

[54] **SHIP PROPULSION SYSTEM HAVING SEPARATE PROPULSION UNITS FOR CRUISE AND LOW SPEEDS**

2,190,617	2/1940	Steinen.....	115/50 X
2,585,502	2/1952	Schneider.....	115/50
2,678,019	5/1954	Couch.....	115/52 X
3,326,296	6/1967	Hill et al.....	115/52 X

[75] Inventors: **Rudolf Laucks; Werner Fork**, both of Heidenheim (Brenz); **Harald Gross**, Sohnstetten, all of Germany

FOREIGN PATENTS OR APPLICATIONS

358,656	4/1938	Italy.....	115/52
570,457	2/1933	Germany.....	115/52

[73] Assignee: **Firma J. M. Voith GmbH**, Heidenheim, Germany

[22] Filed: **Aug. 14, 1970**

Primary Examiner—Trygve M. Blix
Assistant Examiner—Carl A. Rutledge
Attorney—Edmund M. Jaskiewicz

[21] Appl. No.: **63,864**

[30] **Foreign Application Priority Data**

Aug. 16, 1969 Germany.....P 19 41 652.5

[52] U.S. Cl.....**115/35, 115/52**

[51] Int. Cl.....**B63h 1/10**

[58] Field of Search.....115/35, 34, 37, 52, 49, 50; 114/162, 163, 169; 416/108, 103, 104

[57] **ABSTRACT**

A ship is provided with a propulsion unit for cruising speed and a cycloidal propeller as a second propulsion unit used for slow speeds. The cycloidal propeller has a propeller housing and a propeller runner with the propeller blades being equi-distantly spaced on a blade orbit and pivotally mounted so that the blades may be pivoted in directions parallel to the direction of travel of the ship. The cylinder propeller may be used as a non-rotating passive rudder when the ship is cruising and may also be used for steering. Structures are disclosed for pivoting of the blades into various positions.

[56] **References Cited**

UNITED STATES PATENTS

2,155,892	4/1939	Steinen.....	115/52 X
2,155,456	4/1939	Steinen.....	115/52

21 Claims, 16 Drawing Figures

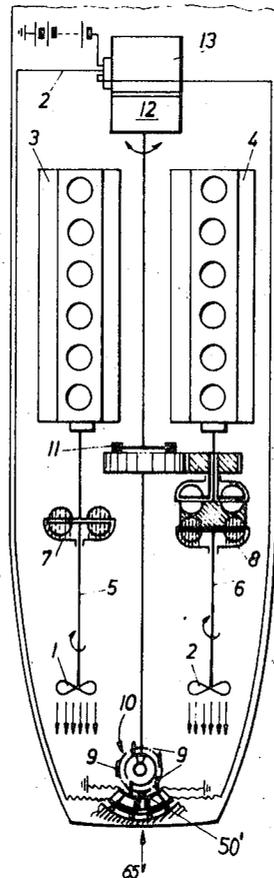


Fig. 1

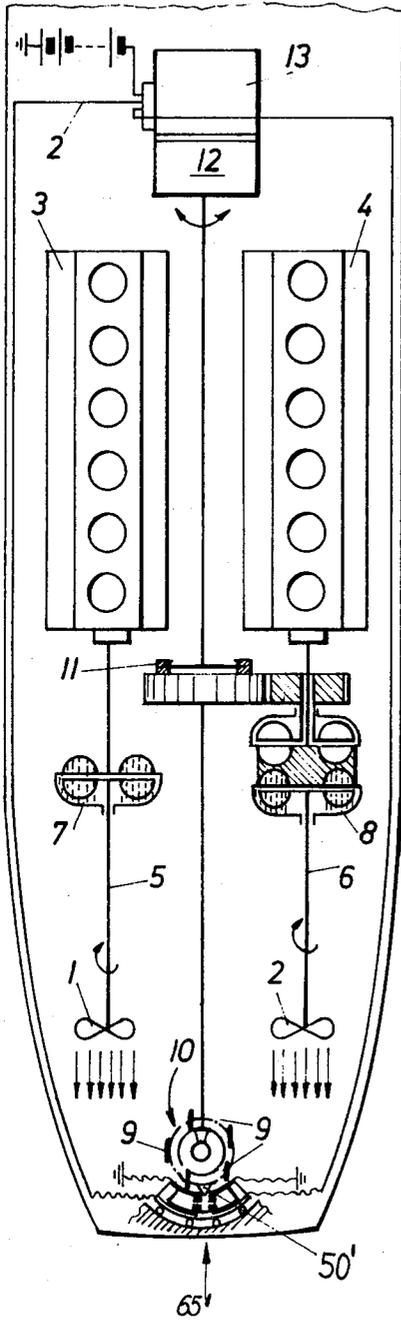
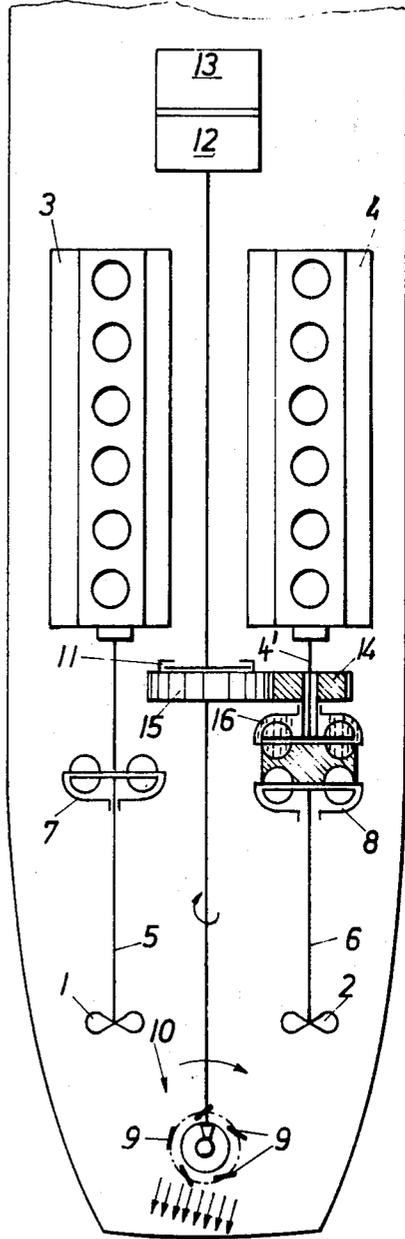
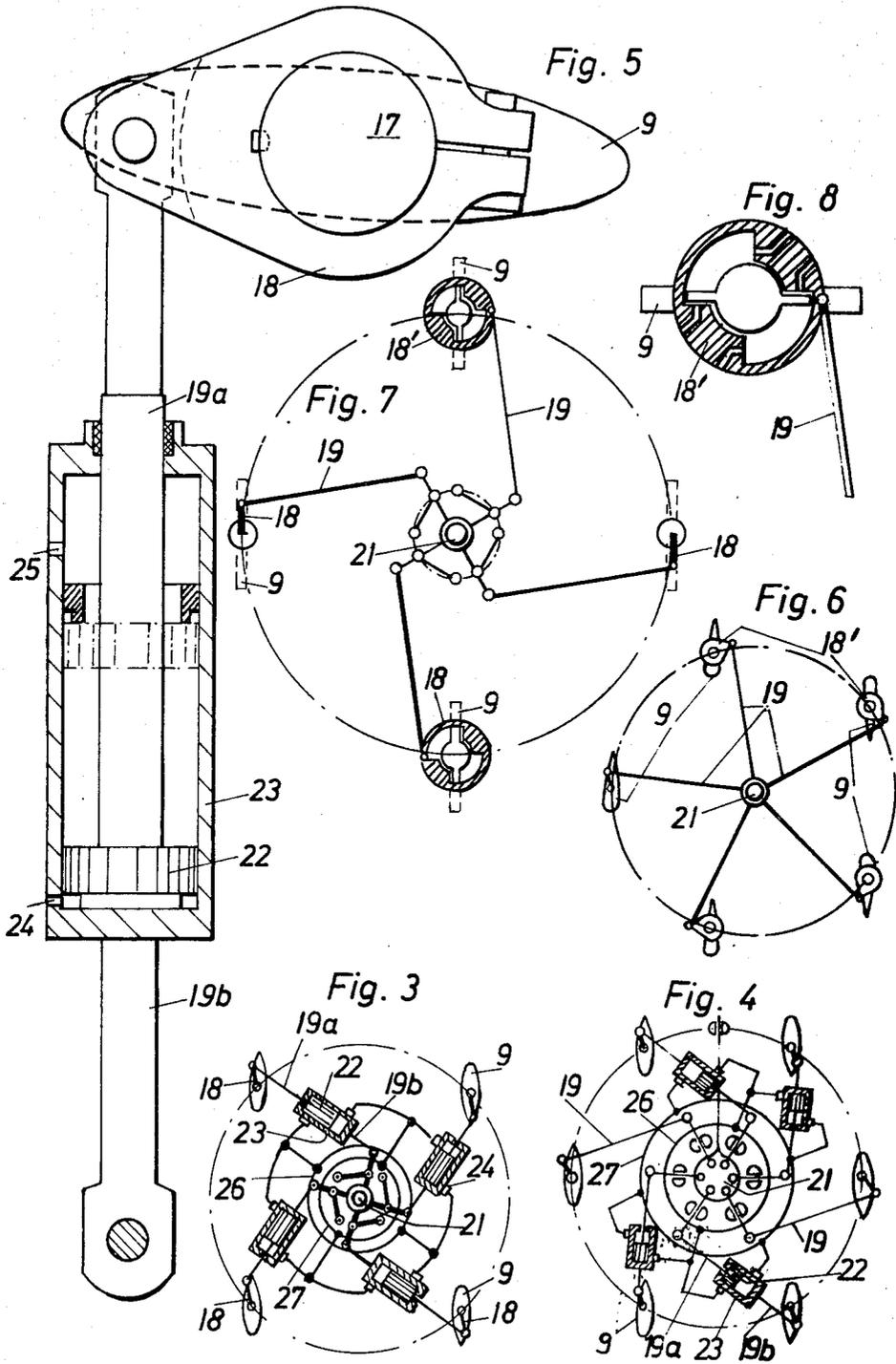


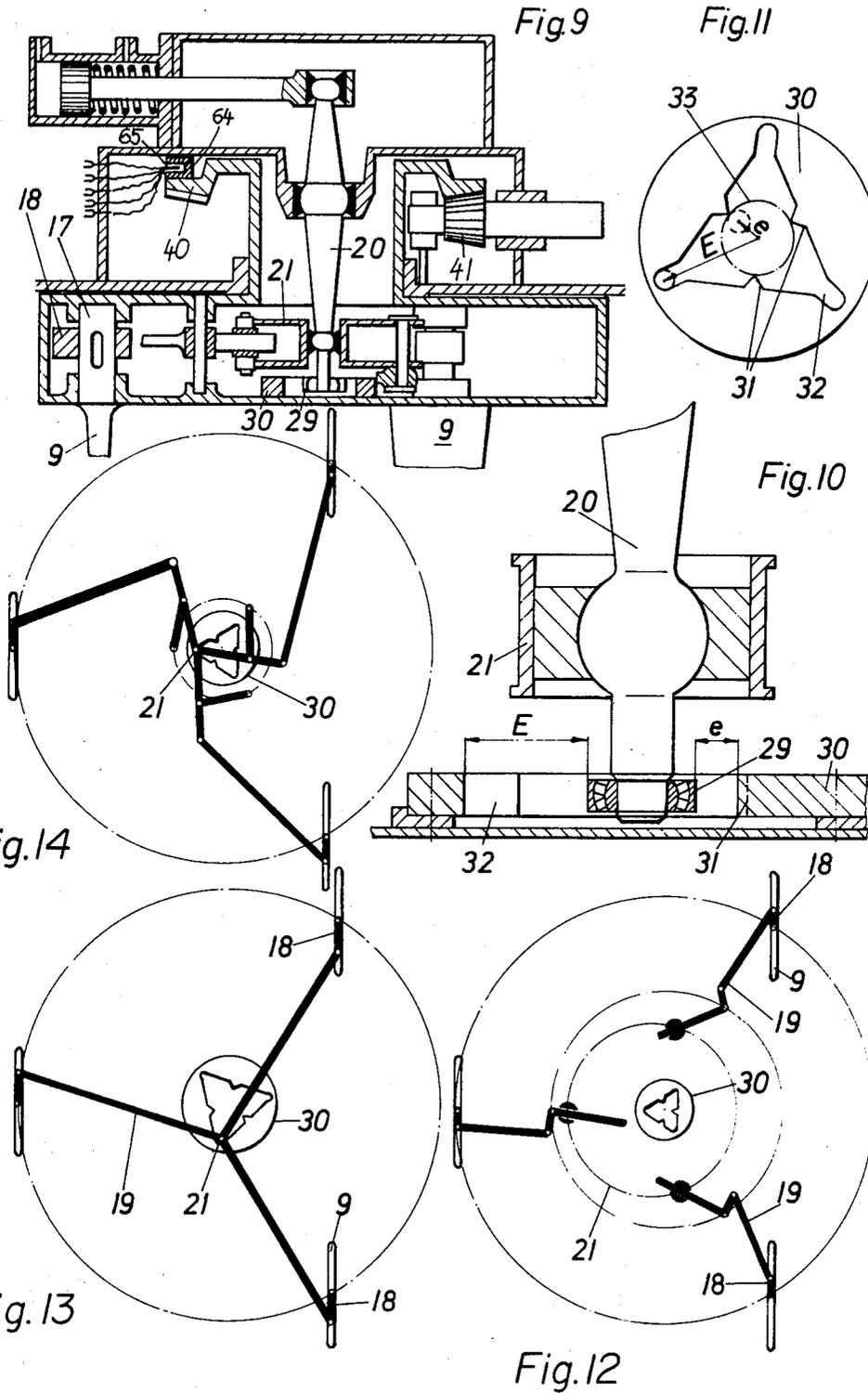
Fig. 2

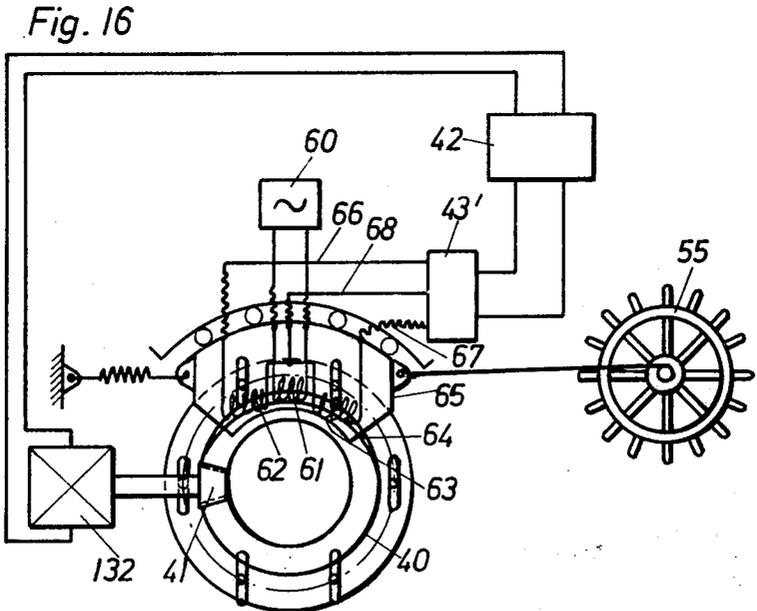
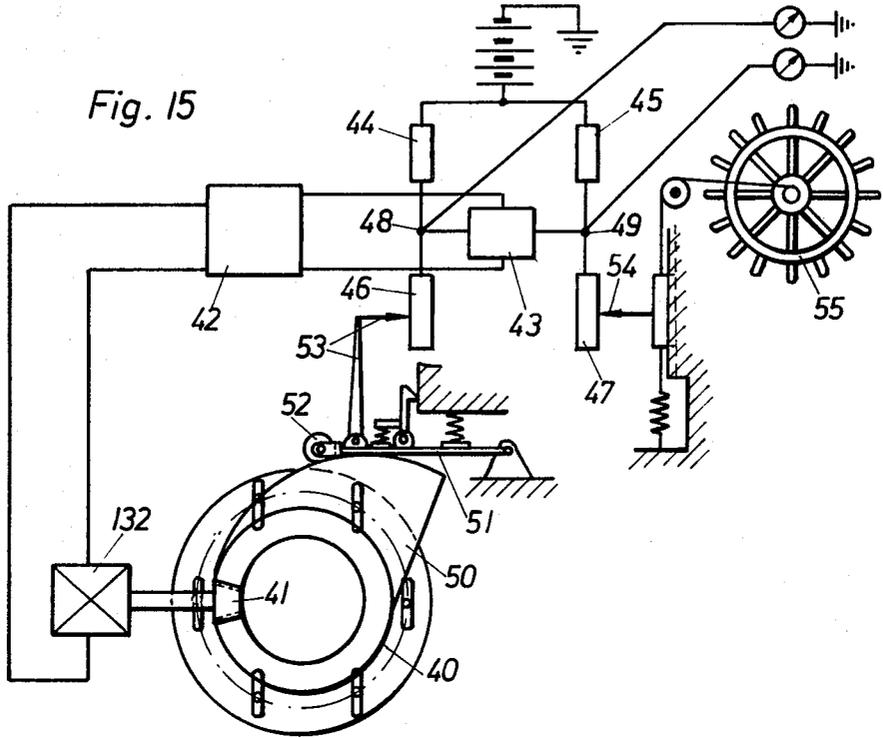


INVENTORS
RUDOLPH LAUCKS
WERNER FORK
HARALD GROSS

Edmund M. Gaskiewicz
ATTORNEY







SHIP PROPULSION SYSTEM HAVING SEPARATE PROPULSION UNITS FOR CRUISE AND LOW SPEEDS

The invention relates to a ship with at least one propulsion element intended for cruising speed and in addition with a propeller intended for slow speed (slow forward and afterward movement and maneuvering). These ships are able to travel fast and must also have good maneuverability, utilizing a conventional ship's propulsion system which operates with a high degree of efficiency and a passive rudder when travelling on the high seas, while employing an active rudder, suitable for propulsion as well as for direction changing, when travelling for example on inland waterways, in port zones and in minefields. The combination of these two properties, namely good maneuverability and good cruising characteristics, can only be obtained with substantial cost in terms of propulsion and rudder means; the requirements include for cruising, a ship's propeller and a rudder, pivotable about a vertical axis, as well as for maneuvering a propulsion system (the active rudder), adapted to be variable as regards jet direction and jet intensity.

At cruising speeds, which may be very high, particularly in naval vessels, and in which the propulsion element for maneuvering is not used, there are also flow losses and interference with laminar smooth flow. To eliminate such interference and losses it has been proposed for a maneuvering propulsion system in the form of a cycloidal propeller, to be lifted out of the water or, to operate as a turbine, to allow it to run idle. By appropriate displacement of the control center of the cycloidal propeller when operating as a turbine, it is possible to obtain a predetermined direction of the propeller jet which permits steering of the ship. However, the cycloidal propeller cannot be operated as a turbine in all speed ranges because the turbine torque required to overcome bearing friction is too small in relation to the speed range; the cycloidal propeller must therefore be power-driven at low revolutions so as to give no forward thrust.

The disadvantage of the first-mentioned construction is the extensive construction cost (the entire propulsion system must be raised) and the loss of loading space in the ship, such space being required for the retracted position of the propeller. The disadvantages of the other known propulsion systems occur in operation. The turbine operation of the maneuvering propeller result in losses and interference with laminar or smooth flow. Moreover, owing to the constant operation in cruising, the system is subject to continuous wear; in some cases power input is also required. Operation thus becomes complex. Maintenance will be required at shorter intervals. Moreover, the continuous rotation of the maneuvering propeller results in a substantial increase of the noise level of the ship, a feature which is undesirable in naval vessels since they can be located more readily and over longer distances.

According to the present invention, there is provided a ship with at least one propulsion element intended for cruising speed and in addition with a propeller intended for slow speed said propeller having a propeller runner and propeller blades which can be set parallel with the direction of travel of the ship. There is also provided for such a ship a cycloidal propeller comprising a

propeller housing and a propeller runner wherein said propeller blades are equidistantly disposed on a blade orbit.

A cycloidal propeller is referred to as such because of the cycloidal paths the blades follow through the water; an alternative term for cycloidal propeller is blade wheel propeller.

Using the invention, the flow resistance of the slow speed and maneuvering propeller constructed as a cycloidal propeller can be nearly eliminated in cruising without complicating operation nor providing complex constructions which occupy useful space. Instead, by disconnecting the slow speed travel propeller from its prime mover and by optional coupling the propeller runner to a conventional steering gear the propeller may be employed for passive steering and, in normal cases, even may be used as a complete substitute for a conventional sheet rudder; at least such a rudder can be constructed of a substantially smaller size.

By equipping a ship in accordance with the invention it is possible, to propel and to steer the ship, when travelling in port, with the cycloidal propeller and, when cruising, to produce the thrust with the main propulsion element while continuing to employ the runner of the cycloidal propeller as a non-rotating passive rudder. To this end, it is necessary for the cycloidal propeller to be uncoupled from its prime mover and to drive the ship with the main propulsion element; furthermore it is necessary for the cycloidal propeller to be shut down and to be coupled to the steering gear, to align the propeller blades into their parallel positions and, by means of the steering gear, to pivot the runner of the cycloidal propeller into the longitudinal axis of the ship while maintaining the relative positions of the blades.

In preparation for passive steering, some blades are pivoted into the direction of travel of the ship such that their leading edges (in propeller operation) remain leading edges while other blades are pivoted so that their trailing edges (in propeller operation) become leading edges in passive steering operation. Thus, in order to obtain good flow conditions around the blades in passive steering it is appropriate for the cross sections of the propeller blades to be shaped for the mode of operation which predominates in terms of time and power; namely, the cross sections of the blades are preferably constructed, as symmetrical elongated ovals, for example approximating ellipses.

The means for pivoting the blades into the uniform parallel positions should be as simple and rugged as possible. This requirement can be satisfied by a cycloidal propeller. The cycloidal propeller would have a kinematic blade guidance system for imparting the oscillatory motion to the blades when the cycloidal propeller is acting as a propulsion unit, and coupling members coupling the blades to the kinematic blade guidance system; if there are at least three blades at least some of the coupling members may be adjustable such that the angular relationship of the respective blades to the guidance system can be changed to set all the blades parallel to the direction of travel of the ship, and the adjustable coupling members may incorporate pressure fluid (e.g. hydraulic) rams to change said angular relationship. There may be coupling rods coupling the kinematic guidance system with respec-

tive blade levers fixed in a rotational sense to the respective blades, and at least two of the coupling rods may be provided with means for optionally elongating or shortening the coupling rods by a fixed amount. In an advantageous embodiment, each of the coupling rods which can be elongated or shortened has two parts, one part being provided with a double-acting ram cylinder which is coaxial with the coupling rod and the other part being provided with a double-acting ram piston slidable in the cylinder between two fixed stops, the cylinder and piston forming a ram; the stops may be adjustable. The particular description of the embodiments illustrated in the accompanying drawings discloses how the adjusting travels required for a cycloidal propeller having four, five or six blades, can be made as short as possible, and claims 9 to 11 set out some preferred arrangements.

In a three-bladed cycloidal propeller which is provided with a blade guidance system having a central control member which can be moved into any desired position of limited eccentricity by means of e.g. hydraulic servo-motors (normally through a control arm) and which rotates about the said eccentric position when the propeller runner rotates and which is stationary as regards the direction of eccentricity, the propeller blades can be aligned into a uniform parallel position without complex provisions, merely by adopting a special embodiment for the kinematic blade guidance system of the propeller. In such a blade guidance system the central control member may have the shape of a disc having a coaxial orbit of evenly distributed links each of which is connected to the coupling rod of the pertaining blade. In those three positions of the stationary propeller runner in which one blade is parallel to the direction of travel of the ship, the central control plate can be placed in an eccentric position of abnormally great eccentricity (namely positioned in the direction of travel of the ship in the case of a cycloidal propeller with a sliding-link kinematic system, but towards said one blade in the case of a propeller with an angle-link kinematic system or sliding-crank kinematic system) so that the said blade which is parallel to the direction of travel of the ship remains in a position tangential to the blade orbit and the two other blades are pivoted into positions which are parallel to the tangential position of the first-named blade. Furthermore, provisions are made to maintain the direction of eccentricity of the central control plate relative to the propeller runner when this is pivoted by the steering gear. These provisions can be obtained in a particularly simple manner if a control arm (which is normally connected with the central control plate by a ball joint) is provided with a cam follower (for instance a pin coaxial with the control arm and having a roller which can be displaced angularly) and if a cam (for instance a cam disc) with a generally radially inwardly directed guide track is fixed to the body of the propeller runner coaxially thereto and lies in a plane perpendicular to the axis of rotation of the propeller runner, so that the cam may cooperate with the said cam follower, the cam track being generally of equilateral triangular shape; the medians of the triangle will normally be coincident with the radii through the propeller blade shafts, and if the propeller has a sliding-link kinematic blade guidance system, the mid-points

of the sides of the triangle will be nearest the blade shafts while if the propeller has an angle-link or sliding-crank kinematic blade guidance system the corners of the triangle will be nearest the blade shafts. It is useful to have a symmetrical protuberance in the middle of each side of the generally equilateral triangle of the cam and directed towards the center of the triangle, for deflecting the cam follower from a position of unstable equilibrium.

In another system for aligning the propeller blades in parallel, the blades of the cycloidal propeller are coupled to blade levers connected by the coupling rods to the kinematic blade guidance system, the coupling between at least some of the blades and their respective blade levers being rotatably adjustable to set all the blades, from the tangential position, parallel with the direction of travel of the ship. In the case of cycloidal propellers having an even number of blades, two diametrically opposed blades may be non-rotatably coupled to the blade levers and the remaining blades have means for pivoting the respective blades relative to the blade levers from the tangential position into a position aligned at right angles to the line connecting the first two blades, i.e. the blades disposed in adjacent quadrants are aligned by the pivoting apparatus into the parallel position, namely through as many degrees of arc as their angular separation from the nearest non-rotatably coupled blade and in the direction of rotation which is opposite to that required to reach the nearest non-rotatably coupled blade. A similar relationship must be observed for propellers with an odd number of blades since only one blade thereof can be non-rotatably coupled to the kinematic system and the remaining blades must be moved by the pivoting apparatus from the tangential position into the parallel position, namely through as many degrees of arc as their (smaller) angular separation from the non-rotatably coupled blade and in the direction of rotation which is opposite to that required to reach the non-rotatably coupled blade by the shortest route.

The blade adjusting system can be applied with particular advantage to four-bladed propellers. In such a propeller, two diametrically opposed blades are moved from the tangential position into the uniform parallel position by the kinematic blade guidance system itself while only the remaining two blades are so adjusted in parallel positions by the pivoting apparatus operated by auxiliary power. The rotatably adjustable couplings may comprise double-acting pressure fluid rams (e.g. rotary rams) for altering the angles between the blades and the blade levers.

In a further embodiment of the invention and to facilitate the longitudinal alignment of the parallel propeller blades when changing from active to passive steering, angle position measuring means are provided on the rotating part of said propeller and on a part fixed to the ship's hull, are adapted to co-operate with each other, being movable relative to each other and are adapted so supply a signal corresponding to the magnitude and direction of the deviation of the propeller runner from the coincidence position of the measuring means.

To enable the rudder position to be adjusted by the ship's wheel and also to pivot the rudder automatically into the coincidence position of the angle measuring

means and to be stabilized in the specified set position means may be provided on the steering gear which start the steering gear and therefore the propeller runner in the direction towards the coincidence position of the measuring means when a rudder deflection signal is received; the angle position measuring means on the part fixed to the ship's hull can be moved by means of the steering wheel of the ship in both directions from a middle position or the signals given by such measuring means may be unbalanced with respect to a mean signal value such that a deviation from the coincidence position may be simulated at will, the mean signal value preferably being a zero value.

In an appropriate embodiment, the angle position measuring means include a bridge circuit of variable value electrical elements, said bridge circuit being arranged so that it can be unbalanced by rotation of said propeller runner or by movement of the ship's wheel by coupling at least one electrical element to a part rotating with said propeller runner and by coupling another electrical element with the steering wheel of the ship, in the course of a steering wheel motion. Therefore, the bridge circuit is so constructed that the signals produced by one unbalancing action or the other are superimposed on each other with respect to their direction and produce a common resulting signal which tends to start the steering gear and therefore tends to move said propeller runner in the direction in which the corresponding adjustment of the electrical element coupled to said runner causes the common signal to disappear or to be brought to a set mean value.

In an advantageous embodiment, the electrical element which is unbalanced by the rotation of said runner is coupled to said runner by an asymmetrical cam and a cam follower, the cam being mounted on a rotating part of the propeller and extending over the angular zone of the steering motion, and the cam follower being linked to an adjustable part of the electrical element; preferably, the cam follower can be lifted when said propeller is acting as a propulsion unit.

This mechanical coupling of the adjustable electrical elements to the rotating part of the propeller or to the ship's wheel may be replaced by a coupling without physical contact if the electrical element is inductively coupled; in one such arrangement, the angle position measuring means is in the form of a differential transformer comprising a primary winding and at least one secondary measuring winding and disposed on the ship's hull near said propeller periphery, the coils of said transformer being inductively coupled to each other by means of an inductive core which moves with said runner and passes close to the transformer when being moved so that the width of the air gap between the core and the transformer windings depends on the deviation of the core from its middle position, the core preferably being symmetrically constructed and extending over part or all of the range of pivotal motion of the propeller runner in passive steering.

The invention will be further described, by way of example, with reference to the embodiments illustrated in the accompanying drawings, in which:

FIGS. 1 and 2 are diagrammatic views of a ship's stern and its propulsive system with an active and passive rudder for travel at cruising speed (FIG. 1) and for maneuvering (FIG. 2), respectively;

FIG. 3 is a plan view, partly in section, showing the construction of a four-bladed cycloidal propeller with sliding-crank kinematic blade guidance system, which propeller can also be employed as a passive rudder;

FIG. 4 is a plan view, partly in section, showing a cycloidal propeller as above, with six blades and sliding-link kinematic blade guidance system;

FIG. 5 is a plan view, partly in section, showing the construction of the coupling rods for blade adjustment provided in the propellers of FIGS. 3 and 4;

FIGS. 6 and 7 are plan views (FIG. 7 partly in section) showing the arrangements for blade adjustment on a five-bladed and on a four-bladed cycloidal propeller respectively having a sinusoidal or a sliding-crank kinematic blade guidance system;

FIG. 8 is a plan view, partly in section, showing the pivoting apparatus for a blade of the propeller of FIG. 7 with the blade in the tangential position;

FIG. 9 is a vertical section through a three-bladed cycloidal propeller having an angle-link kinematic blade guidance system;

FIG. 10 is a plan view showing apparatus within the propeller for obtaining and securing one defined relative position between the central control plate of the kinematic blade guidance system and the propeller runner;

FIG. 11 is a plan view showing the disc cam for the apparatus of FIG. 10;

FIG. 12 to 14 are plan views showing three three-bladed cycloidal propellers with a kinematic blade guidance system of the angle-link, sinusoidal or sliding-crank types respectively, in each case in an extreme eccentric position of the central control plate of the kinematic system so that the blades are all aligned in parallel with each other; and

FIG. 15 and 16 are two diagrams showing how to sense the angular position of the propeller runner and how to control said position from the steering wheel.

FIG. 1 illustrates the state of the ship's propulsion means for travelling at cruising speed. Two ship's propellers 1 and 2 are coupled to associated diesel engines 3 and 4 by filling the hydrodynamic couplings 7 and 8 which are disposed in the propeller shafts 5 and 6. Blades 9 of a cycloidal propeller 10 are all aligned in parallel to each other and to the direction of travel of the ship; the stationary runner of the cycloidal propeller is coupled to the steering gear via friction clutch 11, the steering gear being constructed as an electric motor 13 which is provided with a reduction gear 12. The steering gear 12, 13 is actuated (only the basic principle of the operation of the switch 65' is shown in FIG. 1, and only by way of example — more details are given below), by sliding a reversing switch 65' which moves with the ship's wheel; the contacts of the switch 65' are open only in the middle position and the switch is actuated by a cam 50' mounted on the cycloidal propeller 10 and is adapted, depending on the direction in which it is slid, to connect the electric motor 13 to the main current supply to rotate it in the forward or reverse direction; steering gear 13 is moved in accordance with the sliding travel of the reversing switch 65' so that the cam 50' and therefore the direction of the propeller blades 9 always follows the middle position of the switch 65' as selected by the helmsman. With this method of coupling the propul-

sion and rudder elements to the respective prime movers, propulsion will be produced by the ship's propellers 1 and 2 while the travelling direction is defined and steered with the cycloidal propeller functioning as a passive rudder.

The configuration of the propulsion and rudder elements illustrated in FIG. 2 is for maneuvering in confined waters; both ship's propellers 1 and 2 are shut down by emptying the associated hydrodynamic couplings 7 and 8 and the cycloidal propeller is disengaged from the steering gear by disengaging the coupling 11. Filling of the hydrodynamic coupling 16 (disposed in the output shaft 4' of the engine 4 and coupled by a gear transmission system 14, 15 to the drive shaft of the cycloidal propeller) couples the cycloidal propeller 10 to the diesel engine 4 to function as a propulsion machine for maneuvering. The propeller blades 9 will then be in the normal operating position and the ship is steered and propelled by a propulsion jet whose magnitude and direction is adjusted from the ship's wheel.

In FIGS. 3 and 4 the adjustability of the propeller blades 9 is illustrated by reference to examples of two different cycloidal propellers. The cycloidal propellers have been described in the relevant literature (for example in Voith Forschung und Konstruktion, No. 18, May 1967) and for this reason the design and the method of operation of the hydraulic and steering system is assumed to be known. It should merely be mentioned that each cycloidal propeller has a kinematic guidance system for each blade the guidance system being adapted to rotate with the propeller runner, the said kinematic guidance system being identical for all the blades of one and the same cycloidal propeller and adapted to impart the associated blade, during rotation of the propeller runner, an oscillatory pivoting motion about the tangential position of that blade. This oscillatory pivoting motion is accomplished by means of a coupling rod 19 and a blade lever 18 which is non-rotatably coupled to the blade shaft 17 (see FIG. 9). The amplitude and phase of the amplitude of the oscillatory pivoting motion and therefore the jet intensity and the jet orientation are selected by choice of the eccentric position of a central control plate 21, common to all the guidance systems associated with the blades. The said central control plate 21 can be eccentrically displaced in all directions by the control arm 20 which can be pivoted by means of hydraulic servomotors arranged in two mutually perpendicular directions.

As illustrated in FIGS. 3 to 5, a double-acting hydraulic ram is disposed in some or all of the coupling rods. That is to say, such a coupling rod comprises two parts 19a and 19b one of which carries a ram piston 22 and the other of which carries a ram cylinder 23 which cooperates with the ram piston. Stop abutments restrict the stroke of the ram piston 22 within the ram cylinder 23 to an extent that each of these two bipartited coupling rods can assume only two different fixed lengths. Each ram cylinder is provided with two pressure inlet connections 24 and 25 one of which leads into the 'elongating' pressure chamber while the other leads into the 'shortening' pressure chamber. One pressure connection of each coupling rod cylinder of a propeller communicates with one of two ring mains 26

common to all cylinders while another pressure connection communicates with the second ring main 27. Both ring mains are adapted to rotate with the propeller (a feature which is however not illustrated) and each communicates via a respective stationary shaft bush with a respective stationary pipeline; the ring mains can be selectively pressurized. The connections which are biased in passive rudder operation and those which are biased in active rudder operation, i.e. those coupling rods which are shortened relative to the normal length and those which are elongated relative thereto, are explained below.

Since the angular adjustment of the blades for changing from active to passive rudder operation is obtained by length adjustment of a coupling rod 19 which acts on a pivoting blade lever 18, and since moreover the blade lever 18 is almost parallel to the central plane of the blade, the coupling rod adjusting system will at the most permit pivoting of the blades 9 through about 60° from the tangential position, otherwise the coupling rod 19a and the blade shaft 17 would obstruct each other. In order that the smallest possible pivoting travels may be obtained, alignment of the blades 9 for passive rudder operation must be selected relative to the star shape formed by the blade shafts and the propeller center to provide angles between the parallel direction of the blades and the radial direction leading from the center to each blade shaft which are as obtuse as possible.

In other words: with the coupling rod system described above, the cycloidal propeller runner must be pivoted in an angular position in an imaginary system of co-ordinates in which the ordinate is disposed along or parallel to the fore-and-aft axis of the ship and in which the origin is disposed in the propeller center so that the blade shafts are positioned as far as possible from the ordinate, the positive direction of the ordinate corresponding to the forward direction of the ship, the positive direction of the abscissa coinciding with a radius to the forward rotating blade. Thus, the plane of the system of coordinates is divided into four quadrants, a first quadrant extending between both the positive co-ordinates, the second, third and fourth quadrants following said first quadrant in the direction of rotation of the propeller runner.

In assuming the aforementioned circumferential position of the propeller runner, the coupling rods of the blades disposed in the first and third quadrants of the system of co-ordinates must be shortened relative to the normal length and the coupling rods of the blades disposed in the second or fourth quadrants respectively must be elongated. For this purpose, the shortening pressure inlets of the blades disposed in the first and third quadrants and the elongating pressure inlets of the blades disposed in the second and fourth quadrants are connected to a ring main 27 which is pressurized in passive rudder operation. The other inlets are connected to another ring main 26 which is pressurized in active rudder operation.

In passive rudder operation, one single or two diametrically opposed blades are disposed on the abscissa. The lengths of the coupling rods associated with the blades disposed on the abscissa (see FIG. 4) remain unchanged. The length of any other coupling rod must be varied by an amount sufficient to enable the as-

sociated blade to be pivoted through the smallest possible angle to reach its parallel position (parallel to the ordinate).

FIGS. 6, 7 and 8 show a different method of pivoting the propeller blades. In this case, the blade lever 18' of each blade which is not disposed on the abscissa of the above mentioned system of co-ordinates is constructed as a double-acting pivoting apparatus (see FIG. 8 for example). Since this apparatus permits pivoting travels of one part relative to the other of substantially more than 90°, the considerations governing the abovementioned coupling rod adjustment will not apply.

In the blade lever adjusting system, the runner of the cycloidal propeller is orientated in the co-ordinate system in such a position relative to the direction of travel of the ship that, when there is an odd number of blades, one blade lies on the abscissa and when there is an even number of blades, two blades lie on the abscissa. In this orientation of the runner, the blades which lie on the abscissa, are already parallel with the fore- and aft axis of the ship if they are in the tangential position. The remaining blades must be moved from the tangential position into the uniform parallel position (parallel with the fore-and-aft axis of the ship), by means of the pivoting apparatus disposed on the blade levers 18'. Accordingly, each aforementioned blade must be rotated through an angle equal to the angle between the radius to the blade shaft and the abscissa in order to reach its parallel position. The pivoting apparatus incorporated into the blade levers 18' must be constructed and connected to the pressure source in a corresponding manner.

FIG. 10 shows a detail of the three-bladed propeller illustrated as a section in FIG. 9. The control arm 20 is extended as its lower end to form a pin 28 with which it supports a roller 29, capable of angular movement and co-operating with a disc cam 30 which is fixed to the base of the propeller runner.

The disc cam 30 is shown in FIG. 11 as a detail. Its cam track is substantially an equilateral triangle. Deflecting protuberances 31 are provided at the middle of the sides while recesses 32 having a width equal to the diameter of roller 29 are provided in the corners. FIG. 11 also shows in dot-dash lines a circle 33 which circumscribes the space for the motion of the roller 29 relative to the disc cam 30 in normal operation of the cycloidal propeller as a propulsion unit with the greatest normal eccentricity e and the contour of the roller. If the control arm 20 is thrust by the action of servomotors in a certain direction when the propeller runner is at rest, until the roller 29 abuts upon the disc cam, the roller 29 exerts a force component in the circumferential direction via the flanks on to the disc cam 30 and therefore on to the entire propeller runner and rotates same until the roller 29 engages in a recess 32. In this position the propeller runner is fixed in the circumferential direction within the range of displacement which remains available to the control arm 20 which is biased by hydraulic force. The abnormal eccentricity E assumed by the control disc 21 when the roller 29 is positioned in a recess 32 causes the blades of a three-bladed cycloidal propeller to be moved into a unified parallel position. To this end the disc cam 30 has to be in the correct angular position relative to the propeller runner or to the star shape defined by the

blade shafts 17 and the propeller center. In a propeller having an angle-link kinematic blade guidance system (FIG. 12) or in the case of a propeller having a sliding-crank kinematic blade guidance system (FIG. 14) the corners of the cam triangle of the disc cam must be aligned relative to the blade shafts; in the case of a propeller with a sliding-link kinematic blade guidance system, the perpendiculars to the middles of the sides must be aligned to the blade shafts.

FIG. 15 shows diagrammatically an electric control system for stabilizing and for adjusting a cycloidal propeller runner acting as a passive rudder. The numeral 40 indicates a crown wheel shown in FIG. 9 which is driven via the bevel pinion 41 by the steering gear 13 to pivot the propeller runner when it functions as a passive rudder. The steering gear is prepared for clockwise and anti-clockwise rotation and is supplied with power for such clockwise or anti-clockwise rotation by a power amplifier 42, in accordance with an incoming signal for rudder operation. The power amplifier 42 obtains the signal from a measuring amplifier 43 (or 43' in FIG. 16) which determines the balance or unbalance in terms of the magnitude and direction as defined by a resistance bridge circuit.

The resistance bridge circuit may be understood as an adjustable circuit element with a number of variables (degrees of freedom), that is to say it can be unbalanced from a plurality of different positions independently of each other from its zero balance or a bridge unbalance, capable of producing a well-defined signal, may be produced by altering different variables.

In the system of FIG. 15, a bridge circuit of four resistors is provided. Two resistors 44 and 45 thereof are pre-set adjustable resistors and the two other resistors 46 and 47 are sliding resistors which are varied in steering operation; with this arrangement, no signal will appear in the measuring amplifier only if the voltage potentials at the points 48 and 49 are of equal magnitude. If the voltage potential at point 48 is lower than at point 49 owing to a smaller voltage drop across the sliding resistor 46 than the normal value, the steering gear will be set in motion via the measuring amplifier and the power amplifier to pivot the runner of the cycloidal propeller in a clockwise direction. The effective resistance of the sliding resistor 46 is therefore increased via the cam 50 mounted on the crown wheel 40, a follower roller 52 mounted on a follower arm 51 and a sliding contact 53 which is earthed. Thus, the voltage potential at the point 48 is increased. This movement of the propeller runner is continued until the potential difference between the points 48 and 49 has once again disappeared. For as long as the resistance value of the sliding resistor 47 is not varied, the voltage potential at point 49 will remain unchanged and the process described hereinabove will take place, via the cam 50, follower roller 52 and sliding contact 53, only after the zero balance of the resistance bridge is disturbed. This may occur by the water due to a reaction moment surge overcoming the static resistance of the steering gear. Thus, as long as the sliding resistor 47 remains unchanged, the apparatus will function as a regulator to keep the propeller runner in its set position.

Any change of the resistance 47, by displacement of a sliding contact 54 also earthed, by means of the steer-

ing wheel 55 also unbalances the bridge with the consequence that a signal is detected by the measuring amplifier 43, is power-amplified and moves the steering gear in the direction in which, by virtue of the mechanical coupling of propeller runner and sliding resistor 46, the effective resistance value of resistor 46 is adapted to that of the resistor 47 which is adjusted by the steering wheel. The sliding contact 53 will therefore always follow the position of the sliding contact 54 or, after any interference, will be returned to the preselected set position.

Thus, the voltage potential at the point 48 is a measure of the actual position of the runner of the cycloidal propeller when the propeller is used as a passive rudder while the voltage potential at the point 49 indicates the set position of the runner.

When changing from passive to active steering the follower arm 51 must be lifted and held out of the range of the cam 50. This takes place by a pawl 56 engaging a nose 57 of the propeller housing 58 (shown schematically in FIG. 15). If passive steering with the cycloidal propeller is to be resumed, the mechanical coupling between the propeller runner or the cam 50 and the sliding resistor 46 is restored by disengaging of the pawl 56 from the nose 57. In most cases, the follower roller 52 will then be in a position in which the resistance bridge 44 through 47 is unbalanced and the steering gear will continue to operate automatically until the follower roller 52 has moved into a position corresponding to the setting of the sliding contact 53.

FIG. 16 shows an arrangement the principle of which is very similar. By contrast to FIG. 15, however, it discloses a measuring circuit incorporating inductive resistances the mutual coupling state of which is varied in the event of disturbances or if the setting is changed, thus unbalancing the measuring circuit. The system incorporates a differential transformer with a center primary coil 61, energized from an alternating current source 60, and one measuring coil 62 or 63 respectively disposed on the right and left of primary coil 61. These coils are disposed on a coil support 65 which is adjustable by means of the steering wheel and is disposed to swivel about the axis of rotation of the propeller runner. An induction segment 64 is mounted on the crown wheel 40. The coil support 65 can be moved by the steering wheel over the entire possible adjusting range of the cycloidal propeller runner when the propeller functions as a passive rudder; the induction segment 64 must extend over an arc covering at least the extension of the coils.

If the set and measured positions of the propeller runner correspond, both coils 62 and 63 will be identically and inductively coupled to the center primary coil 61 and a voltage of equal magnitude relative to the common middle conductor 68 is induced in said coils. This voltage can be tapped off from the two coil ends facing away from each other. If the induction segment 64 is displaced relative to the coil support 65, the induction symmetry will be disturbed and one coil will have a voltage induced in it which is higher than in the other, the voltage of one of the external conductors (for example 66) relative to the middle conductor 68 being higher than that of the other (for example 67). A measuring amplifier 43' will supply, after appropriate amplification in the power amplifier 42, a correspond-

ing impulse to the steering gear which by analogy to the system of FIG. 15, starts to operate and continues to move the rudder in a direction until the deviation from the set position disappears.

Since the position of the coil support 65 relative to the induction segment 64 can be changed in two ways which are independent of each other, it is possible for the measuring circuit to be unbalanced by two different methods. Since any unbalance is automatically eliminated, it is possible, as already described, for one method of balancing/unbalancing to be utilized for the purpose of monitoring and stabilizing the measured value while the other method is utilized for providing the set value.

The last described modification offers the advantage over the system of FIG. 15 that there is no mechanical coupling between the propeller runner and the measuring bridge, but only a coupling which is free of physical contact and wear, which will improve the reliability of operation. When changing from active to passive steering, the induction segment 64 may come to rest in a position in which it is distant from the coils and identical voltages would then be induced in both coils 62 and 63; therefore, a voltage must be artificially maintained for a short period in one of the conductor pairs 66/68 or 67/68 so that the steering gear pivots the induction segment 64 into an oppositely asymmetrical position to produce an apparent coincidence between the set position and the actual position. After removal of the "artificial" voltage, which once again results in an asymmetrical voltage distribution in the measuring circuit, the induction segment 64 which is now near the measuring coils is once again pivoted into the set position and the symmetry of induction is restored.

It is understood that this invention is susceptible to modification in order to adapt it to different usages and conditions and, accordingly, it is desired to comprehend such modifications within the invention as may fall within the scope of the appended claims.

What is claimed is:

1. A ship comprising at least one propulsion element intended for cruising speed and in addition a propeller intended for slow speed, said propeller being a cycloidal propeller having a propeller runner and having at least three propeller blades equidistantly disposed on a blade orbit on said runner, means on said cycloidal propeller for positioning all of the blades thereon parallel to the direction of travel of the ship when the propeller is not rotating so as to provide good flow conditions around the blades when the propulsion unit for cruising speed is in operation, a kinematic blade guidance system for imparting to the propeller blades an oscillatory motion about a tangential position wherein the respective propeller blade is tangential to the blade orbit when the cycloidal propeller is acting as a propulsion unit, and, for each blade, a coupling member coupling the pertaining blade to the kinematic guidance system, at least some of the coupling members being adjustable such that the angle relationship of each adjustable coupling member to the pertaining blade can be changed to set all the blades parallel with the direction of travel of the ship.

2. A ship as claimed in claim 1 wherein the adjustable coupling members are coupling rods coupling the kinematic guidance system with respective blade levers

fixed to the respective blades, at least two of the coupling rods being provided with means for optionally elongating or shortening the coupling rods by fixed amounts to change the said angular relationship.

3. A ship as claimed in claim 2 wherein each of the adjustable coupling rods has two parts, one part being provided with a double-acting ram cylinder which is coaxial with the coupling rod and the other part being provided with a double-acting ram piston slideable in the cylinder between two fixed, but adjustable stops, the cylinder and piston defining a ram.

4. A ship as claimed in claim 3, wherein the cycloidal propeller has four propeller blades and four coupling rods and wherein the length of the coupling rods of all the blades can be varied from the normal length by an amount to pivot the respective blades through 45° from a tangential position, two diametrically opposed coupling rods being extensible relative to their normal length and the other two coupling rods being contractible, the elongating pressure chambers of the rams in the coupling rods of two diametrically opposed propeller blades and the contracting pressure chambers of the other two rams being connected in parallel to a distributing pipe, the remaining pressure chambers being connected with each other to another distributing pipe.

5. A ship as claimed in claim 3, wherein the cycloidal propeller has five propeller blades and five coupling rods and wherein a first blade which, in tangential position, is also directed in the direction of travel of the ship has a coupling rod of fixed length, while the length of the two adjacent coupling rods can be varied from the normal length by an amount to pivot the respective blades through 72° from the tangential position, and the length of the remaining coupling rods can be varied from the normal length to pivot the respective blades through 36° from the tangential position, and the respective rams are so arranged and have their pressure chambers so communicating with each other that when the rams are pressurized, the blade immediately adjacent in the clockwise direction to the said first blade is pivoted in the anti-clockwise direction and the blade immediately adjacent in the anti-clockwise direction is pivoted by 72° in the clockwise direction and the next blades in the clockwise direction are pivoted in the clockwise and anticlockwise directions respectively, and wherein the blades are pivoted back if pressure is applied to move the rams in the opposite direction.

6. A ship as claimed in claim 3, wherein the cycloidal propeller has six propeller blades and the coupling rods of two diametrically opposed blades have a fixed length and the length of the remaining coupling rods can be varied by an amount to pivot the blade through 60° from the tangential position, the rams being so arranged and having their pressure chambers so communicating with each other that when the rams are pressurized, the respective blades adjacent in the clockwise direction to the blades with the fixed length coupling rods and the blades adjacent in the anti-clockwise direction to the blades with the fixed length coupling rods are pivoted in the clockwise direction and anti-clockwise direction respectively through 60° from their tangential positions into the parallel positions, and are pivoted back into their tangential positions when pressure is applied to move the rams in the opposite direction.

7. A ship as claimed in claim 1 wherein the adjustable coupling members incorporate pressure fluid rams.

8. A ship as claimed in claim 1, wherein the blades of the cycloidal propeller are coupled to blade levers connected to the blade guidance kinematic system, the coupling means between at least some of the blades and their respective blade levers being rotatably adjustable to set all the blades parallel with the direction of travel of the ship.

9. A ship as claimed in claim 8, wherein the cycloidal propeller has an even number of propeller blades and two diametrically opposed blades are non-rotatably coupled to the pertaining blade levers and each remaining blade has means for pivoting, relative to the pertaining blade lever, from the tangential position into a position aligned at right angles to the line connecting the first two blades.

10. A ship as claimed in claim 9, wherein the cycloidal propeller has four blades and pivoting means are provided for pivoting the respective blade through 90° .

11. A ship as claimed in claim 8, wherein the cycloidal propeller has an odd number of propeller blades and one blade is non-rotatably coupled to its blade lever and each remaining blade has means for pivoting its blade shaft relative to its blade lever from its tangential position into a position at right angles to the line connecting the first blade to the axis of rotation of the propeller runner.

12. A ship as claimed in claim 8, wherein the rotatably adjustable coupling means comprise a double-acting pressure fluid ram for altering the angles between the propeller blade and its blade lever.

13. A ship comprising at least one propulsion element intended for cruising speed and in addition a propeller intended for slow speed, said propeller being a cycloidal propeller having a propeller runner and having at least three propeller blades equidistantly disposed on a blade orbit on said runner, means on said cycloidal propeller for positioning all of the blades thereon parallel to the direction of travel of the ship when the propeller is not rotating so as to provide good flow conditions around the blades when the propulsion unit for cruising speed is in operation, a kinematic blade guidance system having a central control member which is adapted to rotate with the propeller runner and whose axis is moveable by gear means into any desired position of limited eccentricity, the kinematic blade guidance system being so constructed that when said propeller runner is stationary, at least in one of those three positions of the propeller runner in which the radius to one propeller blade is at right angles to the direction of travel of the ship, the central control member can be moved into an eccentric position of abnormal magnitude so that the one blade is pivoted into the tangential position and the two other blades are pivoted into a position parallel thereto, and wherein the cycloidal propeller further has means for retaining the direction of eccentricity of the central control member relative to the propeller runner when the propeller runner is pivoted.

14. A ship as claimed in claim 13, wherein a central control arm is connected with the central control member by a ball joint and is provided with a cam follower, a cam having a generally inwardly directed guide track substantially of equilateral triangular shape and

lying in the plane of rotation of, and being fixed coaxially to, the propeller runner so that the said cam cooperates with the said cam follower.

15. A ship as claimed in claim 14, wherein the cam track has, in the middle of each side of the triangle, a preferably symmetrical protuberance directed towards the center of the triangle for deflecting the cam follower from a position of unstable equilibrium.

16. A ship comprising at least one propulsion element intended for cruising speed and in addition a propeller intended for slow speed, said propeller being a cycloidal propeller having a propeller runner and having at least three propeller blades equidistantly disposed on a blade orbit on said runner, means on said cycloidal propeller for positioning all of the blades thereon parallel to the direction of travel of the ship when the propeller is not rotating so as to provide good flow conditions around the blades when the propulsion unit for cruising speed is in operation, a two-part angle position measuring means with the two parts adapted to co-operate with each other and being moveable relative to each other, one part being arranged on the propeller runner or on the crown wheel, the other part being arranged on the ship's hull, said two parts are adapted to supply a signal corresponding to the magnitude and direction of the deviation of the said propeller runner or the said crown wheel from the coincidence position of the measuring means.

17. A ship as claimed in claim 16, wherein means are provided on the steering gear which start the steering gear and therefore the said propeller runner in the direction towards the coincidence position of the measuring means when a rudder deflection signal is received and the part of the angle position measuring means fixed to the ship's hull can be moved by means of the steering wheel of the ship about a middle position or about a mean signal value such that a deviation from the coincidence position may be simulated at will.

18. A ship claimed in claim 16, wherein the said angle position measuring means include a bridge circuit

of variable value electrical elements, said bridge circuit being arranged so that it can be unbalanced by rotation of the said propeller runner, or by movement of the steering wheel by coupling at least one electrical element to the part connected to the propeller runner and by coupling another electrical element with the steering wheel of the ship and wherein the bridge circuit is so constructed that the measuring signals produced by one unbalancing action or the other are superimposed on each other with respect to their direction and produce a common resulting signal which tends to start the steering gear and therefore tends to bring the propeller runner in that position in which the corresponding adjustment of the electrical element coupled to the said propeller runner causes the common signal to disappear or to be brought to the said mean signal value.

19. A ship as claimed in claim 18, wherein the electrical element which is unbalanced by the rotation of the propeller runner is coupled by an asymmetrical cam and a cam follower, the cam being mounted on the propeller runner or on a rotating part fixed to the propeller runner and extending over the angular zone of the steering motion, and the cam follower being linked to an adjustable part of the electrical element.

20. A ship as claimed in claim 19, wherein the cam follower can be lifted off when said propeller is acting as a propulsion unit.

21. A ship as claimed in claim 16, wherein the angle position measuring means comprises a differential transformer having a primary winding and at least one secondary measuring winding disposed near the propeller periphery on the ship's hull, the coils of said transformer being inductively coupled to each other by means of an inductive core which moves with said propeller runner and passes close to the transformer when being moved so that the width of the air gap between the core and the transformer winding depends upon the deviation of the core from its middle position.

* * * * *

45

50

55

60

65