SHIP CONTROL SYSTEM

Filed March 14, 1961 3 Sheets-Sheet 1

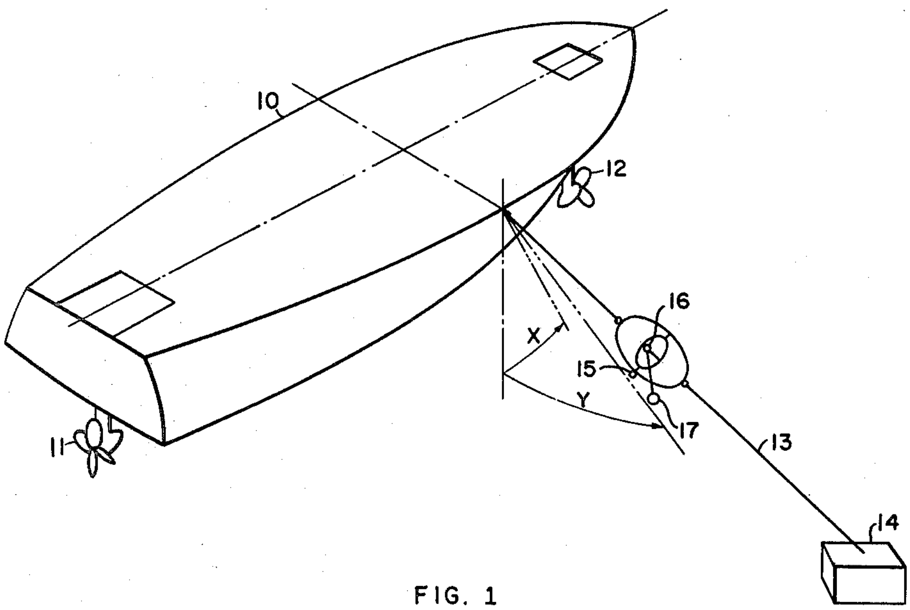

FIG. 1

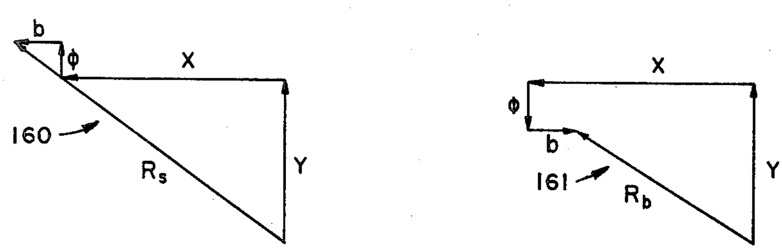

FIG. 4

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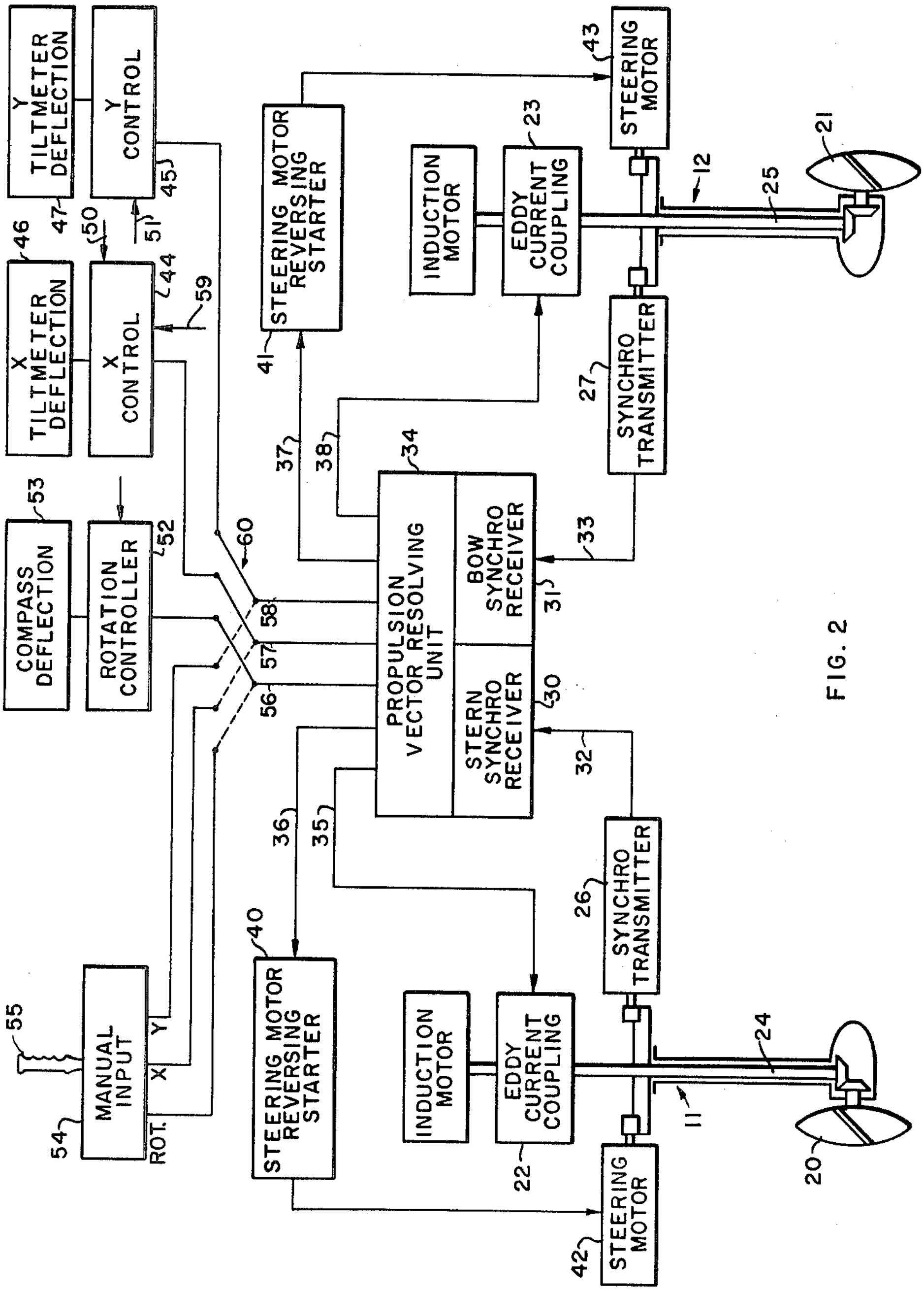

FIG. 2

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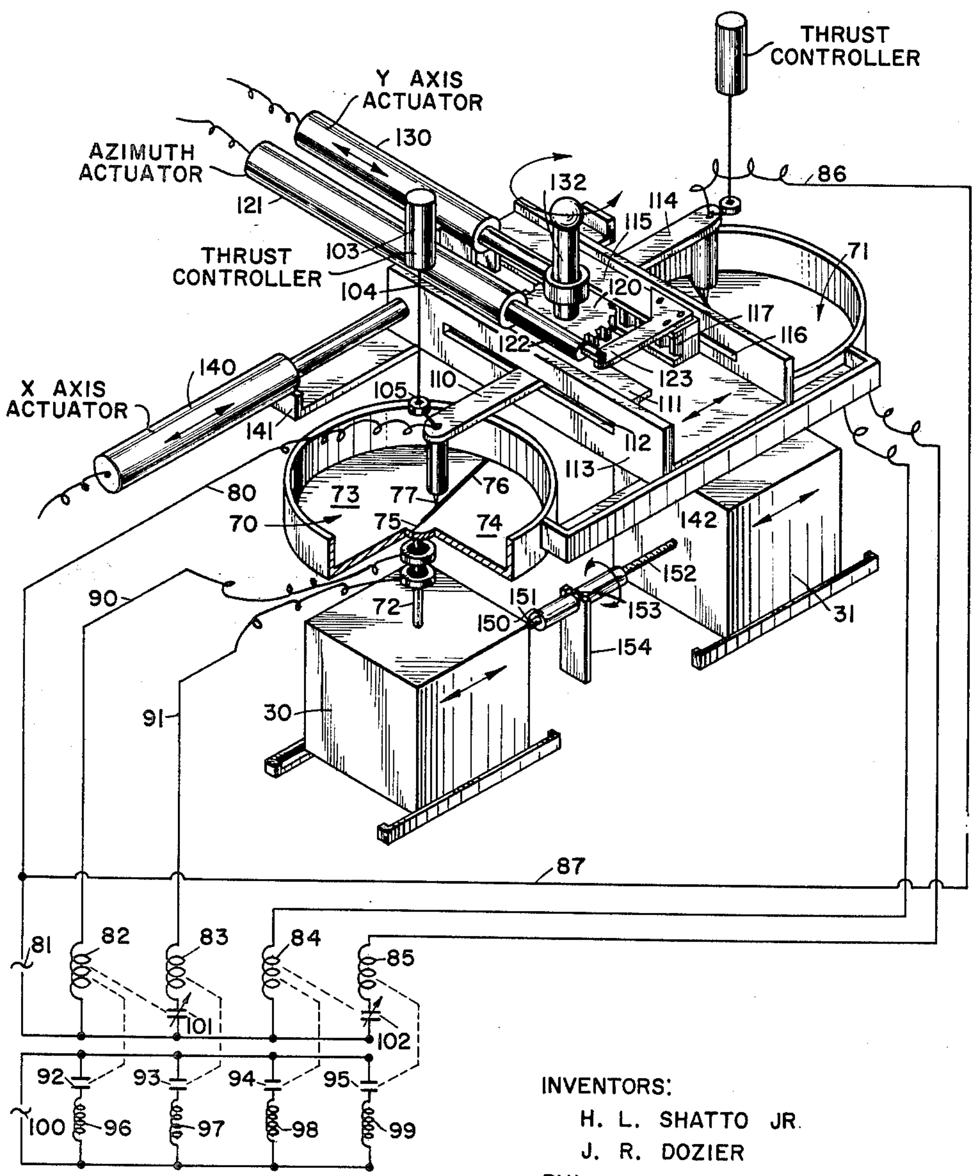
FIG. 3



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3,187,704
SHIP CONTROL SYSTEM

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11 Claims. (Cl. 114—144)

This invention pertains to a novel device or system to anchor a marine vessel dynamically over a particular location on the floor of a body of water and to provide a vessel with a high degree of maneuverability.

In offshore drilling operations it is desirable to be able to drill from a floating vessel which is merely maintained over the spot on the ocean floor and is not required to be anchored or otherwise fastened to the ocean floor. In the past, it has been the practice to either erect a tower over the desired location and drill from a fixed platform on the tower or anchor a floating vessel over the spot and drill from the anchored vessel. In either case, the drilling platform or vessel has been attached to or anchored to the ocean floor in order to maintain it in a fixed location. While these methods are satisfactory they have several disadvantages. For example, the use of a fixed tower is limited to rather shallow depths while the use of an anchored vessel requires the placement of suitable anchors in a plurality of directions to maintain the vessel in position. The placement of these achors requires a considerable amount of time which greatly increases the cost of drilling and is, of course, impossible in deep water.

In addition to drilling vessels many other vessels must be maintained over a fixed spot or maneuvered in narrow channels. For example, oceanographic, weather, salvage and radar vessels must be maintained in fixed locations. Similarly, fire boats and tugboats must be maneuvered in limited areas. Thus, while this invention is described below as applied to a drilling vessel, it can be used to anchor dynamically any vessel or to maneuver any type of vessel.

The high cost of the prior methods of operation could be avoided if it were possible to maintain a floating vessel over the desired drilling spot without the use of anchors or other fastening means. In such an operation, it would only be necessary to move the drilling vessel to the desired location and hold it in position while the drilling operation is performed and then move on to the next spot. Such an operation would have considerable advantage especially during the early stages of offshore operations when only shallow core wells are to be drilled.

Accordingly, it is the principal object of this invention to provide a unique method and apparatus for dynamically anchoring a vessel in a desired location and orientation or for providing a high degree of vessel maneuverability.

A further object of this invention is to provide a novel control apparatus for automatically positioning a vessel over a desired location or maneuvering a vessel along a desired course.

A further object of this invention is to provide a novel method and apparatus by which an operator may manually position a single control device to maintain a vessel over a desired location or to maneuver the vessel over a desired course.

Another object of the present invention is to provide a vessel with a plurality of propulsion units having variable thrust and a vairable direction of thrust through a full circle with a novel control system which separately varies the magnitude of the thrust and its direction for each of the units to maintain the vessel over a desired position or to maneuver the vessel over a desired course.

A still further object of the present invention is to provide a vessel having a plurality of propulsion units with an automatic system for varying the thrust and direction of

thrust of the propulsion units to maintain the floating vessel over a desired position.

A still further object of the present invention is to provide a unique control system for controlling the magnitude of the thrust and the direction of thrust of a plurality of propulsion units displaced from the center of rotation of a vessel to maintain the vessel over a desired position. The control system utilizes information indicating the measured horizontal position of the vessel to compare with the desired position as well as the measured heading of the vessel to compare with the desired heading to provide signals for controlling the magnitude of the thrust and the direction of the thrust of the propulsion units.

A still further object of this invention is to provide a novel control system for controlling the magnitude of the thrust and direction of the thrust of a plurality of propulsion units displaced from the center of rotation of the vessel to maintain the vessel over a desired position or maneuver the vessel along a desired course. The control system utilizes a vector resolving unit which provides for the gang operation of the propulsion units to provide substantially parallel thrust vectors to obtain a resultant horizontal thrust vector and to modify the individual thrust vector of each propulsion unit by the vector addition of rotational vectors substantially tangential to the circumference of a circle drawn through each propulsion unit about the center of rotation of the vessel.

A still further object of this invention is to provide a vector resolving unit that accepts command signals indicating desired resultant net horizontal and rotational thrust to be provided to the vessel.

A still further object of this invention is to provide a vector resolving unit that accepts command signals from a single natural and comprehensible manual control to provide a high degree of manual maneuverability for a vessel.

A still further object of this invention is to provide a vector resolving unit that accepts command signals from automatic controllers that indicate the desired movement of vessel in two directions at an angle to each other and the desired rotation of a vessel.

The above objects and advantages of this invention are achieved by providing multiple propulsion units mounted on a vessel and displaced from its center of rotation. Each propulsion unit is provided with a means for varying the magnitude of its thrust as well as the direction of the thrust in much the same manner as one varies the magnitude or direction of thrust of an outboard motor. A means is provided for determining the horizontal or angular displacement of the vessel from its desired location, such as the use of visual or electronic inspection of reference points, mechanical or electrical measurements of displacement from a desired location, and a compass heading. These position signals are compared either manually or by automatic controllers with the desired position, and corrective command signals are sent to the vector resolving unit. The vector resolving unit provides gang operation of the propulsion units to provide parallel thrust vectors to obtain a resultant horizontal thrust vector and to modify the individual thrust vector of each propulsion unit by vector addition of a rotational vector.

In order to prevent the control system from frequent radical changes in the direction of the thrust of the propulsion units when the propulsion units are operating at near zero magnitude of thrust, it is desirable to provide a differential bias system which results in a bias vector for each propulsion unit, the vector sum of all the individual bias vectors being equal to zero.

From the description, it is clear that the control system of this invention permits most efficient use of the propulsion units with minimum interference between various desired corrective actions. For example, the vessel may be rotated about its rotational axis without requiring additional corrective actions to eliminate the erroneous interjection of translation vectors. Similarly, the vessel may be translated without requiring corrective action to prevent rotation.

The above objects and advantages of this invention will be more easily understood from the following detailed description when taken in conjunction with the attached drawings, in which:

FIGURE 1 is a schematic representation showing the location of the two propulsion units on the floating vessel and a means for determining its displacement from a desired position;

FIGURE 2 is a block diagram illustrating one embodiment of the control system of this invention;

FIGURE 3 is a pictorial representation of a mechanical vector resolving unit which permits either manual or automatic control of a vessel; and,

FIGURE 4 is a vector diagram illustrating the vector resolving for the bow and stern propulsion units.

Referring to FIGURE 1, there is shown a vessel **10** having a propulsion unit **11** located at its stern and a second propulsion unit **12** located at its bow. The two propulsion units are located along the central axis of the vessel **10** and each rotates about a vertical axis intersecting this axis. Each of the propulsion units is provided with a means for individually varying their direction of thrust as well as the magnitude of their thrust. Suitable units are electrically driven outboard motor type units in which the speed of rotation of the propellers may be varied to vary the thrust supplied and the complete unit rotated about a vertical axis to vary the direction of thrust.

Also shown in FIGURE 1 is a method for utilizing a taut guide line **13** to determine the displacement of the vessel from its desired location. The guide line **13** is connected to the vessel **10** at its upper end and to an anchor **14** at its lower end with the anchor **14** being disposed at the desired location of the vessel. The angular deflection of the guide line from the vertical is measured in two vertical planes at right angles to each other as indicated by the angles x and y in FIGURE 1. The deflection of the guide line may be measured by various means, for example, a pair of potentiometers **15** and **16** disposed at right angles to each other and operated by a gimbal mounted pendulum **17**. A tiltmeter of this general construction and suitable for measuring the angular deflection of a taut line is disclosed and claimed in a copending application of Kenneth Foster, Serial No. 830,604, filed July 30, 1959.

In addition to measuring the angular displacement of the vessel from its desired location the compass heading of the vessel is determined. This, of course, may be accomplished by any known type of compass but preferably a gyrocompass is used in order to obtain an electrical signal which is related to the compass heading.

Referring to FIGURE 2, there is shown a block diagram of one embodiment of this invention. Two propulsion units **11** and **12** are disposed at the bow and stern of the floating vessel, respectively. The disposition of the propulsion units is shown in FIGURE 1 in which the units are illustrated as being disposed in wells formed in the bow and stern of the vessel **10**, respectively. The propulsion units are provided with a thrust generating means such as propellers **20** and **21** driven by a variable speed drive means, for example an electric motor of the induction type coupled to the propellers through eddy current couplings **22** and **23**. Similarly, the propulsion units may be rotated about their vertical axes **24** and **25** in order to vary the direction of the thrust.

From the above description it can be appreciated that the propulsion units are very similar to outboard motors except for the fact that they are driven by an electrical means and their propellers may be rotated through 360 degrees. Several types of propulsion units fulfilling these requirements are available.

The propulsion units are provided with synchro-transmitters **26** and **27** which provide a signal indicating the direction of thrust of the propulsion unit relative to the vessel. The synchro-transmitters **26** and **27** are coupled to synchro-receivers **30** and **31**, respectively, by means of circuits **32** and **33**. The synchro-receivers **30** and **31** form a part of the vector resolving unit **34** which receives information from various sources and provides signals for controlling the stern and bow propulsion units. The vector resolving unit **34** will be described in greater detail below.

The vector resolving unit **34** provides four signals which are schematically illustrated by the lines **35**, **36**, **37** and **38**. The lines **35** and **38** represent control signals suitable for controlling the thrust of the propulsion units. These lines are shown as being connected to eddy current couplings **22** and **23** of the propulsion units **11** and **12**, respectively. The lines **36** and **37** represent signals which are used to control the direction of the thrust of the two propulsion units **11** and **12**, respectively. The signals represented by the lines **36** and **37** are supplied to the steering motor reversing starters **40** and **41** which in turn start, stop and reverse the steering motors **42** and **43**, respectively.

The vector resolving unit **34** receives signals representing the desired thrust to be supplied in the x and y planes as well as the rotational thrust required of the propulsion units. The desired thrust in the x and y planes is determined by controllers **44** and **45**. Each of these controllers receives a separate signal from the tiltmeter potentiometers **46** and **47** which measure deflections in the vertical planes disposed at right angles as explained above. The controllers **44** and **45** can be commercial controllers that have, in addition to set point adjustments **50** and **51**, conventional control response adjustments such as proportional, reset and derivative actions. In addition, the controller **44** is supplied with an input **59** which supplies an anti-oscillation vector as described more fully below. The rotational controller **52** receives a signal from gyrocompass **53** and is similar to controllers **44** and **45** in its actions.

The vector resolver can also receive signals from a single manual input **54**. The manual input provides three output signals comparable to those supplied by controllers **44**, **45** and **52**. In addition, the manual controller has a handle **55** which may be moved by an operator in the direction in which he desires the vessel to move or rotate the handle to rotate the ship without a change in horizontal thrust vector. Both the manual control **54** and the controllers **44**, **45** and **52** supply signals illustrated by the lines **56**, **57** and **58** which are vectorially combined in the vector resolving unit **34**. A three-pole switch **60** is provided for coupling either the controllers **44**, **45** and **52** or the manual controller **54** to the resolver **34**.

From the above discussion it can be appreciated that means have been provided by which two propulsion units located in the bow and stern of the vessel may be positioned in order to maintain the vessel over its desired position or move it along a desired course. The propulsion units are provided with a variable thrust means as well as a means for varying the direction of the thrust in order that the vessel may be maintained over its desired location or moved over a course. The vector resolving unit **34** provides signals for controlling both the magnitude of the thrust supplied by each of the propulsion units as well as the direction of the thrust. In order to provide the required control signals the vector resolving unit receives signals indicating the direction in which each of the propulsion units must be directed and the thrust required of each unit to move the vessel back to its desired location.

Referring now to FIGURE 3, there is shown an electromechanical controller for performing the operations of the vector resolving unit **34** described above. The vector resolving unit consists of the two synchro-receivers 30 and 31 described above which drive potential disks 70 and 71. Each of the synchro-receivers drives a similar potential disk and only the one related to the receiver 30 will be described in detail. The synchro-receiver 30 has a rotating shaft 72 which is connected to the potential disk 70. The disk 70 is divided into two halves 73 and 74 by means of insulating strips 75 and 76 with the insulating strip 75 being of relatively narrow width while insulating strip 76 is of more substantial width. The exact width of the two insulating strips 75 and 76 may vary, the only requirement being that the pick-up or brush 77 described below should bridge the strip 75 but fail to bridge the strip 76. Thus, when the pick-up means 77 is disposed along insulating strip 76 no current will flow through the lead 80 connected thereto. The lead 80 is coupled to a power supply 81 and to one side of a series of relay coils 82, 83, 84 and 85. The pick-up of the disk 71 is coupled in parallel with the pick-up 77 by leads 86 and 87. The leads 90 and 91 from the halves 73 and 74 of the potential disk 70 are coupled to the other ends of the relay coils 82 and 83. The leads from the two halves of the potential disk 71 are similarly coupled to the other ends of relay coils 84 and 85. The relay coils 82–85 operate relay contacts 92–95, respectively, to control the flow of current from a source 100 through the coils 96–99.

The relay contacts 92 and 93 operate the coils, 96 and 97 respectively, in the steering motor reversing starter 40 which causes the steering motor 42 to rotate either counterclockwise or clockwise. In a like manner, the contacts 94 and 95 operate the coils, 98 and 99 respectively, in the steering motor reversing starter 41 which causes the steering motor 43 to rotate either counterclockwise or clockwise. Disposed in series with the relay coils 83 and 85 are normally closed contacts 101 and 102 which are operated by the relay coils 82 and 84, respectively.

In order to best understand the operation of the potential disk pick-up combination, only the operation of the disk 70 and pick-up 77 will be described. As the pick-up 77 is moved from the wide insulating strip 76 it will cause the relay coil 82 or 83 to be energized depending into which half of the disk 70 the pick-up is moved. To prevent an ambiguity as the pick-up is moved over the narrow insulating strip 75 the normally closed contacts 101 are inserted in series with the coil 83 and operated by the coil 82. Thus, the contacts 101 will remain closed as the pick-up passes from the half 74 until the pick-up makes contact with the half 73 at which time the contacts 101 will open. It can also be seen from the above description that when the pick-up is in contact with the half 74 the relay coil 83 will be energized to close contact 93, thus energizing the starter coil 97 from source 100. Relay coil 82 is similarly energized when the pick-up is in contact with half 73 to close contacts 92 and energize coil 96. Of course, coil 96 should cause rotation of the steering motor 42 in one direction while coil 97 energizes the steering motor 42 to rotate in the opposite direction. The circuits associated with the potential disk 71 cause the steering motor 43 to operate in the same manner.

From the above discussion it is appreciated that if the pick-up 77 is moved in the direction that one wishes the stern propulsion unit to be directed the circuits will cause the steering motor 42 to rotate the propulsion unit to this direction. The steering motor 42 will rotate the propulsion unit until the wide insulating strip 76 of the potential disk is again aligned with the pick-up. The potential disk is, of course, rotated by the synchro-transmitter receiver combination 26 and 30. In order to provide a means for changing the thrust of the propulsion unit a displacement type actuator 103 is used. The actuator 103 is coupled to the pick-up 77 by means of a flexible cable 104 that passes through a bushing 105 located at the central axis of the disk 70. Thus, the farther the pick-up 77 is moved from the center of the disk 70 the greater will be the thrust supplied by the propulsion unit.

The single potential disk 70 provides a means for resolving the displacement of the pick-up 77 in two directions to obtain the desired direction of the propulsion unit and the desired thrust of the propulsion unit. Of course, the potential disk 71 will similarly resolve the displacement of its associated pick-up to control the direction and thrust of the bow propulsion unit 12. It is thus easily seen that if the pick-ups associated with the potential disks 70 and 71 were moved in unison that the vessel 10 of FIGURE 1 could be moved longitudinally, laterally or merely rotated about its center of rotation.

In order to move the pick-ups in unison the pick-up 77 is attached to an arm member 110 which extends outwardly from a channel-shaped support 111. The arm member 110 and support 111 are disposed for sliding movement in a slot 112 formed in one of the flanges of a channel-shaped base 113. The pick-up associated with the disk 71 is connected to a similar arm 114 attached to a channel-shaped support 115. The arm 114 is also disposed for sliding movement in a slot 116 formed in the other flange of the channel-shaped base 113.

A rack member 117 is formed on or attached to the surface of the support 115 opposite the surface to which the arm 114 is attached with a similar rack being disposed on the support 111. A pinion member 120 is disposed between the rack 117 and the second rack mounted on the support 111. The pinion 120 is held in position by flanges which extend out over the rack 117 and similar flanges formed on the support 111.

A rotational actuator 121 which is controlled by the signal 56 of FIGURE 2 is secured to the bracket 111. The actuator 121 must be an actuator which may be controlled by the signal 56 or the signal must be converted. For example, in the case of a hydraulic actuator and an electrical signal, the signal would have to be converted before they could be used to control the movement of the actuator. The piston rod 122 of the actuator 121 is coupled to an arm 123 by means of a pin with the arm 123 being secured to the support 115.

From the above description it can be appreciated that as the piston rod of the actuator 121 reciprocates, it will cause the rack 117 and support 115 to move longitudinally along the face of the flange on the channel-shaped base 113. As the support 115 moves in one direction the support 111 will move in the opposite direction. Thus, the pick-up 77 and the pick-up associated with the potential disk 71 will move in opposite directions across the face of the two potential disks.

The y actuator 130 is rigidly secured to the bottom of the channel-shaped base 113. The piston rod 131 of the actuator 130 is rotatably connected to a shaft 132 which extends upwardly from the pinion 120. Thus, as the piston rod 131 of the actuator 130 reciprocates it moves the pinion 120 and the two racks as a unit in a direction parallel to the axis of the base 113. The y actuator 130 is positioned by the signal 58 of FIGURE 2 and it may be necessary to convert the signal 58 to operate the actuator 130.

The x actuator 140 is fastened to a way 141 which supports one end of the base 113, with the other end of the base being supported in a similar manner by a way 142. The piston rod 143 of the actuator 140 is rigidly secured to the supporting base 113, thus as the piston rod moves it will move the supporting base 113 along the ways 141 and 142. This movement will cause the pick-ups associated with the potential disk to move in unison in a direction at right angles to the movement of the pick-ups by the actuator 130.

The shaft 132 which extends from the pinion 120 is used as a manual control since it may be used to move the two pick-ups in two directions at right angles to each other and to move them in opposite directions. The first two movements are obtained by moving the shaft 132 in the desired directions while the last movement is obtained by rotating the shaft 132. Of course, it is necessary to inactivate the actuators 121, 130 and 140 when the pick-ups are manually positioned.

In addition to the above-described method for effecting manual control of the propulsion units, one could use the system shown in FIGURE 2 in combination with the vector resolver shown in FIGURE 3. If the system of FIGURE 2 is to be combined with the system shown in FIGURE 3, the manual control device 54 should consist of a series of three potentiometers for supplying electric signals such as would be supplied to the controllers 44, 45 and 52. These potentiometers would all be operated by a single control handle 55 which could be moved in the direction in which it was desired to move the vessel and rotated to rotate the vessel with substantially no translation movement. The control handle 55 moves two potentiometers disposed at right angles to each other to supply the x and y signals and when rotated it positions a third potentiometer to supply a rotational signal. The three signals supplied from the manual control 54 are supplied to the actuators 121, 130 and 140 in the same manner as the signals from the controllers 44, 45 and 52 are supplied. Thus, the manual control provides an easy means by which one can exert manual control over the system to direct the vessel along a desired course or maintain it dynamically anchored over a fixed position.

When the two propulsion units are run at substantially zero speed the vector resolving unit of FIGURE 3 will call for frequent and large rotational movements of the propulsion units in order to maintain the vessel dynamically anchored over the fixed position. In order to prevent these frequent and large rotations of the propulsion units a turn buckle arrangement is provided on the vector resolver. The turn buckle consists of a threaded tubular member 150 and two threaded shafts 151 and 152. The threaded shafts thread into the tubular member 150 and are securely attached to the two synchro-receiving units 130 and 131. A groove 153 is formed in the center of the tubular member 150 with a support member 154 being disposed to engage the groove. Thus, when the tubular member is rotated it will move the synchro-receiving units 130 and 131 closer or farther apart. As the pick-ups for the two potential disks 70 and 71 are displaced from the center of the disks by the turn buckle arrangement they will cause the units to rotate at slow speeds while facing in opposite directions. This will introduce a biasing or anti-oscillation effect to the system and prevent the frequent and large rotational changes described above.

In order to both understand the operation of the vector resolving unit, reference is now made to FIGURE 4 showing a two vector diagram 160 and 161. The vector diagram 160 shows the vector resolution for the stern propulsion unit 11 while the diagram 161 illustrates the vector resolution for the bow propulsion unit 12. In both of the vector diagrams the vectors x and y represent the signals supplied by the x and y controllers 44 and 45 of FIGURE 2. As explained above, these controllers receive signals from a tiltmeter which are related to the displacement of the vessel from its desired location. The signals are the angle between a taut line and the vertical in two planes at an angle to each other. The controllers compare the signals received from the tiltmeter with preset values and supply related signals to the vector resolving unit. In addition, the controllers should be capable of supplying a derivative or proportional action in order that they may prevent the control system from over correcting and thus hunting or oscillating. The term ϕ represents the signal supplied by the rotation of controller 52.

This vector is proportional to the rotational force required to return the vessel to its required heading. As shown in FIGURE 4, the x and y vectors are added by the resolving unit of FIGURE 3 while the rotational vectors ϕ are added for one propulsion unit and subtracted for the other. This, of course, provides for the most efficient use of the propulsion effect of two units since the units will work together in the x and y direction to move the boat lateral to return it to its desired position while they work in parallel directions to rotate the boat with substantially no lateral displacement. In addition, a fourth vector b is shown in FIGURE 4 which represents the biasing or anti-oscillation effect supplied by the turn buckle arrangement described above. The vector resolving unit resolves the vectors as shown in FIGURE 4 and supplies two vectors R_s and R_b related to the magnitude of the thrust required of the stern and bow propulsion units and the direction of thrust for the stern and bow propulsion units. The vector resolving unit in FIGURE 3 supplies the magnitude of this vector by means of the displacement type actuator 103 while it supplies a direction of the thrust by displacing the pick-up 77 radially around the potential disk 70.

From the above description, it is seen that the vector resolving unit of FIGURE 3 purely resolves the vectors which are proportional to the desired lateral displacement of the vessel and the rotational displacement of the vessel. By purely resolving these vectors the unit provides two resulting vectors which describe the magnitude of the thrust required of each propulsion unit as well as the direction of thrust for each propulsion unit. While the system is described as applied to two propulsion units it could, of course, be used with any number of propulsion units merely by utilizing additional potential disks and pickup arrangements. Likewise, the propulsion units could be located anywhere on the vessel other than at the center of rotation of the vessel and the resolving unit would still provide for the most efficient use of the thrust available from the propulsion units. Of course, it would be necessary to adjust the signals supplied from the resolving unit to each of the propulsion units to correct for the different distances between the propulsion units and the center of rotation of the vessel.

While the above description has been related solely to the mechanical vector resolving unit shown in FIGURE 3, it is readily apparent that other means may be utilized for purely resolving the vectors. For example, a completely electrical analog could be constructed to replace the mechanical system shown in FIGURE 3.

In an electrical analog, the bias or anti-oscillation vector b could be added to the vector x for one propulsion unit and subtracted for the other propulsion unit from the vector by means of summing amplifiers and similarly, the rotational vector ϕ could be added to the vector y for one propulsion unit and subtracted from the vector y for the other propulsion unit. The Cartesian coordinates represented by the vectors x and y, thus modified, could then be converted to the polar coordinates or vectors representing propulsion unit thrust magnitude and direction by means of electrical resolvers. The scalar magnitude of the resultant could be used directly to control the propulsion unit thrust, and the direction of the resultant could be compared electrically with the propulsion unit direction by means of synchros and the difference used to redirect the propulsion unit.

Also, it can be appreciated from the above description that the control system of this invention can utilize inputs other than the x and y displacement vectors and the compass heading vector shown in FIGURES 1 and 2. For example, the system could use inputs from electronic locating devices, such as radar, loran or shoran equipment. Such inputs would indicate the displacement of the vessel from its desired location in the form of two vectors and a vector which would indicate the difference between the actual heading of the vessel and its desired heading. The vector resolving unit of FIGURE 3 would then resolve these vectors to determine what corrective action should be taken with regard to the propulsion units. Similarly, one could merely utilize an operator to visually observe the position of the vessel with relation to its desired position or course or then move the manual control handle 55 of FIGURE 2 in the direction required to return the vessel to its desired position or course. This type of manual operation would be advantageous when it is desired to move a vessel along a narrow waterway or maneuver a vessel in confined space.

Accordingly, while but a single embodiment of this invention has been described in detail, it obviously is susceptible to many modifications and changes within its broad spirit and scope. Thus, this invention should not be limited to the specific details described herein but only its broad spirit and scope.

We claim as our invention:

1. A marine vessel positioning system comprising: at least two propulsion means located on said vessel at separate positions spaced from the center of rotation of said vessel, first control means coupled to each of said separate propulsion units for directing the thrust effect of said propulsion units in a horizontal plane, second control means coupled to each of said separate propulsion units to vary the thrust effect of said propulsion units; locating means disposed on the vessel for determining its actual location and heading relative to its desired location and heading; a third control means coupled to said locating means to determine the difference between the actual location and heading of the vessel and the desired location and heading, said third control means generating control signals related to said difference; actuating means coupled to said third control means to actuate said first and second control means for positioning said first and second control means in response to the control signals.

2. A system for maintaining a marine vessel over a desired position comprising: separate propulsion means located at the bow and stern of the vessel, each propulsion means having a first control means to vary the direction of its thrust and a second control means to vary the magnitude of its thrust; a first position detecting means disposed on said vessel for detecting the horizontal position of the vessel in two directions at an angle to each other and for supplying analog signals of said detected position; a second position detecting means for detecting the heading of the vessel and supplying an analog signal of said detected heading; a controller means coupled to said first and second detecting means for comparing said analog deflection signals and said analog heading signal with signals representing desired values of the deflection and heading signals, said controller means also being coupled to a vector resolving unit to determine the required thrust vector of each propulsion unit; said vector resolving unit providing output signals indicating the desired direction of the thrust of each propulsion unit and separate output signals representing the magnitude of the thrust of each propulsion unit required to return the difference between the actual values of said deflection and heading signals and their desired values to zero.

3. A system for maintaining a floating vessel over a desired location on the ocean floor comprising: separate propulsion means located at the bow and the stern of said vessel, each propulsion means comprising a propeller driven by a variable torque motor means and a rotation means for rotating the thrust direction of each drive unit through 360° about a vertical axis; first detector means disposed on a guide line anchored to the said location on the ocean floor at one end and on the vessel at the other end, said detector means measuring the angle between said guide line and the vertical in two planes at an angle to each other and supplying output signals proportional to each of said measured angles; a synchro unit coupled to each propulsion unit to determine the direction of the thrust effect of each propulsion unit; a compass means positioned on said vessel to determine the geographical heading of the vessel; a control device comprising two spaced disks formed of conducting material, with each disk being divided into halves by separate insulating strips on each side of the center of said disk, one of said insulating strips being narrow and the other wide, a separate pick-up being of insufficient width to bridge the wide insulating strip on one side of the center of the disk but of sufficient width to bridge the narrow insulating strip on the other side of the center of the disk; circuit means for applying an electrical potential to both halves of each disk; the synchro unit of one propulsion unit being coupled to a synchro-receiving unit disposed to rotate one of said disks, the synchro unit of the other propulsion unit being coupled to a synchro-receiving unit disposed to rotate the other of said disks; a first actuator coupled to the compass means and disposed to move the pick-ups of both disks in opposite directions in relation to the difference between the actual and desired headings; second and third actuators coupled to said first detecting means and disposed to move said pick-ups in unison in two directions at an angle to each other; the pick-up of one disk being coupled to the rotation means of the propulsion unit whose synchro unit is coupled to the synchro-receiver of said one disk and the other pick-up being coupled to the rotation means of the other propulsion unit whereby said rotation means will rotate the propulsion units to align the pick-ups of both disks with the wide insulating strips on each disk; and control means coupled to the variable thrust drive means of each propulsion unit and to the pick-up of each disk to generate a signal to control said variable thrust drive means of each propulsion unit in proportion to the displacement of the pick-up from the center of the disk.

4. A system for controlling the movement of a vessel comprising: at least two propulsion units disposed on said vessel in a spaced relationship and at locations spaced from the center of rotation of said vessel; detecting means disposed on the vessel for determining the horizontal position of the vessel along two axes at an angle to each other; compass means disposed on the vessel to determine the heading of the vessel; a first means for comparing the horizontal position of the vessel with the desired position and for converting the difference into two thrust vectors at an angle to each other; second means for comparing the compass heading with the desired heading of the vessel and converting the difference into a rotational couple; said first and second means being coupled to a vector resolving unit, said vector resolving unit resolving said vectors to obtain a separate thrust vector for each propulsion unit indicating the thrust and direction anywhere in a full circle to be supplied by each unit and said vector resolving unit being coupled to a control means disposed on each propulsion unit whereby the thrust and the thrust direction of each propulsion unit is controlled to return the vessel to its desired position.

5. The system of claim 4 wherein the detecting means determines the translational displacement of the vessel in a direction parallel to the longitudinal axis of the vessel and in a direction normal to the longitudinal axis of the vessel.

6. The system of claim 5 wherein the vector resolving unit adds the translational thrust vectors for all propulsion units and subtracts the rotational thrust vector from the sum of the translational thrust vectors for some propulsion units and adds the rotational thrust vector to the sum of the translational thrust vectors for the remaining propulsion units.

7. The system of claim 4 in which a third means is coupled to the vector resolving unit to supply a differential anti-oscillation vector to the vector resolving unit.

8. A method for controlling the position of a vessel comprising: measuring the horizontal position of the vessel along two axes at an angle to each other, comparing the

measured vessel position along each axis with the desired vessel position along each axis and generating position correction components for each axis, the vector sum of said components representing the basic thrust and direction of thrust required of a plurality of propulsion units; measuring the heading of the vessel, comparing the measured vessel heading with the desired vessel heading and generating heading correction vector couple components along said axes; adding scalarly for each axis said position correction components to said heading correction couple components, the sign of the said heading correction components being chosen for said addition for each propulsion unit such that a minimum of interference will be caused between position correction and heading correction; resolving the sum of all axial components for each propulsion unit into a polar vector representing the required thrust magnitude and direction for that propulsion unit and controlling each propulsion unit to obtain the said required thrust and direction.

9. A system for controlling the position of a vessel comprising: measurement means for determining the position of the vessel in coordinates with axes in a horizontal plane and at some angle with each other; controller means for each of the two separate axes of said coordinates, each controller means having adjustable means for setting the desired position value along each axis, and for setting the gain and other controller actions, said controller means comparing the measured position value with the desired position value along each axis and providing a control output signal for each of the axis being controlled necessary to restore any displacement from the desired position value for that axis; vector resolving means to convert said axis control signals into a resulting polar vector representing thrust magnitude and direction required to restore the desired position of the vessel and propulsion means capable of providing variable thrust in any required direction in a full horizontal circle and arranged and controlled to provide the thrust and direction represented by said polar vector.

10. The system of claim 9 in which vessel heading is measured and the value of that heading is supplied to a third controller having adjustable means for setting the desired heading value and for setting the gain and other controller actions, the output of said third controller providing a signal which is proportional to the rotational couple required to restore desired vessel heading, said third controller being coupled to said vector resolving means, at least two propulsion units, said vector resolving means resolving said rotational couple and said polar vector separately for each propulsion unit, at least two of said propulsion units being disposed away from the vessel's center of rotation to provide said rotational couple and the rotational vectors of said rotational couple being aligned normal to a line drawn from each propulsion unit through the vessel's center of rotation.

11. A method for controlling the movement of a vessel comprising:

determining the actual location and heading of the vessel relative to the desired location and heading of the vessel;

utilizing the determined location and heading of the vessel to generate vectors representing for a plurality of propulsion units the rotational and translational thrust required to move the vessel to the desired position and heading;

generating an anti-oscillation vector;

vectorially resolving the rotational, translational and anti-oscillation vectors to obtain a propulsion vector for each propulsion unit representing the required thrust and direction of thrust for the propulsion unit; and

controlling the propulsion units in response to said propulsion vectors to obtain the required thrust and direction of thrust for each propulsion unit.

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