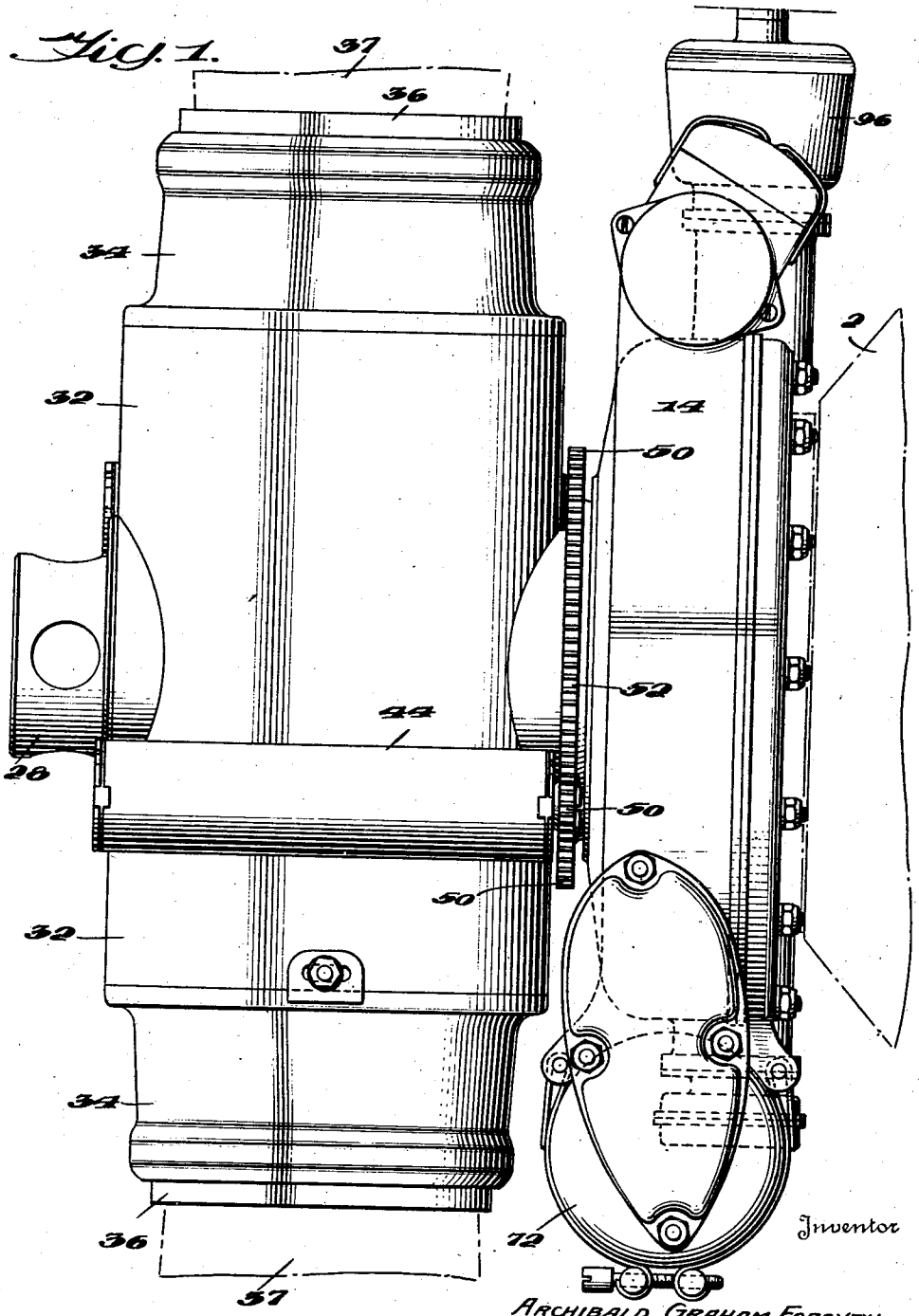
March 2, 1948. A. G. FORSYTH 2,437,188

SELF-CONTAINED VARIABLE PITCH PROPELLER UNIT

Filed Jan. 19, 1943 7 Sheets-Sheet 1

Fig. 1.



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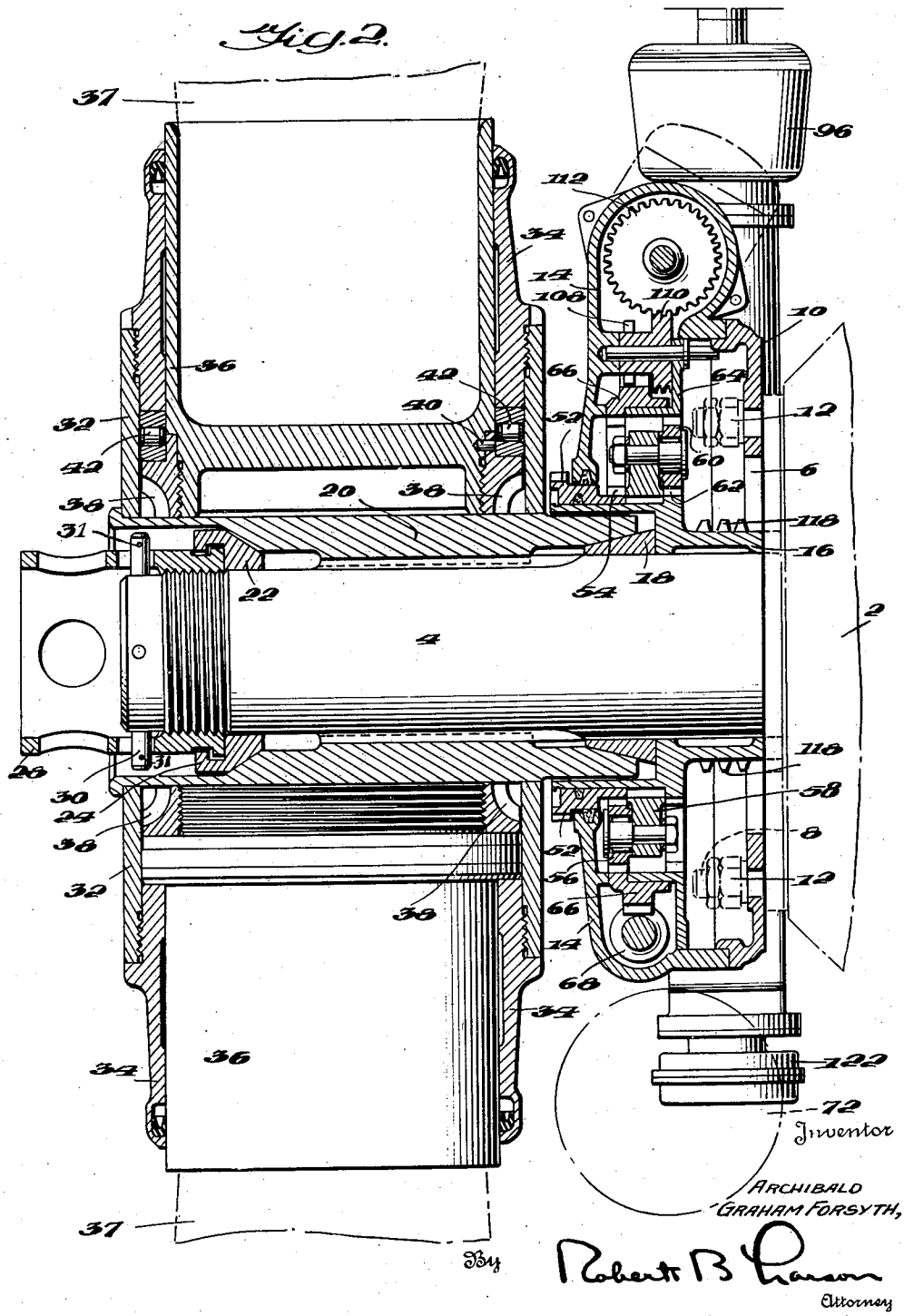
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SELF-CONTAINED VARIABLE PITCH PROPELLER UNIT

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Fig. 2.



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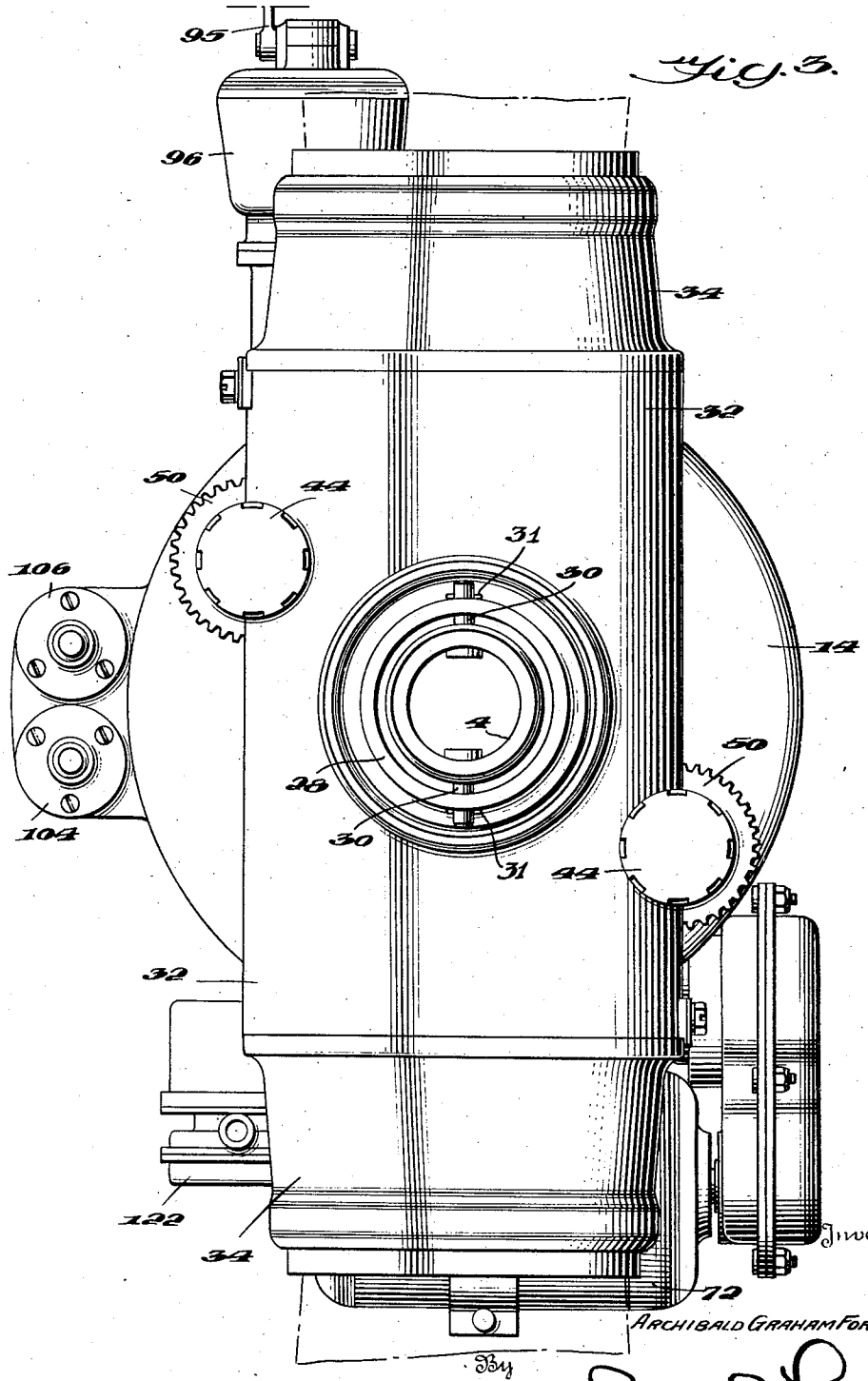
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SELF-CONTAINED VARIABLE PITCH PROPELLER UNIT

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Fig. 3.



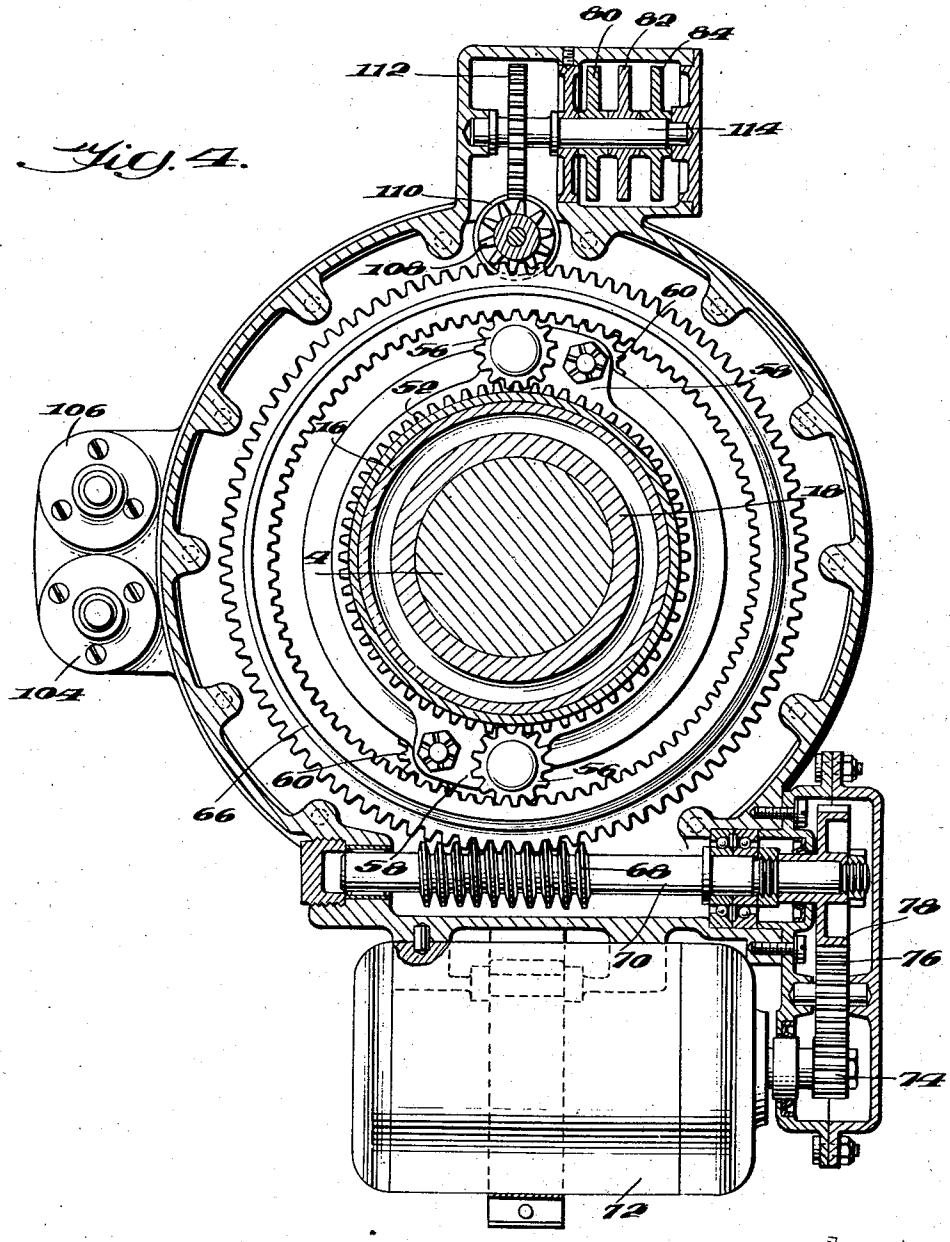
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SELF-CONTAINED VARIABLE PITCH PROPELLER UNIT

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Fig. 4.



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SELF-CONTAINED VARIABLE PITCH PROPELLER UNIT

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Fig. 5.

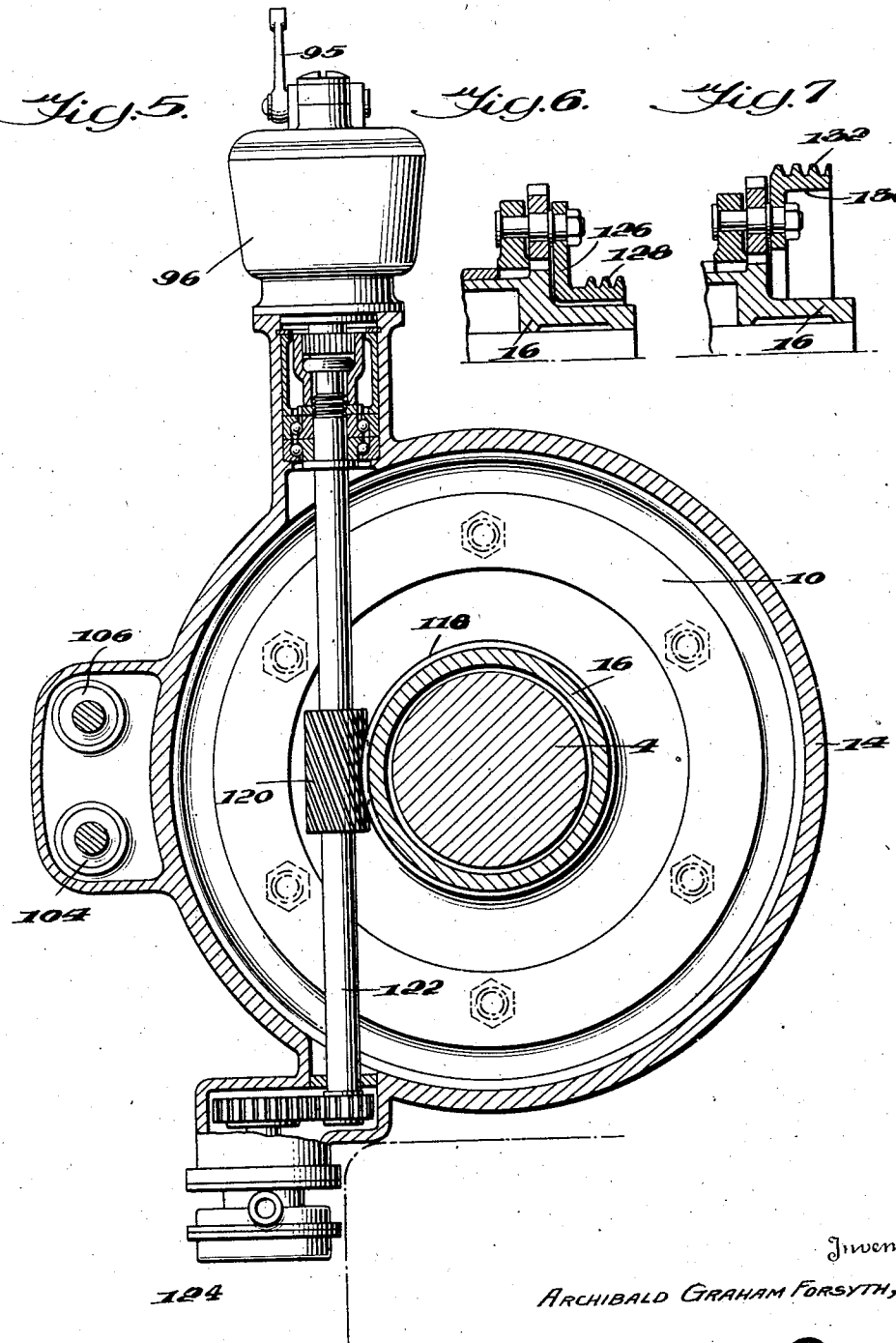


Fig. 6.

Fig. 7

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SELF-CONTAINED VARIABLE PITCH PROPELLER UNIT

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Fig. 8.

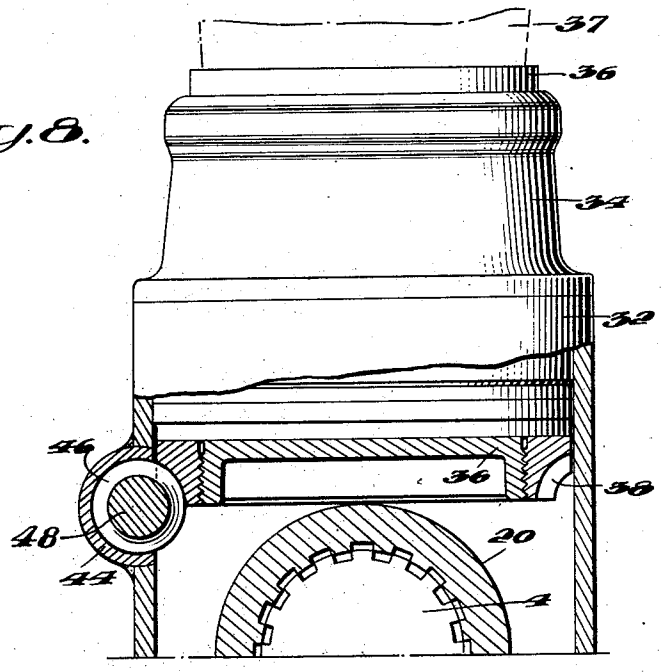


Fig. 9.

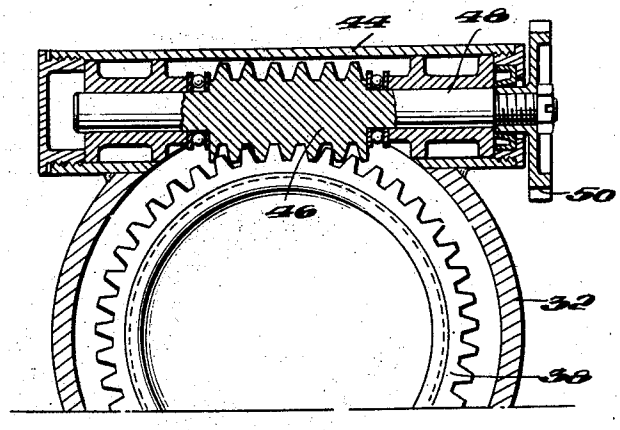
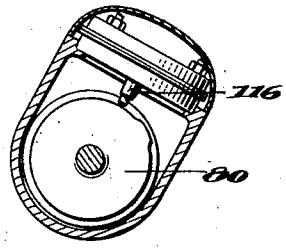


Fig. 10.



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SELF-CONTAINED VARIABLE PITCH PROPELLER UNIT

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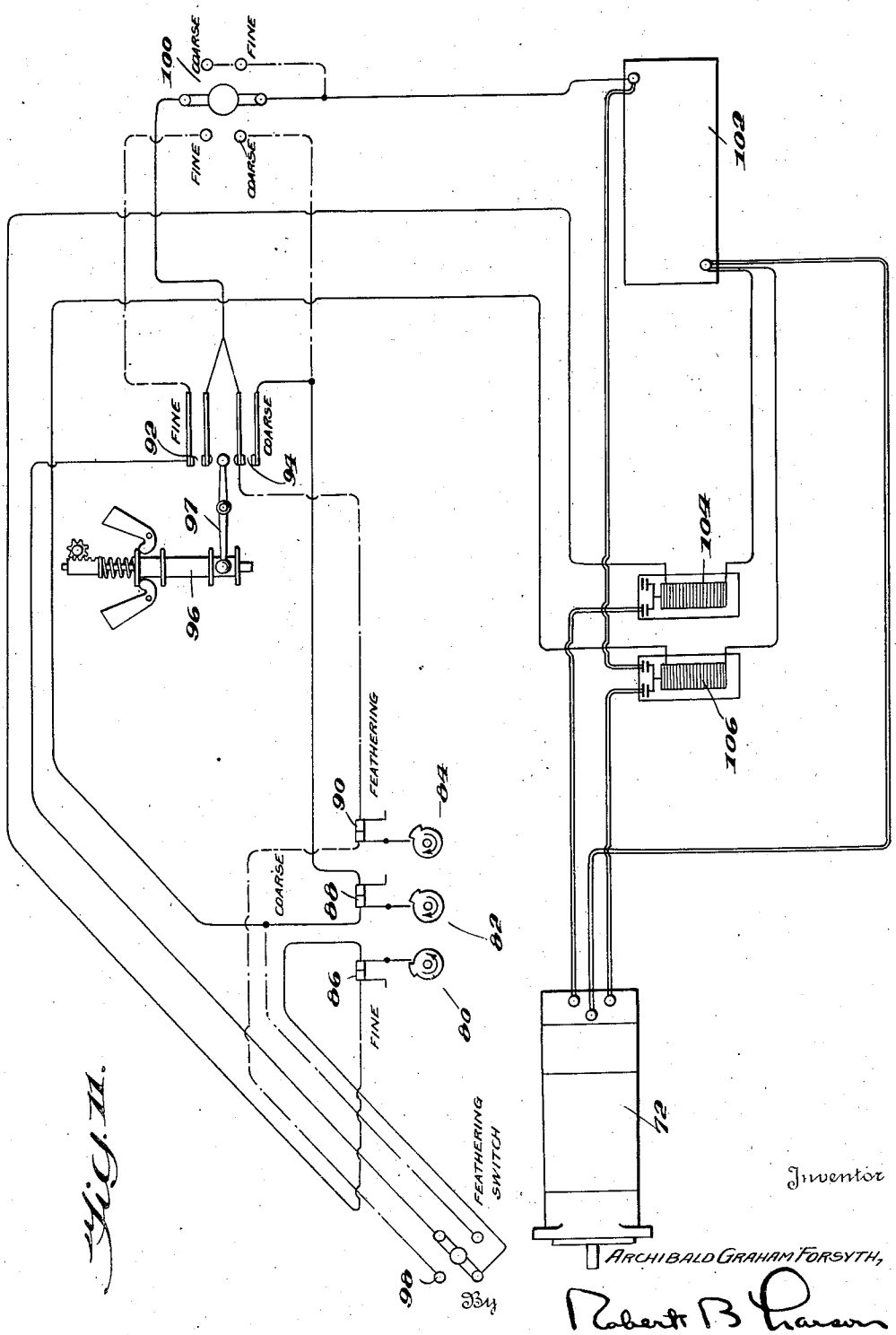


Fig. 11.

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2,437,188

UNITED STATES PATENT OFFICE

2,437,188

SELF-CONTAINED VARIABLE PITCH PROPELLER UNIT

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Application January 19, 1943, Serial No. 472,882

4 Claims. (Cl. 170—163)

1

This invention relates to variable pitch propeller systems and more particularly to a self-contained unit for variable pitch propeller systems.

In my copending application, Serial No. 449,123, filed June 30, 1942, I have illustrated and described a variable pitch propeller system having many advantages. The present invention from an operational standpoint possesses many features in common with that disclosed in the application to which reference has been made. However, the present invention comprises a self-contained unit which, as such, can be readily attached to any standard aircraft internal combustion engine of any power output. The unit is small in its dimensions, light in weight and comparatively simple to manufacture, to operate, adjust, assemble, take down and repair. The invention is so designed that upon mere assembly over the propeller drive shaft and simple attachment to the front facing of the engine, the device is ready for operation.

The device comprising the invention is a complete unit with its electric motor for changing the pitch, the governor, switches, solenoids and de-icing pump. The only connections necessary after installation on the propeller drive shaft being the electrical connections to the battery, the connection of the governor range control to the cockpit or cabin, and the pipes to the de-icing pump, if this be used.

It is the principal object of the invention to provide such a device. Another important feature of the invention resides in the particular disposition and arrangements of the parts, a feature presenting difficulties of attainment because of the severe requirements and space limitations. Units have been known heretofore but these have been complicated in structure, whereas the present invention eliminates complicated mechanism and results in a device which can be produced cheaply and easily maintained while admirably fulfilling all requirements of a modern propeller control arrangement.

Still another object of the invention resides in a self-contained variable pitch changing control unit adaptable for use with contra-rotating propellers mounted on co-axial drive shafts.

A further object of the invention resides in a unit for effecting a change of pitch of the propeller blades and for controlling the extent of change to suit various operating conditions, such unit being electrically or hydraulically driven by means carried by and comprising a part of the unit.

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The invention has for a further object the provision of a unit for variable pitch propellers, which unit can be completely tested before shipment. This is made possible by virtue of the fact that the unit does not depend on any auxiliary connections to, or driven by, an internal combustion engine. The present invention carries its own anti-freeze lubrication.

The device which will be described is particularly adapted for four engines in particular now in large scale production and in which no provision has been made on the engine to drive a governor, pumps, or for oil ducts or the like which are ordinarily required for the usual variable pitch propeller systems.

It is highly advantageous to provide a structure in which the propeller hub structure and propellers may be removed quickly for inspection. The invention provides for this in such manner as not to make necessary the removal or disturbing of the control unit mounted between the propeller hub structure and the engine.

These and other objects of the invention will be more apparent from the following description and claims when read in the light of the accompanying drawings in which:

Fig. 1 is a side elevation of the invention.

Fig. 2 is a vertical section through the device shown in Fig. 1.

Fig. 3 is a front elevation.

Fig. 4 is a cross sectional view taken on the line 4—4 of Fig. 1.

Fig. 5 is a cross sectional view showing the means for driving the governor and the de-icing pump.

Figs. 6 and 7 are sectional details showing alternate forms of gearing.

Fig. 8 is a partial view of the hub, a portion being broken away to show the gearing for effecting a change in pitch of the propeller blades.

Fig. 9 is a sectional view taken on the line 9—9 of Fig. 8.

Fig. 10 is a partial section of the cam operated switch mechanism, and

Fig. 11 is a diagrammatic showing of the control circuit.

The self-contained, easily assembled, electrically controlled unit comprising the invention is adapted, as shown in Figs. 1 and 2, to be mounted at the forward end of the internal combustion engine 2 about the propeller drive shaft 4. The unit is adapted to be fitted to the engine 2 without making any modifications in the engine.

Engines of the type used in aircraft are usually provided with a front facing 6 having a plurality

of bolts 8 protruding forwardly. The rear end of the unit is provided with a flanged member 10 having openings for the bolts 8 whereby the member 10 may be secured to the facing 6 by the nuts 12.

The flanged member 10 supports a housing 14 for gearing employed for changing the pitch of propeller blades, as will be described hereinafter.

An irregularly shaped ring member 16 is keyed to the propeller drive shaft 4 against the engine thrust bearing nut which revolves with the propeller shaft. Forwardly of the ring member 16 on the propeller drive shaft is a wedge-shaped cone or collet 18, a hub sleeve 20 keyed to the drive shaft 4, a second wedge-shaped collet 22 having an inwardly directed lock flange 24, engaged by an annular groove 26 in the locking nut 28 adapted to be screwed on the threaded outer end of the propeller drive shaft 4. The locking nut 28 is provided with openings to receive the locking pins 30 which after being pushed radially outward are secured in such position by wiring 31 as will be clearly apparent from Figs. 2 and 3.

The hub sleeve 20 rigidly supports the tubular member 32 which, at each end, threadedly receives the sleeves 34. These sleeves, in turn, receive the socket members 36 in which the roots of the propeller blades 37 are rigidly mounted. The socket members 36 are threaded at their inner ends and annular worm gears 38 are mounted thereon and secured rigidly by lock pins 40. Between the annular worm gears 38 and the sleeves 34 are roller bearings 42.

The tubular member 32 has two longitudinally disposed smaller tubular members 44 rigid therewith (see Fig. 9) in which are mounted worms 46 engaging the annular worm gears 38 as will be apparent from Figs. 8 and 9. This structure per se has been disclosed in my copending application Serial No. 464,369, filed November 3, 1942, now abandoned, to which reference is made. The worms 46 are mounted on shafts 48, the rear ends of which protrude from the tubular members 44 and rigidly support the spur gears 50.

The spur gears 50 are engaged by a large ring gear 52 (see Fig. 1) adapted to be driven by mechanism to be described presently. It should now be apparent that upon rotation of the large ring gear 52, the spur gears 50 will be rotated, thus actuating the worm 46, engaging the annular worm gears 38. The propeller blade socket members 36 are thus rotated about their longitudinal axes to effect a change in the pitch of the propeller blades 37.

With reference now to Figs. 2 and 4, it will be observed that the gear 52 is mounted for rotation on the member 16. At its inner end the gear 52 is provided with gear teeth 54 engaged by a pair of pinions 56 mounted on the spider 58.

The spider also carries another pair of pinions 60 engaging teeth 62 on the intermediate portion of member 16 and also teeth on a ring member 64 rigid with the housing 14. The first pair of pinions 56 also engage teeth on the ring gear 66 mounted for rotation on the ring member 64.

Ring gear 66 has outer peripheral gear teeth engaged at one point by the worm 68 mounted on the shaft 70 (Fig. 4) and adapted to be rotated by the electric motor 72 through gearing 74, 76 and 78, the gear 78 being secured on the shaft 70.

Since the member 16 rotates with the propeller drive shaft 4 at all times the internal combustion engine is running, the spider 58 will rotate with the propeller drive shaft at all times in the same direction but at a slower speed. If it is desired to change the pitch of the propeller blades, the electric motor 72 is energized to rotate in one direction or the other and the worm 68 will rotate ring gear 66, thus causing rotation of pinions 56 and through them, the ring gear 52. Obviously, ring gear 52 will not be rotated without actuation of the electric motor 72 since pinions 56, when the motor 72 is still, merely ride between the ring gears 66 and 52 without driving either.

Control means are provided for the pitch changing mechanism described. Such control means operate similarly to those described and shown in my copending application, Serial No. 449,123, referred to above. They are comprised of the circuit diagrammatically illustrated in Fig. 11, including the cams 80, 82 and 84 adapted respectively to actuate the switches 86, 88 and 90. Also included in the circuit are the control switches 92, 94, actuated by the governor 96 driven by the internal combustion engine. The hand switches 98, 100 provide manual control as will be described hereinafter. Also included in the circuit is the battery 102, the solenoids 104, 106 and the electric motor 72.

While not shown in Fig. 11, the electric motor 72, aside from driving the worm 68, also drives the control cams 80, 82 and 84, each in the direction of the arrowed lines in Fig. 11. The manner in which these control cams may be rotated by the electric motor 72 is shown in Figs. 2 and 4. Ring gear 66 is engaged by a spur gear 108 having a laterally extending portion provided with a worm 110 engaging a worm gear 112 fixed to shaft 114 on which the control cams 80, 82 and 84 are mounted to rotate with the shaft.

As illustrated in Fig. 10, the cams, such as 80, may be adapted to engage switch members, such as 116, capable of reciprocating longitudinal movement and normally urged by spring means (not shown) against the cam surfaces. The switch members 116 actuate the switches 86, 88 and 90, diagrammatically shown in Fig. 11.

The governor 96 advantageously may be driven from the propeller drive shaft 4. As described heretofore, ring member 16 is keyed to the propeller drive shaft. This member 16 is provided with worm teeth 118 engaging worm gear 120 carried by the shaft 122 (see Fig. 5), one end of which is connected to drive the governor. The other end of shaft 122 may be connected to drive other mechanism such as a de-icing pump 124. Where a de-icing pump is driven by shaft 122, it is best to have the de-icing fluid piped from a separate container (not shown). Then, should by chance these pipes break, the running of the propeller will not be affected in any way.

Alternative arrangements for driving the governor are illustrated in Figs. 6 and 7. In each of these figures the member 16 does not have worm teeth 118 as in Fig. 2, but in lieu thereof (Fig. 6) the spider 58 itself carries a flanged annular ring 126 provided with teeth 128 for engaging worm 120. The arrangement in Fig. 7 has a similar ring 130, carried by the spider 58, said ring 130 being of greater diameter than ring 126 and having teeth 132 on its outer periphery. With such arrangements, different operating ratios can be attained. It is of course apparent that use of such arrangements requires a relocation of shaft 122 and worm 120 further to the left of the position in which they are shown in Fig. 5. These alternate arrangements for driving the governor

are sometimes necessary. For example, if the propeller shaft is driven directly by the internal combustion engine without the use of intermediate reduction gearing, the governor would operate much too fast for practical use. The alternate arrangements shown make it possible to reduce the governor speed very simply, thus rendering the unit even more adaptable to all types of engines whether or not they be provided with reduction gearing.

It is believed expedient at this point to describe generally the operation of the invention. From the legends on Fig. 11, it will be seen that switch **98** is a hand-feathering switch. Switch **100** is also a hand-operated switch for overriding the governor **96** at the will of the pilot. Switches **86**, **88** and **90** are respectively, fine pitch, coarse pitch and feathering pitch limit switches. If desired a fourth switch and cam (not shown) may be employed for reverse pitch. A circuit adapted for this purpose is shown in my copending application Serial No. 449,123.

The fine pitch limit switch **86** and the coarse pitch limit switch **88** are both located in the normal circuit and are so arranged as to remain closed during normal operation. Hand feathering switch **98** is normally in the position shown in Fig. 11 so that the feathering circuit (shown in broken lines) is normally broken.

The governor, driven by the internal combustion engine, as described, is first adjusted by actuation of the hand lever **95**, which is, by means not shown, connected for operation from the cockpit. The adjustment of the governor forms no feature of the present invention. It is shown and described in my copending application Serial No. 449,123 to which reference may be had. The governor actuates the pivoted switch lever **97** so that it will either close the fine pitch switch **92** or the coarse pitch switch **94**. In accordance with which of these switches is actuated, the electric motor **72** will rotate in one direction or the other toward fine pitch or coarse pitch. Operation of the electric motor, as described, rotates the cam members **80**, **82** and **84** and if the electric motor **72** rotates for too great a length of time in either of the two directions, the cam members **80** and **82** will actuate either the fine pitch limit switch **86** or the coarse pitch limit switch **88**, thus breaking the normal circuit and cutting off the electric motor.

The fine pitch limit switch **86** and the coarse pitch limit switch **88** control the predetermined coarse and fine pitch positions of the propeller blade pitch. For example, the fine pitch limit switch **86** only comes into operation during take-off and the coarse pitch limit switch **88** acts to prevent overpitching in a dive. As will be described later, this switch is closed by the feathering control switch **98** thereby attaining the feathering position to be determined by cam **84**. In normal flight the pitch of the propeller blade will remain substantially constant intermediate between fine and coarse pitch and the cams **80** and **82** are so arranged that they will not break the normal circuit unless the predetermined dangerous limits of fine and coarse pitch are attained.

The governor arrangement illustrated in Figure 11 is similar to that shown in Figs. 2 and 3 of my application, Serial No. 449,123. It will be noted from that application that when the engine is stopped, the spring on the governor moves the weights into fine pitch position, closing the switch **92**. The coarse pitch switch **84** can only be closed when the engine is running. With such an arrangement, when the aircraft is about to land with the engine throttled, the blades are brought to fine pitch position, and when on the ground after the engine is stopped, the blades will continue to move toward fine pitch until the electric motor is stopped by the fine pitch limit switch **86**. This insures that the blades are always left in a fine pitch position for a take-off.

Should it become necessary for any reason to "override" the governor, this may be accomplished by the pilot by manually operating the hand controlled switch **100**, which is in the circuit indicated by dot and dash lines. Thus, in accordance with the actuation of this switch and the consequent cutting out of the governor, the electric motor **72** can be actuated either in the direction of coarse pitch and it is then only shut off by the actuation of the hand controlled switch **100**, or by actuation of the fine pitch and coarse pitch limit switches **86** or **88**.

When it is desired to feather the propeller blades, it is necessary for the pilot to actuate the hand feathering switch **98** so that the normal circuit (full line) is broken and the feathering circuit (indicated in dot and dash lines) is made. In the feathering circuit is the feathering limit switch **90**. During normal operation, when the normal circuit is closed, this feathering limit switch **90**, of course, is dead, since no current passes through the feathering circuit.

Operation of the feathering switch **98** to close the feathering circuit, passes current through the contacts of the feathering limit switch **90** and at the same time, since the coarse pitch limit switch **88** is bridged and dead, the cam **82**, though tripping the coarse pitch limit switch **88**, will not shut-off the electric motor **72**. The feathering cam **84** is so designed that if the pitch change in the direction of feathering becomes excessive, this cam will trip the feathering limit switch **90** and thus shut-off the electric motor. When the feathering limit switch **90** is broken, the fine pitch limit switch **86** is still alive, and because of the fact that the governor has moved the pivoted switch lever **97** into fine pitch position, the electric motor **72** is reversed and consequently the pitch of the propeller is restored to normal running position somewhere between the limits defined by the fine pitch limit switch **86** and the coarse pitch limit switch **88**.

It should also be obvious that actuation of the hand controlled switch **100** can be used to bring the propeller blades back to normal position. It is necessary, of course, to return the feathering switch **98** to the position shown in Figure 11 so as to break the feathering circuit and close the normal running circuit.

Attention is called to the fact that with the hand controlled switch **100**, it is not only possible to override the governor but to change the pitch of the propellers at will and to leave the blades set at the best position for economical cruising. For example, the blades can be feathered by operation of this switch **100** provided that the feathering switch **98** is put into feathering position. As shown in Figure 11, moving the switch **100** in a counter-clockwise direction from the position shown, the first set of terminals will cut out the governor and complete the fine pitch circuit. Moving it clockwise to the first set of terminals in that direction will close the coarse pitch circuit. Continuing in the same direction, to a position at right angles to the first position, will effect an "off" position in which the blades

are locked. This switch 100 obviously can be rotated as much as 360° in either direction. It will be apparent that usually the switch 100 will remain in a normal running position in which the governor is in actuation but can be used, for example, on long cruises and the like so that the pilot can set the pitch in the best possible position for economical operation.

While, in general, the structure for accomplishing the desired results has been described, it should be pointed out that one of the principal objects of the invention resides in the particular form and disposition of the various parts. With but very little working space available, the invention admirably utilizes this space to the best advantage while at the same time, the invention is comprised of self-contained units which are readily assembled and removed.

In applying the unit, it is only necessary to attach member 10 to the engine facing 6 by nuts 12, slide member 16 on the propeller drive shaft 4, add the housing 14 with mechanism therein and the mechanism carried thereby, together with ring gear 52 in place on member 16, and then complete the structure by adding cone or collet 18, propeller hub sleeve 20 and the hub structure proper is described hereinbefore, the collet 22, the locking nut 28 and locking pins 30. It is manifest that the unit may be taken down or dismantled with equal facility.

It will also be apparent that the unit requires no conduit connections to the internal combustion engine, and further that, being driven by electrical means, no use of congealable oil from the engine is required.

It will be noted further that the housing 14 of the unit is adapted to contain its own lubrication, which preferably may be of the anti-freeze variety.

While it has not been shown herein, it will be apparent that the invention may be employed with two hub structures mounted on coaxial propeller drive shafts. In such instance, the pitch changing gearing for the forward hub structure may be similar to that shown herein, and may be driven by a gear on the other end of shaft 48 (see Fig. 9) by connecting gearing such as that shown in Fig. 5 of my application Serial No. 465,618, filed November 14, 1942, now Patent No. 2,426,007, or in Fig. 9 of my application Serial No. 449,123.

Changes in structure may be made without departing from the concept of the invention which should not be limited in scope except to that extent indicated in the following claims.

I claim:

1. A control unit for variable pitch propeller systems having propeller hub structure provided with pitch changing gearing, said unit being dimensioned to be removably positioned surrounding the propeller drive shaft between the propeller hub structure and the engine with the propeller drive shaft extending entirely through the unit, said control unit comprising a sleeve extending substantially the entire axial length of the unit and comprising the annular inner wall of the unit, means mounting said sleeve in a position surrounding the propeller drive shaft for

rotation therewith, gear teeth on said sleeve, a stationary toothed ring gear coaxially mounted about said sleeve and radially spaced therefrom, a ring spider surrounding said sleeve, pairs of pinions carried by said spider, one pair of said pinions engaging the teeth on said sleeve and the teeth on said ring gear, a second toothed ring gear mounted for rotation about said sleeve, a third toothed ring mounted for rotation on a portion of said sleeve, a second pair of said pinions engaging said second toothed ring gear and said third toothed ring, motor means for driving said second toothed ring gear, said third toothed ring having a gear portion engageable with the pitch changing gearing of the propeller hub structure, and a housing, said housing supporting said motor means, said housing and said sleeve together comprising a complete enclosure for all of the other named elements of said unit with the exception of said gear portion and said motor means, and providing unitary support for the entire unit.

2. A control unit as set forth in claim 1, a governor carried by the housing, a drive shaft within the housing and driven by said sleeve for driving the governor, and switch means actuated by the governor for controlling said motor.

3. A control unit as set forth in claim 2, cam means within said housing and operated by said second toothed ring gear, and switch means carried by said housing and operable by said cam means for overriding said governor.

4. A control unit as set forth in claim 1, a governor carried by the housing, a drive shaft within the housing for driving said governor, a ring gear carried by said spider for driving said drive shaft, and switch means actuated by the governor for controlling the motor.

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