March 22, 1966 W. BAER 3,241,618

ROTARY BLADE PROPELLER WITH PROTECTION AGAINST OVERLOAD

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Fig. 1

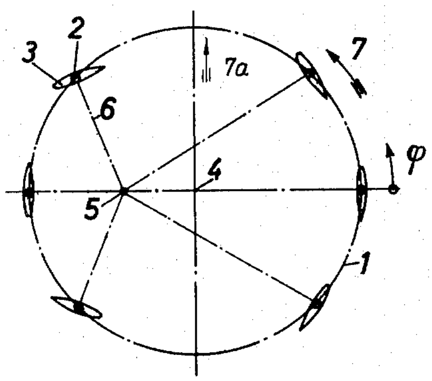

Fig. 2

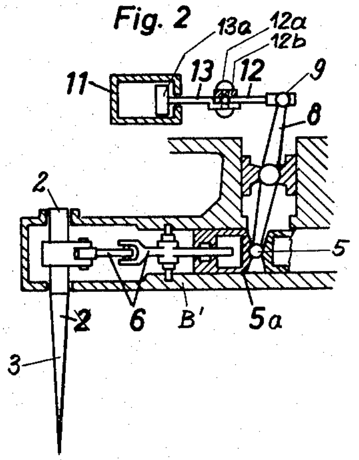

Fig. 3

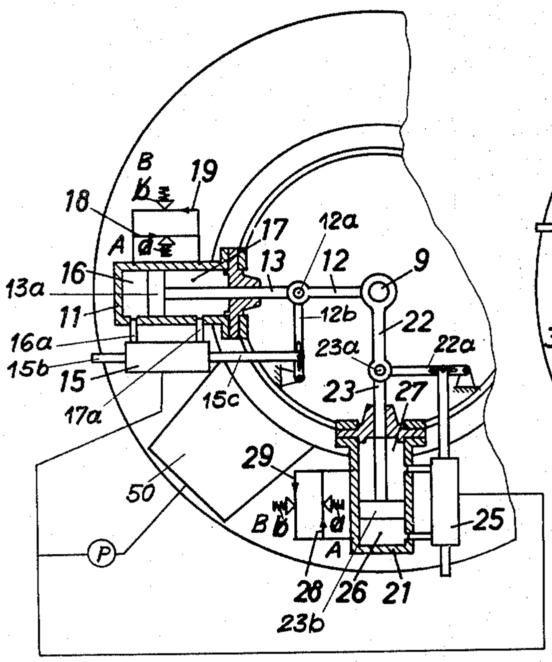

Fig. 4

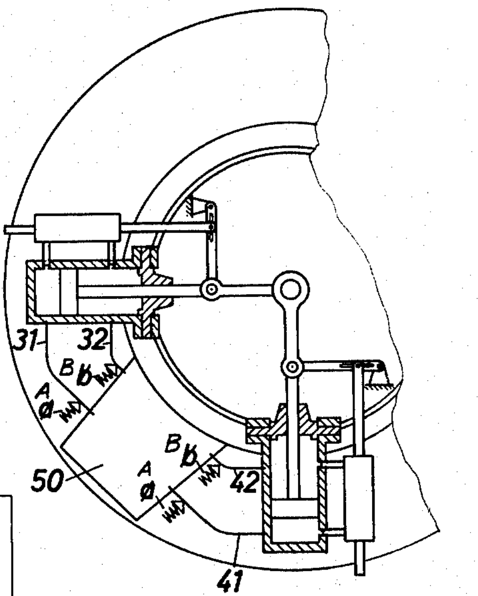

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Fig. 5

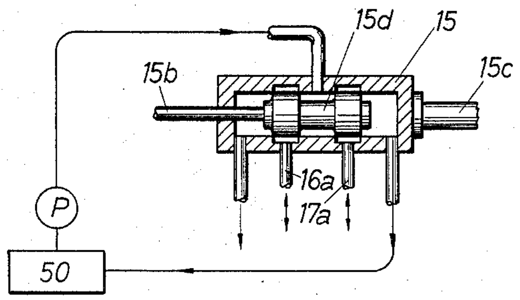
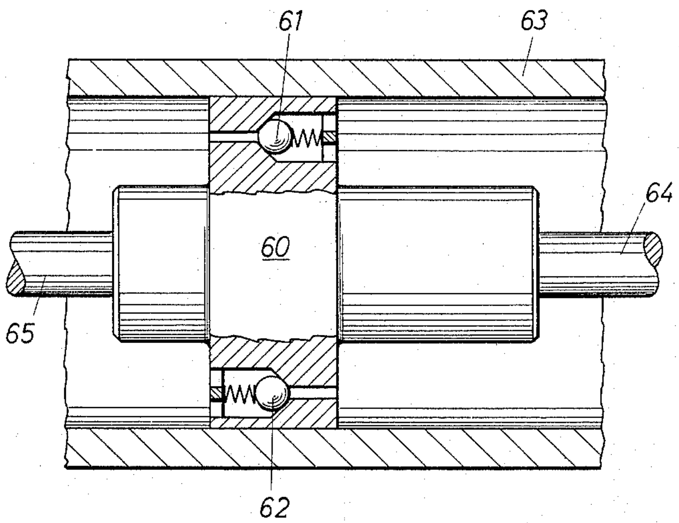


Fig. 6



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ROTARY BLADE PROPELLER WITH PROTECTION AGAINST OVERLOAD

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6 Claims. (Cl. 170—148)

This invention relates to propellers of the Voith-Schneider or cycloidal type and is particularly concerned with a protective arrangement for propellers of this nature.

A Voith-Schneider or cycloidal propeller comprises a body rotatable on an axis, usually vertical, and having a plurality of blades depending from beneath the body and rotatable on their axes, so that as the body rotates the blades can supply propulsive effort in one direction to the body which will be transmitted to a ship or the like carrying the propeller.

On a diameter at right angles to the direction of propulsion the blades are tangential to the circle passing through the center of rotation of the blades, which circle also represents the path taken by the blades. On the diameter extending in the direction of the propulsive effort developed by the propeller, those of the blades at the leading side of the propeller have their front ends tilted outwardly with respect to the said circle, whereas at the other end of the diameter, and which is the trailing side of the propeller, the blades have their front ends tilted inwardly of the said circle.

Propellers of this nature have a central control member operatively connected with the blades so that the adjusting of the blades angularly as the propeller body rotates can be determined by adjustment of the control member. The control member is usually operated by one or more fluid servomotors, so that the control member can be positioned in place relative to the body within the limits of movement of the control member and thereby determine the direction of the propulsive effort developed by the propeller.

The blades of such propellers not only carry the normal loads imposed thereon by developing the aforementioned propulsive effort, but can also become loaded by objects floating in the water, such as ice or pieces of wood, or other debris. Such floating objects not only endanger the rapidly moving propeller blades, but also endanger the linkages inside the propeller body by means of which the angularity of the blades is adjusted.

Numerous devices have been proposed for protecting the propeller blades and the control linkages therefor, but none heretofore have provided an adequate remedy. The interposition of easily broken elements in the linkage is effective for reducing the possibility of damage, but such an element, once broken, leaves at least one of the blades of the propeller inoperative. Furthermore, such an arrangement provides merely overload protection for the individual blades and does not provide any protection against repetitive shocks to the propeller as will occur when the several rapidly moving blades strike an obstruction one after the other.

It has also been proposed to include pretensioned elements in the linkage connection or in the blade positioning levers so that such elements can come into action at a predetermined maximum load on the propeller blades. This arrangement, similarly to the one above referred to, provides only overload protection for the blades individually, and also leaves at least one of the blades of the propeller inoperative after the pretensioned element operates.

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With the foregoing in mind it is a particular object of the present invention to provide a device for the protection for cycloidal or Voith-Schneider propellers in which none of the propeller blades become inoperative after the overload protection arrangement has operated.

Still another object of the invention is the provision of a device for the protection for protecting the blades and linkages of a cycloidal propeller in which the blades and the linkages pertaining thereto are automatically restored to operative position after disengagement of the blades from the obstruction or floating object which the blade or blades engage.

The present invention, in brief, is practised by providing pressure limiting means in association with the fluid operated servomotors connected to the adjustable control member by means of which the blade angles are adjusted.

More specifically, the fluid servomotors pertaining to the control member are provided with relief valves that limit the maximum pressure that can be developed therein, such pressure being greater than the normal pressures encountered during operation of the propeller under the usual conditions.

The aforementioned relief valves can be arranged to bypass fluid from either end of the servomotors to the other thereof, or can be connected between opposite ends of the servo motor and the fluid supply tank for the servomotors hydraulic system, or the relief valves can be mounted directly in the servomotor pistons.

In any case, when a blade of the propeller encounters an obstruction, one or more of the relief valve means will operate and the control member will move out of position in such a manner that the obstructed blade, together with all the other blades of the propeller, will be turned in one direction or the other, and thereby avoid, or disengage itself from the obstruction. After the blade has been disengaged from the obstruction, the fluid pressure in the servomotor will return the control member to its original position, and the propeller will become fully operative, exactly as it was before the obstruction was encountered. Since all of the blades are operated by a single control member, the turning of one blade is, of course, accompanied by the turning of all other blades at the same time. Thus, if a blade is obstructed, and the blades turn to clear the obstruction, the natural delay in restoring the blades to the original position thereof, will prevent the blades following the obstructed blade from becoming similarly obstructed.

The exact nature of the present invention will be more fully comprehended upon reference to the following specification taken in connection with the accompanying drawings wherein:

FIGURE 1 is a somewhat diagrammatic view showing the various positions occupied by a propeller blade during one complete rotation of the propeller with the propeller developing thrust in the direction toward the top of the drawing;

FIGURE 2 is a somewhat schematic sectional view showing a portion of the propeller body and one propeller blade and the adjusting linkage for the blade;

FIGURE 3 is a plan view looking down on the top of the propeller showing the two servomotors pertaining to the control member to be moved thereby and showing relief valves connected between the opposite ends of the servomotor cylinders;

FIGURE 4 is a view like FIGURE 3, but shows the relief valves connected between the servomotors and the oil reservoir for the servomotor hydraulic system;

FIGURE 5 is a schematic sectional view showing one of the servomotor control valves; and

FIGURE 6 is a fragmentary sectional view showing how the relief valves could be built directly into the servomotor pistons.

Referring to the drawings somewhat more in detail, in FIGURE 1 the path of movement of the blades is indicated by the dot-dash circle **1**. The blades of the propeller are mounted on rotation axes **2** and the blades **3** pivot about their respective axes to vary the angle of attack thereof as the propeller rotates.

In FIGURE 1 only one blade **3** is illustrated in the several positions which it occupies during one rotation of the propeller in the direction of the arrow **7**. The various blade positions indicated by angle phi are at all degrees, 45°, 135°, 180°, 225°, and 315°. The blades are adjustable by linkages generally indicated at **6**, which are under the control of a control member having a control center **5**, which is movable in any direction from a center position **4**. As illustrated in FIGURE 1, the propeller will develop thrust in the direction of the arrow **7**_a_ in FIGURE 1 as it rotates in the direction of the arrow **7**.

Turning now to FIGURE 2, it will be seen that control center **5** is formed in the center of control member **5**_a_ which is movable in the body B′, and which control member is operatively connected to the afore-mentioned control linkage **6** in any conventional manner. Lever **8** pivotally mounted in body B is connected by link **12** to rod **13** which extends from servomotor piston **13**_a_ that is reciprocable in servomotor cylinder **11**. Rod **13** and link **12** are pivotally interconnected by a pin **12**_a_, and which pin also pivotally connects to rod **13** and link **12** a feed back link **12**_b_ which influences a servomotor control valve.

Referring now to FIGURE 3, it will be seen that piston **13**_a_ in cylinder **11** divides the cylinder into chambers **16** and **17**. These chambers are selectively supplied by conduits **16**_a_ and **17**_a_ from a servovalve **15** which has a valve member connected by linkage **15**_b_ with a control arrangement, not shown, that is under the control of the ship's operator.

The body of valve **15** is connected by rod means **15**_c_ with the aforementioned feed back link **12**_b_, so that upon adjustment of the valve member of valve **15**, movement of servomotor piston **13**_a_ will be effected, and this movement will feed back through link **12**_b_ into the body of valve **15** and restore the initial conditions between the valve body and the valve member therein.

As will be seen in FIGURE 3 a second servomotor generally indicated at **21** is provided and it is provided with a control valve **25**, and the construction and arrangement thereof is the same as the servomotor just described, except that the two servomotors are disposed at right angles to each other so that lever **8** can have the upper end **9** thereof adjusted in any direction any amount within the limits of movement of the servomotor from the center point **4**.

Servomotor **21** has a rod **23** pivotally connected at **23**_a_ to link **22** leading to the upper end of lever **8** and at point **23**_a_ there is also connected the feed back link **22**_a_ which is connected to the body of servovalve **25**. Piston **23**_b_ of servomotor **21** divides the interior of the cylinder into chambers **26** and **27** which correspond to chambers **16** and **17** of the first mentioned servomotor.

According to the present invention each servomotor cylinder has two relief valves A and B pertaining thereto, relief valve A being adapted to open toward the inner end of the respective cylinder, and relief valve B being adapted for opening toward the outer end of the respective cylinder.

Conduits **18** and **19** pertaining to cylinder **11** connect the opposite sides of the relief valves to points on the cylinder **11** generally in alignment with the points of connection with the cylinder of conduits **16**_a_ and **17**_a_. Conduits **28** and **29** in connection with servomotor **21** similarly connect opposite sides of the aforementioned relief valves with spaced points of the servomotor cylinder.

In either case, when a blade of the propeller is obstructed and the load imposed on the blade is transmitted through linkage **6** thereof back to control member **5**_a_, this load in turn is imposed on lever **8** and from the upper end **9** of the said lever into the respective servomotors, one or more of the relief valves will open and permit movement of the servomotor and the linkage connected thereto, and therefore, of the blades of the propeller, whereby the propeller will clear itself of the obstruction. After the obstruction is cleared from the propeller, the servomotor which has yielded, or both thereof if yielded, will return to the original starting position and the propeller will continue to operate. Since propellers of the type illustrated turn quite rapidly, the blades follow one another quite rapidly, and when the blades turn to clear an obstruction from one thereof, the next following blade to come within range of the obstruction will not yet be restored fully to working pitch.

As will be seen in FIGURE 3 the propeller is provided with a reservoir **50** to which is connected a pump P that supplies pressure fluid to the servomotor valves **15** and **25** and from which valves fluid exhausted from the servomotors is returned.

FIGURE 4 shows an arrangement substantially identical to that illustrated in FIGURE 3 except that in FIGURE 4 all of the relief valves A and B for the two servo motors open toward reservoir **50**, and valve A is connected by conduit **31** with a point near one end of one servomotor cylinder, while the adjacent valve B is connected by conduit **32** with a point of the other end of the servomotor cylinder. As to the other servomotor the same type of relief valves A and B are employed and these are connected in the same manner by conduits **41** and **42** with the pertaining servomotor cylinder.

A typical servo valve is diagrammatically illustrated in FIGURE 5, valve **15**, for example, wherein it will be seen that the rod **15**_c_ is connected to the body of the valve so that the body is movable independently of the valve member **15**_d_ which, as mentioned before, is under the control of the pilot actuated linkage **15**_b_.

FIGURE 3 shows the relief valves connected between spaced points of the servomotor cylinders. These valves could, of course, be connected between the conduits **16**_a_ and **17**_a_ with the same effect. FIGURE 4, on the other hand, shows the relief valves connected between the servomotor cylinders and the tank **50**.

FIGURE 6 shows relief valves mounted directly in a servomotor piston. In FIGURE 6 the servomotor piston is indicated at **60** and a first relief valve **61** therein opens from the left side of the piston toward the right side, while a second relief valve **62** therein opens from the right side of the piston toward the left. The FIGURE 6 arrangement functionally thus corresponds to the arrangement of FIGURE 3, because pressures in excess of normal in either end of the srevomotor cylinder **63** will effect communication of that end of the cylinder with the opposite end thereof, thereby permitting movement of the servomotor piston in its cylinder.

It will be appreciated that there is a differential area from one side of the servomotor piston to the other, but this will not affect the operation of the overload system because as soon as the servomotor piston moves the servomotor valve will be opened and this will take care of the excess fluid. It is possible, of course, to provide the servomotor piston with a tail rod having the same cross sectional area as the working rod, whereby no problem with respect to different quantities of fluid will exist. In FIGURE 6, for example, the working rod extending from piston **60** is indicated at **64** and the provision of a tail rod **65** on the other side of the piston of the same cross sectional area will eliminate any possible problem in connection with movement of the servomotor piston according to either of the FIGURE 3 or 6 modifications.

In FIGURE 4 the problem does not exist because the opposite sides of the piston are connected with the tank or reservoir **50** through the respective linkage relief valves A and B. In this modification, should it be necessary to supply makeup fluid to the servomotor cylinder chambers that increase in volume when the servomotor piston yields, this could be accomplished by bypassing the relief valves with check valves opening toward the respective servomotor cylinders.

It will be appreciated that the protective arrangement of the present invention is fully effective only when the servomotor pistons are not positioned at an extreme end point of their travel. This, however, does not restrict the effectiveness of the system because the ship would not be propelled at full speed in water containing obstructions, such as ice floes. Rather, the ship would be operating at a reduced speed, and the propeller would be at some intermediate pitch position and the servomotor pistons would not be at either extreme end of their travel.

It will be 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 this invention as may fall within the scope of the appended claims.

What is claimed is:

1. A cycloidal propulsion propeller having a body, a plurality of blades pivotally mounted on substantially parallel axes on said body in circumferentially spaced relation thereon, a control member substantially centrally located in said body operatively connected with said blades and movable relative to the body for adjusting the pitch of the blades whereby the propeller will develop propulsive effort, control means connected with said control member for adjusting the position thereof in said body relative to a central neutral position, said control means comprising two angularly related servomotors connected to said control member, each said servomotor comprising a hydraulic system including control valve means having feedback linkage means connected to said control member reversibily controlling the supply of fluid to the respective said servomotor, and relief valve means connected in said hydraulic system operable for exhausting fluid from the pertaining said servomotor whereby deflection of said control member is permitted upon impact to a blade upon development of a pressure therein exceeding the pressures encountered in normal operation of the propeller.

2. A cycloidal propulsion propeller having a body, a plurality of blades pivotally mounted on substantially parallel axes on said body in circumferentially spaced relation thereon, a control member substantially centrally located in said body operatively connected with said blades and movable relative to the body for adjusting the pitch of the blades whereby the propeller will develop propulsive effort, control means connected with said control member for adjusting the position thereof in said body relative to a central neutral position, said control means comprising two angularly related servomotors connected to said control member, each said servomotor comprising a hydraulic system including control valve means having feedback linkage means connected to said control member reversibly controlling the supply of fluid to the respective said servomotor and relief valve means connected in said hydraulic system operable for exhausting fluid from the pertaining said servomotor whereby deflection of said control member is permitted upon impact to a blade upon development of a pressure therein exceeding the pressures encountered in normal operation of the propeller, each said servomotor including a cylinder and a piston reciprocable therein, and said relief valve means being connected between spaced points of the pertaining said cylinder and being sensitive to excessive pressure in either end of the said cylinder for by-passing fluid therefrom to the other end of the cylinder.

3. A cycloidal propulsion propeller having a body, a plurality of blades pivotally mounted on substantially parallel axes on said body in circumferentially spaced relation thereon, a control member substantially centrally located in said body operatively connected with said blades and movable relative to the body for adjusting the pitch of the blades whereby the propeller will develop propulsive effort, control means connected with said control member for adjusting the position thereof in said body relative to a central neutral position, said control means comprising two angularly related servomotors connected to said control member, each said servomotor comprising a hydraulic system including control valve means having feedback linkage means connected to said control member reversibly controlling the supply of fluid to the respective said servomotor and relief valve means connected in said hydraulic system operable for exhausting fluid from the pertaining said servomotor whereby deflection of said control member is permitted upon impact to a blade upon development of a pressure therein exceeding the pressures encountered in normal operation of the propeller, each said servomotor including a cylinder and a piston reciprocable therein, and said relief valve means being mounted in the pertaining said piston and being sensitive to excessive pressure on either side of the piston for by-passing fluid therethrough to the other side of the said piston.

4. A cycloidal propulsion propeller having a body, a plurality of blades pivotally mounted on substantially parallel axes on said body in circumferentially spaced relation thereon, a control member substantially centrally located in said body operatively connected with said blades and movable relative to the body for adjusting the pitch of the blades whereby the propeller will develop propulsive effort, control means connected with said control member for adjusting the position thereof in said body relative to a central neutral position, said control means comprising two angularly related servomotors connected to said control member, each said servomotor comprising a hydraulic system including control valve means having feedback linkage means connected to said control member reversibly controlling the supply of fluid to the respective said servomotor, and relief valve means connected in said hydraulic system operable for exhausting fluid from the pertaining said servomotor whereby deflection of said control member is permitted upon impact to a blade upon development of a pressure therein exceeding the pressures encountered in normal operation of the propeller, each said servomotor including a cylinder and a piston reciprocable therein, a supply reservoir for hydraulic fluid for said hydraulic system, and said relief valve means being connected between spaced points on the pertaining said cylinder for each system and said reservoir and opening toward said reservoir in response to excessive pressure in the pertaining end of said cylinder.

5. The invention defined in claim **2**, said relief valve means comprising first and second relief valves mounted directly in said servomotor piston, each of said relief valves controlling separate passageways through said piston, said first relief valve opening from the left side of the piston to the right side thereon and said second relief valve opening from the right side of the piston to the left side thereof.

6. The invention defined in claim **2**, said relief valve means comprising first and second relief valves positioned in separate conduits, each conduit having its opposite ends connected to the said spaced points of the pertaining cylinder and thus being in communication with the inner and outer ends of said servomotor cylinder and in by-passing relation to the piston therein, said first valve opening toward the inner end of the cylinder and said second valve opening toward the outer end of the cylinder.

References Cited by the Examiner

UNITED STATES PATENTS

2,015,514	9/1935	Ehrhart	170—148
2,155,892	4/1939	Von Den Steinen	115—52 X
2,864,239	12/1958	Taylor	60—52
2,992,632	7/1961	Nichols	7—61 X

FOREIGN PATENTS

864,455	1/1941	France.

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