May 20, 1941. G. ALGARSSON **2,243,046**

SELECTIVE TWO PITCH AIRSCREW

Filed Jan. 16, 1939 6 Sheets-Sheet 1

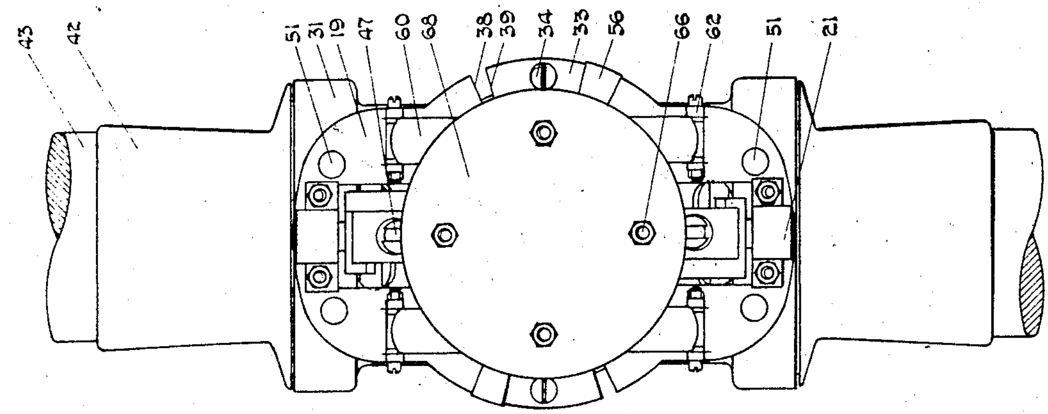

FIG. 17.

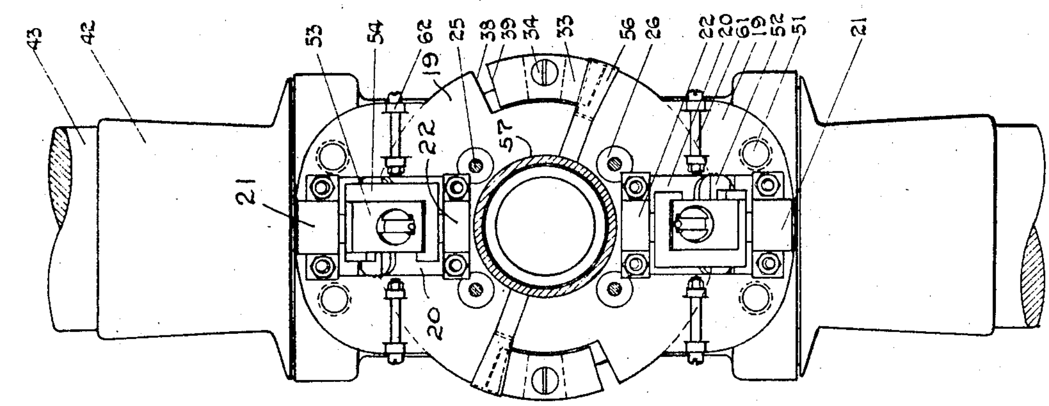

FIG. 2

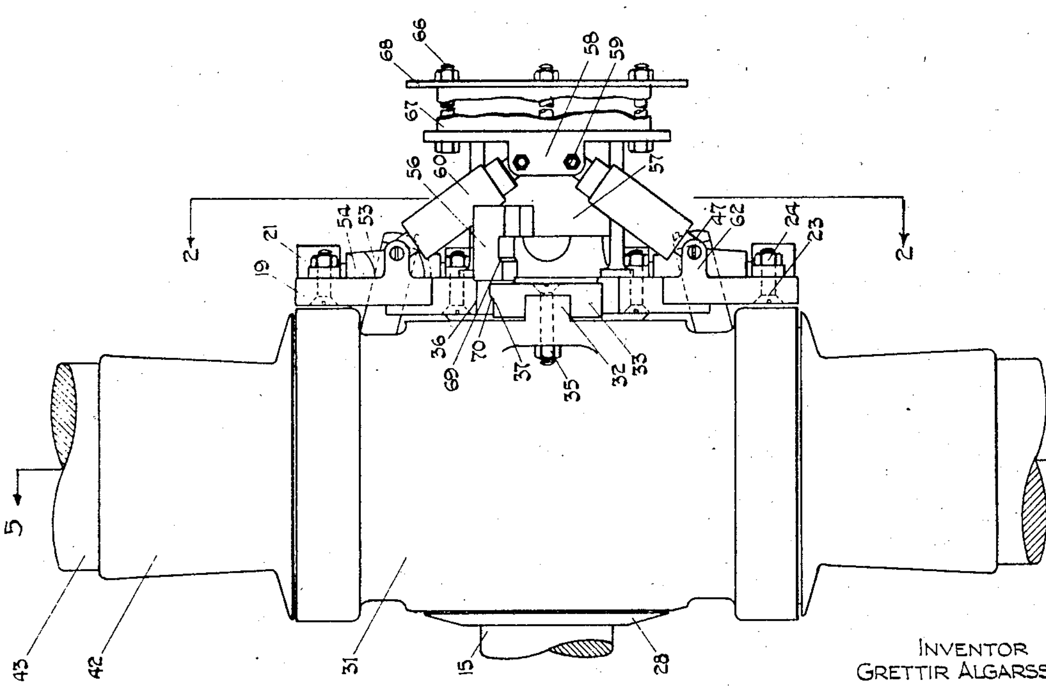

FIG. 1

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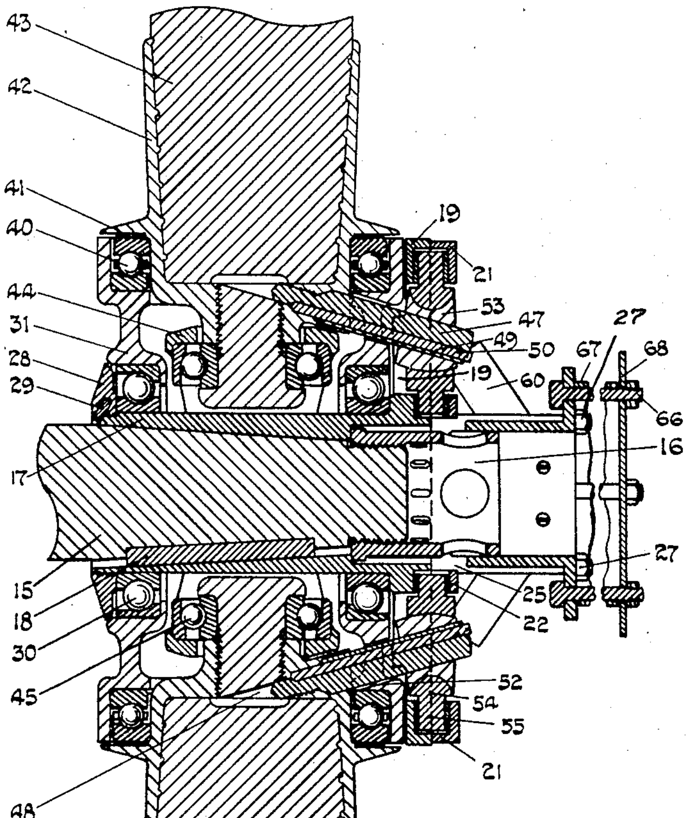

FIG. 3.

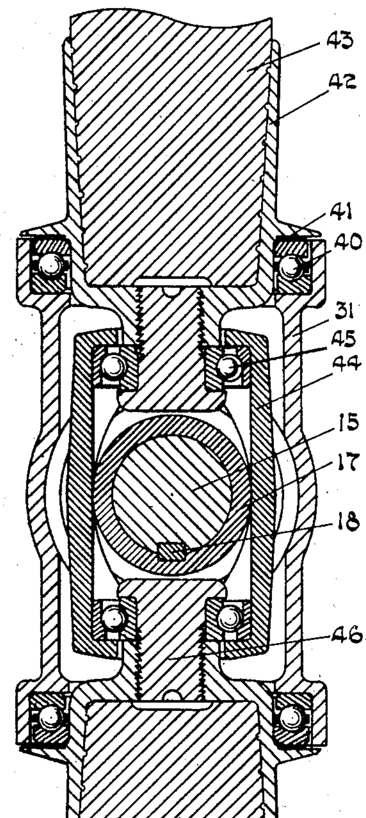

FIG. 5.

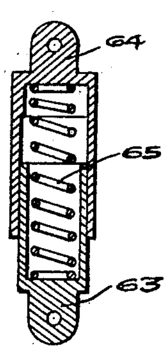

FIG. 4.

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SELECTIVE TWO PITCH AIRSCREW

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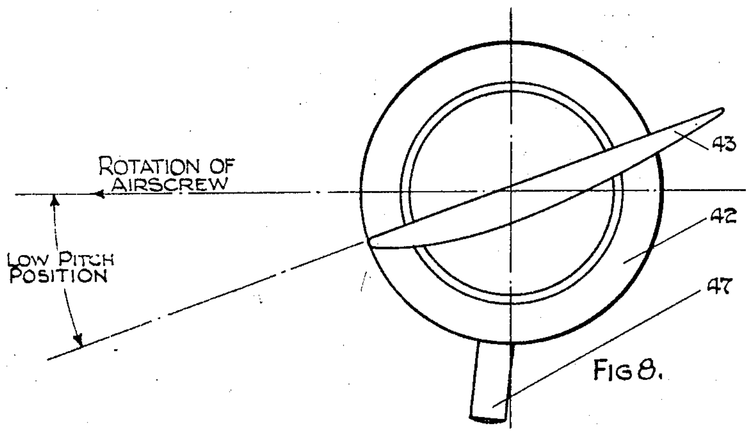

FIG 8.

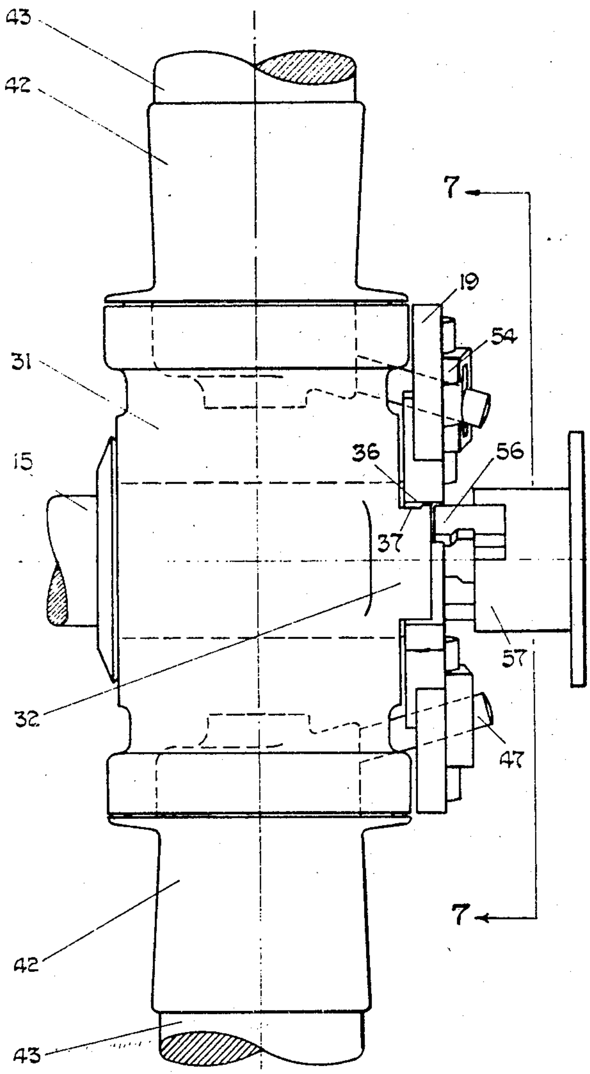

FIG. 6

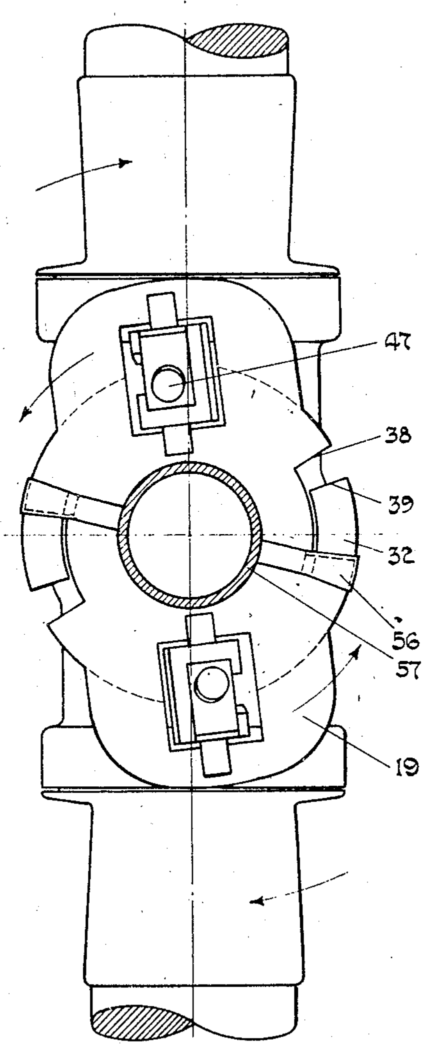

FIG. 7.

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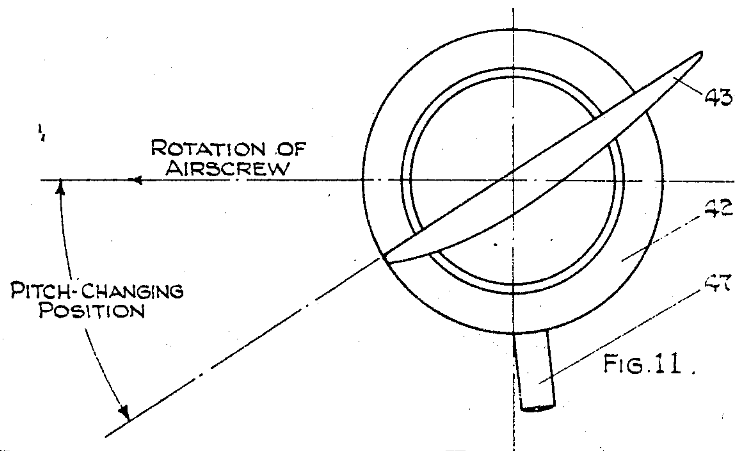

FIG.11.

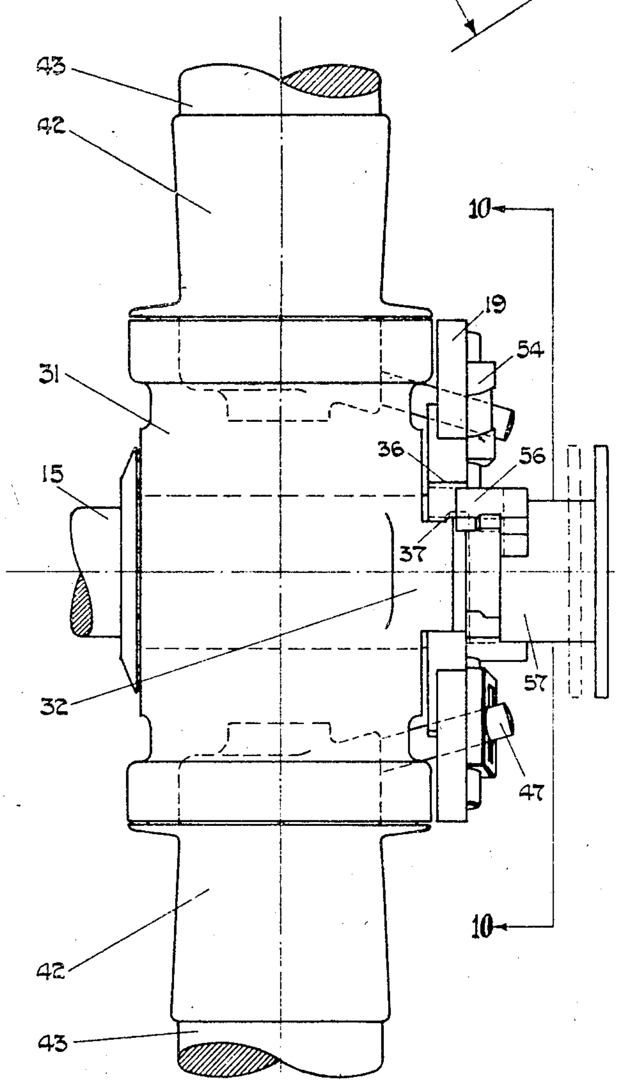

FIG.9.

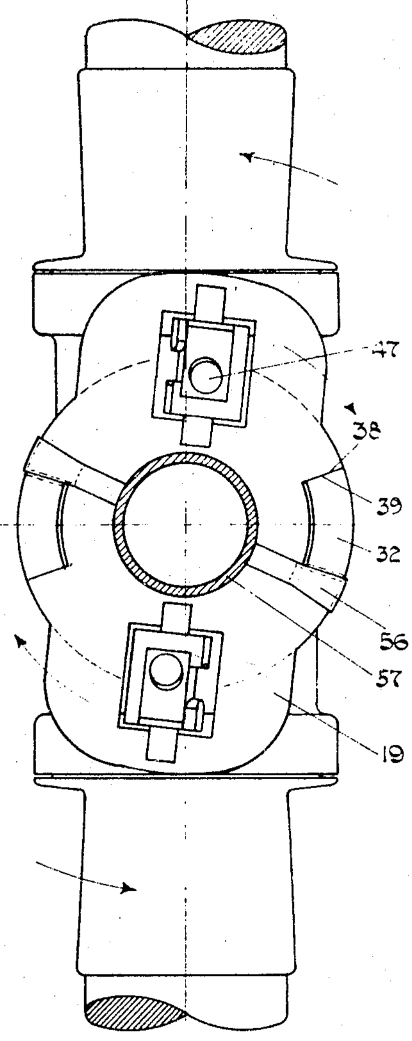

FIG. 10

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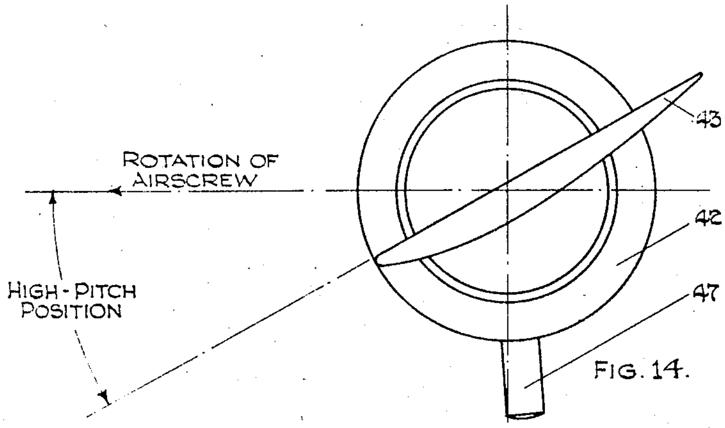

FIG. 14.

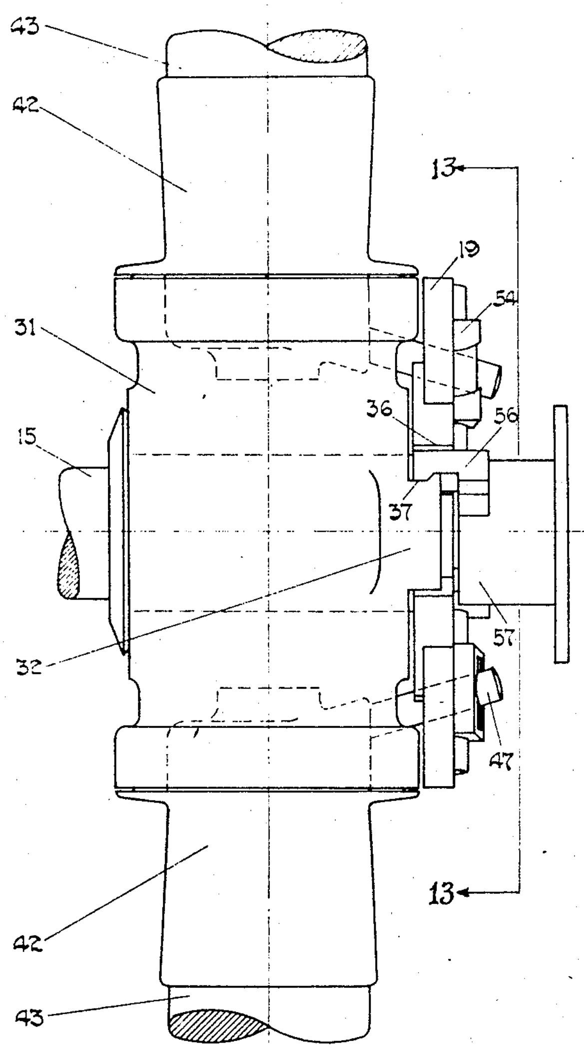

FIG. 12

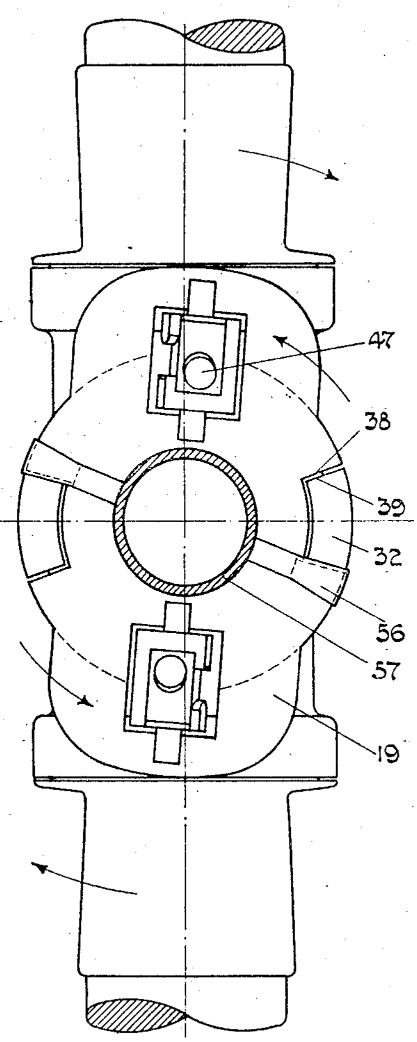

FIG. 13.

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SELECTIVE TWO PITCH AIRSCREW

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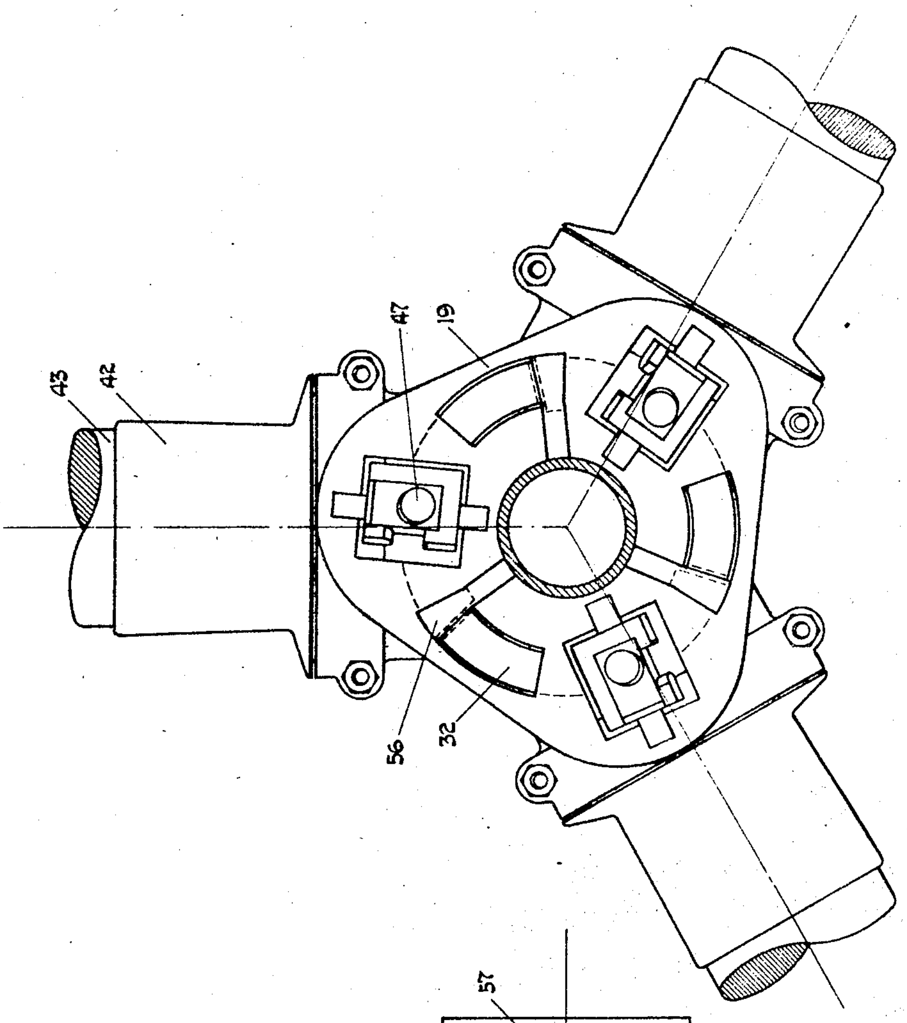

FIG. 16.

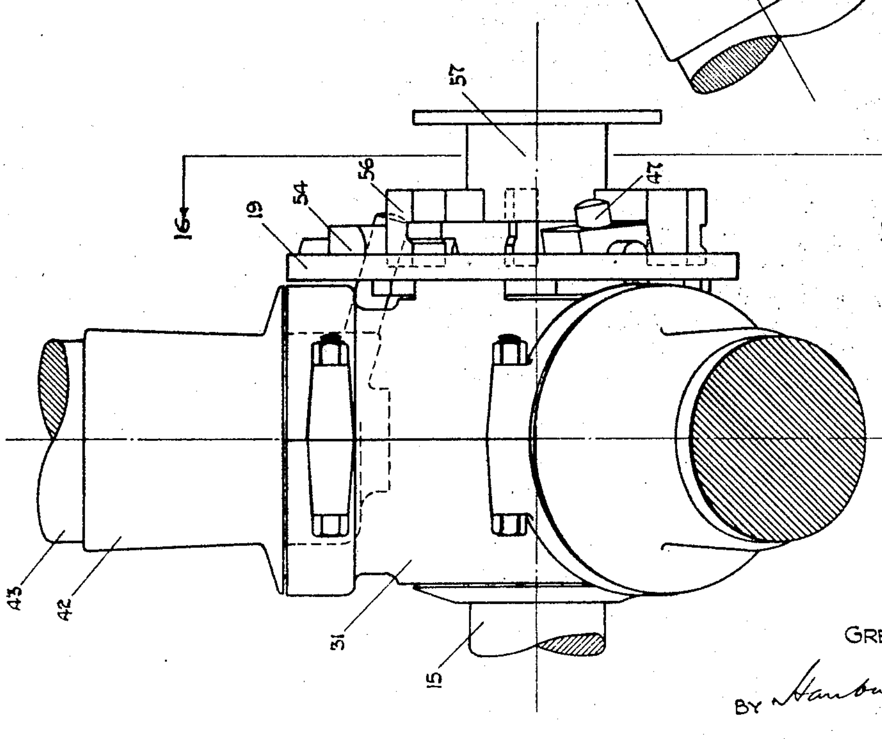

FIG. 15.

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Patented May 20, 1941

2,243,046

UNITED STATES PATENT OFFICE

2,243,046

SELECTIVE TWO PITCH AIRSCREW

Grettir Algarsson, Montreal, Quebec, Canada

Application January 16, 1939, Serial No. 251,109

11 Claims. (Cl. 170—162)

This invention relates to selective two pitch airscrews as described in the present specification and illustrated in the accompanying drawings that form part of the same.

The invention consists essentially in the utilization of the torque reaction of the airscrew to alter the pitch of the blades, as pointed out in the claims for novelty following a description in detail of an acceptable form of the invention.

The objects of the invention are: to take advantage of the natural tendency of the airscrew to lag behind or overrun the engine, this tendency being utilized to vary the pitch setting of the airscrew blades; to place the selection of the pitch within the control of the pilot without adding to the number of controls; to render impossible change of pitch of the blades to high pitch setting at low speeds or to low pitch setting at high speeds of the aircraft; to eliminate all control connections to the airscrew; to provide improved takeoff and permit the efficient development and use of the power available at low airspeeds; to provide a mechanism applicable to standard equipment without alteration thereof; to reduce the number of working parts, thereby simplifying manufacture and upkeep; to permit axial penetration of the airscrew hub thus facilitating installation of a gun, firing through the hub; and generally to increase the efficiency of the aircraft by permitting heavier takeoff loads and increased speeds.

According to the invention an airscrew is provided in which a low pitch and a high pitch setting are available. The changes from low pitch to high pitch and vice versa depend in part upon the speed of the aircraft but the instant at which change of pitch takes place is fully within the control of the pilot and may be delayed indefinitely if desired.

When it is desired to change pitch, all that is necessary is to slow down the engine, allowing the airscrew to overrun the engine for an instant. When this occurs the pitch changing mechanism unlocks, permitting the airscrew to change pitch, if the speed of the aircraft is such as to warrant a change of pitch. As long as the engine is driving the airscrew the mechanism is locked, and no change of pitch can occur until the pilot causes the airscrew to overrun the engine.

In the preferred form of the invention, described in detail hereinafter, the hub casing, in which the blades are mounted, is permitted a limited rotation with respect to the mounting sleeve which is keyed or splined to the engine crankshaft in the same manner as a fixed pitch airscrew. Journal blocks, carried by the mounting sleeve, engage with pitch levers, attached to the blade roots, causing the blades to change pitch as the hub casing rotates with respect to the mounting sleeve. Stop surfaces on the mounting sleeve, transmit the torque of the engine to corresponding stop surfaces on the hub casing, either directly, holding the blades in low pitch, or through interposed spacers, thus holding the blades in high pitch. The spacers are inserted between the stop surfaces when the speed of the aircraft is above a selected value by the pressure of an anemometric disc carried at the front of the hub, and are extracted from between the stop surfaces by the pressure of springs which overcome the pressure on the disc when the speed of the aircraft is below the selected value.

Referring to the drawings,

Figure 1 is a side elevation of an airscrew hub of the preferred variety.

Figure 2 is a sectional front elevation on the line 2—2 of Figure 1, with the spring cartridges removed.

Figure 3 is a sectional side elevation corresponding to Figure 1.

Figure 4 is a sectional view of a spring cartridge.

Figure 5 is a sectional front elevation on the line 5—5 of Figure 1.

Figure 6 is a diagrammatic side elevation of the hub illustrated in the previous figures, showing the relative positions of the mounting sleeve, hub casing, blades and spacers in the low pitch position.

Figure 7 is a sectional front elevation on the line 7—7 of Figure 6.

Figure 8 is a diagrammatic plan showing the pitch setting of the upper blade in Figure 7.

Figure 9 is a diagrammatic side elevation corresponding to Figure 6, but showing the relative positions of the various parts in the pitch changing position. The dotted lines show the spacers in the inward position.

Figure 10 is a sectional front elevation on the line 10—10 of Figure 9.

Figure 11 is a diagrammatic plan showing the pitch setting of the upper blade in Figure 10.

Figure 12 is a diagrammatic side elevation corresponding to Figure 6, but showing the relative positions of the various parts in the high pitch position.

Figure 13 is a sectional front elevation on the line 13—13 of Figure 12.

Figure 14 is a diagrammatic plan showing the pitch setting of the upper blade in Figure 13.

Figure 15 is a diagrammatic side elevation of a three bladed airscrew showing the relative positions of the mounting sleeve, hub casing, blades and spacers in the pitch-changing position.

Figure 16 is a sectional front elevation on the line 16—16 of Figure 15.

Figure 17 is a front elevation of the hub shown in Figures 1 and 2.

The airscrew hereinafter described is composed of parts which may be classified in three groups.

First, parts that do not move in relation to the engine crankshaft.

Second, parts that move in relation to the first group as the airscrew blades change pitch.

Third, parts that move in relation to the first and second groups in cooperation with the anemometric disc.

The engine crankshaft, to which the parts classified in the first group are rigidly attached, is designated by the numeral 15. The crankshaft 15 has a tapered end terminating in a threaded portion to receive the retaining nut 16.

The mounting sleeve 17 is kept on the crankshaft 15 by the retaining nut 16 and held against relative rotation by the key 18.

Integral with the mounting sleeve 17 is the torque plate 19 which has a rectangular orifice 20 near the root of each blade. At the outside and inside, respectively, of the orifices 20 are the bearing caps 21 and 22 which are attached to the torque plate by the flat head machine screws 23 and their elastic stop nuts 24.

The spacer guide studs 25 are screw-threaded into the torque plate 19 and are prevented from unscrewing by the corners of the bearing caps 22 which are recessed into the flanges 26 which are integral with the guide studs. The stop nuts 27 limit the forward movement of the third group of parts.

Screw-threaded on to the rear end of the mounting sleeve is the bearing adjustment ring 28, which is locked in its correct position, by means of the grub screw 29, before the mounting sleeve is attached to the crankshaft 15.

The parts mentioned so far comprise the first group and are all rigidly held in relation to the crankshaft.

Carried on the mounting sleeve 17 by the ball bearings 30 is the hub casing 31. Integral with the hub casing are the torque stops 32 on which the adjustment bars 33 are mounted by means of the flat headed machine screws 34 and the elastic stop nuts 35.

These adjustment bars 33 are in the plane of rotation of the torque plate 19 and, consequently, limit the rotation of the hub casing in relation to the mounting sleeve. Stop surfaces 36 and 37 on the torque plate 19 and the adjustment bars 33, respectively, provide ample bearing surface to transmit the engine torque from the torque plate to the hub casing.

Further stop surfaces 38 and 39 on the torque plate and adjustment bars, respectively, limit the relative rotation of the hub casing in the opposite direction and provide bearing surfaces to transmit the torque of the airscrew to the engine, when the former tends to overrun the latter. It will be observed that the engine is assumed to have right-hand rotation, as indicated by arrows in the various figures.

The spacers 56, which will be described in detail hereafter, are insertable between the stop surfaces 36 on the torque plate 19 and the stop surfaces 37 on the adjustment bars 33.

Carried on the hub casing 31 by means of the ball bearings 40 and the adjustment washers 41 are the root sleeves 42. The blades 43 are mounted in the root sleeves in any suitable manner.

A central link 44 passes around the mounting sleeve, but does not bear upon it, housing the ball bearings 45 which take the centrifugal pull of the blades 43 and root sleeves 42 through the pins 46. The pins 46 are screw-threaded into the root sleeves with a buttress thread, designed to take a maximum of tensile load with a minimum of resultant bursting stress upon the root sleeve, and are locked against unscrewing by the ends of the pitch levers 47 which enter the holes 48, drilled in the pins 46 after tightening up on the inner races of the ball bearings 45.

The pitch levers 47 are rigidly mounted in the root sleeves 42, being accurately fitted into holes drilled in the bases of the blade roots and screw-threaded into them near the ends which lock the pins 46. The pitch levers are locked against unscrewing by the lock pins 49 which are held in place by the split pins 50 at the outward ends of the pitch levers 47.

The assembly consisting of hub casing, root sleeves, central link bearings, pins and pitch levers cannot come apart in any particular so long as the split pins 50 remain in place.

If the adjustment washers 41 are of the right thickness the blades will be correctly mounted on the hub casing and the ball bearings 40 and 45 will all simultaneously receive the correct amount of pre-load. Substitution of adjustment washers 41 will correct inaccuracies in pre-load and also provides a means of roughly balancing the blades, precise balance being achieved by varying the amount of lead held in the undercut holes 51.

The pitch levers pass through the orifices 52 in the hub casing. These orifices are so shaped that the pitch levers can move freely, with the blades, through the maximum pitch range that could be required. The outer ends of the pitch levers pass through the orifices 20 in the torque plate 19 and are connected with the latter by means of the journal pieces 53 and the journal blocks 54. The journal blocks 54 have projecting stub axles 55 which are attached to the torque plate by the bearing caps 21 and 22 in such a manner as to permit rotation about and a limited movement along the axes of their stub axles.

The journal pieces 53, which are drilled to receive the pitch levers 47, are carried by the journal blocks 54 in such a manner as to permit angular change between the pitch levers and the stub axles 55.

When the stop surfaces 36 are in contact with the stop surfaces 37, the torque plate 19 is in a definite position in relation to the hub casing and, as the torque of the engine driving the airscrew is transmitted through these stop surfaces, they will be held in this relative position. As the pitch levers are mounted rigidly in the root sleeves 42, but connected towards their outer ends with the torque plate, the airscrew blades are held in an unchanging pitch position. When the torque plate 19 is rotated in relation to the hub casing, separating the stop surfaces 36 and 37, the outer ends of the pitch levers must move with it in relation to the hub casing which carries the root sleeves, thus increasing the pitch of the blades until such increase of pitch is arrested by contact between the stop surfaces 38 on the torque plate and the stop surfaces 39 on the adjustment bars.

It will thus be seen that the hub casing, carrying the blades with it, is allowed a limited rotation with regard to the mounting sleeve, but that any such relative rotation must be attended by a corresponding change of pitch setting, owing to the arrangement of the pitch levers mounted in the blade roots and the journal blocks mounted in the torque plate.

The third group of parts, those moving in relation to the first and second groups in cooperation with the anemometric disc, consists of the spacers together with the anemometric disc and springs which control their movement in and out between the stop surfaces 36 and 37, when these latter are separated owing to the airscrew tending to overrun the engine.

The spacers 56, which, when interposed between the stop surfaces 36 and 37, hold the airscrew blades in the high pitch position, are integral with the spacer ring 57 (see Figure 6), which is mounted on the spacer guide studs 25. The spacer ring 57 is provided with lugs 58 (see Figure 1) on its inward side through which machine screws 59 are fastened by means of elastic stop nuts. Spring cartridges 60 are journalled at one end on the machine screws 61 which are fastened through lugs 62 on the torque plate by means of other elastic stop nuts. Referring to Figure 5 it will be seen that each spring cartridge comprises two closed ended cylinders 63 and 64, one slidably mounted within the other, containing a compression spring 65 exerting pressure tending to separate the cylinders, thereby lengthening the cartridge. Mounted in front of the spacer ring by means of the metallic bracing bolts 66 and the bracing tube 67 is the anemometric disc 68.

The spacers are provided with bevelled steps 69 which fit into correspondingly bevelled depressions 70 in the adjustment bars 33 when the airscrew is in the high pitch setting.

Referring to the drawings it will be understood that, so long as the engine is transmitting torque to the airscrew, the stop surfaces 36 and 37 will be in contact, unless they are held apart by the spacers 56. There are, therefore, two pitch positions or settings available while the engine is driving the airscrew. The low pitch position is that in which the stop surfaces 36 and 37 are in direct contact, and the high pitch position is that in which the spacers are held between the stop surfaces.

While in the low pitch position, the spacers cannot enter between the stop surfaces, and while in the high pitch position the spacers are locked in place by the bevelled steps 69 and 70.

A third pitch position is assumed when the stop surfaces 38 and 39 are in contact, i. e., when the airscrew overruns the engine. This is the pitch-changing position and is slightly higher than the high pitch position, the stop surfaces 36 and 37 being sufficiently far apart to permit the spacers to enter or withdraw from between the stop surfaces in response to the action of the third group of parts.

The operation of the third group of parts is as follows:

The spacer ring 57, together with the spacers 56, bracing bolts 66, bracing tube 67 and anemometric disc 68, is held in the outward or low pitch position, against the aerodynamic pressure upon the disc 68, by the compression springs 65 operating within the spring cartridges 60. As the speed of the aircraft increases, the aerodynamic pressure upon the disc 68 increases, until a speed is reached at which the pressure upon the disc overcomes the pressure of the springs, and the whole group of parts commences to move inwards toward the high pitch position, i. e., that in which the spacers are interposed between the stop surfaces 36 and 37.

The spring cartridges 60 are carried at an angle to the line of movement of the spacer ring 57, and this angle increases as the spacer ring moves inward, against the springs. As a consequence of this change of angle, a constant pressure on the disc 68 produces an increasing pressure against the springs. The springs are so designed that their pressure, as they are compressed, does not increase as rapidly as the corresponding resultant of a constant pressure upon the disc.

Operation

The effect of this arrangement is that once the parts composing the third group start to move inward, under aerodynamic pressure on the disc, they immediately travel the whole distance, being opposed by a decreasing resistance, i. e., they "trip." This tripping action also occurs in the opposite direction, when changing from high pitch to low, owing to the fact that the spring pressure does not decrease as rapidly as the opposing resultant of the pressure on the disc (which latter may be considered as being constant for the fraction of a second required to "trip" the mechanism).

The third group of parts will hereinafter be referred to as the "trip" mechanism.

In the operation of the airscrew as a whole, the actual operation of changing pitch is accomplished by causing the airscrew to overrun the engine, thereby turning the blades into the extreme high pitch or pitch-changing position, and then causing the engine to drive the airscrew, thus turning the blades to as low a pitch as the stop surfaces 36 and 37 (which transmit the torque of the engine to the airscrew blades) will permit. The function of the "trip" mechanism is to separate the stop surfaces by the thickness of the spacers, thereby holding the blades in high pitch, if the speed of the aircraft is high enough to cause the mechanism to "trip" inward, or to allow the stop surfaces to come together, thereby permitting the engine to turn the blades into low pitch, if the speed of the air-screw is low enough to cause the mechanism to "trip" outward.

The thickness of the spacers, therefore, determines the pitch range or difference between low and high pitch, and it will be understood that substitution of adjustment bars 33 of varying thickness at the surface 37 will vary the low pitch position.

Substitution of bracing bolts and tubes of different lengths permit any required adjustment of the distance between the front of the airscrew hub and the disc 68, and changing the size of the disc or the strength of the springs will vary the pressure required to "trip" the "trip" mechanism, thereby varying the "critical" speed of the aircraft, i. e., the speed at which change of pitch can be accomplished.

Considering the operation of the airscrew during an imaginary flight. During the takeoff the airscrew will be in low pitch and will remain in low pitch until the "critical" speed is reached. Once the airspeed has risen above the critical value, the pilot can change to high pitch at any moment he selects, but the airscrew will not change to high pitch until the pilot closes the throttle to the required extent. Once in high pitch, the airscrew will remain there until the airspeed has fallen below the critical value and even then will not return to low pitch unless the pilot makes the required movement of the throttle.

The foregoing description applies specifically to the form of the invention illustrated in the figures including the three blades airscrew shown in Figures 15 and 16.

Many other forms however, could be used without going beyond the scope of the invention. For instance, the arrangement of the "trip" mechanism could be varied, or the torque plate could be placed behind the hub instead of in front, thus causing the engine torque to turn the blades to high pitch, and using the spacers to hold the blades in low pitch, etc.

In all its forms, however, it may be seen that the selective two pitch airscrew which is the subject of this application, is one that can be changed from low pitch to high pitch or vice versa at the will of the pilot, but is proof against accidental or mistaken changes into high pitch at too low an airspeed or into low pitch at too high an airspeed.

What I claim is:

1. In a two pitch airscrew, a driven mounting sleeve, a hub casing so mounted on said sleeve as to permit rotation thereon and provide one limiting position when the driven sleeve is imparting torque to the airscrew and another limiting position when the airscrew overruns the driven sleeve, blades rotatably mounted in the hub casing, means causing the blades to rotate in the hub casing as the casing rotates on the sleeve, spacers insertable when the airscrew overruns the driven sleeve, changing the limit of rotation and pitch setting of the airscrew when the driven sleeve is again imparting torque to the airscrew, and means actuated by aerodynamic pressure controlling the insertion or extraction of the spacers and the pitch setting of the airscrew.

2. In a two pitch airscrew, a driven mounting sleeve, a hub casing rotatably mounted on said sleeve, stops on the hub casing, stops on the sleeve engaging with the stops on the hub casing and providing one limiting position when the driven sleeve is imparting torque to the airscrew and another limiting position when the airscrew overruns the driven sleeve, blades rotatably mounted in the hub casing, means causing the blades to rotate in the hub casing as the casing rotates on the sleeve, spacers insertable between the stops when the airscrew overruns the driven sleeve, changing the limit of rotation and pitch setting of the airscrew when the driven sleeve is again imparting torque to the airscrew, and means actuated by aerodynamic pressure controlling the insertion or extraction of the spacers and the pitch setting of the airscrew.

3. In a two pitch airscrew, a mounting sleeve, a hub casing journalled on said sleeve, stops on the hub casing, stops on the sleeve engaging with the stops on the hub casing and limiting its rotation with respect to the sleeve, spacers insertable between the stops on the hub casing and the stops on the sleeve, blades rotatably mounted in the hub casing, means connecting the blades with the sleeve causing the former to rotate as the latter rotates in relation to the hub casing, and means including a disc supported against the pressure of the airstream by springs controlling the insertion of the spacers between the stops on the sleeve and hub casing.

4. In a two pitch airscrew, a mounting sleeve, a hub casing journalled on said sleeve, stops on the hub casing, stops on the sleeve engaging with the stops on the hub casing and limiting its rotation with respect to the sleeve, adjustment bars secured to said stops to adjust the limits of said rotation, spacers insertable between the stops on the hub casing and the stops on the sleeve, blades rotatably mounted in the hub casing, means connecting the blades with the sleeve causing the former to rotate as the latter rotates in relation to the hub casing, and means including a disc supported against the pressure of the air stream by springs, controlling the insertion of the spacers between the stops on the sleeve and hub casing.

5. In a two pitch airscrew, a mounting sleeve, a torque plate integral with said sleeve, a hub casing rotatably mounted on the sleeve, stops on the torque plate and on the hub casing limiting their relative rotation, blades rotatably mounted on the hub casing, means causing the blades to change pitch in agreement with relative rotation of the hub casing and sleeve, spacers insertable between the stops on the torque plate and those on the hub casing, said spacers, when inserted, narrowing the limits of relative rotation between the hub casing and the sleeve, and means including a disc supported against the pressure of the airstream by springs, said means causing the spacers to trip inwards or outwards in agreement with variations in aerodynamic pressure on the disc.

6. In a two pitch airscrew, a mounting sleeve, a torque plate integral with said sleeve, a hub casing rotatably mounted on said sleeve in front of the torque plate, stops on the torque plate and on the hub casing limiting their relative rotation, blades rotatably mounted on the hub casing, means causing the blades to change pitch in agreement with relative rotation of the hub casing and sleeve, spacers insertable between the stops on the torque plate and those on the hub casing, said spacers, when inserted, narrowing the limits of relative rotation between the hub casing and the sleeve, and means including a disc supported against the pressure of the airstream by springs, said means causing the spacers to trip inward interposing between the stops as the disc moves outward under pressure of the springs and to trip outward escaping from between the stops as the disc moves inward under aerodynamic pressure.

7. In a two pitch airscrew, a mounting sleeve, a torque plate integral with said sleeve, a hub casing rotatably mounted on said sleeve behind the torque plate, stops on the torque plate and on the hub casing limiting their relative rotation, blades rotatably mounted on the hub casing, means causing the blades to change pitch in agreement with relative rotation of the hub casing and sleeve, spacers insertable between the stops on the torque plate and those on the hub casing, said spacers, when inserted, narrowing the limits of relative rotation between the hub casing and the sleeve, and means including a disc supported against the pressure of the airstream by springs, said means causing the spacers to trip inward interposing between the stops as the disc moves inward under aerodynamic pressure and to trip outward escaping from between the stops as the disc moves outward under pressure of the springs.

8. In a two pitch airscrew, a mounting sleeve, a torque plate integral with said sleeve, a hub casing rotatably mounted on said sleeve in front of

the torque plate, stops on the torque plate and on the hub casing limiting their relative rotation, blades rotatably mounted on the hub casing, means causing the blades to change pitch in agreement with relative rotation of the hub casing and sleeve, spacers insertable between the stops on the torque plate and those on the hub casing, said spacers, when inserted, narrowing the limits of relative rotation between the hub casing and the sleeve, and means including a disc supported against the pressure of the airstream by springs, said means causing the spacers to trip inward interposing between the stops as the disc moves outward under pressure of the springs and to trip outward escaping from between the stops as the disc moves inward under aerodynamic pressure, said spacers having bevelled projections engaging with correspondingly bevelled recesses in the surfaces of the stops against which they bear when inserted between the stops.

9. In a two pitch airscrew, a mounting sleeve, a torque plate integral with said sleeve, a hub casing rotatably mounted on said sleeve behind the torque plate, stops on the torque plate and on the hub casing limiting their relative rotation, blades rotatably mounted on the hub casing, means causing the blades to change pitch in agreement with relative rotation of the hub casing and sleeve, spacers insertable between the stops on the torque plate and those on the hub casing, said spacers, when inserted, narrowing the limits of relative rotation between the hub casing and the sleeve, and means including a disc supported against the pressure of the airstream by springs, said means causing the spacers to trip inward interposing between the stops as the disc moves inward under aerodynamic pressure and to trip outward escaping from between the stops as the disc moves outward under pressure of the springs, said spacers having bevelled projections engaging with correspondingly bevelled recesses in the surfaces of the stops against which they bear when inserted between the stops.

10. In a two pitch airscrew, a mounting sleeve, a torque plate integral with said sleeve, a hub casing rotatably mounted on the sleeve, stops on the torque plate and on the hub casing limiting their relative rotation, blades rotatably mounted on the hub casing, a central link passing around the sleeve and rotatably attached to the roots of the blades, means causing the blades to change pitch in agreement with relative rotation of the hub casing and sleeve, spacers insertable between the stops on the torque plate and those on the hub casing, said spacers, when inserted, narrowing the limits of relative rotation between the hub casing and the sleeve, and means including a disc supported against the pressure of the airstream by springs, said means causing the spacers to trip inwards or outwards in agreement with variations in aerodynamic pressure on the disc.

11. In a two pitch airscrew, a mounting sleeve, a torque plate integral with said sleeve, a hub casing journalled on the sleeve, stops on the hub casing engaging with corresponding stops on the torque plate to limit the rotation of the hub casing on the sleeve, blades rotatably mounted in the hub casing, a lever secured to the root of each blade extending radially therefrom, a journal piece journalled on each lever, a journal block engaging with each journal piece and so mounted on the torque plate as to cause rotation of the blade as the hub casing rotates in relation to the torque plate, spacers insertable between the stops on the hub casing and the stops on the torque plate when the hub casing and blades have overrun the mounting sleeve to the limit of relative rotation permitted, a disc mounted in front of the airscrew exposed to the airstream, springs opposing inward movement of the disc under pressure of the airstream, means connecting said disc with said springs causing the disc to trip inwards or outwards when the pressure in either direction starts it moving, and means to insert and extract the spacers in agreement with movement of the disc.

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