April 27, 1965 D. E. SINGELMANN 3,180,300

SPEED REDUCING UNIT FOR POSITIONING A HYDROFOIL ASSEMBLY

Filed Oct. 1, 1963 4 Sheets-Sheet 1

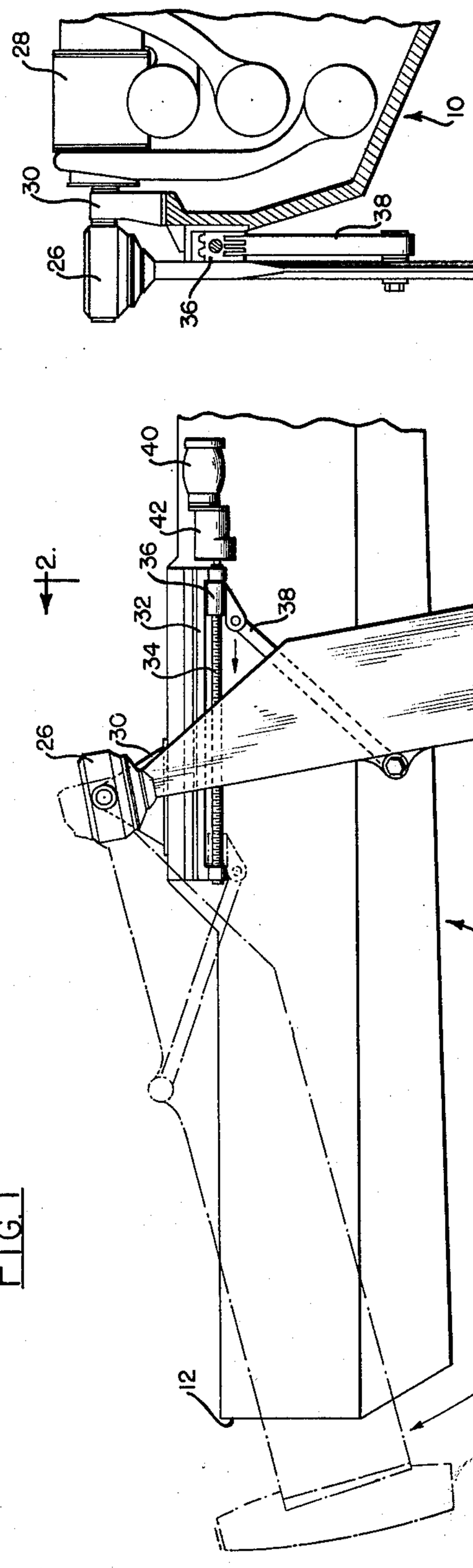

FIG. 1

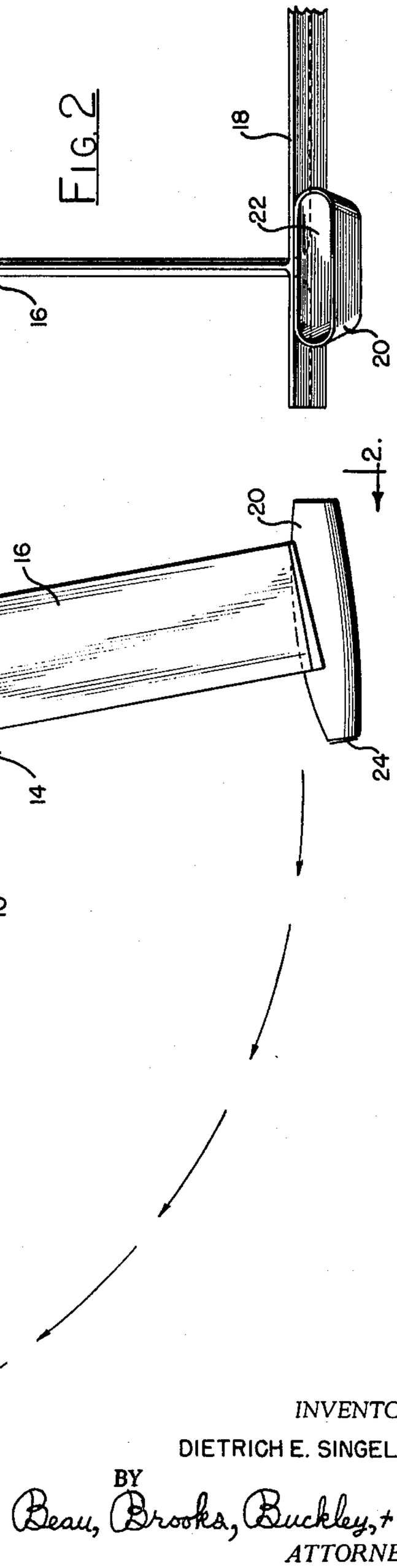

FIG. 2

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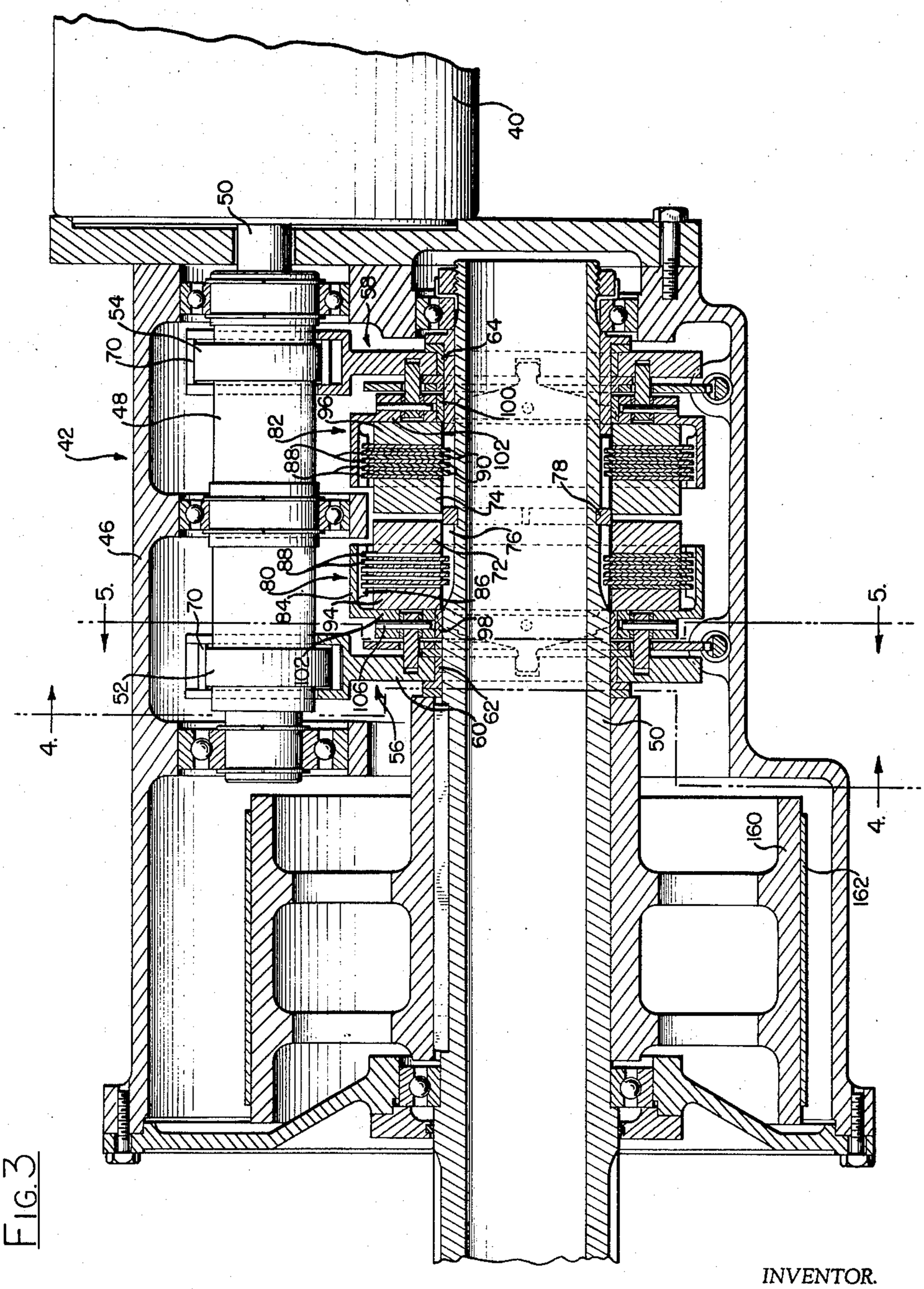

FIG. 3

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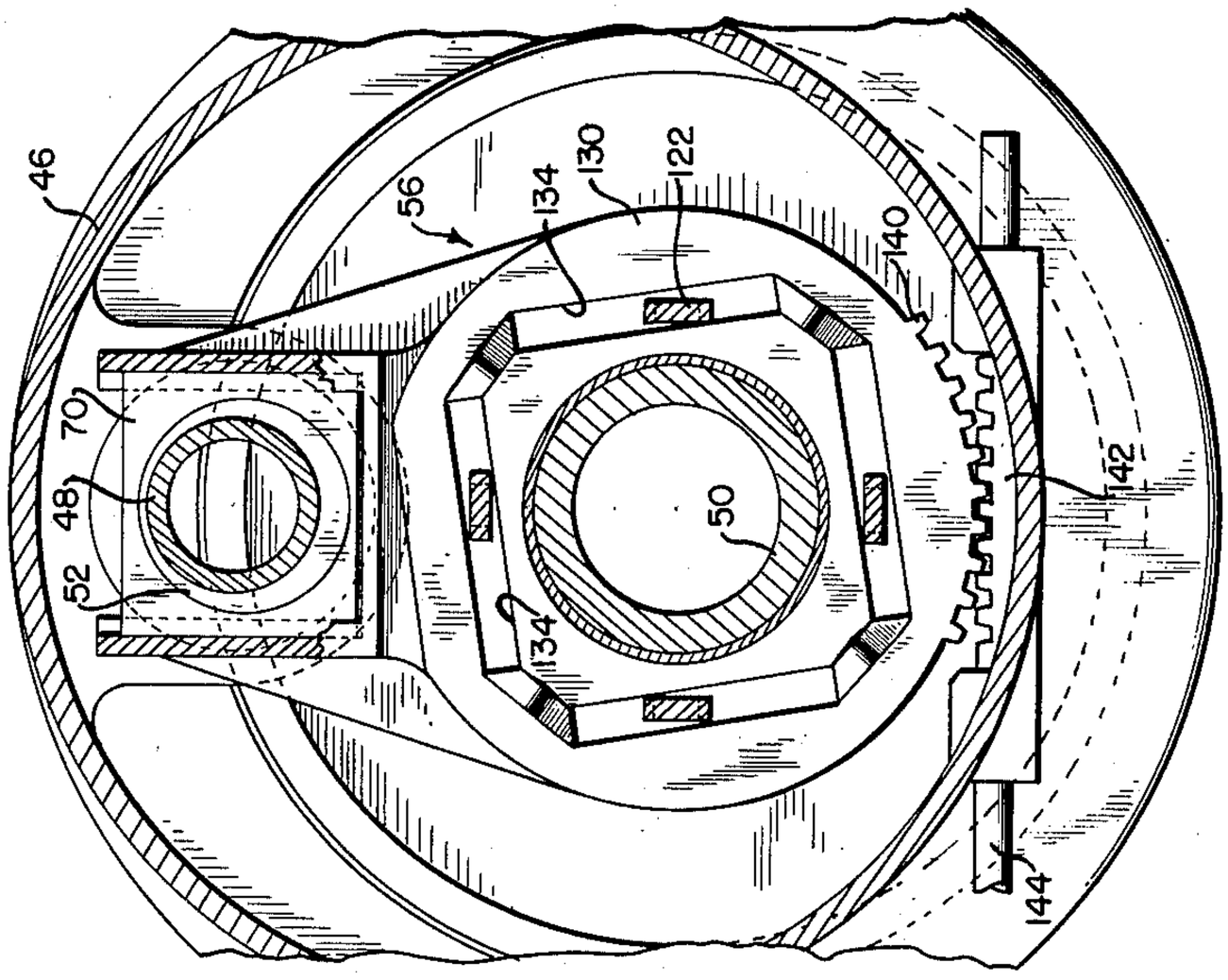

FIG. 5

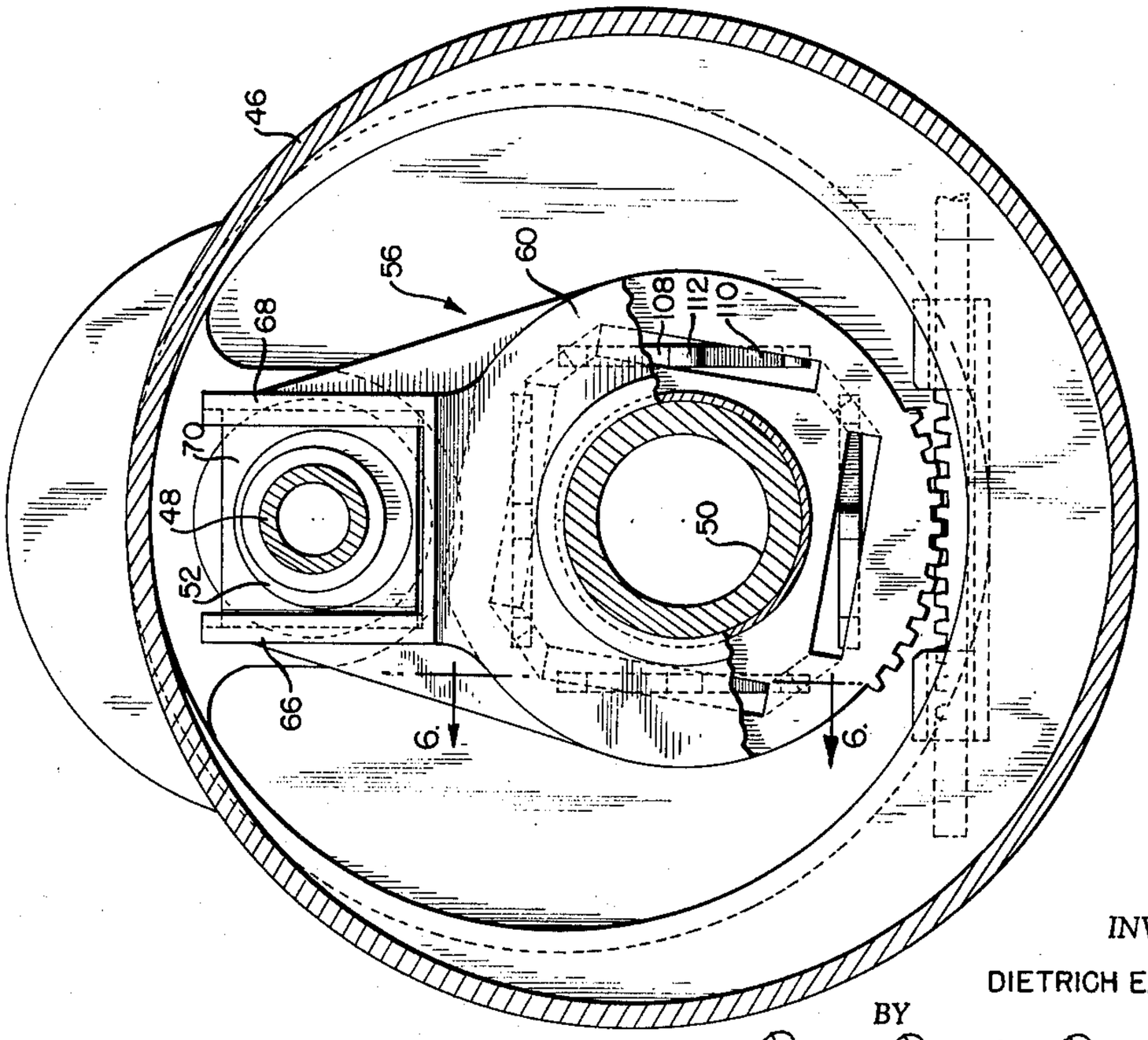

FIG. 4

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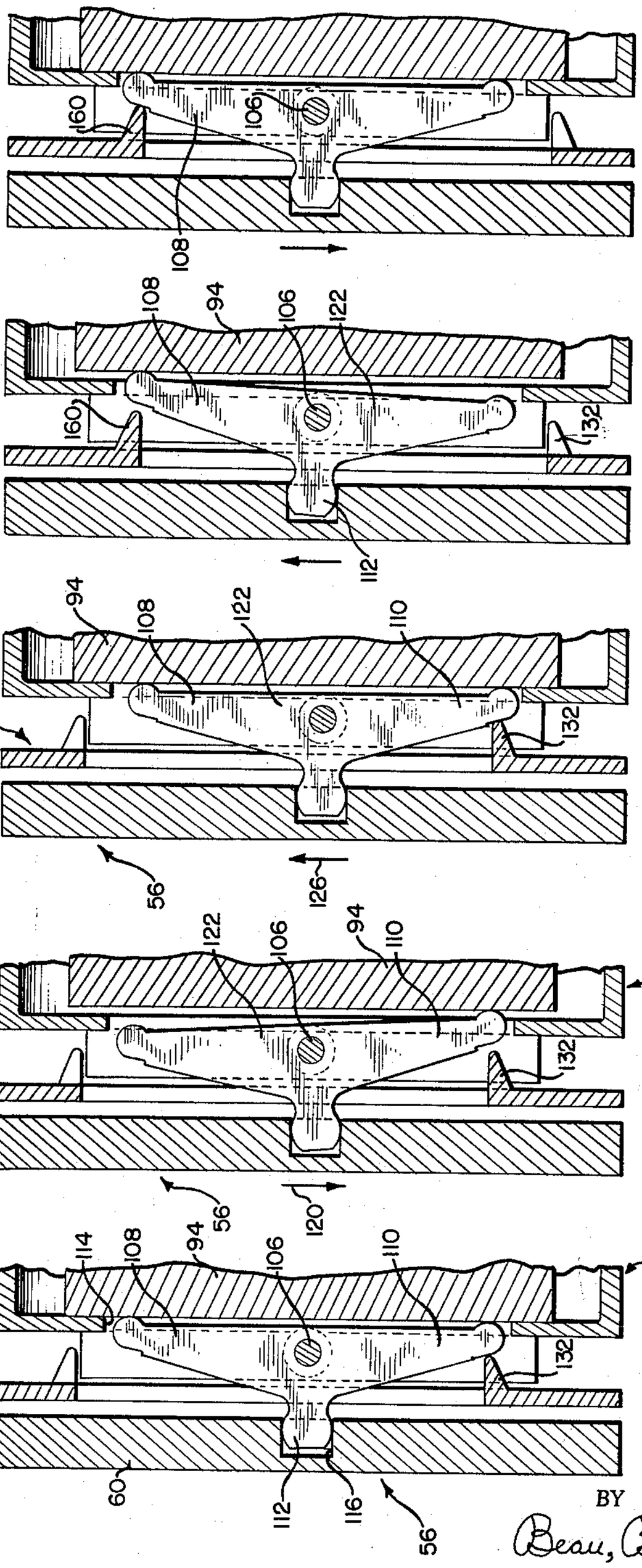

FIG. 10

FIG. 9

FIG. 8

FIG. 7

FIG. 6

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Patented Apr. 27, 1965

3,180,300
SPEED REDUCING UNIT FOR POSITIONING A HYDROFOIL ASSEMBLY

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Filed Oct. 1, 1963, Ser. No. 312,942
9 Claims. (Cl. 114—66.5)

This invention relates to aquatic vehicles of the hydrofoil type and pertains, more particularly, to a novel combination in such vehicles and a speed reducing unit peculiarly adapted for usage in conjunction therewith.

Aquatic vehicles of the hydrofoil type operate upon the principle of a submerged or partially submerged hydrofoil assembly which depends from and thereby extends below the hull of the vehicle so that the hull is elevated above the water surface as the vehicle moves so that friction is reduced and much greater speeds can be attained for the same power consumption. Since hydrofoil assemblies normally extend a substantial distance below the bottom of the hull, they represent a limitation as to the maneuverability of such vehicles in shallow water. Therefore, it is of primary concern in connection with this invention to provide an improved aquatic vehicle of the hydrofoil type wherein the hydrofoil assembly or assemblies is movable between an operative, depending position and a position in which it is swung upwardly out-of-the-way to permit the vehicle to traverse and maneuver in shallow water.

Ancillary to the above object, it is of concern in connection with this invention to provide an improved speed reducing assemblage which is particularly and peculiarly adapted for utilization in conjunction with a movable hydrofoil assembly as aforesaid so that the hydrofoil assembly may be swung between its operative and inoperative positions by relatively simple and yet wholly effective means.

Another object of this invention is to provide an improved speed reducing assembly particularly adapted for the purposes described hereinabove, in which a drive shaft is rotated by a suitable motor and wherein one-way clutch devices on a driven shaft are utilized to impart unidirectional motion to the driven shaft without the aid of gearing or the like so that the speed of rotation of the driven shaft is responsive to the torque load imposed on such shaft whereby an efficient, lightweight and compact assemblage is provided.

Another object of this invention is to provide an improved hydrofoil assembly for aquatic vehicles which is of generally U-shaped configuration and is so dimensioned and positioned relative to the hull of the vehicle as to permit the hydrofoil assembly to be swung between a generally vertical, depending operative position to an upwardly swung out-of-the-way position wherein the hydrofoil assembly is, in the latter position, disposed clear of and beyond one end of the hull.

A further object of this invention is to provide an improved speed reduction assemblage substantially as aforesaid wherein out-of-phase eccentric members disposed on a drive shaft are utilized to impart relatively opposite oscillatory motions to a plurality of levers, which levers are pivoted for oscillation about the axis of a driven shaft and wherein one-way clutch means is associated with each lever to impart step-by-step rotary motion to the driven shaft for one direction of oscillation of each of the levers.

Other objects and advantages of the invention will appear from the description hereinbelow and the accompanying drawing wherein:

FIG. 1 is a side elevational view showing a portion of an aquatic vehicle constructed in accordance with this

invention and showing, in full and dot-dash lines, the operative and inoperative positions of the hydrofoil assembly;

FIG. 2 is a vertical section taken substantially along the plane of section line 2—2 in FIG. 1;

FIG. 3 is a longitudinal section taken through the speed reducing assemblage according to this invention;

FIG. 4 is a transverse sectional view taken substantially along the plane of section line 4—4 in FIG. 3 showing details of the actuating levers and the control plate for effecting relatively reverse motions of the driven shaft;

FIG. 5 is a vertical section taken substantially along the plane of section line 5—5 in FIG. 3 showing further details of the speed reducing assemblage; and

FIGS. 6–10 inclusive are enlarged sectional views illustrating the motion transmitting parts in various positions thereof and also showing the cam plate for effecting relatively reverse unidirectional motions to the driven shaft.

With reference at this time more particularly to FIG. 1, the hull of an aquatic vehicle is designated therein generally by the reference character 10, the reference character 12 indicating the stern portion of such hull. The hydrofoil assemblage is indicated generally by the reference character 14 and consists essentially of a pair of strut members 16 which depend normally generally vertically downwardly from the opposite sides of the hull 10 and which are interconnected by the hydrofoil member 18, see particularly FIG. 2. Each strut 16 houses a suitable vertical shaft (not shown) which, at its lower end, is connected to a pump mechanism (not shown) disposed within a pump housing 20 having an open mouth 22 and an open rearward end 24 whereby to induct water through the housing 20 and impart forward motion to the hull 10, in a conventional manner. The upper end of each strut 16 is provided with a gear box 26 and a suitable prime mover 28, preferably in the form of a turbine, is provided with a drive shaft which is gear connected to the upper end of the aforesaid vertical shafts for the pump within the gear box 26 to impart the requisite motion to the pumps.

The gear box 26 in each case is pivotally connected to the sides of the hull 10 as by the bearing block or bracket members 30 at either side of the hull and, in this fashion, the entire U-shaped hydrofoil assembly is pivotally connected at its upper end to the hull 10. Therefore, the hydrofoil assembly may be swung between the operative, generally vertical depending position shown in FIG. 1 to the out-of-the-way dash-dot line position shown in FIG. 1. As aforesaid, the hydrofoil assembly is of U-shaped configuration and it is positioned on the hull 10 such that, in the inoperative position shown in FIG. 1, the hydrofoil assembly clears beyond the stern portion 12 so as to provide a maximum of clearance beneath the bottom of the hull to permit the vehicle to maneuver and traverse shallow waters.

To effect the aforesaid positioning of the hydrofoil assembly, a suitable journal or bearing assembly 32 is provided along one side of the vessel which rotatably supports a spindle or screw actuating shaft 34. The spindle 34 is operatively engaged with a translatory nut member 36 which may of the recirculating ball type and this nut, in turn, is pivotally connected, as by a link 38 to the strut 16 substantially as is shown in FIG. 1. The spindle 34 is rotated by a driving motor 40 operating, through a speed reducing mechanism 42, to impart a sinusoidal step-by-step motion to the spindle or screw shaft 34. From FIG. 1, it will be readily apparent that the torque required to be applied by the screw shaft 34 will steadily increase as the hydrofoil assembly is moved between its

full and dot-dash line positions and it is a particular feature of this invention that the speed reducing unit 42 is torque responsive so as to impart relatively rapid motion of the translatory screw 36 during such time as a relatively light load is placed upon the moving assemblage and wherein the speed of rotation of the spindle 34 is materially reduced as the torque load increases. In this fashion, movement of the hydrofoil assembly between its operating and non-operating positions is as rapid as possible while, at the same time, permitting a sufficiently great speed reduction to be effective under increasing loads as to allow a relatively lightweight and compact power assembly to be utilized.

The speed reducing assembly per se is shown more clearly in FIG. 3 wherein it will be seen that such assemblage 42 includes a housing 46 journaling the driving shaft 48 and the driven shaft 50, which may comprise an integral extension of the spindle 34, in spaced parallel relation to each other, substantially as is shown. The drive shaft 48 may be an extension of or rigidly affixed to the drive shaft 51 of the motor 40 and is, in any event, provided with a pair of eccentric circular portions 52 and 54 which are disposed in 180° phase opposition to each other substantially in the manner as is shown. The levers 56 and 58 are disposed in association with the two eccentrics 52 and 54, each of such levers having a generally circular boss portion 60 as is shown in FIG. 4 which surrounds the driven shaft 50 and is journaled thereon by a suitable bushing member 62 or 64 whereby the levers are free to rotate relative to the driven shaft. Each lever also includes a bifurcated end portion presenting the spaced channel arm portions 66 and 68, see particularly FIG. 4, which slidably receive the blocks 70 which are apertured to rotatably receive the circular eccentrics 52 and 54. In this fashion, it will be apparent that rotation of the drive shafts 48 will impart oscillatory motions to the levers 56 and 58 and, by virtue of the 180° phase opposition of the eccentrics 52 and 54, that relatively opposite oscillatory motions will be imparted to the levers.

To effect a driving connection between the oscillatory levers 56 and 58 and the driven shaft 50, a clutch means is utilized. In a specific example shown, the clutch means comprises a pair of clutch rings 72 and 74 which are internally splined to thus engage with the external spline 76 on the inner end of the drive shaft 50, substantially as is shown. A split ring member 78 is received in a suitable groove circumferentially extending around the drive shaft 50 and serves to constitute a locating member for the two rings 72 and 74. The carrier assemblies 80 and 82 are associated with the respective rings 72 and 74 and each of these carriers includes an annular flange portion 84 provided with internal splines such as those indicated by the reference character 86 so that alternate annular clutch disks 88 are engaged with the carrier while interleaved alternate clutch disks 90 are splined engaged with the driven shaft 50. Thus, although alternate clutch disks are rigidly attached to the carriers 80 or 82 and the driven shaft 50, these several clutch disks are free to slide or move axially of the driven shaft 50 so as to effect a clutching action therebetween, the rings 72 and 74 acting as reaction members against which these clutch plates may bear.

The squeezing action on each stack of clutch plates is effected by means of one of the pressure plate members indicated by reference characters 94 and 96, each of such pressure plates being of annular configuration and being rotatably received on the driven shaft 50 within the confines of its associated carrier 80 or 82. Each of the carriers 80 and 82 is rotatably received on the driven shaft 50, there being bushing 98 or 100 provided for this purpose, substantially as is shown and the manner in which the drive is effected is by a plurality of circumferentially spaced actuating finger means pivotally carried by the web portion 102 of each carrier 80 or 82. Each actuating finger is pivotally carried by its associated carrier through the medium of radially extending pivot pins such as that indicated by the reference character 106 and each finger is provided with a pair of bearing arm portions 108 and 110 substantially as is shown in FIG. 6 and an intermediate ball portion 112. The web 102 of each carrier is provided with elongate slots 114 disposed in circumferentially spaced relationship concentric with the driven shaft 50 for receiving the elongate fingers and the ball 112 in each case projects laterally from each web to be received in a suitable socket portion 116 formed in the face of the circular portion 60 of an associated lever 56 or 58.

The operation of the device is effected by virtue of the oscillatory motions of the levers 56 or 58. With reference to FIG. 7, in response to oscillation of the lever 56 in the direction as indicated by the arrow 120, the finger member 122 will be caused to rock about its pivot pin 106 in the manner indicated since the carrier 80 will tend to remain stationary to permit this action. The rocking motion of the finger will cause movement of the pressure plate 94 to the right in FIG. 7 to compress the stack of clutch disks previously mentioned until such time as sufficient friction is attained as to carry the carrier 80 along with the oscillatory motion of the lever 56. In other words, the rotation of lever 56 in the direction of arrow 120 (FIG. 7) will at first simply rock the finger 122 about its pivot 106 without any tendency to carry the carrier along with the rotation of the lever 56. As soon, however, as the finger 122 engages the pressure plate 94 and commences to squeeze the clutch discs together, the finger 122 will tend to "lock up" and to thereby impart rotation and torque to the carrier 80. However, the finger 122 will actually "lock up" at different relative positions of rotation about its pivot 106, dependent upon the degree of squeezing on the clutch discs which is required to overcome the torque load on the driven shaft 50.

It will be appreciated that while the lever 56 is moving in the direction of the arrow 120, the other lever 58 will be moving in the relatively opposite direction and, as will be described hereinafter, such relatively opposite movement of either of the levers is inoperative to impart rotational movement to the screw or spindle 34 through the driven shaft portion 50 thereof so that, at the time under consideration, it is only the lever 56 which is imparting rotary motion to the spindle 34. As soon as the lever 56 reaches its end of oscillatory motion and starts to reverse its direction so as to move in the direction of the arrow 126 as shown in FIG. 8, drive from this lever will be terminated and immediately drive will be picked up by the other lever 58. To prevent reverse rotation of the spindle 34 as the lever 56 moves in the direction of the arrow 126, a cam plate assembly indicated generally by the reference character 130 is utilized. In the position of the parts as shown, in response to movement in the direction of the arrow 126, the arm portion 110 of the finger 122 engages the cam member 132 to prevent the other arm portion 108 from engaging the pressure plate member 94 and urging the same to frictionally engage the stack clutch disks or plates. Thus, on the return portion of the oscillation of the lever 56, the drive is idle and ineffective. That is to say, rotation of the lever 56 in the direction of arrow 126 (FIG. 8) will at first rock the finger 122 about its pivot 106 until the lower end 110 of the finger engages the cam member 132. This again "locks up" the finger 122 and causes the carrier to be rotated now with the lever 56. However, since the finger 122 has been "locked up" by engaging the cam member 132 (FIG. 8) instead of by squeezing the clutch discs together (as in FIG. 7), continued rotation of the lever 56 simply causes the carrier 80 to rotate idly, without imparting drive to the spindle 34.

The cam plate is of generally circular form as is shown in FIG. 5 and is provided with a plurality of rectangular slots 134 to clear the respective fingers and in the specific embodiment shown, the periphery of the cam plate 130 is

provided with gear teeth **140** meshing with a reciprocatory rack member **142** having an actuating rod portion **144** extending outwardly of the housing **46**. Thus, through the medium of the rod **144**, the cam plate **130** can be relatively rotated with respect to the levers **56** and **58**. In the position shown, the cams **132** serve to block the arm portion **110** by engagement therewith for return motions in the directions of the arrow **126** for the levers **56** and **58** whereas the cam plate has additional cam portions **160** which, as is shown in FIGS. 9 and 10, block the upper arm portions **108** of the fingers. Therefore, relatively reverse directions of rotation can be imparted to the spindle **34** dependent upon the positioning of the cam plate **130**.

By the very nature of the construction, it will be manifest that the speed in which the spindle **34** is rotated is responsive to the torque load imposed thereon. For example, in a specific embodiment of the invention, with the speed of the motor **40** operating at 1740 revolutions per minute, the rotational speed of the spindle **34** varied between 20 revolutions per minute and 5 revolutions per minute as the torque load was increased from the minimum to the maximum thereon. The reason for this, of course, is that the greater the torque load, the greater the pressure must be transmitted by the fingers against the pressure plates **94** and **96** to effect the requisite frictional interengagement between the clutch parts. Thus, the greater the load is imposed upon the spindle **34**, the less total amount of oscillatory motion of the levers **56** or **58** will be imparted to the carriers **80** and **82**. Thus, the amount of rotational motion imparted by each lever **56** or **58** grows less as the torque load on the spindle **34** is increased. It will further be noted that the rotary motion imparted to the spindle **34** is in sinusoidal unidirectional steps due to the oscillatory nature of the movement of the levers **56** and **58**.

When the assemblage is to be lowered between its out-of-the-way and operative positions, it will be appreciated that the speed reduction unit will, in effect, be mainly attempting to hold back the motion of the hydrofoil assembly. For this reason, and due to the nature of the rotary motion imparted to the spindle **34**, vibrations will tend to be set up unless some means is provided for placing a preload on the system. This is accomplished in the specific embodiment shown by means of a brake **160** and associated brake band **162**, operating in an entirely conventional manner and effected in braked condition when the load is being lowered.

It is to be understood that certain changes and modifications as illustrated and described may be made without departing from the spirit of the invention or the scope of the following claims.

I claim:

1. A gear reduction unit comprising, in combination,
a drive shaft and a driven shaft disposed in spaced, parallel relation,
said drive shaft having a plurality of out-of-phase eccentrics thereon,
a lever associated with each eccentric, each lever being pivoted about the axis of said driven shaft and having a forked end straddling an associated eccentric so that the levers are oscillated in response to a unidirectional rotation of the drive shaft,
and clutch means coupling each lever to said driven shaft in response to movement of said levers in one direction.

2. In an aquatic vehicle of the type having a hull and a pivoted hydrofoil assembly normally depending from the hull so that forward motion of the vehicle and elevation of the hull above the water surface may be accomplished; means for pivoting said hydrofoil assembly from its normal depending position to an upwardly swung position,
said means comprising an elongate screw having a nut thereon in which the nut is connected to said hydrofoil assembly for movement of the latter as aforesaid in response to translatory motion of the nut, a drive shaft disposed in spaced parallel relation to said screw, a motor for driving said drive shaft, and gear reduction means connecting said drive shaft with said screw,
said gear reduction means comprising a pair of eccentrics rigid with said drive shaft and displaced 180° with respect to each other, a lever for each eccentric pivoted about the axis of said screw and each lever having a bifurcated end portion straddling its associated eccentric so that rotation of said drive shaft imparts relatively opposite oscillatory motions to said levers, and one-way clutch means connecting each lever to said screw.

3. In a reduction unit, in combination,
a housing journalling a drive shaft and a driven shaft in spaced parallel-relation,
a pair of levers journalled on said driven shaft and having bifurcated end portions extending radially therefrom and straddling said drive shaft,
said drive shaft having a pair of circular eccentrics rigid therewith and disposed in 180° phase relation with each other, said end portions of the levers being in straddling relation to said eccentrics so that the levers are oscillated in relatively opposite directions in response to rotation of said drive shaft,
reaction plate means fixed to said driven shaft,
a clutch plate carrier journalled on said driven shaft adjacent each lever,
a pressure plate journalled on said driven shaft within each carrier,
a stack of clutch plates disposed between each pressure plate and the reaction plate means, each stack having drive plates connected to an associated carrier and driven plates connected to said driven shaft,
a set of finger members pivotally carried by each carrier, each finger member having opposite end portions engageable with an associated pressure plate to urge the same toward the reaction plate means and a knob engaged by an associated lever for rocking the finger members in response to oscillation of said levers,
and means for selectively maintaining one end portion of each finger out of contact with said pressure plate.

4. The assembly as defined in claim 3 wherein the last means comprises a blocking plate for each set of finger members.

5. The assembly as defined in claim 3 wherein said finger members are pivotally connected to said carriers about axes extending radially of said driven shaft.

6. In an aquatic vehicle having a hull, a generally U-shaped hydrofoil unit pivotally mounted on said hull for movement between an operative, generally vertical depending position and a generally horizontal position clearing one end of said hull,
prime mover means mounted in said hull and having drive shaft means extending along the axis of pivotal mounting of the hydrofoil unit into driving relation to such unit,
means for moving said hydrofoil unit between the stated positions thereof,
the last means comprising a screw shaft journalled along one side of said hull, a nut engaged on said screw shaft, linkage means extending between said nut and said hydrofoil unit, a motor having a drive shaft adjacent said screw shaft, and torque-responsive speed reduction means connecting said drive shaft to said screw shaft.

7. In a vehicle as defined in claim 6 wherein said speed reduction means includes a pair of diametrically displaced eccentrics on said drive shaft, a pair of levers journalled about the axis of said screw shaft and respectively oscillated in relatively opposite directions by said eccentrics, a pair of driven clutch rings fixed to said

screw shaft, a pressure plate spaced from each clutch ring and movable axially of said screw shaft, interleaved drive and driven clutch plates stacked between each pressure plate and clutch ring, a carrier journalled on said screw shaft adjacent each pressure plate and to which said drive plates are connected, and finger means pivoted on each carrier and connected to respective levers for rocking motion in response to oscillation of the levers in one direction to bear against and axially shift said pressure plates toward said clutch rings.

8. In a vehicle as defined in claim 7 including means for selectively controlling the rocking motion of said finger means to effect relatively reverse rotation of said screw shaft.

9. In a vehicle as defined in claim 8 wherein the last means is a cam plate adjacent each carrier and surrounding said screw shaft, each cam plate being rotatable and having spaced cam elements thereon for selectively blocking one direction of rocking movement of said finger means.

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