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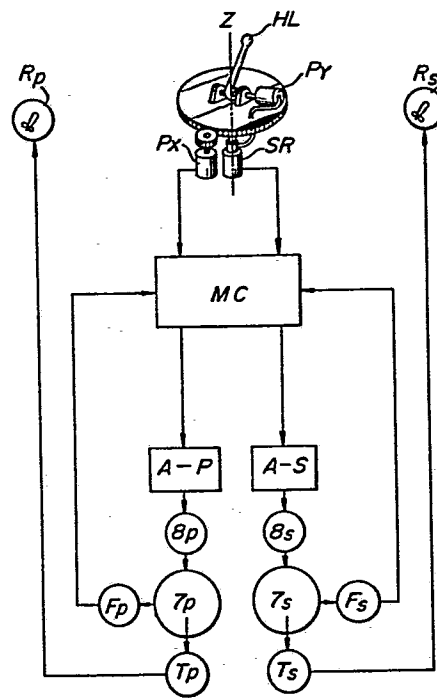
⑤④ Ship maneuvering gear.

⑤⑦ Ship maneuvering gear for a ship having two 360°-turning propellers disposed symmetrically relative to the ship's central bow-stern line, has a rotatable hand lever (HL) and an arithmetic circuit (MC) which responds to the rotation of the hand lever. When the hand lever (HL) is rotated by an angle relative to the ship's bow-stern direction, the output from the arithmetic circuit (MC) controls the orientations of the two propellers so that the composite propulsive power of the two propellers causes the ship to move in a lateral or obliquely lateral direction without causing any turn of the ship, which direction is in agreement with said angle of rotation of the hand lever.

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FIG.5



SHIP MANEUVERING GEAR

This invention relates to a ship maneuvering gear, and more particularly to a maneuvering gear of a ship having two or more propulsion units whose thrusts can be turned to any direction at will, which propulsion units are for instance rotating-blade propellers (e.g., Voith-Schneider propellers) or Z-type propellers turnable about vertical axes perpendicular to propeller shafts thereof.

Two maneuvering gears have been used heretofore to control two propellers. However, it has been proposed recently to use one maneuvering gear with one lever or handle to maneuver the two propellers so as to facilitate easy maneuver (for instance, Japanese Patent Publication No. 47,234/1976).

In a previously proposed one-lever maneuvering gear, the ship can be controlled by the one maneuvering lever so as to move ahead or astern, to turn, or to stop, but the proposed one-lever maneuvering gear does not allow lateral movement or obliquely lateral movement of the ship. What is meant by the lateral or obliquely lateral movement of a ship is a movement of the ship in the lateral or obliquely lateral direction without any turning of the ship.

More specifically, propulsion units are generally

mounted on a ship astern of the center of turning thereof (the center of turning of a ship is generally located close to the midpoint of the ship length in most types of ship). In a ship with the propulsion units mounted astern, the obliquely lateral movement ahead is impossible, although the obliquely lateral movement astern is possible to a certain extent. A maneuvering gear of the prior art for the ship with the propulsion units mounted astern has shortcomings in that the direction of the ship's lateral movement astern does not coincide with the direction of the maneuvering lever, and that the lateral movement of the ship is impossible.

Sometimes, propulsion units are mounted close to the bow of a ship, and the ship's center of turning comes astern the propulsion units in this case. A maneuvering gear of the prior art for a ship with the propulsion units mounted close to the bow thereof has shortcomings in that the obliquely lateral movement astern is impossible, although the obliquely lateral movement ahead is possible to a certain extent, that the direction of the ship's lateral movement ahead does not coincide with the direction of the maneuvering lever, and that the lateral movement of the ship is impossible.

Therefore, an object of the present invention is to obviate the abovementioned shortcomings of the prior art, by providing an improved ship maneuvering gear to

facilitate lateral movement and obliquely lateral movement of a ship through manual operation of one hand lever.

Another object of the invention is to provide a ship maneuvering gear in which the manually set direction of the hand lever coincides with the direction of the actual lateral or obliquely lateral movement of the ship.

Thus, the ship maneuvering gear of the invention ensures easy and accurate maneuver of a ship.

To fulfil the aforesaid objects, in a ship having a port propeller of 360°-turning type and a starboard propeller of 360°-turning type disposed symmetrically relative to a ship's central bow-stern line through a ship's center of turning, a preferred embodiment of the ship maneuvering gear according to the present invention controls the orientations of the two propellers by regulating the orientations of one maneuvering lever so that the two propellers produce a composite propulsive force acting on the ship's center of turning in a lateral or obliquely lateral direction, which direction coincides with the orientation of the maneuvering lever. More specifically, when the maneuvering lever is turned by an angle θ relative to the ship's bow-stern direction, one of the two propellers is turned about a center of turning thereof by an angle $90^\circ + \theta - \gamma$ relative to the ship's bow-stern direction while the other one of the two propellers is turned about a center of turning thereof by an angle $90^\circ - \theta - \gamma$ relative to the

ship's bow-stern direction, y being an angle between the ship's central bow-stern line and a line from the ship's center of turning to the propeller's center of turning.

The aforesaid 360° -turning propellers can be replaced with rotating-blade propellers (e.g., Voith-Schneider propellers). When two rotating-blade propellers are used, if the maneuvering lever is turned by an angle θ as described above, the rotating blades of the two propellers are so controlled as to produce thrust with the aforesaid orientations $90^\circ + \theta - y$ and $90^\circ - \theta - y$ respectively.

For a better understanding of the invention, reference is made to the accompanying drawings, in which:

Fig. 1A is a schematic vertical sectional view of a ship maneuvering gear according to the present invention;

Fig. 1B is an explanatory diagram showing the arrangement of a worm gearing means in the maneuvering gear of Fig. 1A;

Fig. 2 is a schematic partial plan view of a ship, showing the disposition of two propellers mounted thereon;

Fig. 3 is a partially cutaway perspective view of an operating board of the maneuvering gear of the invention;

Fig. 4 is an explanatory diagram showing the range in which a hand lever is moved;

Fig. 5 is a block diagram of the electric circuit

of the ship maneuvering gear of the invention;

Fig. 6 shows a maneuvering schedule of two propellers by the ship maneuvering gear of the invention;

Fig. 7 is a diagram illustrating the operating principles of a ship maneuvering gear of the invention under typical operating conditions;

Figs. 8 through 10 are diagrams similar to Fig. 7, showing the operations under different operating conditions;

Fig. 11 is a diagram similar to Fig. 7 for a ship having propulsion units mounted ahead of the ship's center of turning; and

Figs. 12 and 13 are block diagrams of two examples of the arithmetic circuit and the servo amplifier.

Throughout different views of the drawings, 1 is a prime mover, 2 is a horizontal intermediate shaft, 3 is an upper bevel gear, 4 is a vertical intermediate shaft, 5 is a lower bevel gear, 6 is a propeller shaft, 7_p , 7_s are propellers, 8_p , 8_s are hydraulic motors, 9 is a worm gear shaft, 10 is a vertical turning shaft, 11 is an operating board, HL is a hand lever, P_X , P_Y are synchro motors or potentiometers, SR is a slip ring, MC is an arithmetic circuit, A-P, A-S are servo amplifiers, F_p , F_s are feedback detector means, T_p , T_s are synchro transmitters, R_p , R_s are registers, S/A is a synchro analog converter, COMP is a phase comparator, AD is an adder, DS is a differential

synchronizer, SYR is a synchronous rectifier, CH is a change-over switch, O is a ship's center of turning, A, B are propeller's centers of turning, X is a ship's central bow-stern line, θ is a rotating angle of the hand lever HL, and γ is an offset angle of the propeller's centers of turning A and B.

Fig. 1 through Fig. 5 illustrates an embodiment of the ship maneuvering gear according to the present invention as applied to a ship with two 360° turning propulsion (Z-type propulsion) units.

Figs. 1A, 1B, and 2 show the mechanism of a 360°-turning propulsion unit. Output power from a prime mover 1 is transmitted to a port or starboard propeller 7_p or 7_s through a horizontal intermediate shaft 2, an upper bevel gear 3, a vertical intermediate shaft 4, a lower bevel gear 5, and a propeller shaft 6. A hydraulic motor 8_p or 8_s is connected to a worm shaft 9, so as to turn the propeller 7_p or 7_s about the axis of a vertical turning shaft 10 by the movement of the worm shaft 9 activated by the hydraulic motor 8_p or 8_s .

Figs. 3 through 5 show the structure and formation of the ship maneuvering gear of the invention. Referring to Fig. 3, an operating board 11 of the maneuvering gear has a hand lever 11. As shown in Fig. 4, the hand lever HL is a maneuvering lever which can be inclined relative to a vertical center line (coinciding with the Z-axis of

Fig. 4) up to a certain predetermined angle (up to 35° in the illustrated embodiment) and can be freely rotated about the center line within a circle $\underline{h}$ defined by a 360° rotation of the upper end of the hand lever HL with 35° inclination. P_X and P_Y are synchro motors (having a trademark of SELSYN motor) or potentiometers to detect the rotation and inclination of the hand lever HL, and the outputs thereof are applied to an arithmetic circuit MC so as to produce signals to actuate the hydraulic motors 8_p and 8_s through servo amplifiers A-P and A-S. The hydraulic motors 8_p and 8_s turn the propellers 7_p and 7_s respectively, while feedback potentiometers F_p and F_s compares the actual orientations of the propellers 7_p and 7_s against set values determined by the arithmetic circuit MC. Synchro transmitters T_p and T_s transmit signals representing the actual orientations of the propellers 7_p and 7_s to the operating board 11, and registers R_p and R_s including servo receiving indicated the actual orientations of the propellers 7_p and 7_s in response to the signals from the synchro transmitters T_p and T_s respectively.

The synchro motor or potentiometer P_X to detect the rotation of the hand lever HL may be disposed above or below the slip ring SR of Fig. 3 in tandem therewith, which slip ring SR is disposed along the vertical central axis Z of Figs. 3 and 4.

During regular cruising of a ship having the

maneuvering gear of the aforesaid formation according to the present invention, the direction of propulsion acting on the ship is set by the rotating angle of the hand lever HL while the magnitude of the propulsive power or the ship speed is controlled by regulating the inclination of the hand lever HL.

Figs. 12 and 13 show two examples of the arithmetic circuit MC and the servo amplifiers A-P and A-S, in which examples the detecting means P_X and P_Y are assumed to be synchro motors whose outputs are applied to the arithmetic circuit MC so as to produce signals applicable to the hydraulic motors 8_p and 8_s through the servo amplifiers A-P and A-S.

In the example of Fig. 12, the two output signals from the synchro motors P_X and P_Y are applied to synchro analog converters S/A of the arithmetic circuit MC for analog conversion. Outputs from the synchro analog converters S/A are applied to and processed by an adder AD, and the output from the adder AD is amplified by an amplifier AMP. The amplified signal from this amplifier AMP is applied to feedback adders FAD to which signals from the feedback detector means F_p and F_s for the propellers 7_p and 7_s are also applied, so as to effect arithmetic operations necessary for the desired feedback control. The feedback detector means F_p and F_s of this example can be potentiometers.

The output signals from the feedback adders FAD are amplified by amplifying circuits AMP of the servo amplifiers A-P and A-S. In the servo amplifiers A-P and A-S of this example, phase comparators COMP receive the amplified signals from the amplifying circuits AMP thereof and compare the received signals against a reference so as to separate clockwise instruction signals from counterclockwise instruction signals. Each servo amplifier A-P or A-S is connected to two magnetic valves MV, so that the corresponding hydraulic motor 8_p or 8_s is selectively driven either clockwise or counterclockwise.

In the example of Fig. 13, the signal from each of the synchro motors P_X and P_Y is applied to both of the two differential synchronizers DS of the arithmetic circuit MC respectively. The differential synchronizers DS of this example also receives signals from the feedback synchro motors F_p and F_s for the propellers 7_p and 7_s , so as to effect the arithmetic operations necessary for the desired feedback control. The output signals from the arithmetic circuit MC are applied to the servo amplifiers A-P and A-S, where synchronous rectifiers SYR separate clockwise instruction signals from counterclockwise instruction signals based on the nature of the output signals from the arithmetic circuit MC, e.g., potentials thereof, and the thus separated instruction signals are amplified by amplifier circuits AMP provided for each of the clockwise

and counterclockwise instruction signals. Each servo amplifier A-P or A-S is connected to the corresponding hydraulic motor 8_p or 8_s through two magnetic valves MV, as in the case of the example of Fig. 12.

As noted above, the example of Fig. 13 uses feedback synchro motors F_p and F_s instead of the feedback potentiometers of the example of Fig. 12.

When either one or both of the detecting means P_X and P_Y are potentiometer, only the example of Fig. 12 can be used, and the operations of the maneuvering gear with such detecting potentiometers are similar to those with the detecting synchro motors as described in the foregoing, except that the synchro analog converters S/A can be dispensed with in the case of the detecting potentiometers.

The foregoing descriptions of the examples of Figs. 12 and 13 refer to the control mode for regular cruising of the ship. To provide an additional control mode for the lateral or obliquely lateral movement of the ship, the following modifications are necessary; namely, in the example of Fig. 12, a changeover switch and another circuit to carry out the arithmetic operations for the aforesaid additional control mode to be described hereinafter are connected to the adder AD of the arithmetic circuit MC; in the example of Fig. 13, a changeover switch and another circuit to carry out the arithmetic operations for the

aforesaid additional control mode to be described hereinafter are connected to the differential synchronizers DS of the arithmetic circuit MC. The changeover switches are connected in such a manner that either of the aforesaid two control modes, one for regular cruising and one for lateral or obliquely lateral movement, can be easily selected by operating the changeover switch.

Fig. 6 shows a maneuvering schedule during regular cruising for the maneuvering gear of the invention in terms of the relationship among the positions of the hand lever HL, orientations of the propellers 7_s and 7_p as indicated by the registers 8_s and 8_p (arrows in Fig. 6), and the moving direction of the ship (arrows in Fig. 6). For instance, Operation No. 1 shows that the hand lever HL is held upright with its top H' at the neutral position to keep the ship at rest. Operations No. 2 and No. 3 show that the ship moves ahead at full and middle speed and that the orientations of the propellers vary with the ship speed even when the ship moves straightly ahead. Operations No. 4 and No. 5 show that the ship moves ahead while turning port and starboard and that the two propellers assume identical orientations at full speed but the two propellers assume different positions at middle speed as shown by dotted lines of Fig. 6. Similarly, the ship can be maneuvered so as to turn starboard and port about one point or to move back simply by setting the hand lever HL

accordingly as shown in Fig. 6.

As described in the foregoing, in the ship maneuvering gear of the invention, the hand lever HL can be rotated and inclined to any position in the 360° range, so that the ship can be maneuvered to move not only ahead and back but also sideways, and the composite propulsive power of the two propellers 7_p and 7_s can be varied from zero to the maximum by controlling the inclination of the hand lever HL while maintaining the constant propulsive powers at the individual propellers. Accordingly, the ship speed can be controlled from stop as instructed by the upright or neutral position of the hand lever HL to the full speed as instructed by the maximum inclination of the hand lever HL.

In a preferred embodiment of the invention, functions of lateral movement and obliquely lateral movement of a ship are included by providing a program to effect such movements in the arithmetic circuit MC of Fig. 5. As shown in Fig. 3, a changeover switch CH is mounted on the operating board 11, and the arithmetic circuit MC is switched between the maneuver for regular cruising as described in the foregoing by referring to Figs. 3 through 5 and the maneuver for the lateral or obliquely lateral movements.

The principles for effecting the lateral and obliquely lateral movements of a ship by the ship

maneuvering gear of the invention will be now explained. Fig. 7 shows an embodiment for a ship having two 360° -turning propellers 7_p and 7_s , but the present invention is not restricted to such propellers and any propulsion units whose thrust direction can be turned 360° such as rotating-blade propellers (e.g., Voith-Schneider propellers) can be used together with the ship maneuvering gear of the invention.

Referring to Fig. 7, the two propellers 7_p and 7_s can be turned 360° about their counters of turning A and B respectively. The port and starboard propellers 7_p and 7_s are disposed symmetrically relative to a ship's central bow-stern line X through a ship's center of turning O, so that the propeller's centers of turning A and B are disposed on the port side and starboard side astern of the ship's center of turning O and the distance between the centers O and A is the same with the distance between the centers O and B. When the hand lever HL is turned to a position having an angle θ relative to the ship's bow-stern direction parallel to the ship's central bow-stern line X, one of the two propellers is turned to a position where thrust thereof has an angle $90^\circ + \theta - y$ relative to the ship's bow-stern direction while the other one of the two propellers is turned to a position where thrust thereof has an angle $90^\circ - \theta - y$ relative to the ship's bow-stern direction, y being an angle between the ship's central bow-stern line X and a line from the ship's center of

turning O to the propeller's center of turning A or B , whereby the ship is propelled into an obliquely lateral direction with an angle θ relative to the ship's central bow-stern line X .

The reasons for using the aforesaid relationship among the orientations of the hand lever HL and the propellers 7_p , 7_s will now be described.

In Fig. 7, the ship's center of turning O is generally located on the ship's central bow-stern line X near the midpoint of the ship, and the propeller's centers of turning A and B of this embodiment are located astern of the ship's center of turning O . X_p and X_s represent axes through the propeller's centers of turning A and B in parallel to the ship's central bow-stern line X .

When the hand lever HL is pushed down ahead by a maximum extent of 35° and turned by an angle θ relative to the ship's bow-stern direction as shown in Fig. 7, if the changeover switch CH assumes the position for regular cruising maneuver, the propellers 7_p and 7_s are turned by the angle θ from positions 1_p and 1_s aligned with the axes X_p and X_s to positions 3_p and 3_s so as to cause the ship to turn starboard. In the figure, arrows for the propellers represent the orientations of the propellers, and the directions of the propulsive forces generated in the propellers are opposite in sense to those of the arrows for the propellers. If the changeover switch CH is

switched to the position for the lateral or obliquely lateral movement, the port propeller 7_p is slightly turned rightward from the position 1_p to a position 2_p while the starboard propeller 7_s is noticeably turned leftward (upward) from the position 1_s to a position 2_s . To fulfil the obliquely laterally movement of the ship in the direction set by the hand lever HL, the positions 2_p and 2_s must be defined accurately.

Still referring to Fig. 7, a circle with a center at the ship's center of turning O (to be referred to as the "circle O", hereinafter) is drawn so that the extensions of the arrows representing the orientations of the propellers 7_p and 7_s at the positions 2_p and 2_s have tangents to the circle O at points of contact M and N. If such tangents from the points A and B representing the propeller's centers of turning to the aforesaid circle O intersect at a point C, the following relationship is satisfied in the triangle CAB.

$$x = 180^\circ - (\alpha + \beta) \quad \dots\dots\dots (1)$$

$$\text{here, } x \equiv \angle ACB$$

$$\alpha \equiv \angle CAB$$

$$\beta \equiv \angle CBA.$$

In the triangle OAB,

$$y = 90^\circ - (\beta + \delta) \quad \dots\dots\dots (2)$$

$$\text{here, } \delta \equiv \angle CBO.$$

Since $\angle OAB = \angle OBA$,

$$\alpha = \gamma + \angle OAB = \gamma + \beta + \delta \quad \dots\dots\dots (3)$$

here, $\gamma \equiv \angle CAO$.

The line sections AM and BN are tangents to the circle O and the triangle OAB is an isosceles triangle, so that $OA = OB$, $OM = ON$, and $\angle OMA = \angle ONB = 90^\circ$, so that $\triangle OMA \cong \triangle ONB$.

Accordingly, $\gamma = \delta$, and the equation (3) can be rewritten as

$$\alpha = \beta + 2\delta.$$

Thus, the equation (1) can be rewritten as

$$x = 180^\circ - 2(\beta + \delta) \quad \dots\dots\dots (4)$$

Comparing the equations (4) and (2), $x = 2y$ and $\angle ACB = \angle AOB$, so that the point C is on a circle through the three points O, A, and B.

If a composite thrust of the thrusts of the two propellers at the positions 2_p and 2_s in the directions of the tangents of the circles O from the points A and B is determined at the point C, the thrust T_p of the port propeller 7_p at the position 2_p and thrust T_s of the starboard propeller 7_s at the position 2_s produce a composite thrust T whose direction coincides with that of the line segment CO from the point C to the ship's center of turning O.

Thus, when the hand lever HL is turned and set at the direction of the line segment CO, the direction of the composite thrust T of the thrusts T_p and T_s of the two propellers 7_p and 7_s coincides with the thus set direction of the hand lever HL.

Based on the principles described above, the positions 2_p and 2_s to be assumed by the propellers 7_p and 7_s in response to the set position of the hand lever HL can be expressed in the following manner.

When the hand lever HL is turned rightward by an angle θ , $\theta = \angle COX = \angle COA + \angle AOX$ and $\angle COA = \angle CBA = \beta$ while $\angle AOX = y$, so that $\theta = \beta + y$. Accordingly,

$$\beta = \theta - y \quad \dots\dots\dots (5)$$

In the triangle CAB,

$$\alpha = 180^\circ - (x + \beta) \quad \dots\dots\dots (6)$$

In view of the equation (5) and the relationship of $x = 2y$, the equation (6) can be rewritten as

$$\alpha = 180^\circ - (2y + \theta - y) = 180^\circ - (\theta + y) \quad \dots\dots (7)$$

Considering the equation (7), the angle μ between the axis X_p and the line section AC is given as follows.

$$\mu = \alpha - 90^\circ = 90^\circ - (\theta + y) \quad \dots\dots\dots (8)$$

What is meant by the equation (8) is that the position 2_p is reached by turning the propeller 7_p counterclockwise from the axis X_p (direction of straight ahead) by an angle μ .

Similarly, the position 2_s is reached by turning the propeller 7_s clockwise from the axis X_s (direction of straight forward) by an angle w given by

$$w = 90^\circ + \beta = 90^\circ + \theta - y \quad \dots\dots\dots (9)$$

The validity of the aforesaid principles under other ship maneuvering conditions will be now described.

Fig. 8 shows a diagram illustrating angular

relationship among the hand lever HL and the two propellers 7_p and 7_s for the cases of $\theta=90^\circ$ and $\theta=0^\circ$. When the hand lever HL is turned so as to set $\theta=90^\circ$, the angle of orientation μ for the port propeller 7_p is given by the equation (8) as follows:

$$\mu = 90^\circ - (\theta + y) = 90^\circ - 90^\circ - y = -y,$$

so that the port propeller 7_p is turned clockwise by an angle y .

The angle of orientation w for the starboard propeller 7_s under the condition of $\theta=90^\circ$ is given by the equation (9) as follows:

$$w = 90^\circ + \theta - y = 180^\circ - y,$$

so that the starboard propeller 7_s is turned clockwise by an angle $180^\circ - y$.

In this case, the thrusts T_p and T_s of the propellers 7_p and 7_s are aligned with the lines OA and OB passing the ship's center of turning O. Accordingly, the composite thrust T of the two thrusts T_p and T_s in this case is exactly lateral to the ship's central bow-stern line X at the ship's center of turning O, whereby the ship is propelled exactly laterally.

The next case is for $\theta=0^\circ$ actuated by pushing the hand lever HL down straightly ahead. The equation (8) gives the angle of orientation at the position 2_p for the port propeller 7_p as $\mu=90^\circ-(\theta+y)=90^\circ-y$, while the equation (9) gives the angle of orientation at the position 2_s for

the starboard propeller 7_s as $w=90^\circ+\theta-y=90^\circ-y$. Accordingly, the composite thrust of the thrusts generated by the two propellers 7_p and 7_s in this case causes the ship to move straight ahead.

Fig. 9 shows the case in which the angle θ set by the hand lever HL is larger than 90° . In the figure, the orientation of the port propeller 7_p at the position 2_p is shown as $90^\circ-\alpha$ taken in the clockwise direction from the position 1_p , and the equation (7) gives $\alpha=180^\circ-\theta-y$, so that $90^\circ-\alpha=90^\circ-180^\circ+\theta+y=-(90^\circ-\theta-y)$, which coincides with the value given by the equation (8) for this case. The figure also shows the orientation of the starboard propeller 7_s at the position 2_s as $90^\circ+\beta$ taken in the clockwise direction from the position 1_s . In the triangle CAB, the angle β is given by $\beta=180^\circ-\alpha-x$. Since $x=2y$, $\beta=180^\circ-\alpha-2y$. Thus,

$$90^\circ+\beta = 90^\circ+180^\circ-\alpha-2y = 270^\circ-\alpha-2y \quad \dots \quad (10)$$

Since $\theta+\alpha+y=180^\circ$, $\alpha=180^\circ-\theta-y$, and substitution of this α in the equation (10) gives

$$90^\circ+\beta = 270^\circ-180^\circ+\theta+y-2y = 90^\circ+\theta-y,$$

which coincides with the value given by the equation (9).

In this case, the composite thrust T of the thrust generated by the two propellers acts on the ship's center of turning O in an oblique direction, so that the obliquely lateral movement of the ship is effected.

Due to the reasons described above, the inventors

noted the fact that for any angle θ set by the hand lever HL the orientation of the port propeller 7_p is given by $90^\circ - \theta - y$ while the orientation of the starboard propeller 7_s is given by $90^\circ + \theta - y$. Accordingly, the ship maneuvering gear of the invention automatically controls the orientations of the two propellers in response to the angle θ set by the hand lever HL based on the aforesaid angular relationship among the hand lever and the propellers. The control pattern for the lateral or obliquely lateral movement of the ship is different from the control pattern for regular cruising, so that a changeover means is provided to select one of the two control patterns. In the embodiment of Fig. 3, the changeover switch CH is to switch the control between the regular cruising mode and the lateral or obliquely lateral movement mode.

As regards the speed control during the lateral or obliquely lateral movement, the revolving speed of the prime mover driving the propellers can be controlled, for instance by a speed control lever provided on an operating board such as the board 11 shown in Fig. 3. It is also possible to control the revolving speed of the prime mover by the synchro motor or potentiometer P_y to detect the inclination of the hand lever HL, for instance by increasing the revolving speed of the prime mover with the increase of the forward inclination of the hand lever HL. In this case, the ship speed during the lateral or obliquely

lateral movement can be reduced by pulling up the hand lever HL toward the upright position thereof.

The control of the ship speed can be also fulfilled by modifying the orientations of the propellers. In this case, the manner of changing the orientations of the two propellers in response to the pulling up or pushing down of the hand lever HL for the ship speed control is similar to that in the control for the regular cruising, except the following difference. The difference in the manner of changing the propeller orientations is due to the fact that, although the ship speed reduction during the regular cruising ahead or astern or turning can be achieved by pulling up the hand lever HL which pulling up causes the propellers to turn outboard, the turning of the propellers outboard during the lateral or obliquely lateral movement under the control of the invention tends to cause the ship to turn, which turn interferes with the desired lateral or obliquely lateral movement. Accordingly, the following arrangement is necessary to control the ship speed by modifying the orientations of the propellers without causing any turning of the ship during the lateral or obliquely lateral movement thereof.

Referring to Fig. 10, to reduce the ship speed during the obliquely lateral movement of the ship in the direction of angle θ relative to the straight ahead direction (moving ahead starboard), the two propellers are

turned from positions (1) to positions (2) by 90° in response to the pulling up of the hand lever HL to the upright position thereof. More specifically, the port propeller 7_p is turned counterclockwise 90° from the position (1) to the position (2), and the starboard propeller 7_s is similarly turned counterclockwise 90° .

The composite thrust T_2 of the thrusts of the two propellers at the positions (2) of Fig. 10 is directed obliquely lateral through the ship's center of turning O, so that the resultant propulsive force tends to cause the ship to move ahead port so as to brake the movement in the direction of ahead starboard.

If a stronger brake action than the aforesaid oblique propulsive force is desired, the hand lever HL is further pulled away from the upright position to the position (3) which can be reached by turning the hand lever HL 180° from the initial position (1) for the lateral movement in the ahead starboard direction, as shown in the top portion of Fig. 10. Whereby, the two propellers are turned from the positions (1) by 180° until reaching positions (3) through the aforesaid positions (2). At the positions (3), the two propellers produce a composite thrust T_3 , which acts to pull back the ship in a direction 180° away from or just opposite to the direction of the ahead starboard movement.

In the foregoing description, the propellers are

assumed to be mounted on the ship astern of the ship's center of turning O. It should be noted that the maneuvering gear of the invention can be also used with propellers mounted ahead of the ship's center of turning O.

Fig. 11 shows a case in which the propellers are mounted on the bow side of a ship relative to the ship's center of turning O. In this case, when the hand lever HL is turned by an angle θ , the port propeller 7_p is turned by an angle $90^\circ - \alpha$ relative to the direction of the axis X_p , while the starboard propeller 7_s is turned counter-clockwise by an angle $90^\circ - \beta$ relative to the axial direction X_s .

The following relations are satisfied in this case.

$$y = \theta + \alpha$$

$$y + \theta = \beta$$

Accordingly,

$$90^\circ - \alpha = 90^\circ - (y - \theta) = 90^\circ + \theta - y$$

$$90^\circ - \beta = 90^\circ - (y + \theta)$$

The aforesaid equations for $90^\circ - \alpha$ and $90^\circ - \beta$ are identical with the equations (9) and (8) except that the applicable propellers are interchanged between the port and starboard sides.

Thus, it is shown that the ship maneuvering gear can be applied to a ship having two propellers mounted ahead of the center of turning O thereof.

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Although the embodiments described hereinbefore use the Z-type propellers, the rotating-blade propellers such as the Voith-Schneider propellers can be used instead of the Z-type propellers. More particularly, the object of the present invention can be fulfilled by turning the direction of the thrust of the rotating-blade propellers in lieu of the turning of the Z-type propellers in the embodiments described in the foregoing.

As described in the foregoing, the ship maneuvering gear of the invention facilitates lateral or obliquely lateral movement of a ship simply by regulating one hand lever, while keeping the direction of the lateral or obliquely lateral movement in agreement with the orientation of the hand lever. Thus, the present invention has an outstanding effect of providing easy and accurate maneuver of lateral or obliquely lateral movement of a ship which has been difficult to maneuver heretofore.

Although the invention has been described with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example and that numerous changes in details of construction and the combination and arrangement of parts may be resorted to without departing from the scope of the invention as hereinafter claimed.

CLAIMS

1. A maneuvering gear of a ship having a port propulsion unit and a starboard propulsion unit disposed symmetrically relative to a ship's central bow-stern line through a ship's center of turning, thrust direction of each of said propulsion units being turnable 360° about a propulsion unit's center of turning, said maneuvering gear comprising a hand lever that can be rotated 360° , an arithmetic circuit responding to the rotating angle of said hand lever, and an actuating means responding to output of said arithmetic circuit in such a manner that, when the angle of said hand lever relative to ship's bow-stern direction is θ , the actuating means turns one of said propulsion units so as to make the angle of thrust thereof relative to the ship's bow-stern direction $90^\circ + \theta - y$ while turning the other one of said propulsion units so as to make the angle of thrust thereof relative to the ship's bow-stern direction $90^\circ - \theta - y$, y being an angle between the ship's central bow-stern line and a line from the ship's center of turning to the propulsion unit's center of turning.

2. A maneuvering gear as set forth in claim 1, wherein said propulsion units are two 360°-turning propellers each of which can be turned about a vertical axis perpendicular to a propeller shaft thereof, and said propulsion unit's center of turning is said vertical axis of the 360°-turning propeller.

3. A maneuvering gear as set forth in claim 1, wherein said propulsion units are two rotating-blade propellers.

4. A maneuvering gear as set forth in claim 1, wherein said maneuvering gear includes a synchro motor responding to the rotating angle of the hand lever so as to inform the arithmetic circuit of the rotating angle of the hand lever.

5. A maneuvering gear as set forth in claim 1, wherein said maneuvering gear includes a potentiometer responding to the rotating angle of the hand lever so as to inform the arithmetic circuit of the rotating angle of the hand lever.

6. A maneuvering gear as set forth in claim 1, wherein said actuating means includes two hydraulic motors coupled to said propulsion units through worm gearing means.

7. A maneuvering gear as set forth in claim 1, wherein said maneuvering gear includes synchro transmitters producing signals representing orientations of the thrusts of the two propellers and registers having synchro receivers to receive said signals from the synchro transmitters so as to indicate the orientations of the thrusts.

8. A maneuvering gear as set forth in claim 1, wherein said maneuvering gear includes feedback detector means to detect orientations of said thrusts of the propulsion units so as to produce signals showing the detected orientations and servo amplifier means to receive signals from said arithmetic circuit so as to deliver amplified signals to said actuating means; said arithmetic circuit includes two synchro analog converters to convert signals representing the rotating angle and inclination of said hand lever, an adder to add converted signals from said synchro analog converters, and feedback adders to receive signals both from said adder and from said feedback detector means so as to produce output signals of the arithmetic circuit; and said servo amplifier means includes amplifier circuits to amplify signals from said arithmetic circuit and comparator to differentiate clockwise instruction signals to said propulsion units from counterclockwise instruction signals thereto by comparing signals from said amplifier circuits against a reference.

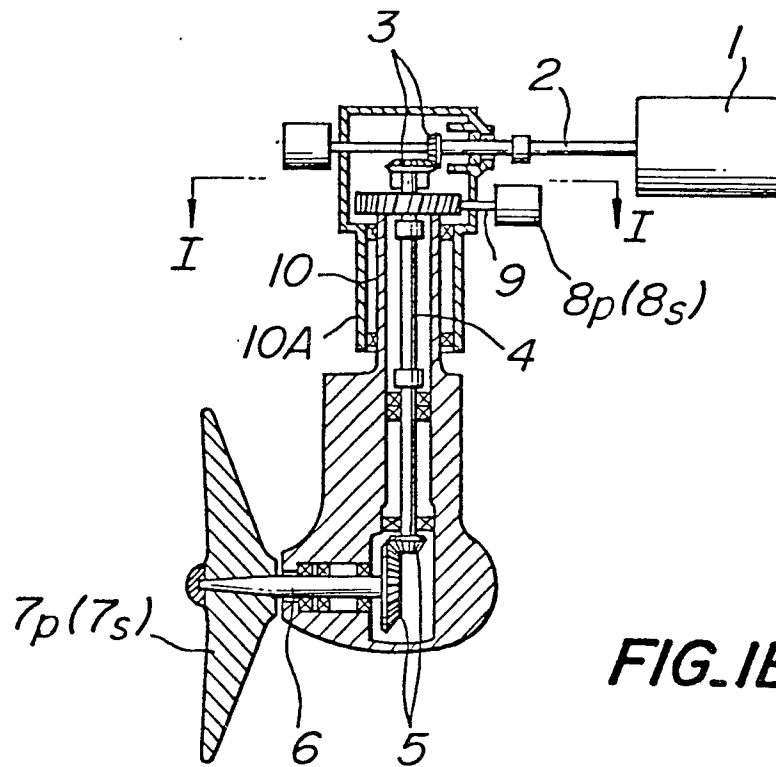
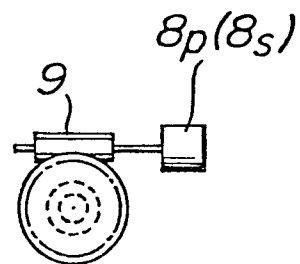
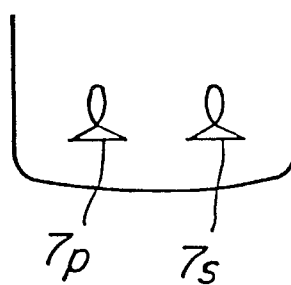
9. A maneuvering gear as set forth in claim 1, wherein said maneuvering gear includes feedback detector means to detect orientations of said thrusts of the propulsion units so as to produce signals showing the detected orientations and servo amplifier means to receive signals from said arithmetic circuit so as to deliver amplified signals to said actuating means; said arithmetic circuit includes differential synchronizer means to receive signals both from said hand lever and from said feedback detector means so as to produce output signals of the arithmetic circuit; and said servo amplifier means includes synchronous rectifier means to differentiate clockwise instruction signals to said propulsion units from counterclockwise instruction signals thereto depending on nature of said output signals from the arithmetic circuit and amplifier circuits to amplify the thus differentiated signals from said synchronous rectifier means.

10. A maneuvering gear as set forth in any one of claims 8 and 9, wherein said feedback detector means are synchro motors coupled to said propulsion units.

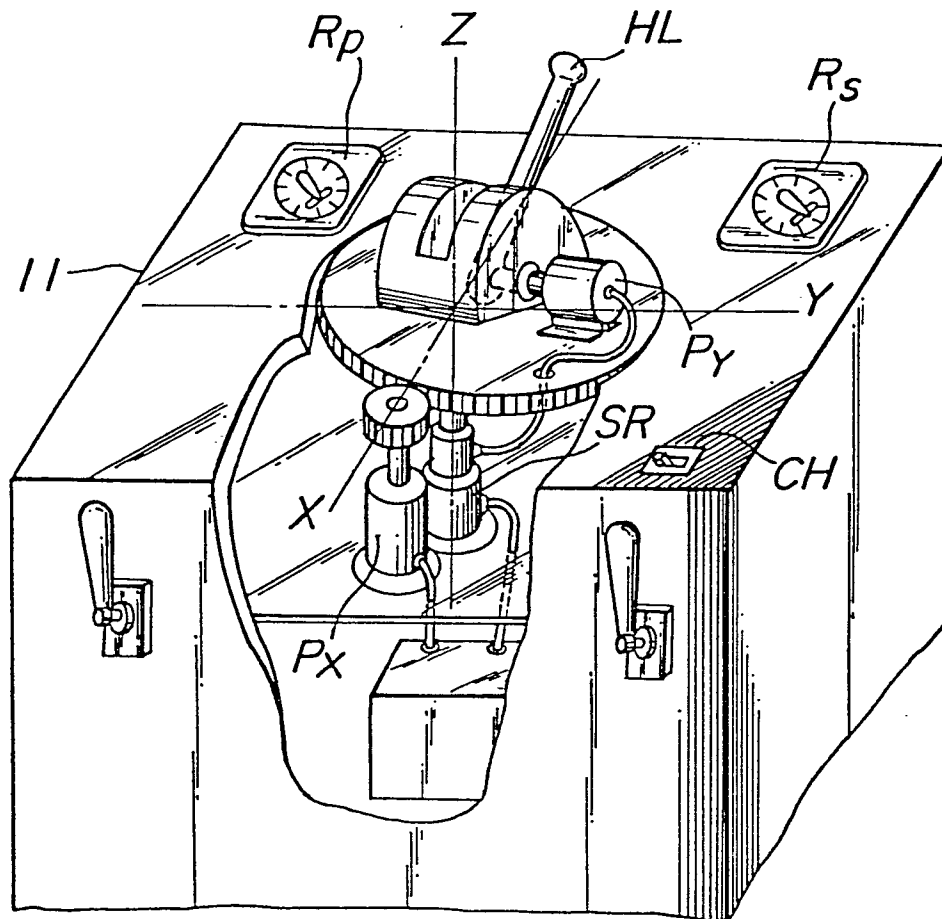
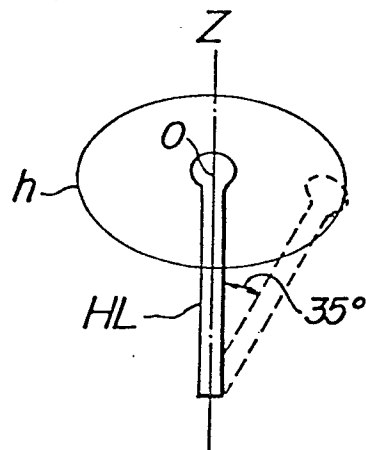
11. A maneuvering gear as set forth in any one of claims 8 and 9, wherein said feedback detector means are potentiometers coupled to said propulsion units.

12. A maneuvering gear as set forth in claim 1, wherein said maneuvering gear includes potentiometers coupled to said hand lever so as to detect the rotation and inclination of said hand lever, and feedback potentiometers to detect orientations of said thrusts of the propulsion units so as to give signals showing the detected orientations, and servo amplifier means to receive signals from said arithmetic circuit so as to deliver amplified signals to said actuating means; said arithmetic circuit includes an adder to add signals from said potentiometer coupled to said hand lever, and feedback adders to receive signals both from said adder and from said feedback potentiometers so as to produce output signals of the arithmetic circuit; and said servo amplifier means includes amplifier circuits to amplify signals from said arithmetic circuit and comparator means to differentiate clockwise instruction signals to said propulsion units from counterclockwise instruction signals thereto by comparing signals from said amplifier circuits against a reference.

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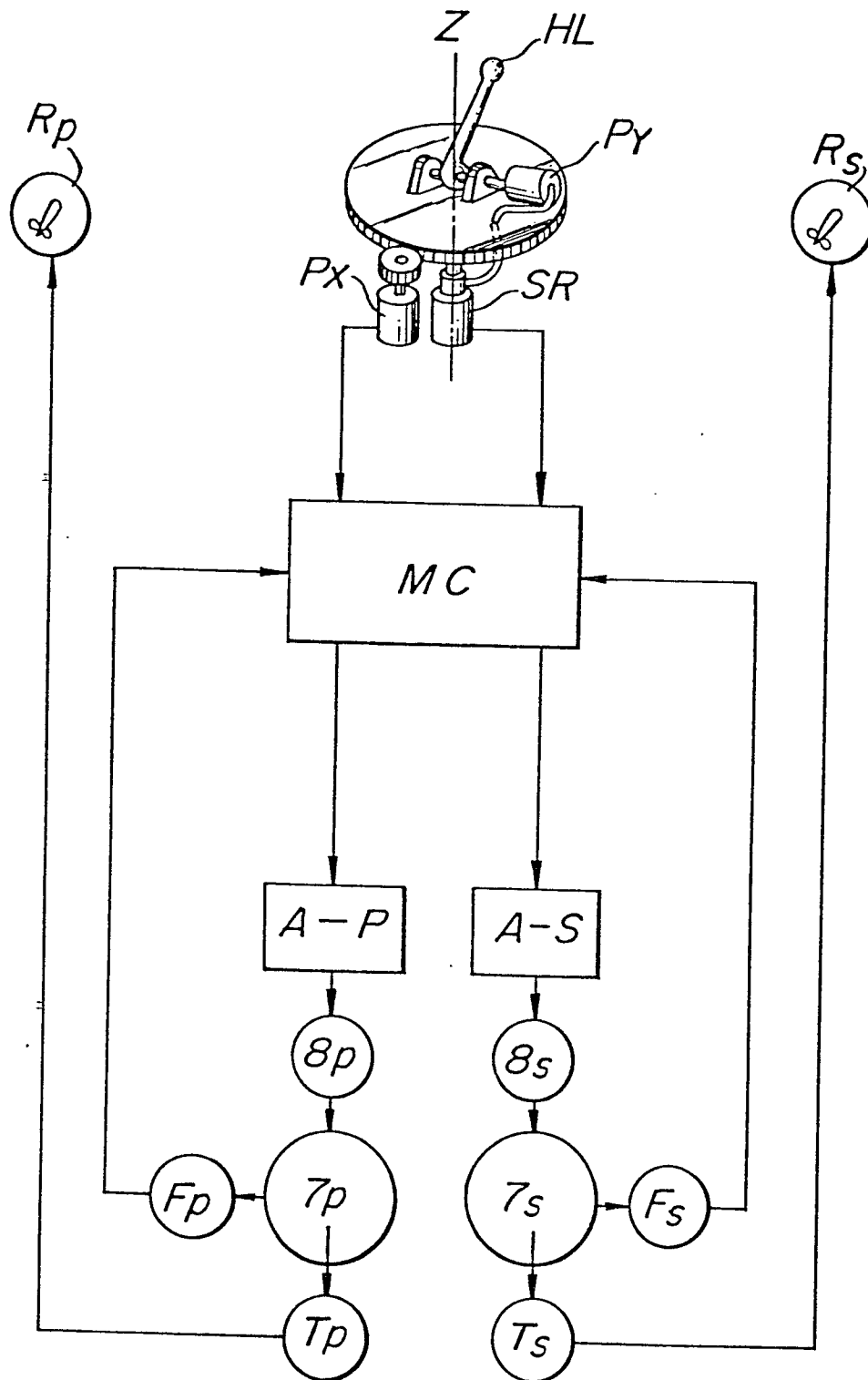
FIG. 1A**FIG. 1B****FIG. 2**

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FIG. 3**FIG. 4**

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FIG. 5

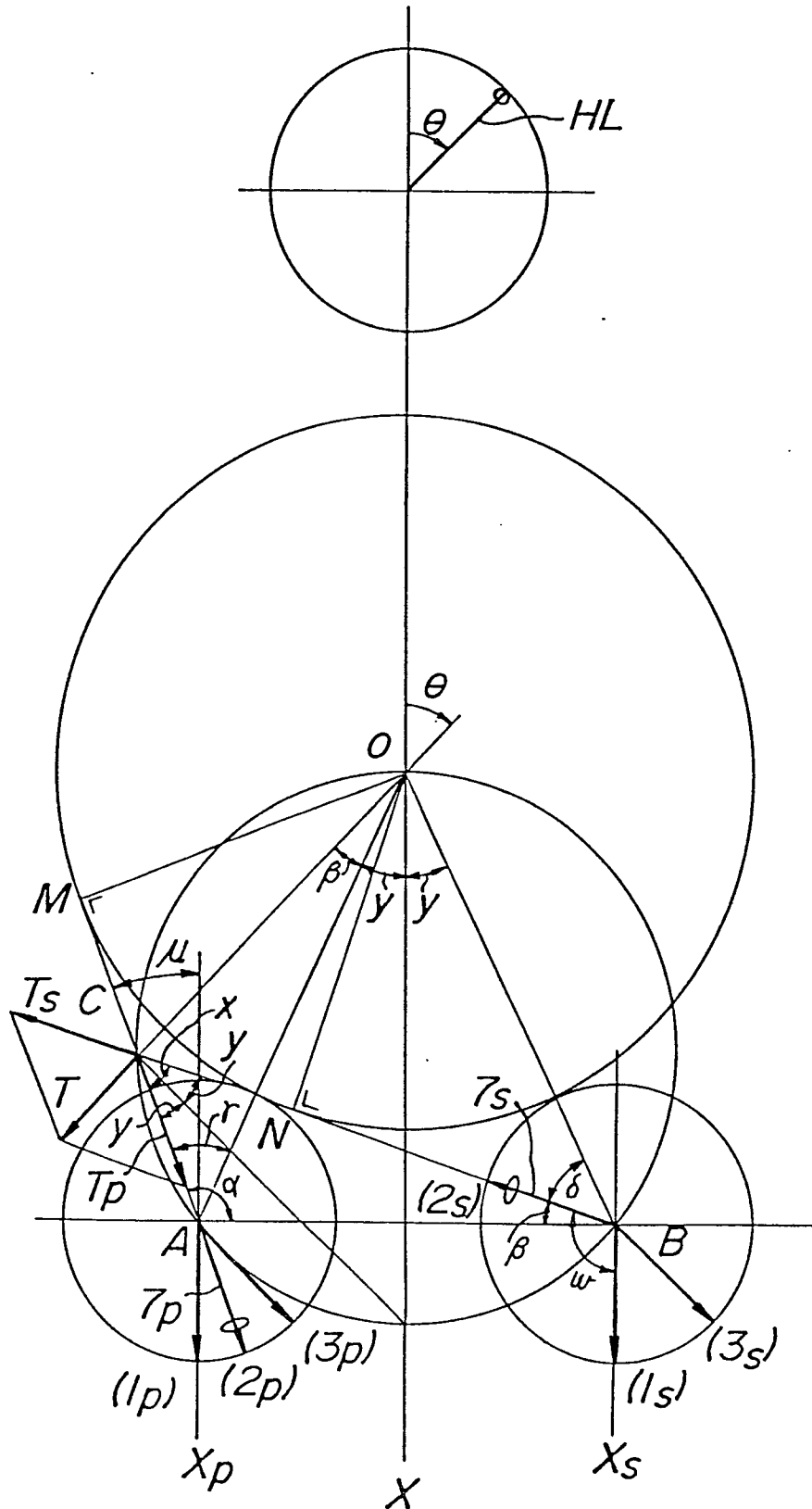


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FIG. 6

Operation NO.	Hand Lever Position	Register		Ship Move- ment	Description
		R_p	R_s		
1					Stop
2					Move Ahead at Middle Speed
3					Move Ahead at Full Speed
4					Move Ahead at Full Speed While Turning Port (Dotted Lines at Middle Speed)
5					Move Ahead at Full Speed While Turning Starboard (Dotted Lines at Middle Speed)
6					Turn Port about One Point (Dotted Lines at Middle Speed)
7					Turn Starboard about One Point (Dotted Lines at Middle Speed)
8					Move Back at Middle Speed
9					Move Back at Full Speed
10					Move Back at Full Speed While Turning Starboard (Dotted Lines at Middle Speed)
11					Move Back at Full Speed While Turning Port (Dotted Lines at Middle Speed)

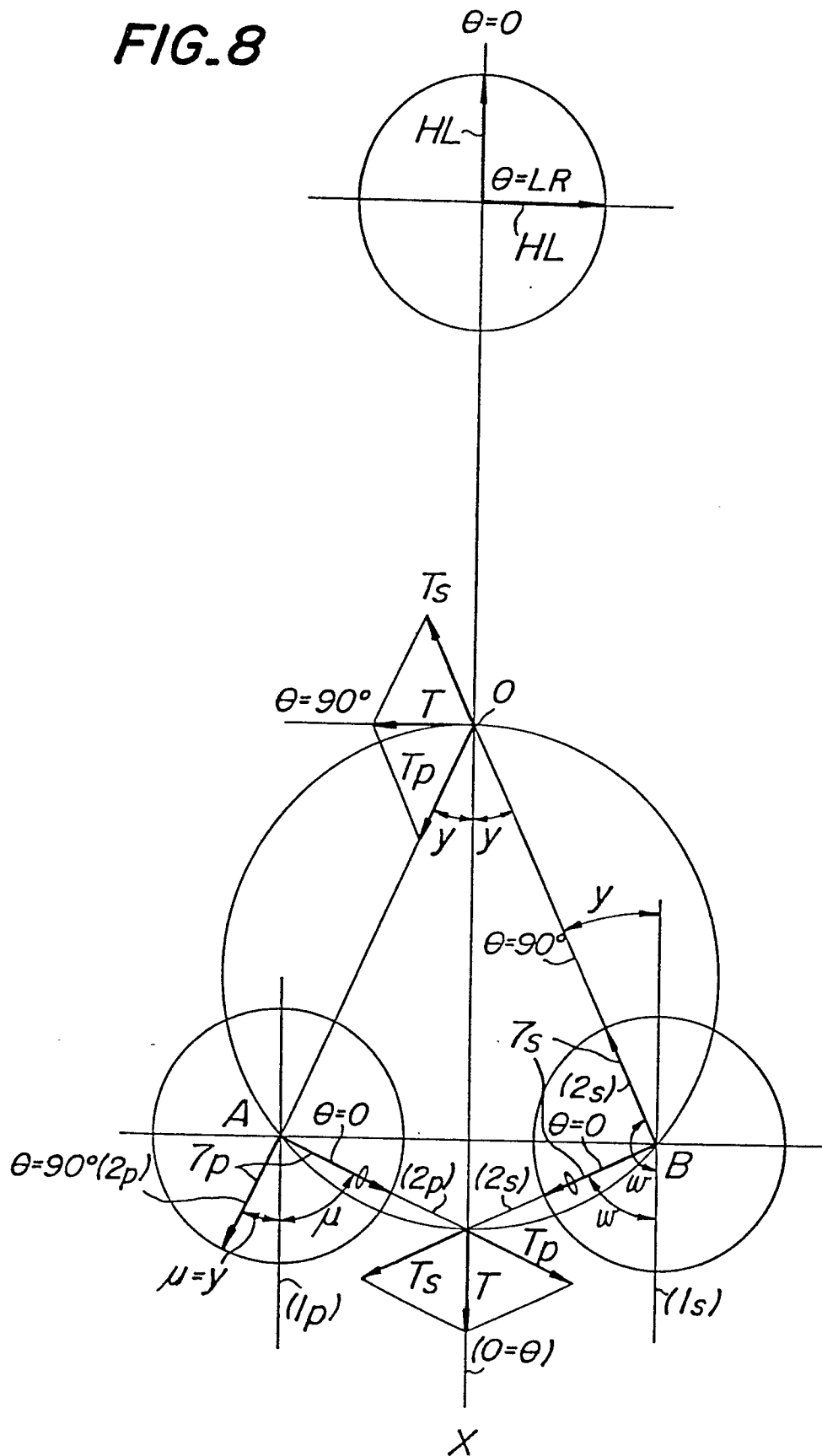
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FIG. 7



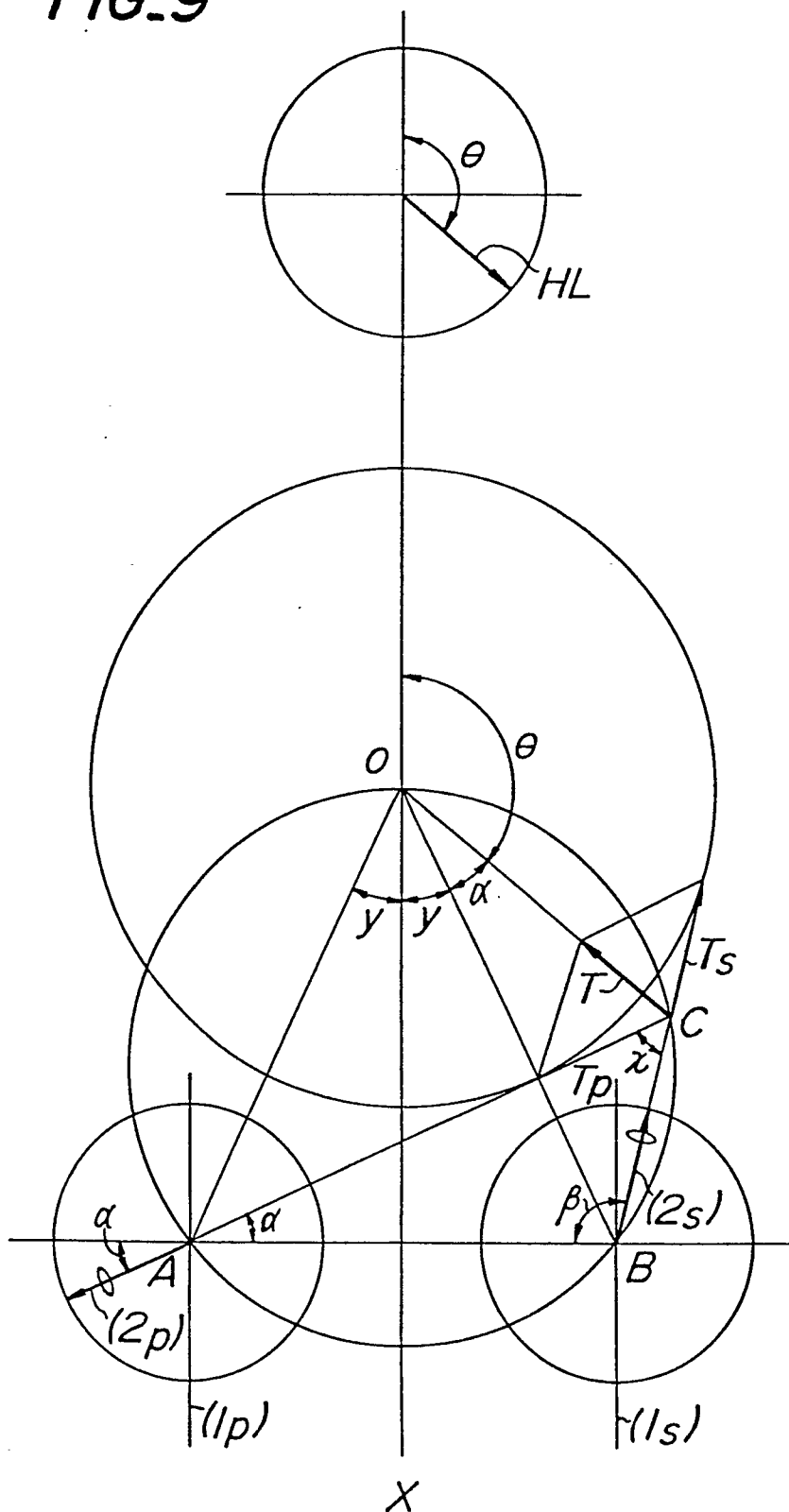
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FIG. 8



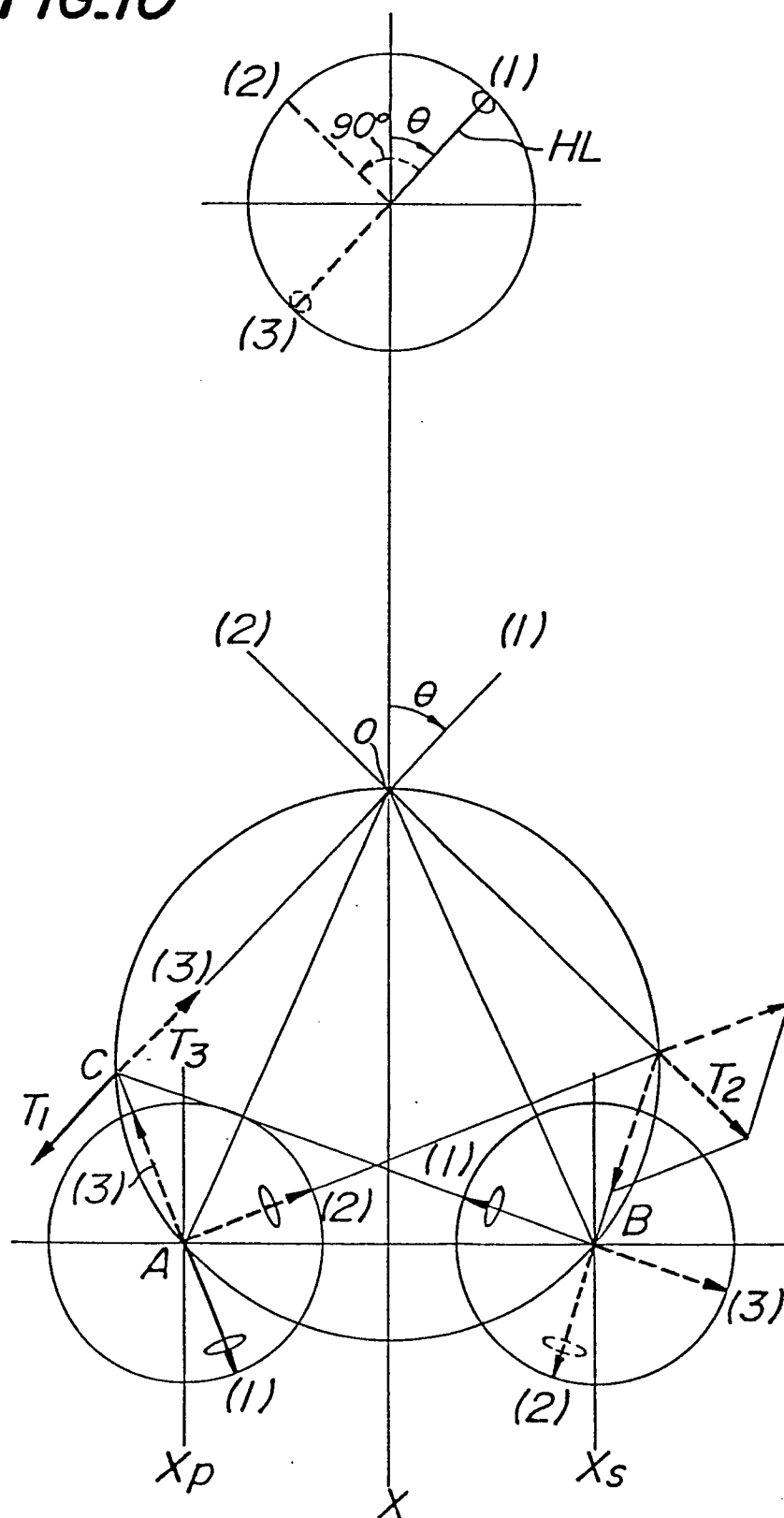
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FIG. 9



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FIG. 10



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FIG. 12

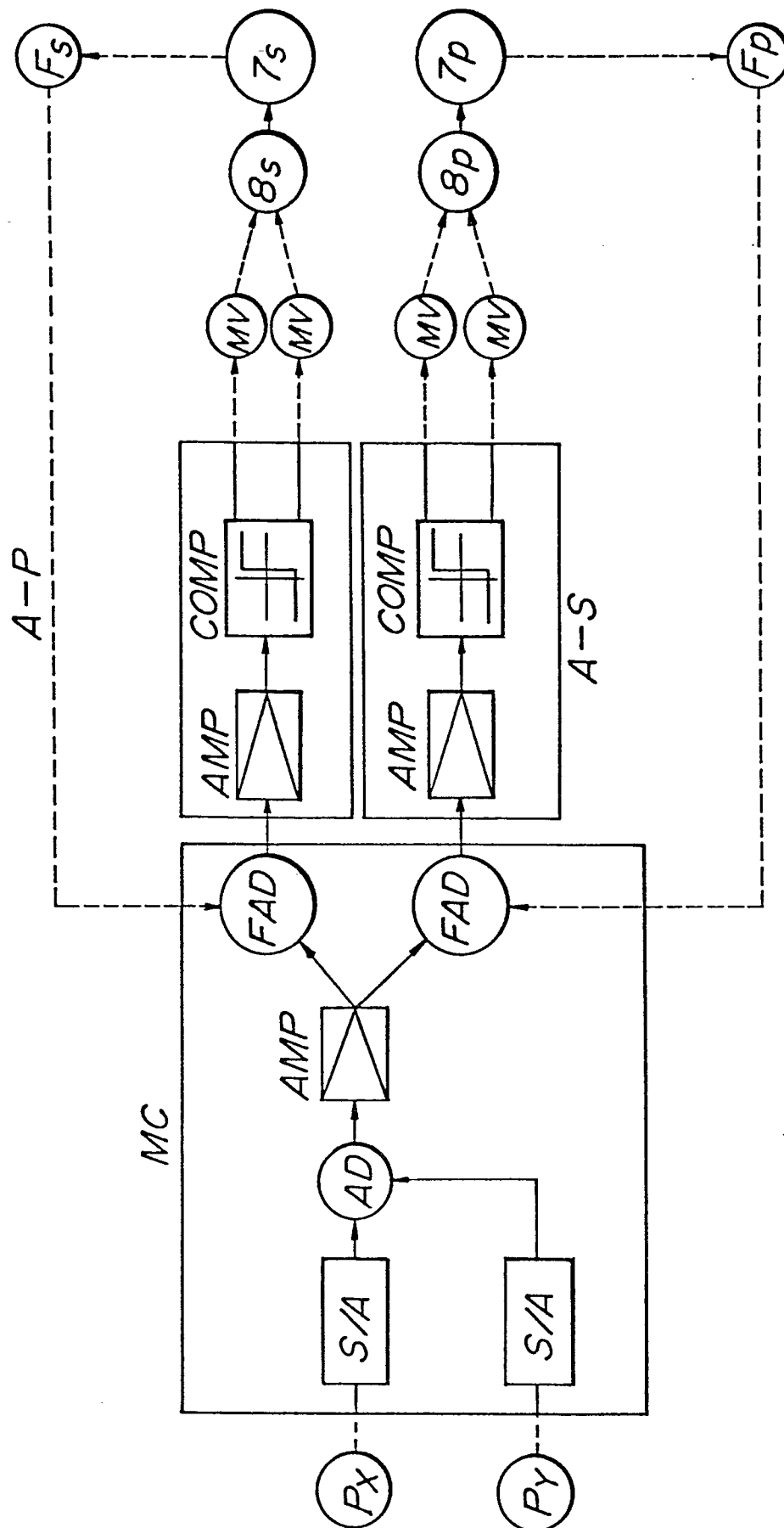


FIG. 13

