to control corresponding prime movers or functioning devices.

Instead of controlling the foregoing systems by electroradiant energy, as hereinafter described, any one of these systems may be controlled in response to sound waves or any other form of compressional waves or of radiant energy in any suitable manner. For instance, in the system shown in Fig. 1, the controlling electromagnets 57 and 58 might be separately controlled in response to submarine sound waves or compressional waves, as shown in Figs. 6 and 7, in which Fig. 6 shows a selective system for the transmission of submarine sound waves, and Fig. 7 shows a corresponding receiving system for the control of a single electromagnet.

The submarine sound transmission system shown in Fig. 6, comprises an electrical oscillator 700 of any suitable construction, the one shown being of well known construction, and including a reciprocatory hollow cylindrical copper vibrator 701 which is arranged to vibrate a flexible circular diaphragm 702 which is secured over a circular opening 703 in one side 704 of a marine vessel and below the surface of the water. The oscillator 700 is provided with an annular field magnet energized by a battery 710 or other suitable source of electric energy, and with a stationary cylindrical armature surrounded by the vibrator 701 and carrying a fixed winding one half of which is wound clockwise around one half of the armature and the other half of which is wound counterclockwise around the other half of the armature. This fixed winding is arranged to be energized by a circuit 711 including an electrical alternator 712 having a predetermined high frequency, and a commutator 713 arranged to be rotated at a predetermined rate to interrupt the circuit 711 at a predetermined frequency less than the frequency of the alternator 712. The circuit 711 is controlled by a switch 714.

The submarine sound receiving system shown in Fig. 7, comprises a circular flexible receiving diaphragm 725, which is secured over a circular opening 726 in one side 727 of the movable vessel which it is desired to control from the transmitting station shown in Fig. 6. The receiving diaphragm 725 is preferably tuned to respond to the frequency of the alternator 712 of the transmitting station and is arranged to reciprocate the hollow cylindrical vibrator 730 of an electrical oscillator 731 constructed as hereinbefore described, and having a field magnet enegized by a battery 732, and a stationary armature surrounded by the vibrator and arranged to produce electrical oscillations in a closed oscillatory circuit including a coil 735, and a variable condenser 736, this closed circuit being tuned to the frequency of the alternator 712 of the transmitting station. The closed oscillatory circuit 735, 736 is arranged to control a closed oscillatory circuit including a coil 737 and a variable condenser 738 which is arranged to control a gaseous detector 740, which is arranged to control a closed oscillatory circuit 741, which is arranged to be energized by a battery 742. The closed oscillatory circuit 741 is tuned to respond to the frequency of the commutator 713 of the transmission station, or in other words, is tuned to the secondary frequency of the transmitted waves, and controls a closed oscillatory circuit 743 which is correspondingly tuned and which controls a mercury vapor or other suitable detector 745, which is arranged to control a circuit including an alternator 746 and an electromagnet which may be either the magnet 57 or the magnet 58 of the hereinbefore described systems.

It is to be understood that when the two electromagnets 57 and 58 of the hereinbefore described systems are controlled respectively by two different receiving systems for submarine sound waves of the construction shown in Fig. 7, the two sound receiving systems are preferably differently tuned so as to respond to transmitting systems which are differently tuned both in respect to their high or primary frequencies, and also in respect to their low or secondary frequencies, although both receiving systems might be tuned to the same primary frequency but to different secondary frequencies respectively, or to different primary frequencies respectively but the same secondary frequency.

In the operation of the system shown in Figs. 6 and 7, the transmitting diaphragm 702 transmits groups of submarine sound waves having a wave frequency equal to

the frequency of the alternator 712, and a group frequency equal to the frequency determined by the commutator 713, and these groups of waves act upon the receiving diaphragm 725 to set up electrical oscillations in the closed oscillatory circuit 735, 736, having a high frequency determined by the frequency of the alternator 712, and a secondary frequency determined by the commutator 713, and this causes oscillations in the secondary closed circuit 741 having a frequency determined by the frequency of the commutator 713, which are effectual to actuate the detector 745 to cause a unidirectional current to flow through the detector from the alternator 746 and thus energize the electromagnet 57.

In Figs. 8 and 9 are shown a selective transmission system for submarine sound waves and a selective receiving system for the same, which may be used to control either one, selectively, or both simultaneously, of the two electromagnets 57 and 58 for controlling the systems shown in Figs. 1, 2 and 3, as hereinbefore described.

The transmission system shown in Fig. 8, comprises a circular diaphragm 750 secured over a circular opening 751 provided therefor in one side 752 of a vessel or other body and arranged beneath the surface of the water. The diaphragm 750 is arranged to be vibrated at a predetermined rate by the vibrator 801 of an electrical oscillator 802 constructed as hereinbefore described, and having a field magnet energized by a battery 803. The outer end of the coil of the armature of the oscillator is connected by a conductor 805 to one pole of an electrical alternator 806 having a predetermined high frequency. The other pole of the alternator 806 is connected by a conductor 807 to two pivoted switches 808 and 809. These switches are arranged to be moved into or out of engagement respectively with two fixed contacts 810 and 813. These two contacts 810 and 813 are connected respectively through a commutator 820 and conductor 821, and through a commutator 825 and conductor 826 with the outer end of a conductor 827 which leads to the inner end of the coil of the armature of the oscillator. The two commutators 820 and 825 are arranged to be rotated at uniform rates and at different speeds respectively so as to interrupt their respective circuits at constant predetermined rates, for instance, of 15,000 per second, and 20,000 per second, while the alternator 806 is arranged to set up oscillations in its circuit of a predetermined high frequency, for instance, of a frequency of 100,000 per second.

The submarine sound receiving system shown in Fig. 9, comprises a flexible circular diaphragm 850, which is secured over a circular opening 851 in one side 852 of the movable vessel which it is desired to control, the diaphragm being arranged beneath the surface of the water, and preferably tuned to the frequency of the alternator 806 of the transmitting station. The diaphragm 850 is arranged to vibrate the vibrator 855 of an electric oscillator 856, constructed as hereinbefore described, and provided with a field magnet energized by a battery 857. The oscillator 856 is connected to produce electrical oscillations in a closed oscillatory circuit 860 which is tuned to the frequency of the alternator 806 of the transmitting station. This closed circuit 860 controls a closed oscillatory circuit 861 which is tuned to the same frequency and which is arranged to control a gaseous detector or other suitable detector 862. The detector 862 controls a circuit including a battery 863 or other source of electrical energy, and two coils or inductances 864 and 865 which are arranged to control two closed oscillatory circuits 866 and 867 which are tuned respectively to the frequencies of the two commutators 820 and 825 of the transmitting station. These two closed circuits 866 and 867 correspond to the two closed circuits 150 and 151 hereinbefore described and shown in Fig. 1. These two closed circuits 866 and 867 of Fig. 7 may be arranged as shown in Fig. 1, to control two detectors corresponding to the detectors 145 and 146, and through the detectors to control two relays 55 and 56, and in this manner control a rudder and other devices, as shown in Figs. 1, 2 and 3, and as hereinbefore described.

The operation of the systems shown in Figs. 8 and 9, is similar to the operation of the systems shown in Figs. 1 to 5, except that instead of controlling the rudder 10 and other devices by electroradiant energy, as in Figs. 1 to 5, the rudder 10 and other devices are controlled by submarine sound waves. When the transmission and receiving systems shown in Figs. 8 and 9 are applied to control the electromagnets 600 and 601 of the system shown in Fig. 3, and it is desired to rotate the rudder 10 in a clockwise direction, the switch 808 of the transmission station is closed against the contact 810, while the switch 809 is left open. This causes the diaphragm 750 to transmit a series of groups of submarine sound waves or compressional waves having a wave frequency equal to the frequency of the alternator 806, and a group frequency equal to the frequency of the corresponding commutator 820. This series of groups of waves acts upon the receiving diaphragm 850, and thus produces a series of groups of electrical oscillations in the closed circuit 860 which act inductively upon the closed circuit 861 to cause the operation of the detector 862, and thus produce electrical oscillations in the closed circuit 863, 864, 965,

having a group frequency corresponding to the frequency of the received waves, and these oscillations act inductively to set up corresponding oscillations in the closed circuit 866, which act ultimately, as hereinbefore described, to energize the corresponding electromagnet 600 to turn the rudder in a clockwise direction, as hereinbefore described, in connection with Fig. 3. In a similar manner, by closing the switch 809 against the contact 913, and leaving the switch 808 open, the rudder 10 of Fig. 3 would be rotated in a counterclockwise direction, and by simultaneously closing both switches 808 and 809 against their contacts 810 and 813, two series of groups of sound waves having different group frequencies respectively would be transmitted to simultaneously energize the two electromagnets 600 and 601 of Fig. 3 to operate the valve or commutator 625, as hereinbefore described.

Although only a few of the many forms in which this invention may be embodied have been shown herein, it is to be understood that the invention is not limited to any specific construction but might be embodied in various forms without departing from the spirit of the invention or the scope of the appended claims.

Having thus fully described this invention, I claim:

1. The combination with a movable body, of means carried thereby and movable with respect thereto for determining the position of said body, stabilizing means including a gyroscope carried by said body and arranged to act upon said first mentioned means, means carried by said body for modifying the action of said stabilizing means upon said first mentioned means and controlling said first mentioned means selectively, comprising a wave responsive device tuned to respond to a given frequency and a plurality of secondary wave responsive devices arranged to be separately controlled by said first mentioned device and separately operative to modify the action of said stabilizing means upon said first mentioned means and to produce contrasting effects upon said first mentioned means respectively, and a device carried by said body and arranged to be controlled by the conjoint action of a plurality of said secondary devices.

2. The combination with a movable body, of means carried thereby and movable with respect thereto for determining the position of said body, stabilizing means including a gyroscope carried by said body and arranged to act upon said first mentioned means, means carried by said body for modifying the action of said stabilizing means upon said first mentioned means and controlling said first mentioned means selectively, comprising a wave responsive device tuned to respond to a given frequency and a plurality of secondary wave responsive devices arranged to be separately controlled by said first mentioned device and separately operative to modify the action of said stabilizing means upon said first mentioned means and to produce contrasting effects upon said first mentioned means respectively, and a device carried by said body and arranged to be controlled by the conjoint and simultaneous action of a plurality of said secondary devices.

3. The combination with a movable body, of means carried thereby and movable with respect thereto for determining the position of said body, stabilizing means including a gyroscope carried by said body and arranged to act upon said first mentioned means, means carried by said body for temporarily terminating the action of said stabilizing means upon said first mentioned means and controlling said first mentioned means selectively, comprising a wave responsive device tuned to respond to a given frequency and a plurality of secondary wave responsive devices arranged to be separately controlled by said first mentioned device and separately operative to temporarily terminate the action of said stabilizing means upon said first mentioned means and to produce contrasting effects upon said first mentioned means respectively, and a device carried by said body and arranged to be controlled by the conjoint action of a plurality of said secondary devices.

4. The combination with a movable body, of a rudder carried thereby and arranged to be moved in contrasting directions for steering said body, means including a gyroscope automatically operative to control said rudder to cause said body to move upon a predetermined course, and means for controlling said stabilizing means and said rudder from a distance comprising a wave responsive device tuned to respond to a predetermined frequency, a pair of secondary wave responsive devices arranged to be controlled either separately or simultaneously by said first mentioned device and tuned to two different secondary frequencies respectively, said secondary devices being separately operative to move said rudder in contrasting directions respectively, and a device arranged to be controlled as a result of the conjoint action of said secondary devices.

5. The combination with a movable body, of a rudder carried thereby and arranged to be moved in contrasting directions for steering said body, means including a gyroscope automatically operative to control said rudder to cause said body to move upon a predetermined course, and means for controlling said stabilizing means and said rudder from a distance comprising a wave responsive device tuned to respond to a predetermined frequency, a pair of secondary wave

responsive devices arranged to be controlled either separately or simultaneously by said first mentioned device and tuned to two different secondary frequencies respectively, said secondary devices being separately operative to move said rudder in contrasting directions respectively, and a device arranged to be controlled as a result of the conjoint and simultaneous action of said secondary devices.

Signed at New York in the county of New York and State of New York this 11th day of June A. D. 1917.

JOHN HAYS HAMMOND, JR.