United States Patent

[11] **3,554,155**

[72] Inventor **Hans Eichinger**
Munich, Germany

[21] Appl. No. **774,028**
[22] Filed **Nov. 7, 1968**
[45] Patented **Jan. 12, 1971**
[73] Assignee **Carl Hurth Maschinen-und Zahnradfabrik**
Munich, Germany
a corporation of Germany
[32] Priority **Nov. 11, 1967, Feb. 21, 1968**
[33] **Germany**
[31] **1,531,749 and 1,650,729**

---

[54] **DRIVE MECHANISM FOR A STEERABLE PROPELLER**
10 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** **115/35**
[51] **Int. Cl.** **B63h 1/14,**
B63h 5/06
[50] **Field of Search** 115/17, 34, 35; 74/797

[56] **References Cited**

UNITED STATES PATENTS

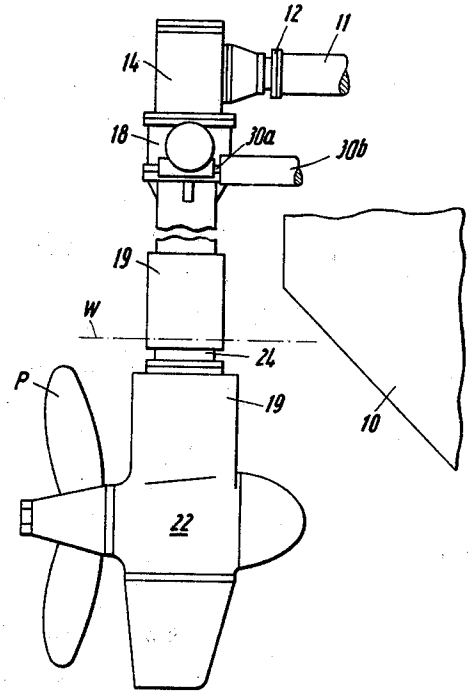
1,389,622	9/1921	Buehler	74/797
3,358,668	12/1967	Post et al.	115/17X

FOREIGN PATENTS

1,234,308	5/1960	France	115/34
983,462	2/1965	Great Britain.	

Primary Examiner—Trygve M. Blix
Attorney—Woodhams, Blanchard and Flynn

ABSTRACT: A steerable propeller for watercraft wherein the propeller is driven through a planetary system, the same being loosely mounted but self-centering in operation. A further feature limits the radial play of the planetary parts to minimize tooth contact when same is not operating.



PATENTED JAN 12 1971

3,554,155

SHEET 1 OF 6

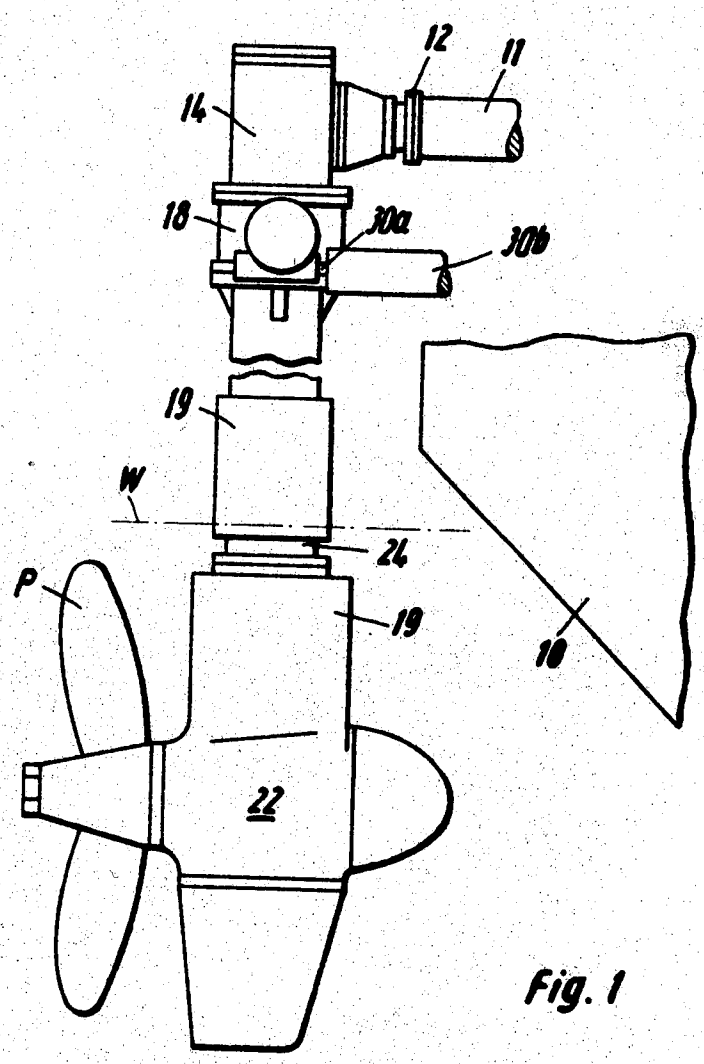


Fig. 1

Inventor:
HANS EICHINGER
BY
Windham Blanchard & Flynn
ATTORNEYS

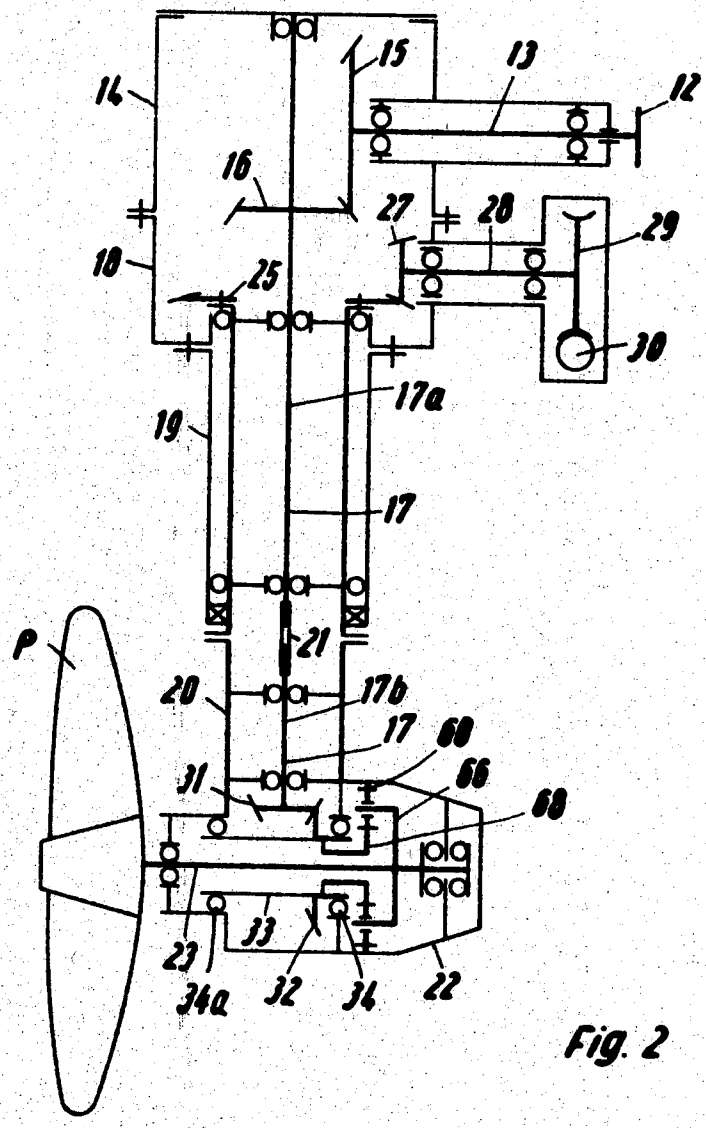


Fig. 2

Inventor:
HANS EICHINGER
By
Woodhams, Blanchard & Flynn
ATTORNEYS

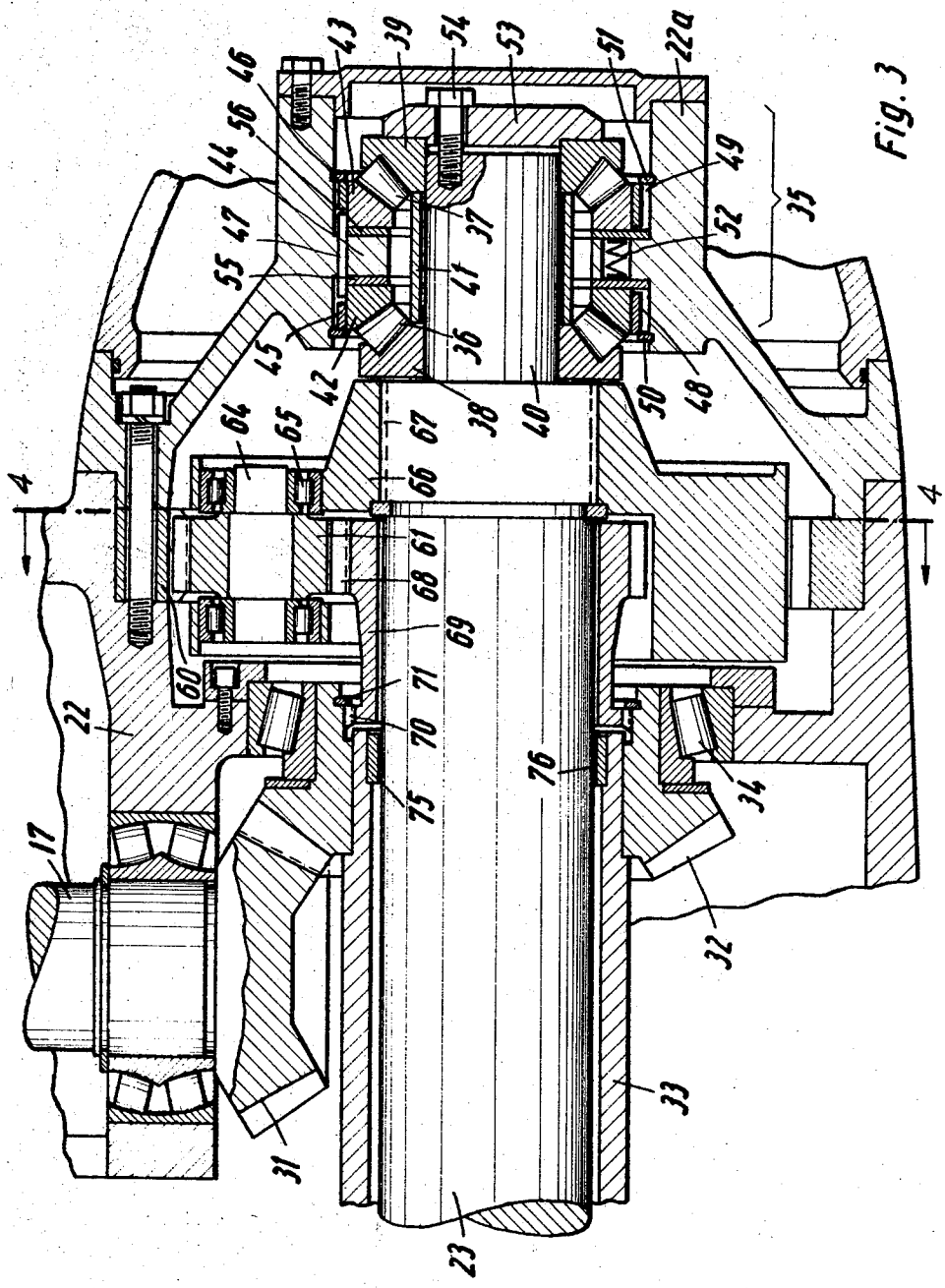


Fig. 3

Inventor:
HANS EICHINGER
BY
Woodhams, Blanchard & Flynn
ATTORNEYS

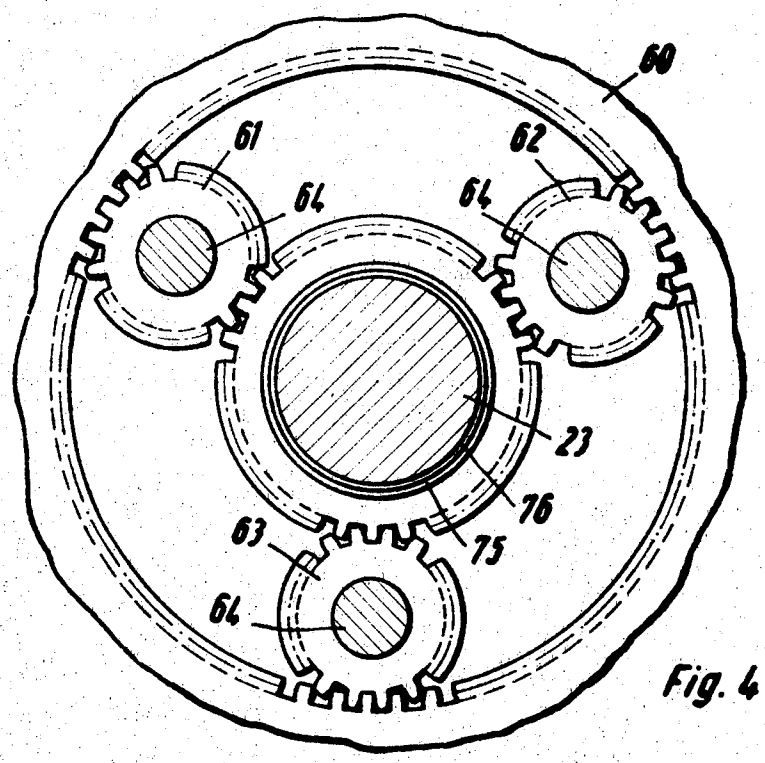


Fig. 4

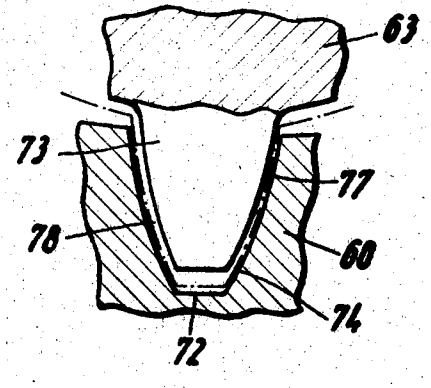
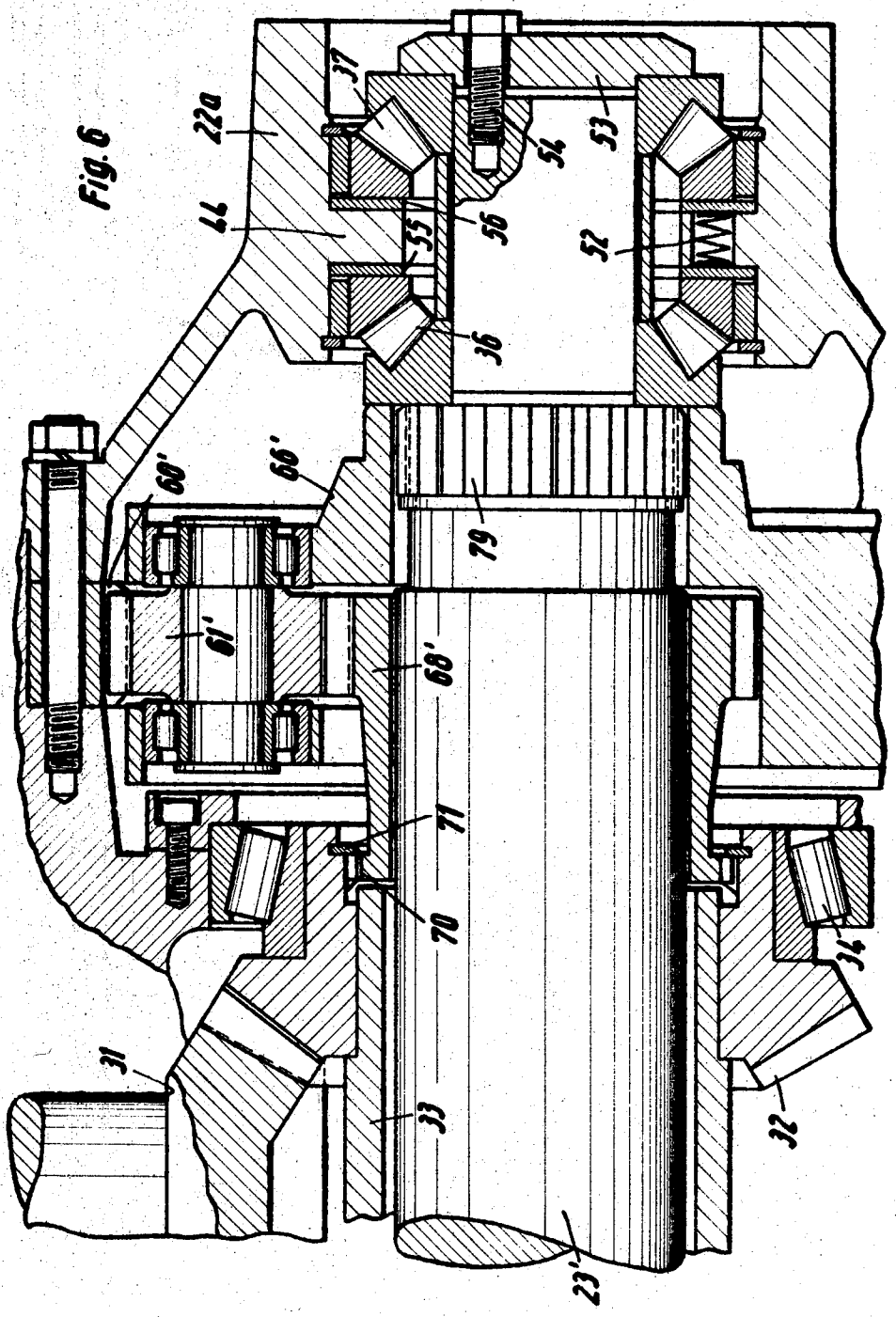


Fig. 5

Inventor:
HANS EICHINGER
By
Woodhams, Blanchard & Flynn
ATTORNEYS

Fig. 6



Inventor:
HANS EICHINGER
By
Woodcock, Blanchard & Flynn
ATTORNEYS

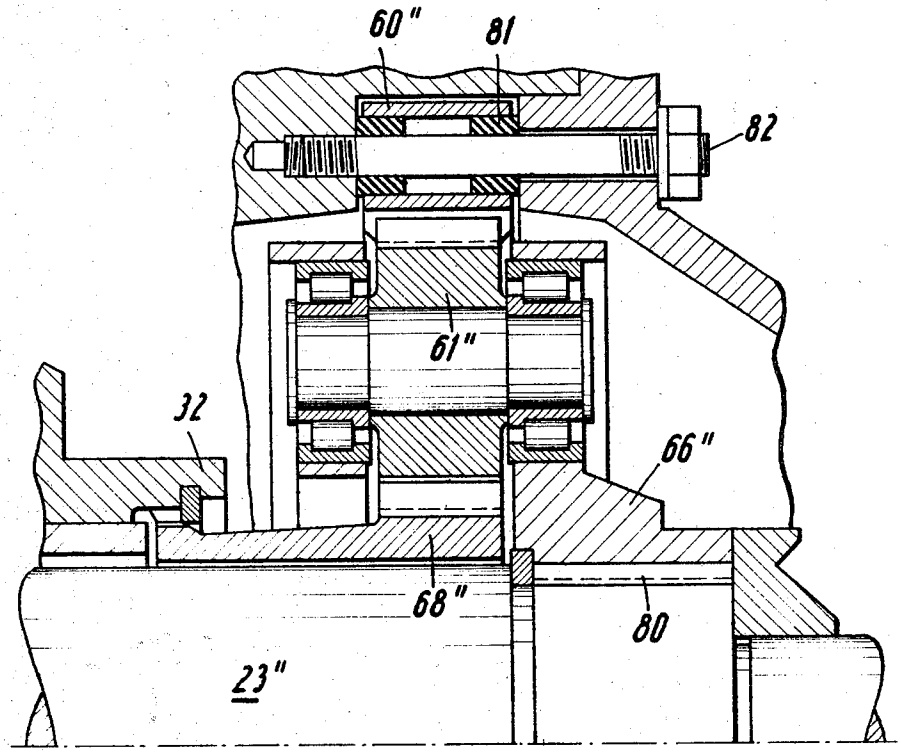


Fig. 7

Inventor:
HANS EICHINGER
By
Woodhams, Blanchard & Flynn
ATTORNEYS

DRIVE MECHANISM FOR A STEERABLE PROPELLER

This invention relates to a drive mechanism for a steerable propeller of a watercraft or the like, said steerable propeller being pivotable about an approximately vertical axis, in which the propeller is driven by a drive motor through a gear train leading underneath the waterline, the underwater portion of said gear train consisting at least partially of a planetary gearing.

Steerable propellers are, as is commonly known, used to drive and steer watercraft. According to one proposal which is not as yet a part of the known art, the torque driving the propeller is transmitted from a gear train positioned above the water to a gear train positioned below the waterline through a shaft which is arranged substantially vertically and operating at a relatively high rotational speed and a small torque. Thus, the moment of reaction which must be resisted by the control unit and, if desired, by a stabilizing blade is minimized. According to the same not yet published proposal, the rotational speed for the propeller in the underwater housing is reduced to a value which is suitable for the propeller, namely, by means of a planetary gearing. This construction has the advantage that a large reduction gearing can be accommodated in a small area, thus, the underwater housing which interferes with the propeller's effectiveness can be maintained small.

Since the planetary gearing must be accommodated in a small zone for the above-described reasons, yet same can be subjected to a relatively high load, for example by a sudden torque on the propeller as when the propeller hits an obstacle, it is necessary both that the reactive effect on the gear train is maintained as small as possible and that care is taken that all possible teeth of the gear train carry load.

To attain this purpose the present invention provides that in a presently known manner at least one of the elements of the planetary gearing, ring gear, sun gear or planet gears, is radially resiliently supported (also referred to as floatingly mounted) and is guided in the teeth of at least one other element which is radially rigidly supported.

A planetary gearing offers special advantages in particular in drive mechanisms in which the torque is guided to the underwater gear train through a vertical center shaft about the axis of which the steering movement is performed and in which no special steps are taken for receiving the moment of reaction. On the other hand, however, it is important that the transfer of torque from the reversing gearing to the planetary gearing is done without deflections in order to prevent jamming or the like from occurring due to the steering movement in the planetary gearing. The invention, therefore, provides that the planetary gearing is positioned behind the reversing gearing and that the reversing gearing is connected to the planetary gearing through a flexible coupling, for example a splined, or toothed, coupling.

A further embodiment of the invention is that two elements, for example the ring gear and the planet gears are resiliently supported and are guided directly or indirectly in the teeth of the third element, for example the sun gear.

According to the invention an advantageous construction is chosen so that the propeller shaft supporting the propeller is rigidly connected to one of the elements of the planetary gearing and that the propeller shaft is radially resiliently supported on the side facing the planetary gearing through which the propeller shaft supports itself, for example through the planetary set on the central internally toothed ring. The internally toothed ring can thereby be rigidly supported which can be advantageous to the sturdiness of the planetary gearing.

If a planetary gearing is not in operation, the gearing elements, if they are supported radially resiliently as in the invention, move downwardly due to the gravity so far that the teeth of the planetary gears (at least one of the planetary gears) lies without play in the tooth space or the tooth spaces. This type of resting load is undesirable because in having no movement one surface hammers into the opposite surface. This hammering can take place during a condition of rest in the housing by means of vibrations applied thereto. The danger in a moving vehicle (as when a boat supplied with such gearing is being driven by some other means and the steerable propeller is idle and is raised out of the water) is much greater if the gear train stands still during such moving.

To overcome this disadvantage, the invention further provides that the gearing member which is to be guided, for example the planetary carrier supporting the planet gears, is supported radially resiliently and that said member, for example the propeller shaft, is surrounded by a sleeve or the like, whereby the play between the sleeve and the surrounded part, thus for example the propeller shaft, is smaller than the radial component of the tooth play between the teeth of the guiding part and the teeth of the guided part so that the unloaded adjustable gearing member is supported on the sleeve but not on the teeth.

A particularly advantageous construction of the invention is that the adjustable and supportable member, for example the planet carrier, is supported at least at one point with a radially adjustable bearing which centers under an axial pressure, for example a conical roller bearing. This advantageous construction is described in detail in connection with one embodiment.

It is advantageous for the above-described embodiment to minimize the normal noise of running if the radially resilient bearing of the propeller shaft is connected with a friction vibration damper.

A further advantageous construction of the invention is that the propeller shaft is supported radially and axially rigidly, that the element driving the propeller shaft, for example the planet gears or the planet carrier, is guided substantially by the teeth of at least one of the other elements, for example the sun gear, and that the element driving the propeller shaft is connected to the propeller shaft through an at least radially flexible coupling element, for example a toothed coupling having radial play. The propeller in this embodiment is uneffected by the flexibility of the invention and this can be of importance for apparatus of large output capacity. A further embodiment, in which the propeller shaft is also rigidly supported, is that the propeller shaft is supported radially and axially rigidly and is essentially rigidly connected to the element of the planetary gearing, for example the planet carrier, said element driving the propeller shaft, and that at least one of the other elements, for example either the ring gear or the sun gear is radially resiliently supported and is guided in the teeth of the planet gears. For all described structures, in particular for the last-described structure, the coupling of the resiliently supported elements with the connecting parts is obtained through resilient members, for example rubber linings or rubber sleeves. Thus the resiliency is combined with a restoring force. Furthermore most elastic materials, for example rubber, have a damping capacity whereby the rubber elements further quiet the running.

Further characteristics and advantages of the invention will be understood by reading the following description.

The invention is illustrated by one embodiment in the drawings, in which:

FIG. 1 is a side elevational view of a so-called steerable propeller for a watercraft, the embodiment referring to the steerable propeller.

FIG. 2 is a longitudinal view of a gear train of the invention.

FIG. 3 is a cross-sectional view of a planetary gearing of the invention in an enlarged scale.

FIG. 4 is a schematical cross-sectional view along the line 4–4 of FIG. 2 whereby the body of the planet carrier is not illustrated and only the planet gears and the corresponding shaft of the gear member are illustrated.

FIG. 5 is a detailed illustration of a tooth and a tooth space to further explain the invention.

FIG. 6 illustrates a modified embodiment for the connection of the propeller shaft to the planetary gearing.

FIG. 7 illustrates a further embodiment of the invention.

The steerable propeller is, for the purpose of driving and steering a watercraft 10 or the like, mounted to a suitable place on the outside of the watercraft, for example to the

stern. The fastening means are known and are therefore not illustrated. The drive is provided by a drive motor (which is provided in the watercraft but which is not illustrated) through conventional drive transfer mechanisms, for example through a transfer shaft **11**, onto the coupling flange **12** of a drive shaft **13**, said drive shaft being supported in an above-water housing **14** of the steerable propeller. A bevel gear **15** is fixedly connected to the free end of the drive shaft **13**. The bevel gear is in a meshing engagement with a bevel gear **16** which is secured rotationally fixed on a center shaft **17**. The center shaft **17** is arranged vertically and extends through the above-water housing **14**, a control housing **18**, a shaft housing **19** and terminates in an underwater housing **20**. The center shaft **17** can be made of several pieces **17***a*, **17***b* for reasons of a favorable installation. The single parts are connected by one or, if desired, several couplings **21**. The propeller is pivoted about the axis of the center shaft **17** for the purpose of steering. The center shaft **17** drives a direction changing gearing, here a gear train comprising a planetary gearing, which is supported in a gear housing **22**. The propeller shaft **23** which carries the propeller P is also supported in the gear housing **22**.

The underwater housing **20** is fastened, here screwed, together with a control sleeve **24**. A platelike bevel gear **25** is secure to the upper end of the control sleeve **24**, said end extending into the control housing **18**. The control sleeve **24** and the platelike bevel gear **25** are concentrically arranged to the center shaft **17** at the bottom end of which is fixed a bevel gear **31**. The shaft housing **19** and the control sleeve **24** are sealed by a suitable sealing. A bevel gear **27** is in meshing engagement with a platelike bevel gear **25**. The bevel gear **27** is fixed to one end of a control shaft **28** which is supported in the control housing **18**. A worm gear **29** is secured to the other end of the control shaft **28**, a worm **30** engaging said worm gear. The worm **30** has a stub shaft **30***a* projecting out of the control housing. A connecting shaft **30***b* being securable to said stub shaft in order to rotate the underwater housing from a steering wheel (not illustrated) through the mentioned elements and to thus pivot the propeller P about the axis of the center shaft **17** and to control the watercraft.

FIG. **3** illustrates in detail the gear train positioned under the water level. The above-mentioned gear **31** is in a meshing engagement with a bevel gear **32** which is secured to a hollow shaft **33**. The hollow shaft **33** or the bevel gear **32** is supported by two bearings **34**, **34***a*. The propeller shaft **23** penetrates through the hollow shaft **33**. The propeller shaft **23** is supported at its right end in the gear housing by means of a double conical roller bearing **35**. The double conical roller bearing **35** comprises two conical roller bearings **36**, **37**, the inner races **38**, **39** of which are positioned on a stub shaft **40** of the propeller shaft **23**. They are spaced-apart by a sleeve **41**. The two inner races are secured to the stub shaft **40** by means of a washer **53** and screws **54**. The outer races **42**, **43** axially abut a flange **44** arranged between said outer rings, said flange forming a unit with the housing **22** or being connected to said housing. Shrunk rings **45**, **46** are shrunk onto the outer rings **42**, **43**, which shrunk rings are slotted. Said slots are engaged by one or several pins **47** which thus prevent the outer rings **42**, **43** from rotating. Clearance **48**, **49** is provided between the neck **22***a* of the gear housing receiving the bearings and the outer shrunk rings **45** and **46**. The outer rings or the shrunk rings are axially secured with snap rings **50**, **51**. Strong springs **52** which axially press onto the outer rings **42**, **43** are provided in the flange **44**, said springs urging the lifting of the conical roller bearing off the flange which, however, is prevented by the washer **53** and the screw **54**. However, the axial springs cause a reduction of the abutment pressure between the outer rings and the flange when the double conical roller bearing **35** is not under stress so that the conical roller bearings, when there is no axial stress, using the clearance **48**, **49** radially, can move radially. Washers **55**, **56** can be inserted between bearing and flange.

An internally toothed, annularly shaped ring gear **60** is centered and screwed (or bolted) in the gear housing **22**. A number of planet gears **61**, **62**, **63** are in meshing engagement with the internal teeth, said planet gears being rotatably but not longitudinally supported in a planet carrier **66** by means of stub shafts **64** and, if desired, bearings **65**. The planet carrier **66** is secured on the propeller shaft **23** with a toothed coupling **67** against rotation and with suitable means against axial movement. The third member of the planetary gearing is an externally toothed sun gear **68** which is in meshing engagement with the planetary gears. The sun gear **68** has a neck portion **69** which at its free end is provided with a toothed coupling **70**. Said coupling engages the internal teeth with which the above-described bevel gear **32** is provided. The sun gear **68** is suspended without other support within such last-named teeth and is guided radially only through same. The sun gear **68** is axially maintained by suitable means for example by a snap ring **71**.

Since the double conical roller bearing **35** is of a radially resilient construction, the planet gears or their planet carrier and indirectly also the sun gear **68** are guided by the meshing teeth on the ring gear **60**.

If a peripheral force acts on the teeth, the teeth are inclined to adjust to the operating pitch circles. However, if a centering peripheral force is not provided, the toothed parts will fall downwardly through gravity inasmuch as the tooth clearance permits such fall. This is schematically illustrated in FIG. **5**. Only a space **72** of the annularly shaped ring gear **60** is illustrated. If the invention is not applied, the planet carrier with the planet gears will slide downwardly until, for example, one tooth **73** lies without play in the respective space **72** (dash-dotted line **74**). During operation the planet carrier would rise again due to the peripheral forces acting on the teeth and the teeth of the planet gears would adjust to the operating pitch circles so that, aside from radially deflecting larger forces, the gearing would run smoothly. However, if the gearing remains in the described rest condition for a long period of time, the tooth flank will hammer itself into the space flank, particularly, if the gearing is in a moving vehicle but itself out of operation as is frequently the case with steerable propellers.

To overcome the above deficiency, the hollow shaft **33** is provided with a sleeve **75** which surrounds the planetary carrier shaft with little play, indicated by the space **76**. Thus, the tooth no longer rests on the space but the propeller shaft rests on the sleeve **75** so that the tooth **73** takes approximately the position as illustrated in full lines in FIG. **5**, so that a space **77**, **78** is provided between the tooth flanks. The planet carrier with the planet gears, and thus also the propeller shaft with the double bearing **35**, are thereby positioned slightly underneath the axis of the ring gear.

When the propeller starts to operate at first it does not have its full torque and more important yet it does not have the full pushing force which is to be received by the conical roller bearing **36**. Thus, the teeth of the planet gears can adjust centrally due to the peripheral forces to the operating pitch circles and also to the planet carrier shaft (propeller shaft **23**), the teeth **73** being slightly above the illustrated place and abutting a space flank. The bearing **35** follows said central movement because a relatively small axial force is at first still present. In the meantime the full pushing force of the propeller has built up. The pushing force maintains the bearing **35** in the central position.

The relatively small sun gear **68** is of a light weight and, in the example, does not require any special measures. If desired, it is of course also possible to apply the invention to the sun gear or to the ring gear.

If the propeller is stopped, the planetary carrier shaft (propeller shaft **23**) returns to lie on the sleeve **75** so that the planetary gears are supported free from the ring gear teeth.

A further embodiment of the planetary gearing for a steerable propeller according to the invention is illustrated in FIG. **6**. The parts illustrated in FIG. **6** are substantially the same as those illustrated in FIG. **3**. The difference is that the propeller shaft itself is supported substantially radially and also axially and also that the internal tooth ring **60'** and the resiliency of

the planet gears 61, 62, 63 is provided in the connection between the propeller shaft 23' and the planet carrier 66'. A toothed coupling 79 is provided for this purpose on the propeller shaft and in the planetary carrier which coupling transmits a torque, however, permits the planetary gears to adjust themselves to the teeth guiding said planet gears, thus for example the teeth of the internal ring gear 60'. The sun gear 68' is also resiliently supported.

A still further advantageous embodiment of the invention is illustrated in FIG. 7. The propeller shaft 23'' is here too like in the embodiment of FIG. 6 positioned rigidly both radially and axially. The planet carrier 66'' is tightly fixed onto the propeller shaft. Suitable teeth or splines 80 are provided for coupling or the securing can be done in any other known manner. Thus, the propeller shaft 23'' with the planet carrier 66'' and the planet gears 61'', 62'', 63'' form a guide for at least one of the sun gears. It is advantageous to support both sun gears 60'' and 68'' resiliently. The sun gear 68'' and the bevel gear 32 are, as above-described or in any other suitable manner, resiliently coupled for this purpose. The internal tooth ring 60'' is freely movably received by screws 82 through rubber sleeves 81 or through equivalent elements. The screws 82 are positioned in the housing. Resilient members which have a damping capacity are very advantageous in a propeller drive. Therefore all other resilient coupling of the planetary gearing can also be provided with rubber intermediate layers or the like. It is also possible to provide between gear hub and tooth ring of the adjustable gears in a known manner a rubber packing by means of vulcanizing or any equivalent means.

The bearings in the gear train of FIG. 2 are illustrated as ball bearings and in the other FIGS. are illustrated as rollers or conical roller bearings. Inasmuch as the bearings are not a part of the invention, nothing is prescribed in this respect (it would also be possible to provide sliding bearings). Lubricating maintenance and sealing elements are not illustrated and described because they are not a part of the invention.

A steerable propeller which, in the underwater portion, is provided with a reduction gearing in form of a planetary gearing has considerable advantages. The torque at the vertical center shaft can be small and thus the reaction moment which acts on the control and/or blade is also correspondingly small which is advantageous as to the construction of the control (steering mechanism) and/or the degree of flow effectiveness. By choosing a planetary gear a large reduction gearing can be placed in a small underwater gearing which also improves the degree of the propeller effectiveness.

This, with respect to the loading capacity, the structure of the planetary gearing is particularly advantageous because jammings or cants due to the control movement cannot occur in the planetary gearing and because the load is distributed to a large number of teeth. Thus, the relationship of the propeller diameter and to the diameter of the underwater gear housing is made more favorable yet. The invention also increases the sturdiness and the operating safety of the steerable propeller.

I claim:

1. A drive mechanism for a propeller positioned below the water line on watercraft and the like, said propeller being driven by an engine inboard of the watercraft, comprising:

frame means;

a drive shaft supported by said frame means for rotation about a generally vertical axis and having a first gear secured to the lower end thereof and rotatable therewith;

enclosure means below said water line of said watercraft secured to said frame means, said lower end of said drive shaft extending into said enclosure means;

a generally horizontal drive shaft rotatably supported in said enclosure means and having said propeller secured to one end thereof externally of said enclosure means and rotatable therewith;

planetary gear means in said enclosure means coupling said first gear on said drive shaft to said driven shaft for effecting a high-ratio reduction of speed from said drive shaft to said driven shaft, said planetary gear means comprising a pair of concentric, radially spaced gear members and a planetary carrier member carrying planetary gears, said planetary gears being mounted for simultaneous meshing engagement with said pair of radially spaced, concentric gear members; and

means floatingly mounting any two of the aforementioned members for a larger radial displacement than would result from normal manufacturing tolerances in said planetary gear means so that said two members are capable of a radial displacement relative to the remaining radially fixed member, the teeth of the radially fixed member guiding the radial displacement of the two floatingly mounted members.

2. The drive mechanism defined in claim 1, wherein said drive mechanism for said propeller includes means for controlling said propeller about a generally vertical axis of a steering shaft, said steering shaft being substantially parallel to said drive shaft.

3. The drive mechanism defined in claim 1, wherein said planetary carrier member is fixedly secured to said driven shaft; and wherein said driven shaft is supported for rotation by bearings located adjacent opposite ends thereof, the bearings adjacent one end permitting a radial displacement of both said one end of said driven shaft and said planet carrier member fixed thereto for providing said floating mounting.

4. The drive mechanism defined in claim 3, including sleeve means surrounding said driven shaft, the spacing between said driven shaft and said sleeve means being less than the radial displacement of said driven shaft whereby said driven shaft will be supported by said sleeve means when said drive mechanism is at rest.

5. The drive mechanism defined in claim 3, including means for supporting said bearings located adjacent said one end of said driven shaft for movement radially of said enclosure means, said bearing supporting means further being responsive to the axial thrust of said propeller to reduce the radial displacement of said one end of said driven shaft to zero.

6. The drive mechanism defined in claim 1, wherein said planetary carrier member is fixedly secured to said driven shaft, said driven shaft being mounted solely for rotation; and wherein said pair of concentric gear members are mounted for radial displacement relative to said driven shaft.

7. The drive mechanism defined in claim 1, wherein said driven shaft is mounted solely for rotation; wherein said planetary carrier member and said driven shaft include means for floatingly mounting said planetary carrier to said driven shaft for radial displacement relative to said driven shaft; and wherein one of said concentric gear members includes means for floatingly mounting same for radial displacement relative to said driven shaft.

8. The drive mechanism defined in claim 1, wherein said planetary gear means includes a second gear in meshing engagement with said first gear, said second gear having first coupling means thereon; one of said concentric gear members having an elongated neck extending axially therefrom, the free end of said neck having second coupling means thereon drivingly engageable with said first coupling means, said driving engagement providing a pivotal mounting for said one of said concentric gear members to permit a radial displacement thereof relative to said driven shaft.

9. The drive mechanism defined in claim 1, including resilient mounting means for floatingly mounting said one of said concentric gear members to said enclosure means to permit a radial displacement of said one of said concentric gear members relative to said driven shaft.

10. The drive mechanism defined in claim 5, wherein said bearing support means includes means capable of frictionally resisting radial movement of said bearings; and wherein the magnitude of said frictional resistance is a function of said axial thrust of said propeller to control said radial displacement of said driven shaft.