Feb. 24, 1953 H. J. NICHOLS 2,629,451

CONTROLLABLE PITCH PROPELLER

Filed Dec. 17, 1945 2 SHEETS—SHEET 1

Fig. 1.

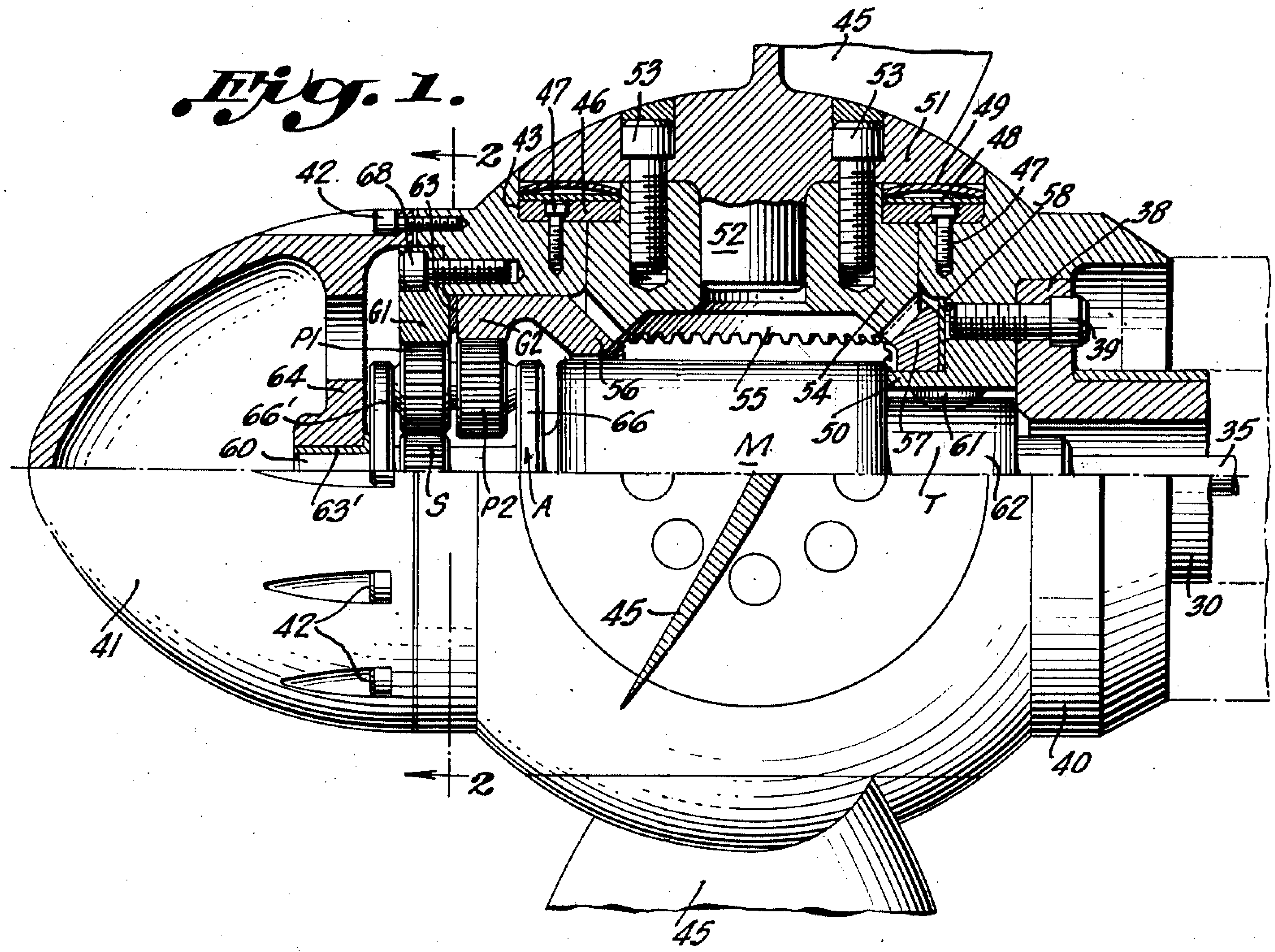
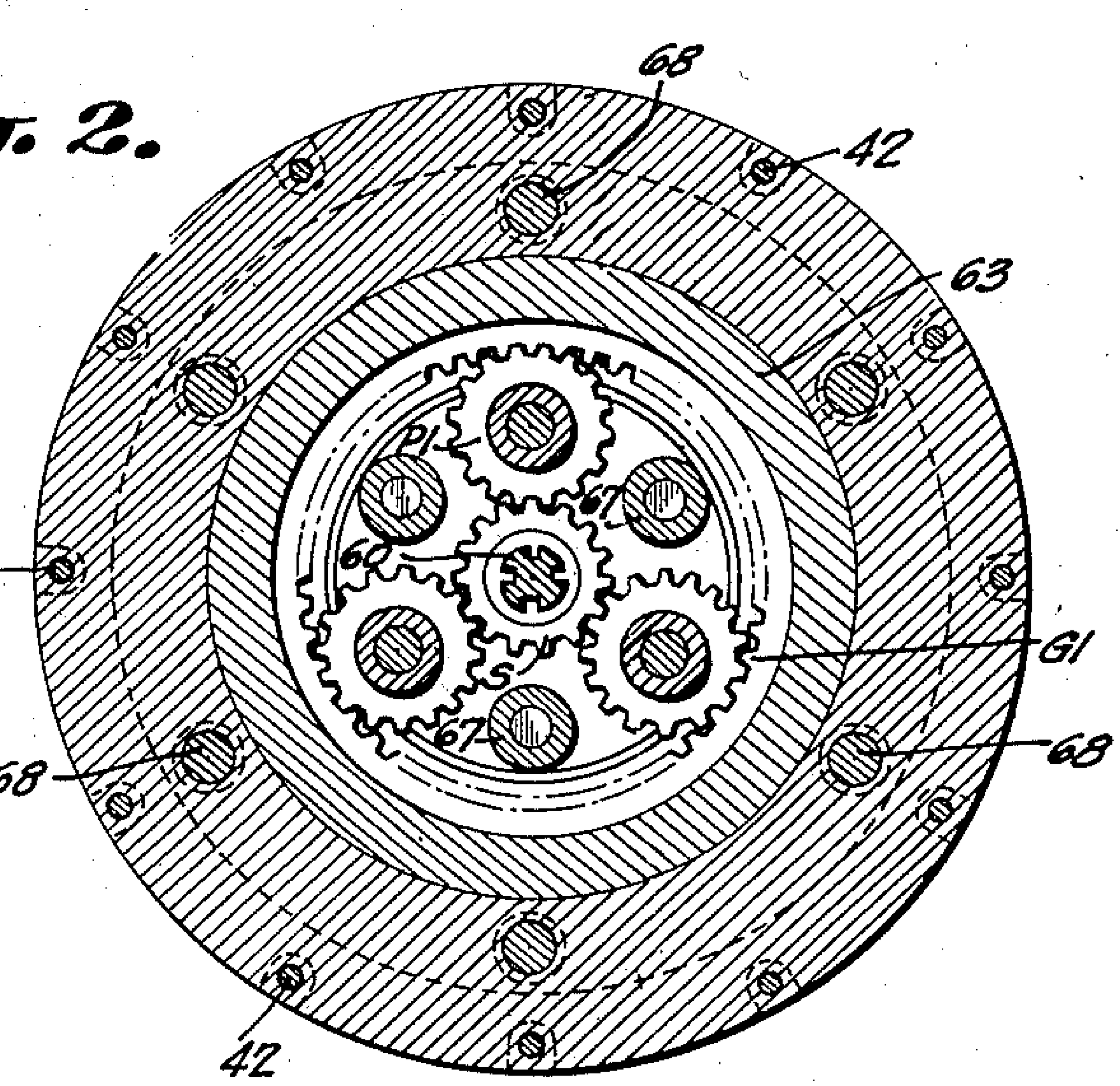


Fig. 2.



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CONTROLLABLE PITCH PROPELLER

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Fig. 3.

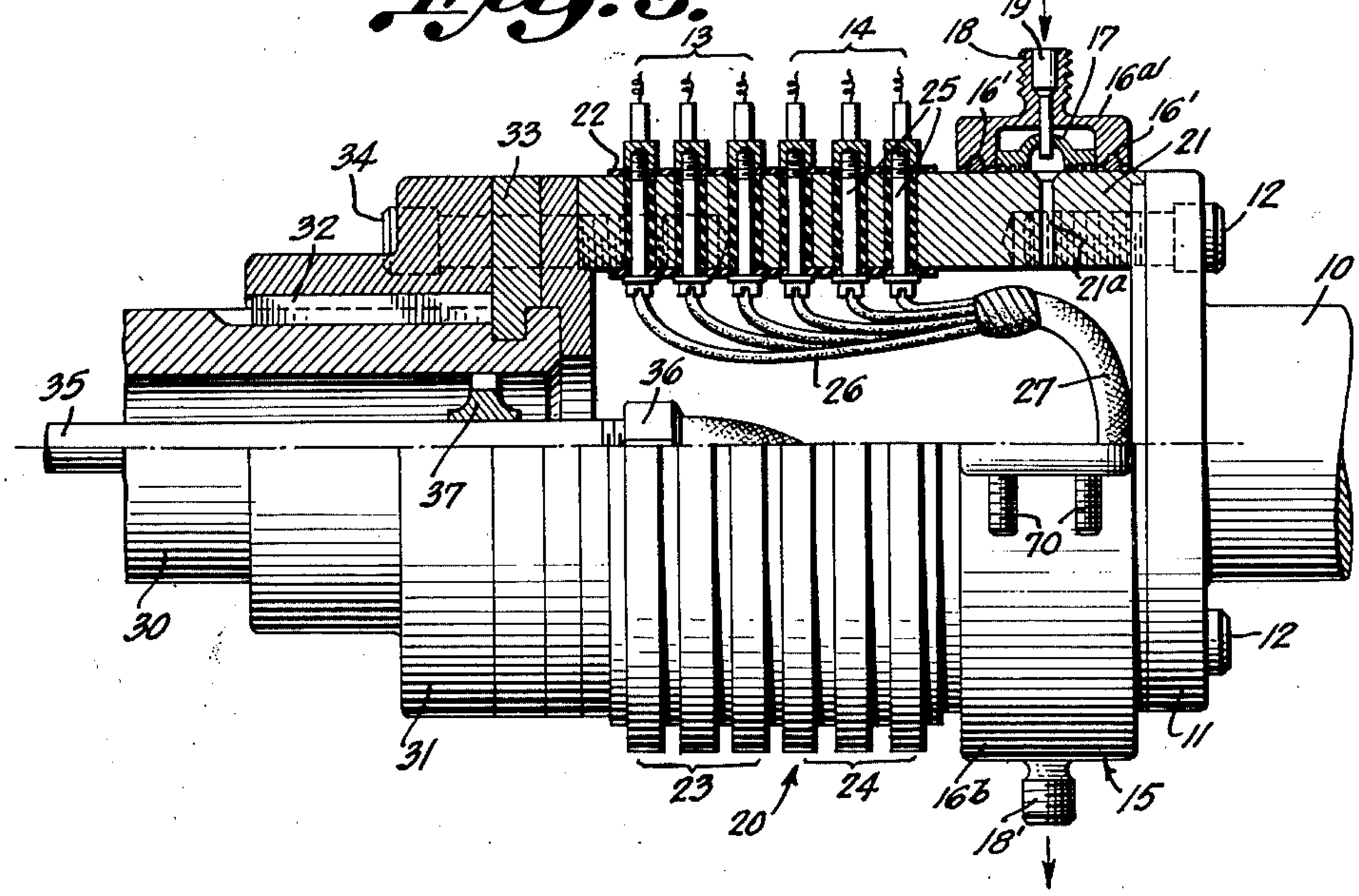
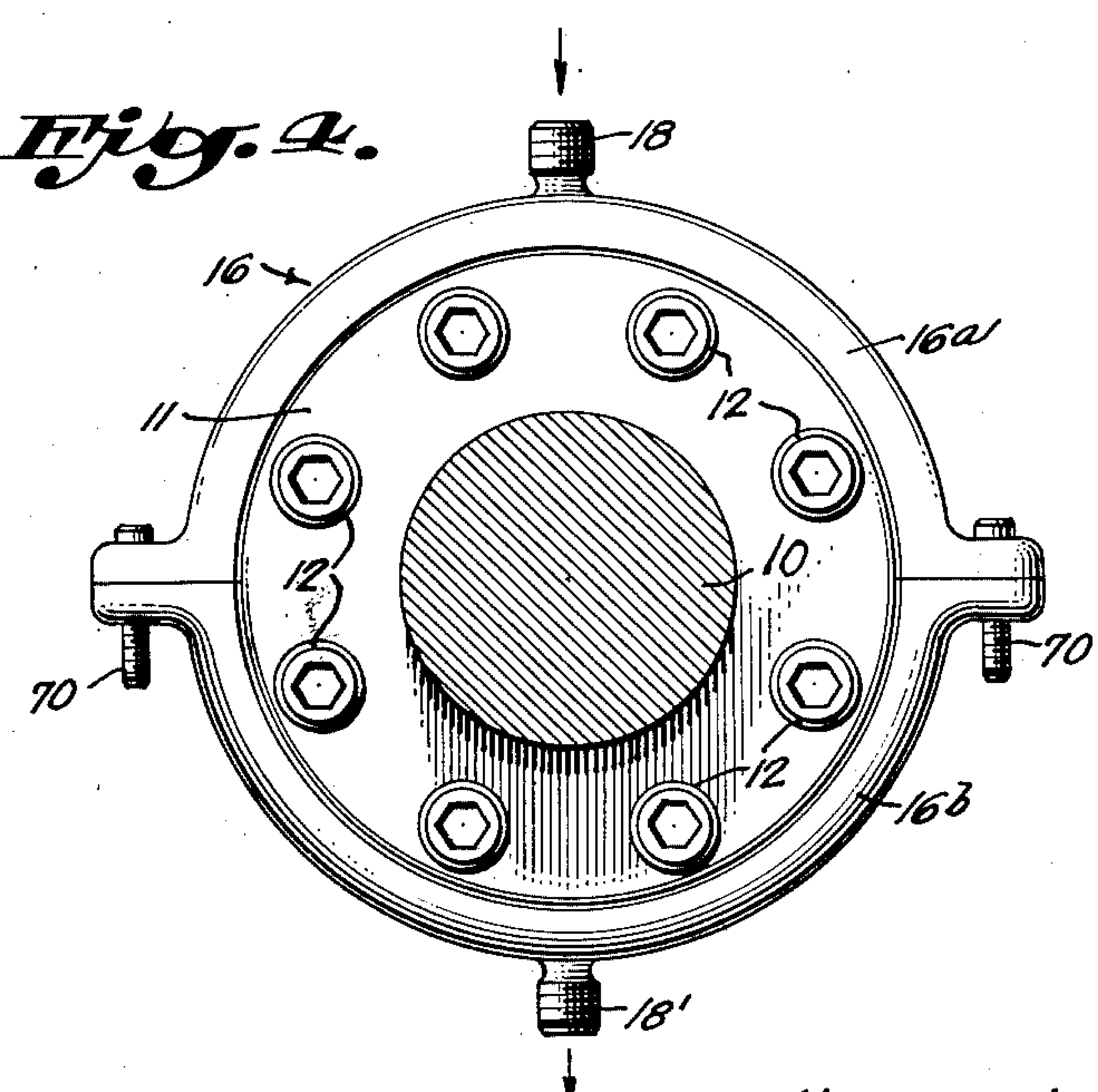


Fig. 4.



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CONTROLLABLE PITCH PROPELLER

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10 Claims. (Cl. 170—160.3)

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This invention relates to controllable reversible pitch propellers, and particularly to such propellers for marine use, and has for one of its principal objects the provision of a propeller of the character described in which the pitch of the blades can be quickly and accurately regulated while the propeller is in rotation under load and in which the blades will be automatically locked against displacement from the pitch to which they have been set during such regulation.

I am aware that numerous variable pitch marine propellers have been proposed and a few have actually been built and put into use. In each instance, however, insofar as I am aware, the variable pitch marine propellers which have been proposed or put into use have been characterized by complexity, bulkiness, abnormal hub size, excessive weight and cost, and other practical objections and disadvantages which have prevented their adoption for general use. I am further aware that it has heretofore been proposed, by means of an electric motor and speed reducing gearing, to vary the pitch angle setting of the blades of a marine propeller. This latter type of pitch varying mechanism undoubtedly offers the possibility of largely overcoming the main objections and disadvantages recited above, and of meeting the need for a compact, reliable, and not too complicated and expensive variable pitch propeller. However, the prior art has not succeeded in devising compact gearing or other mechanism of sufficient torque augmenting power to enable a motor and associated mechanism of practical size to be employed for such pitch changing purposes. The present invention relates, therefore, to improvements in this particular type of variable pitch marine propeller development.

One of the principal requirements of a controllable and reversible propeller of variable pitch type, in which a motor actuates the pitch changing mechanism to vary and set the pitch, is that the actuating mechanism between the motor shaft and the blade roots should greatly augment the motor torque (say between 2000 to 5000 times) without, however, introducing an excessive overall speed-reduction in the mechanism. It has been found by recent experiments that the torque which must be applied to the blade roots to vary the blade pitch while the propeller is operating at full speed and load (and particularly when reversing the pitch under these conditions) is very great, exceeding in some cases one-half the propeller shaft torque. The application of torque of this relative magnitude to the blades obviously requires mechanism of great strength and rigidity. Further, in order to reverse the blade pitch for emergency maneuvering, the mechanism must be relatively quick acting. Furthermore, in order to permit of automatic regulation of the blade pitch, as for example by

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a speed governor, it is essential that the pitch actuating mechanism be self-locking in any position to which the pitch is set.

By my use of a novel compound planetary differential gear system, the desired augmentation of the motor torque, quick reversing, and self-locking action are obtained in combination with compactness, simplicity, rigidity, reliability, high efficiency, and reasonable cost. Such use lends itself to a construction in which the torque augmenting mechanism can be located completely within the hub itself, and the motor can also be located within the hub in direct driving relation to the gearing.

The present invention thus contemplates an arrangement of pitch actuating mechanism in which the torque augmenting gearing as well as the blade actuating gearing are wholly enclosed in the hub per se, and in which the pitch actuating motor can also be located in the hub, whereby the pitch of the blades can be quickly and positively varied while the propeller is rotating at full speed and power.

It is therefore a principal object of the invention to provide a novel combination of gearing specially adapted to meet the requirements for a propeller of the class described and characterized by a unique combination of the qualities of compactness, simplicity, strength, high torque-gain, and self-locking action.

Another object is to provide a controllable pitch propeller system which can be readily applied to existing propulsive installations with the minimum of modification of existing components and arrangements, thus securing substantial economies by modernizing marine installations already in service by the application of controllable pitch propellers thereto.

A further object is to provide an exceptionally simple, compact, and powerful blade actuating mechanism which is economical to manufacture, easy to install and service, and which will ensure reliable operation for long periods without special attention or maintenance.

A further object is to provide a strong and rigid pitch varying mechanism which eliminates any possibility of flutter or vibration of the blades in operation due to excessive elasticity or back-lash in the pitch varying mechanism.

A further object is to provide a pitch varying system of unlimited angular range, including full-feathering and reversing of the blades, which is capable of changing the blade pitch in micrometric increments, yet also is capable of changing the pitch at a rapid rate for maneuvering and meeting emergencies.

A further object is to provide a pitch regulating system whose operating speed is independent of the speed of rotation of the propeller shaft.

A further object is to provide a blade pitch-changing motor and mechanism located entirely in the hub whereby the stresses due to the twisting moment of the blades under load are confined to the hub, and at the same time a rigid and powerful blade actuating mechanism of minimum size, inertia, and cost is obtained.

It has heretofore been proposed to mount a pitch changing motor for a variable pitch propeller in a shaft coupling, and also in the hub cap, but it is believed to be novel in the art to mount such a motor entirely within the hub as contemplated by the present invention, thereby obtaining various advantages as will become apparent as the description proceeds.

With these and other objects in view, as well as other advantages incident to the improved construction, the invention consists in the various parts and combinations thereof set forth and claimed, with the understanding that the several necessary elements constituting the same may be varied in proportions and arrangement without departing from the nature and scope of the invention as defined in the appended claims.

To enable others skilled in the art to comprehend the several underlying features of this invention, that they may embody the same by suitable modifications in structure and relation to meet the various practical applications contemplated by the invention, drawings showing a preferred embodiment of the invention form part of this disclosure, and in such drawings, like characters of reference denote corresponding parts in the several views in which:

Fig. 1 is a longitudinal half-sectional view of a propeller hub embodying the invention.

Fig. 2 is a transverse section taken on line **2—2** of Fig. 1.

Fig. 3 is a longitudinal half-sectional view of a drive shaft coupling embodying certain features of the invention.

Fig. 4 is an end view of the shaft coupling shown in Fig. 3.

Referring now to the drawings, and particularly to Figs. 3 and 4, a preferred construction of a controllable pitch propeller embodying the invention is shown as comprising a main drive shaft **10**, as for example the power output shaft of a propulsion prime mover, having a collar or annular flange **11** upset or otherwise provided thereon at its output end; and a tubular propeller shaft **30** having mounted thereon a demountable flange **31** fixed against rotary movement by means of a key **32** and against longitudinal movement by a split locking ring **33** seated in a groove formed in propeller shaft **30** as shown. The two shafts are rigidly connected in driving relation by means of a novel unitary flange coupling **20**, the main structural component of which is a hollow cylinder or barrel **21**. Flange **11** is preferably strongly fixed to barrel **21** by a circular series of socket-head cap screws **12**, passing through longitudinal holes in that flange; while flange **31** is likewise fixed to barrel **21** by similar socket-head cap screws **34** passing through flange **31** and ring **33**, although conventional through bolts and nuts can of course be used to clamp the flanges and barrel tightly together in driving relation if such construction is preferred.

For purposes of electrical current supply to the pitch actuating motor M and the electrical pitch transmitter T mounted in the propeller hub, as hereinafter described, there are suitably mounted on the exterior of barrel **21** but insulated therefrom by an insulating band **22** two series of three conducting slip rings designated by **23** and **24** respectively; and mounted to ride thereon are two

groups of three brushes designated by **13** and **14** respectively. Since the construction of brush holder assemblies is well known and not a part of this invention, the brushes **13** and **14** are shown schematically and the brush holders therefor are omitted. Insulated metal bolts **25** fix slip rings **23** and **24** in position on barrel **21** and also provide conducting paths from these rings to the oil-proof, insulated conductors **26** which are bound together in a sheath in well known manner to form an insulated cable **27**. A conduit **35** is mounted coaxially in the bore of propeller shaft **30** by means of perforated spacers **37** (one of which is shown while others are suitably located along the length of the bore) for carrying cable **27** to the hub **40**. (See Fig. 1.) A sealing cap **36** is screwed on the end of conduit **35** and serves to seal the point of entry of cable **27** against the entrance of oil into the conduit.

The unitary flange coupling **20** is also provided with rotary shaft sealing means **15** to enable lubricating oil to be supplied to the mechanism housed in the hub. Lubricating oil is supplied to the sealing means from a tank located above the water line by suitable piping in well known manner and therefore not shown. The lubricating oil fills all the void spaces in the coupling, propeller shaft, hub and pitch actuating motor M for the three-fold purpose of providing continuous oil lubrication to all the bearings and working points, conducting heat away from the motor windings, and maintaining a certain hydrostatic pressure in the hub to ensure that water will not enter the hub in event of seepage or leakage at the hub joints or packings. The rotary shaft sealing means comprises a ring housing **16**, preferably split into two halves, provided with two shaft packing rings **16'**, of say felt; and an internal hollow sealing ring **17** fit closely but rotatably to the periphery of drum **21** and having annular labyrinth grooves disposed around the internal surfaces which bear on the periphery of the drum to impede the leakage of oil therebetween. The upper half **16*a*** of the split housing **16** is provided with a threaded nipple **18** adapted for assembly with a suitable pipe fitting of commercial type. A nozzle **19** is tightly fit in the bore of nipple **18** and extends through a closely fit hole in the shell portion of sealing ring **17**, thereby to provide a port of entry for oil into the sealed space within ring **17**. Suitably placed radial holes **21*a*** drilled in barrel **21** provide passage for the oil from the sealing ring into the interior of coupling **20**. The lower half **16*b*** of the split housing is provided with a second threaded nipple **18'**, similar to entrance nipple **18**, but the nozzle **19** and the hole in the inner sealing ring are omitted, whereby nipple **18'** serves as an exit port or drain for any oil which may leak from the inner sealing ring **17** into the housing **16**. It is assumed that suitable piping is provided from nipple **18'** to an oil sump, from which the oil drained from the housing is returned to use. Since there is no oil pressure within the housing, it will be evident that the role of soft packings **16'** is merely to prevent seepage of oil along the surface of drum **21**, the inner sealing ring **17** constituting the effective oil seal with respect to the coupling barrel. Housing **16** is mounted by screws **70** on stationary supporting means (not shown). It will be apparent to those skilled in the art that the novel rotary oil sealing means described is characterised by structural simplicity, ease of manufacture and assembly, and long wearing qualities.

Referring now to Figs. 1 and 2, which show one form of propeller hub construction according to the invention, such includes a main hub member 40, herein for brevity termed a "hub," and a hub cap 41 which closes the outboard end of the hub, said hub being rigidly affixed to flange 38, upset or otherwise provided on the outboard end of propeller shaft 30, by a series of circularly arranged bolts 39 (one being shown) or otherwise as desired. The hub cap 41 is secured to hub 40 by a plurality of longitudinally disposed cap screws 42 as shown, or otherwise as desired. Hub 40 has a plurality of radially extending circular openings or blade sockets 43 (four in the case illustrated) each adapted to mount rotatably a blade 45 by means presently to be described. Each blade socket is step bored to receive a closely fitted locking ring 46 adapted to be secured therein by multiple cap screws 47 as shown. A flat, thin cover ring 48 is placed in the blade socket to cover the heads of cap screws 47; and a sealing ring 49, having a slightly arched section to provide a limited amount of resiliency when subjected to pressure, is placed in the socket over the cover ring to abut against the boss portion 51 of blade 45, which latter is also provided with an axial stub shaft 52. Secured to each blade by a plurality of cap screws 53 seated in counter-bored holes through the boss 51 is a gear ring 54 having a bevel gear 55 formed thereon and mounted in the inner bore of the blade socket for intermeshing engagement with a master bevel gear 56 mounted axially and rotatably in an axial bore of hub 40. A second ring bevel or unison gear 57 may be rotatably mounted on an internal boss 50, formed from the back wall of hub 40, for meshing engagement with the blade bevel gears 55, whereby the rotation of the blades in unison is assisted in event of binding of the blade mountings, although this unison gear is not essential under normal operating conditions. In case the unison gear 57 is used, a ring thrust washer 58 is preferably provided between the back of the unison gear and the hub wall, as shown, to reduce friction and to provide an adjustable and renewable thrust bearing surface at that point.

The blades 45 are assembled in the blade sockets 43 of the hub in the following manner: The thrust washer 58 is first assembled in the position shown over the boss 50 of hub 40, and then unison gear 57 is assembled on boss 50 in the position shown. A blade gear-ring 54 is then dropped into position in predetermined angular relation, with the bevel teeth 55 thereof in mesh with the teeth of the unison gear 57. The locking ring 46 is next placed in the socket and the cap screws 47 screwed tightly into place, followed by cover ring 48 and sealing ring 49. The stub shaft 52 of a blade is then entered into the bore of gear ring 54 and the blade turned until the counter-bored bolt holes in the blade boss 51 align with the proper tapped holes in the ring 54, whereupon the cap screws 53 are entered in these aligned holes and screwed tightly in place. The sockets in the heads of the cap screws are then preferably filled with a non-corrodable fusible alloy, as for example plumber's solder, by the customary tinning and casting process; the bolt holes also being entirely filled and then filed smoothly to the contour of the boss, thereby to prevent loosening of the cap screw, to seal the bolt holes, and to provide a smooth external surface for the blade boss.

The unison gear 57 and the master bevel gear 56 are preferably provided with a number of teeth divisible by the number of blades, and the blade bevel gears 55 with an even number of teeth, whereby all the blades, gears, rings, bolt holes, and other components and details can be constructed in identical manner for interchangeable assembly. The construction described provides the practical advantages of fully interchangeable blades and blade mountings, and also facilitates accurate coordination of the pitches of the individual blades. In the event one or more blades are damaged in service, a new blade can be fitted merely by removing the cap screws and the damaged blade, placing the new blade in position, replacing and tightening the cap screws, and resealing the bolt holes as before. The rest of the hub mechanism need not be disturbed during such blade replacement. It will be appreciated by those skilled in the art that the facility with which blades can be assembled and replaced provides many practical advantages in manufacture, assembly, maintenance and repairs, resulting from the construction shown.

A pitch changing motor M is mounted within the hub 40 in the space bounded by the bevel gearing 55, 56 and with its axis and driving shaft 60 coaxial with the axis of the hub and the propeller shaft, thereby obtaining symmetry of the masses in the hub and preserving dynamic balance of the hub and its mechanism.

The pitch changing motor M is preferably a polyphase induction motor having a squirrel-cage rotor, in which case the motor frame can be of open type to enable the lubricating oil to circulate inside the motor for cooling and lubricating purposes. However, a totally enclosed motor of any type can be used, but less advantageously because of reduced heat-radiating ability. Since the motor itself can be any one of various well-known commercial types, showing the description of details thereof is deemed unnecessary.

Firmly secured to the end frame of motor M nearest the propeller shaft 30, or integral with the frame thereof if preferred, is a cylindrical housing 62 adapted to house in a sealed space therein an electrical transmitter T comprising part of an electrical pitch indicating system, which system however is not a part of the present invention. An electrical pitch controlling and pitch indicating system suitable for use with the present invention and with the motor submerged in the hub is fully shown and described in my copending application Serial No. 618,643, filed September 26, 1945. For present purposes, it is to be understood that motor M is provided with an extension shaft adapted to actuate the electrical transmitter T sealed in housing 62, and that electrical connections to that transmitter and to motor M are provided by the cable 27 in conduit 35 which terminates in housing 62 in the manner shown. Housing 62 also serves as a fixed mounting means for motor M in hub 40 as shown, relative rotation thereof being prevented by a key 61 as shown.

The power output shaft 60 of motor M provides actuating torque for a torque-increasing compound differential gear mechanism comprising a main feature of the invention and now to be described with particular reference to Figs. 1 and 2. Power output shaft 60 is rotatably mounted in a bearing 63 supported in a spider 64 of cap 41 and has tightly fixed thereon a driving sun pinion S. A planetary carrier A, comprising two discs 66, 66′ held firmly in spaced parallel position by pillars 67 (see Fig. 2), carries a plurality of compound planet pinions P1 and P2 rotatably mounted on axles supported by the discs. Three pairs of compound pinions are shown in Fig. 2, but two or more pairs may be used, depending upon load conditions. Each pair of pinions P1, P2 are preferably made integral, but if not, they must be tightly assembled against relative rotation on an axle or quill shaft. Pinion P1 is in meshing engagement with a stationary internal gear G1 fixed to hub **40** by cap screws **68**; while pinion P2 is in meshing engagement with rotatable driven internal gear G2 integral with master bevel gear **56**. A thrust washer **63** is mounted between gears G1 and G2 to take the axial reaction thrust of bevel gear **56**.

To secure smooth running of the gear trains and self-locking action, it is preferred that the circular pitches of the gears in train S, P1, G1, and train P2, G2 respectively, be approximately in the ratio G2—P2/G1—P1.

The planetary compound differential gear train of the invention is characterized by its compactness and simplicity, by the large torque gain readily obtainable thereby, and by the unusual combination of high efficiency and self-locking action. The following example will illustrate the computation of a typical gear ratio:

Let the sun pinion S have 16 teeth, the meshing planet pinion P1 have 17 teeth, the compound planet pinion P2 have 16 teeth, the stationary internal gear, hereafter termed orbit gear G1, have 50 teeth, and the driven internal gear, hereafter termed orbit gear G2, have 47 teeth. For one turn of sun pinion S, which acts as the primary driver element of the entire gear train, the rotation of the planetary carrier A will be:

$$\frac{S}{S+G1}=\frac{16}{16+50}=\frac{16}{66}=.2424 \text{ turn}$$

Considering next the planetary carrier A as the driving member of the gear train, one turn of the planetary carrier will, due to the differential action of compound planet pinions P1 and P2 meshing with gears G1 and G2 respectively, produce a rotation of driven gear G2 of:

$$1-\frac{P2\times G1}{P1\times G2}=1-\frac{16\times 50}{17\times 47}=1-\frac{800}{799}=-\frac{1}{799}$$

But since for one turn of the sun pinion S the planetary carrier makes $^{16}/_{66}$ of a turn, the relative rotation of G2 will be:

$$\frac{16}{66}\times\frac{1}{799}=-\frac{1}{3296} \text{ turn}$$

The minus sign indicates that the gear ratio is negative, that is, orbit gear G2 will rotate in the opposite direction to sun pinion S. Since the torque factor is equal to the inverse of the gear ratio times the mechanical efficiency E of the gear train we have:

$$\text{Torque factor}=3296\times E \text{ approx.}$$

It is known that the mechanical efficiency of a pair of meshing gears of proper material, form, construction and lubrication is approximately 98%, and since there are three pairs of meshing gears in the gear train, the efficiency E would be equal to $.98^3=.94$. Therefore, the

$$\text{Torque factor}=3296\times .94=3100X \text{ approx.}$$

Assuming next that the rated motor speed were 3240 R. P. M., the motor shaft torque per motor horse-power would be equal to:

$$\frac{63,000}{3,240}\times 1=19.4 \text{ lbs. inches/H. P.}$$

and the torque delivered by the gear train would be:

$$3100\times 19.4=60,500 \text{ lbs. inches/H. P. approx.}$$

Assuming further that a pitch change of 60° represents a full pitch-reversal from ahead to astern, the reversing time from full-ahead to full-astern would be:

$$\frac{3296}{3240}\times\frac{60}{6}=10.2 \text{ seconds approx.}$$

In like manner, various combinations of pinions and gears may be selected, by following the teaching of the invention, to suit a wide variety of desired torque factors and rates of pitch change.

The sample calculations given above are illustrative of the torque-increasing power and substantial advantages of the high efficiency, high torque, compact gearing of the present invention. Obviously, with such large torque/H. P. ratios available, an exceptionally small and high-speed motor M can be used to advantage and yet the pitch can be changed at a rapid rate thereby when the propeller is in rotation under full load. It is thus evident that the efficient torque increasing gearing of the invention makes it possible and practicable to locate the pitch changing motor entirely within the constricted confines of the hub, thereby securing the benefits of maximum structural rigidity, with minimum size, inertia, and cost of the pitch changing mechanism.

An additional important advantage arises from the self-locking action of the planetary compound differential gear train of the present invention. It is well established that the reaction of the propeller blades due to centrifugal force and fluid reaction forces produce a very powerful twisting moment tending to turn the blades axially when the propeller is in rotation under full load. This twisting moment is transmitted by the blade gears **55** to master gear **56**, and therefore tends to rotate driven gear G2 relative to stationary gear G1. With the gear train of the present invention, the gears G1 and G2 are cut nearly to the same pitch circle, as are likewise pinion P1 and P2, despite the different number of teeth in these pairs. Hence the effect of this twisting moment acting to turn gear G2 relative to G1 is to produce opposing tangential shear forces on the pinion teeth; but since these pinions are either made integral or are non-rotatably assembled on a common axle, the shear force described causes the pinions to act like keys between the two gears, locking these gears together rigidly against any counter-torque less than the shear value of the gear teeth. Due to the self-locking action described, the blade twisting torque is absorbed by the teeth of gears G1, G2, and pinions P1, P2, hence there is no tendency for sun pinion S, nor the motor shaft **69**, to be rotated by the blade reaction. Consequently, the blade pitch is maintained by the differential gearing as set by the pitch actuating mechanism. Otherwise, complicated braking means, or the equivalent, would have to be applied to the motor shaft or gear train members to prevent counter-rotation by the blade reaction and creep of the blade pitch from the set position. This would greatly complicate, if not render entirely impractical, any construction for mounting the pitch changing motor in the hub. It thus becomes apparent that the self-locking characteristic of the compound differential gearing of the invention, as well as the high torque efficiency thereof, is a vital factor in providing the characteristic simplicity and practicality of the construction of the invention.

The operation of the pitch changing mechanism of the invention is as follows: Pitch controlling means not shown, as for example that shown and described in my copending application Serial No. 618,643, filed September 26, 1945, applies electrical current to the brushes 13 which current is conducted by slip rings 23, via conductors 26 of cable 27, to motor M to energize same in one direction or the other. Motor shaft 60 rotates accordingly to drive sun pinion S, which in turn drives pinion P1 in mesh with stationary internal gear G1 to produce rotation of planetary carrier A. As planetary carrier A revolves, pinions P1 and P2 planetate in gears G1 and G2 respectively, producing creeping differential rotation of gear G2 relative to gear G1 due to the differential gear action previously described. Gear G2 rotates master bevel gear 56 integral therewith, which latter in turn rotates the blade bevel gears 55 to vary the pitch of the blades in unison. When the motor current is cut-off, the motor shaft quickly stops and due to the self-locking action of the differential gearing as previously described, the blade pitch remains in the set position until subsequent pitch-changing as described.

It is to be noted that the blades are rigidly positioned by the blade mountings and the teeth of the bevel gears, internal gears, and pinions. All the gear teeth in the gear train can be cut with a minimum of back-lash, and since there are no elastic members in the primary blade actuating mechanism, flutter or vibration of the blades due to excessive back-lash or elastic strain is effectually suppressed. Further, since the blade reaction stresses are confined to the hub, there is no possibility of critical vibration effects due to elastic shaft reactions, etc. thereby avoiding troublesome vibratory effects which have heretofore been experienced in applications of the prior art.

Concurrently with the pitch changing action described above, the motor M drives the electrical transmitter T, which latter produces electrical indications of the direction and degree of the blade pitch change. These electrical indications are transmitted by the conductors of cable 27 and the associated slip-rings and brushes to remote receiving apparatus, as for example that shown in my copending application Serial No. 618,643, filed September 26, 1945, where the indications are utilized for pitch indicating and automatic follow-up control purposes.

It is to be noted that the pitch changing system of the invention enables the blade pitch to be set to any angular position, since there is no mechanical limitation on the axial rotation of the blades. Consequently, the blade pitch can be set, by suitable motor control means, to neutral pitch, to all forward and reverse operating pitches, and to "full feathered" pitch in the ahead or reverse semi-circles. Pitch range limitation, or so-called "pitch-block," can be set by appropriate means forming part of the pitch control apparatus; but if the limits so set are exceeded, there is no possibility of jambing, deranging, or damaging the pitch changing mechanism. Thus the important objective of unlimited pitch range is secured, so far as the pitch changing mechanism of the invention is concerned, thereby making this mechanism suitable for universal application.

It is of course obvious that the rate of pitch change is entirely independent of the propeller shaft speed, and therefore pitch change can be accomplished with equal facility and speed whether the propeller shaft be at rest or in rotation at full speed. It is also apparent that by providing a gear system of high efficiency, by providing a pitch changing motor and mechanism of low inertia, by eliminating external mechanical connections, by confining the operating forces to the propeller hub, and by inherent simplicity, economy, reliability, and compactness, the controllable pitch propeller system of the invention overcomes the main disadvantages which have heretofore limited the practical application of electro-mechanical variable pitch propellers of the prior art.

Without further description, it is believed evident that the mechanism of the invention provides a powerful, efficient and practical means for varying the blade pitch under all operating conditions. It is also to be particularly noted that the construction of controllable reversible pitch propellers provided by the invention is readily adaptable to the modernization of vessels having fixed blade propellers without extensive alteration of conventional propulsion arrangements.

I claim:

1. A variable pitch marine propeller organization comprising, in combination, a propeller hub structure including a main hub member having an axial bore and a radial socket for each blade; blades each having a spindle rotatably secured in bearings in a blade socket; a bevel blade gear fixed to each blade spindle; a bevel master gear journaled rotatably in said axial bore and meshing in driving relation with said blade gears; a reversible motor mounted in the bore of said hub member and generally within the space bounded by said bevel blade gears; and a differential planetary gear train mounted substantially within said hub member outwardly of said motor and comprising a sun pinion driven by said motor, an internal ring gear fast to said hub member, a driven internal gear fixed to said master bevel gear, and planetary pinions carried by a rotary carrier mounted axially in said hub and driven by said sun pinion and meshing with said internal gears, said gear train being adapted and connected to receive driving torque from said motor and to deliver greatly increased driving torque to said master gear, thereby to vary the pitch of the blades.

2. A variable pitch marine propeller organization combining a propeller hub member adapted for mounting on the end of a shaft and having an axial bore and radial blade sockets; blades each having a root portion journaled for pitch changing movement in a socket; a bevel blade gear fixed on the inner end of each of said root portions; a bevel master gear journaled coaxially within said axial bore and meshing in driving relation with said blade gears; a torque increasing differential planetary gear train mounted substantially within said hub member and having a driving connection to said master gear; and a reversible electric motor mounted in the bore of said hub member and substantially within the space bounded by said bevel blade and said bevel master gears and having a driving connection to said planetary gear train for effecting blade pitch change.

3. A variable pitch marine propeller organ-

ization combining a propeller hub structure including a main hub member for mounting on a shaft and having an axial bore; blades each having a part secured in bearings in said hub member for pitch change; a bevel blade gear fixed to the inner end of each said part; a bevel master gear journaled rotatably in said hub member and meshing in driving relation with said blade gears; a reversible motor mounted in the bore of said hub member and generally within the length of the bore bounded by said blade bevel gears; and a speed reducing differential planetary gear train mounted substantially within said hub member and having a driven connection to said motor and a driving connection to said master gear, whereby the pitch of the blades can be changed upon operation of said motor.

4. In a variable pitch propeller organization, in combination: a hollow propeller shaft; a propeller including a main hub member rigidly affixed to the outboard end of said shaft and a hub cap rigidly affixed to the outboard end of said hub member; blades mounted for axial rotation in said hub member for pitch change; bevel gearing for turning said blades axially mounted entirely within said hub; a reversible motor fixed within said hub member centrally with respect to said bevel gearing; and a high ratio differential planetary gearing mounted substantially within said hub member and having a driven connection to said motor and a driving connection to said bevel gearing, thereby to turn said blades axially in unison to change their pitch.

5. A variable pitch propeller system having, in combination, a hollow propeller shaft; a hub structure including a main hub member affixed to the outboard end of said shaft and a hub cap affixed to the outboard end of said hub member; blades mounted for axial rotation in said hub member; bevel gearing for rotating said blades mounted in said hub member; speed reducing differential planetary gearing mounted substantially within said hub member and having a driving connection to said bevel gearing; a reversible electric motor fixed centrally in said hub member and axially inwardly of said planetary gearing and having a driving connection thereto; coupling means for connecting said propeller shaft to a drive shaft; electrical circuits for conducting electric current to said motor to operate it in either direction extending from said motor and through said hollow shaft to said coupling means; and current conducting means carried externally by said coupling means for connecting an external source of current to said electrical circuits.

6. A variable pitch propeller comprising, in combination, a hub structure including a hollow main hub member for mounting on the outboard end of a drive shaft and a hub cap closing the outboard end of said hub member; radial blades each having a part secured in said hub member for axial rotation; a bevel gear fixed on each said part; a master bevel gear mounted coaxially and rotatably in said hub member and meshing in driving relation with the first-named bevel gears; a reversible motor fixed centrally and coaxially within said hub member; and differential planetary gearing mounted in said hub structure axially outward of said motor and operatively arranged and connected for greatly increasing the driving torque produced by said motor and transmitting same to said master bevel gear, thereby to turn said blades axially in unison to vary their pitch.

7. A controllable reversible pitch marine propeller combining a hollow hub member for mounting on a propeller shaft; a hub cap fastened tightly to the outboard end of said hub member; blades swiveled for axial rotation in said hub member; bevel gearing for rotating said blades axially enclosed entirely within said hub member; a motor fixed centrally within said hub member; and torque increasing differential planetary gearing mounted partly in said hub member and partly in said hub cap, said planetary gearing having a driven connection to said motor and a driving connection to said bevel gearing.

8. In a controllable reversible pitch propeller including a hollow hub structure including a main hub member mounting axially rotatable blades and a hub cap closing the outboard end of said hub member; power mechanism for rotating said blades and being substantially completely enclosed within said hub member, said mechanism comprising bevel gearing for angularly displacing said blades in unison mounted entirely within said hub member, a reversible motor fixed centrally within said hub member, and speed reducing differential planetary gearing operatively connected to be driven by said motor and to drive said bevel gearing mounted in said hub member axially outward of said motor.

9. A variable pitch propeller combining a hollow hub structure including a main hub member and a hub cap closing the outboard end of said hub member; blades mounted for axial rotation in said hub member; bevel gearing for displacing said blades angularly mounted entirely within said hub member; a reversible motor fixed centrally in said hub member; and a differential planetary gearing characterized by a high torque increasing ratio and self-locking action mounted in said hub structure axially outward of said motor, said gearing being operatively arranged and connected for transmitting and multiplying torque from said motor to said bevel gearing whereby the pitch of the blades may be set by operation of said motor and the self-locking action of said differential gearing will maintain the blades at the pitch so set.

10. A variable pitch propeller including a main hub member and a hub cap affixed to the outboard end of said hub member; blades pivoted for rotation in said hub member; bevel gearing for rotating said blades completely enclosed within said hub member; a reversible electric motor fixed substantially centrally within said hub member; and speed reducing differential planetary gearing mounted substantially within said hub member and having a driven connection with said motor and a driving connection with said bevel gearing, whereby the propeller blades may be rotated upon operation of the electric motor.

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