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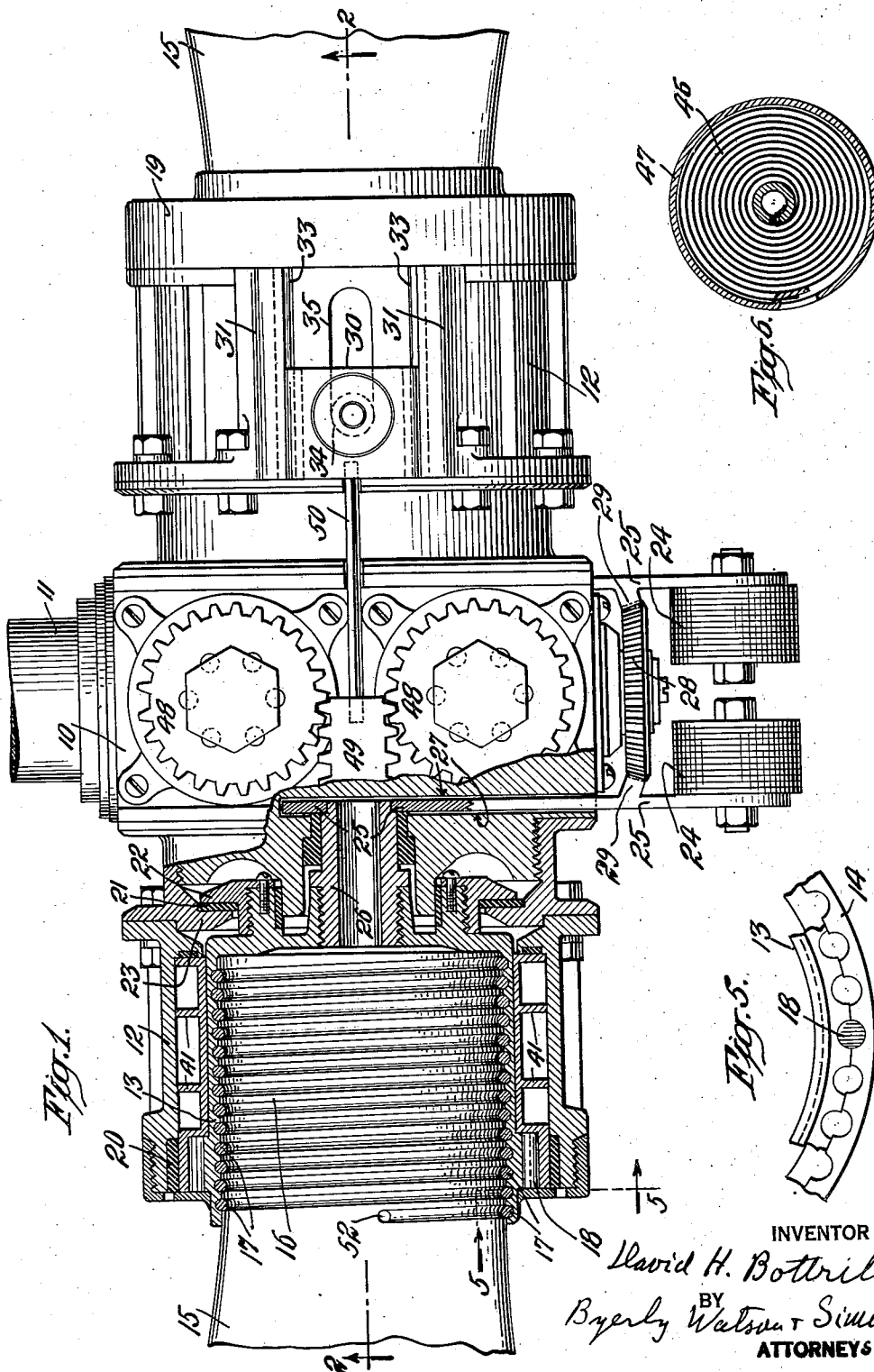
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2,294,868

VARIABLE-PITCH AIRSCREW FOR AIRPLANES

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3 Sheets-Sheet 1



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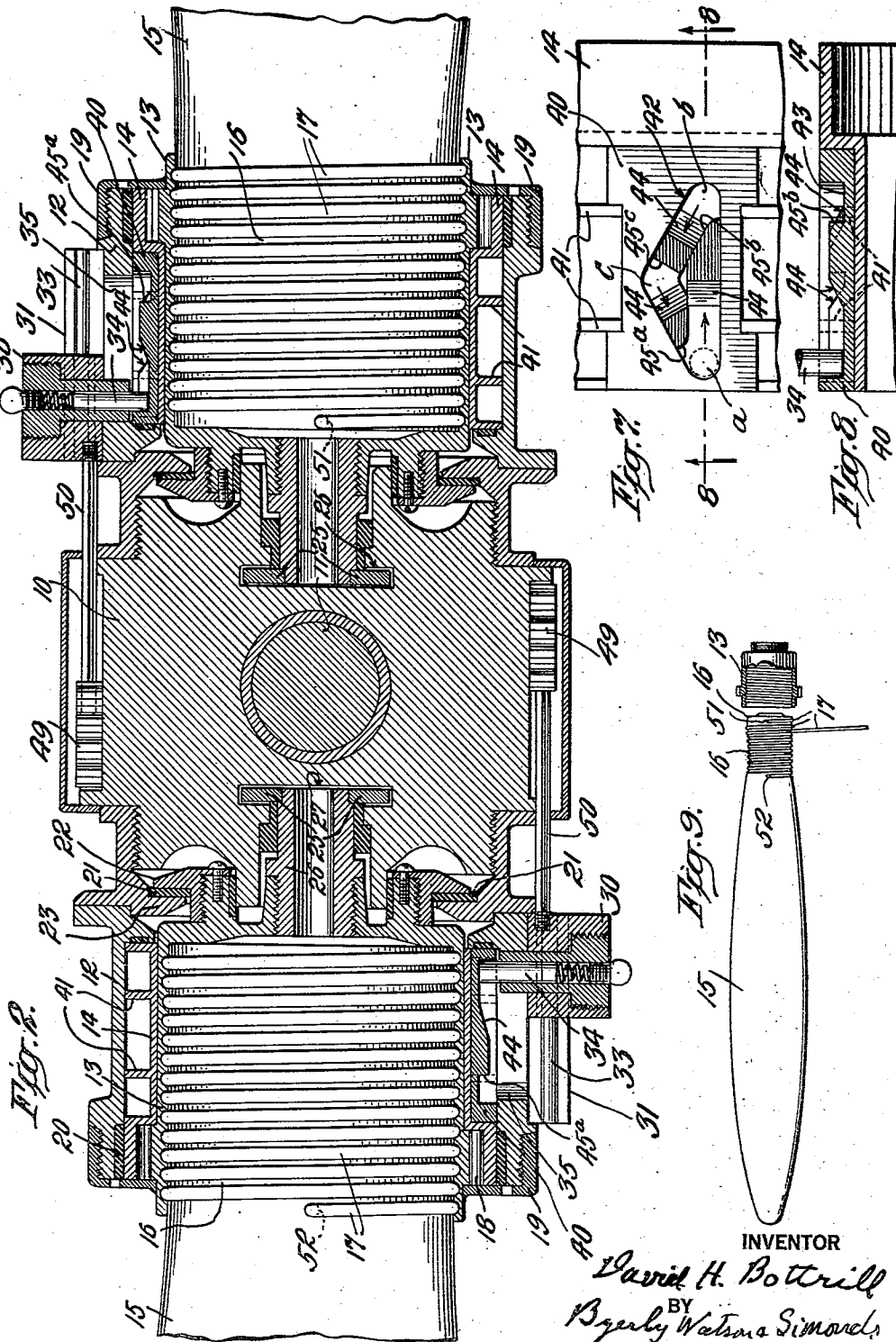
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VARIABLE-PITCH AIRSCREW FOR AIRPLANES

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3 Sheets-Sheet 2



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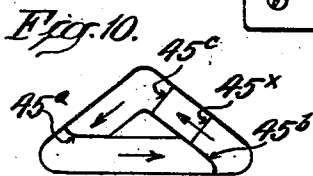
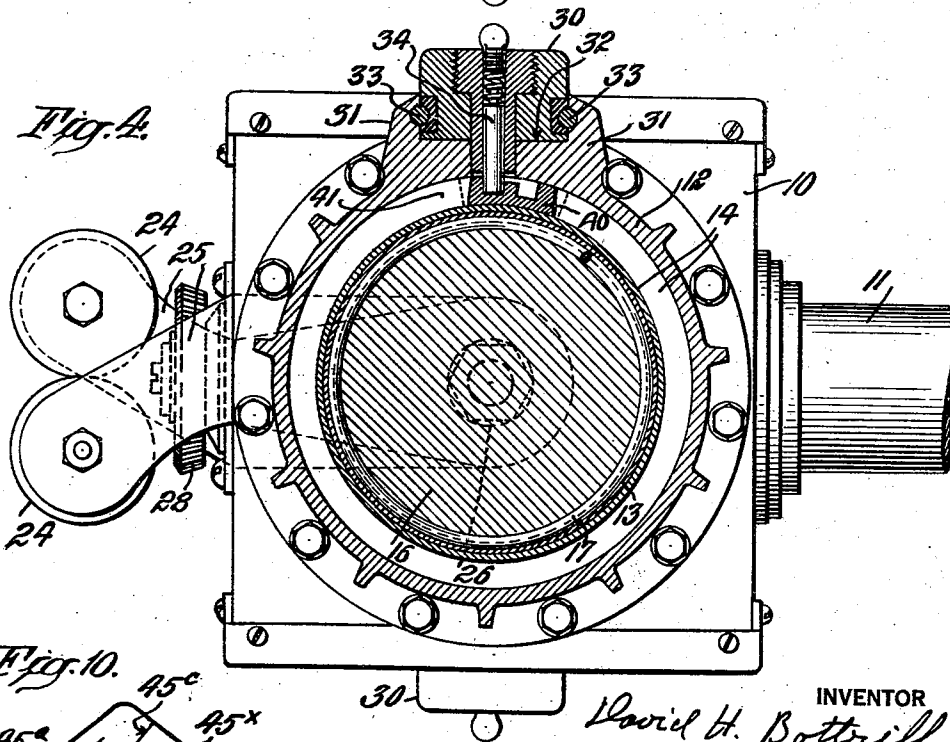
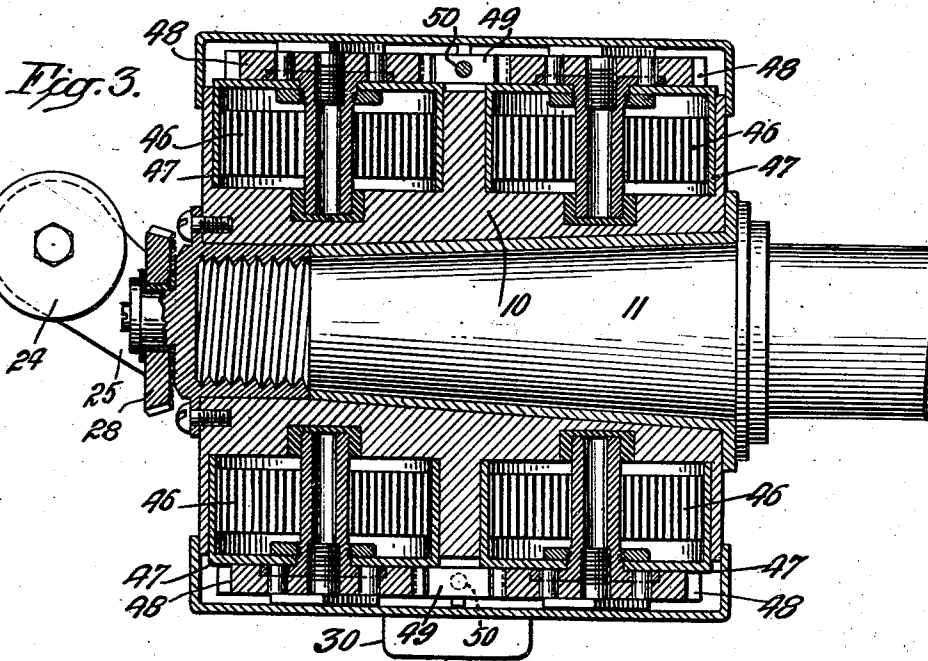
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VARIABLE-PITCH AIRSCREW FOR AIRPLANES

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3 Sheets-Sheet 3



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VARIABLE-PITCH AIRSCREW FOR
AIRPLANES

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5 Claims. (Cl. 170—162)

This invention relates to variable-pitch airscrews for airplanes and aims to provide an airscrew of such simple and strong construction that it may be made light enough and inexpensive enough to be available for use on small airplanes.

A principal object of the invention is to provide a multiple-pitch airscrew of simple construction in which changes in pitch are controlled by the engine throttle in such manner that the correct pitch for different maneuvers is automatically obtained by a manipulation of the engine throttle differing slightly, if at all, from that which would be normally used in carrying out these maneuvers.

In order that the invention may be clearly understood, I will describe the airscrew embodying the various features of the invention which is illustrated in the accompanying drawings:

Figs. 1, 2, 3 and 4, which are on the same scale, show the hub of the airscrew. Fig. 1 is a view looking across the engine shaft, and the left-hand side of this figure is sectioned on the plane which contains both the axis of the blades and the axis of the engine shaft. Fig. 2 is a view looking lengthwise of the engine shaft showing the hub sectioned on the plane which contains the axis of the blades and is perpendicular to the axis of the engine shaft. Fig. 3 is a transverse section of the hub on the plane containing the axis of the engine shaft, and Fig. 4 is a transverse section of the hub on a plane parallel to the axis of the engine shaft and containing the axis of the cam follower.

Fig. 5, on Sheet 1, is a fragmentary section on the line 5—5 of Fig. 1, showing the adjustable connection between the two sleeves forming the blade spindle.

Fig. 6, on Sheet 1, is a face view of one of the coil springs showing the spring casing in section.

Figs. 7 and 8, on Sheet 2, are enlarged views of the cam connecting a centrifugal controlling element with one of the blade spindles. Fig. 7 is a face view of the cam, and Fig. 8 is a section on the line 8—8 of Fig. 6.

Fig. 9, on Sheet 2, illustrates the method by which blades of wood or similar material are secured in a metal sleeve.

Fig. 10, on Sheet 3, is a diagrammatic view of a modified cam.

The airscrew illustrated has a hub consisting of a central body 10 through which the engine shaft 11 extends, and two lateral tubular portions 12 in which the blade spindles are turnably mounted.

Each blade spindle consists of an inner sleeve 13 and an outer sleeve 14. A blade 15 of wood

or composition or similar material has at its inner end a cylindrical stub 16 which is fixedly secured in the inner sleeve 13 by means of a wire thread 17 hereinafter described in detail. The inner and outer sleeves are adjustably connected by means of a pin 18 seated in half-round longitudinal grooves in the inner surface of the outer sleeve and the outer surface of the inner sleeve. By spacing the grooves of the inner and outer sleeves slightly differently, as shown in Fig. 5, a very accurate adjustment of the angular relation between the two sleeves is obtained. The pin 18 is held in the grooves by a cap 19 secured on the outer end of the tubular extension 12 of the hub. A rotary bearing 20 for the blade spindle is provided between the outer sleeve 14 and the hub extension 12, and a thrust bearing 21 is provided between an external flange 22 on the inner sleeve 13 of the spindle and an internal flange 23 secured to the body 10 of the hub.

As the center of gravity of each blade is necessarily spaced from the axis of the blade, the eccentricity of the weight of each blade is balanced by a weight 24 at the outer end of an arm 25 whose inner end is fixed to a short stub shaft 26 extending inwardly from the inner end of the blade spindle. The arms 25 pass through slots 27 in the body 10 which are wide enough to provide for a turning of each blade spindle through an angle sufficient to move the blades from high-pitch position to low-pitch position, and positively limit the turning of the blades to such angle thus insuring that the blades are always in an operative position. As a safety factor, the turning of the two blades may, if desired, be synchronized by means of a miter gear 28 engaging gear segments 29 on the arms 25.

A centrifugal controlling element 30 is provided for each blade spindle. Each centrifugal controlling element 30 is slidably mounted in one of the tubular extensions 12 of the hub. As best shown in Fig. 4, the cylindrical extension 12 carries a boss 31 providing a way 32 in which the element 30 may slide. Rods 33 engaging half-round grooves in the way 32 and the element 30 retain the element 30 in the way and permit it to slide towards and away from the middle of the hub. Each controlling element 30 carries a spring-pressed cam follower 34 which extends through a slot 35 in the tubular portion to engage a cam 40 mounted on the outer sleeve 14 of the blade spindle.

The form of the cam 40 carried by each blade spindle is best shown in Figs. 7 and 8. The cam 40 consists of a block which is notched to fit a

notch in circumferential flanges 41 on the outer sleeve 14 of the blade spindle, so that it is held in immovable relation to that sleeve. The cam contains an endless groove 42 which may have the form of a triangle as shown. The direction in which the cam follower 34 moves around the groove is indicated by arrows on the groove in Fig. 7. To prevent movement of the follower around the groove in the opposite direction, the bottom of the groove is provided with ratchet notches 43 having gradually inclined surfaces 44 which permit the follower to move around in the direction of the arrows and abrupt surfaces 45a, 45b and 45c which positively prevent backward movement of the cam follower when it is in any one of the three corners a, b and c of the triangular groove.

The centrifugal force on each centrifugal element 30 is balanced by two spiral springs 46 mounted in spring casings 47 like watch springs and acting on sprockets 48 which engage a double rack 49 attached by a rod 50 to one of the centrifugal elements 30. The spiral springs are so adjusted that the centrifugal force of the centrifugal elements 30 holds these elements at the outer ends of their ways at maximum engine speed and at an intermediate point at cruising engine speed, while the springs hold the elements at the inner ends of their ways at idling speed.

The mounting and adjustment of the blades 15 will next be described. Each blade 15 consists of wood or of a composition such as wood and Bakelite, which is softer than metal. The cylindrical stub 16 at the inner end of the blade is provided with a pliable external metal thread 17 which is screwed into an internal thread in the sleeve 13 without clearance or even with a negative clearance so as to provide a very secure connection between the blade and the sleeve. The pliable thread 17 is formed of drawn aluminum alloy wire or steel wire. A half-round spiral groove, preferably having a cross-sectional diameter slightly less than the diameter of the wire, is cut in the stub of the blade. One end of the wire is secured in a hole 51 near the inner end of the blade, and the wire is then wound on the blade stub under tension, after which the other end is secured in a hole 52. A half-round spiral groove is cut in the inner surface of the sleeve 13. The cross-sectional diameter of this groove is no greater than that of the tensioned wire. The stub of the blade is then forcibly screwed into the sleeve. The pliability of the external thread on the blade makes it possible to screw it into the internal thread of the sleeve without the clearance which is necessary in ordinary screw threads, and even with a negative clearance. A very secure and tight connection between the blade and the sleeve is thus provided, which has a strength equal to the sheer strength of the wood or a composition of which the blade is made, and which occupies very little radial space.

After the blade has been screwed into the sleeve 13 and before the cap 19 is applied to the tubular extension 12, the blade and inner sleeve 13 are turned in the outer sleeve 14 until the blade occupies the low-pitch position best suited to the particular airplane on which the airscrew is to be used. The pin 18 is then inserted in the two grooves of the sleeves 13 and 14 which are in register when the blade is in this position, and the cap 19 is applied to hold the pin in position.

The operation of the airscrew when in use on an airplane is as follows:

Before the engine is started and also when the

engine is idling before the take-off, the springs 46 hold the centrifugal elements 30 at the inner ends of their ways, that is, in the position shown in Figs. 1 and 2. The cam follower pin 34 of each centrifugal element 30 is then in engagement with the inner corner a of the cam groove 42. This holds the blades in low-pitch position.

When the engine is speeded up to its maximum speed in the take-off, the centrifugal elements 30 move out to the outer ends of their ways. The step 45a of each cam groove prevents the cam pin 34 from moving towards the corner c of the triangular groove 42. Consequently, in the outward movement of the centrifugal elements, each cam pin moves along the long side of the groove 42 to the corner b. As the long sides of the cam grooves are parallel to the axis of the blades, the engagement between the cam follower pins and the grooves holds the blades in low pitch during the speeding up of the engine. A low pitch for the take-off is thus insured.

After the take-off, the engine speed is cut down by the throttle below the normal cruising speed, for example, to half of the maximum speed. This slowing down of the engine and the airscrew allows the springs 46 to draw the centrifugal elements about half-way inward. In this inward movement of the centrifugal elements, the step 45b in each cam groove prevents the pin 34 from moving back along the long side of the groove and requires it to move along one of the short sides of the groove to the corner c. In this movement, the engagement between the pins 34 and the cams turns the blade spindles so as to place the blades in high-pitch position. This turning is effected by a small force, since the eccentricity of the weight of the blades is balanced by the weights 24 and the load on the thrust bearings 21 is reduced fourfold by the fifty per cent. reduction in speed of rotation. After the blades have been placed in high-pitch position by reducing the engine speed below cruising speed, each pin is prevented from moving outward by the step 45c. The engine speed may, therefore, be increased as desired without changing the high-pitch position of the blades.

When a landing is to be effected or when for any reason the pilot desires to place the blades in low-pitch position, it is necessary only to cut the speed of the engine momentarily to idling speed. This permits the springs 46 to draw the centrifugal elements back to the inner ends of the ways bringing each pin 34 back to the corner a of its cam groove, thus turning the blades to low-pitch position. A landing may be effected with the blades in low-pitch position. If, after starting to land, the pilot finds that it is undesirable or unsafe to do so, he can immediately change to a sharp climb by merely advancing his throttle, since the blades remain in low-pitch position during such speeding up of the engine, as explained in connection with the take-off.

Thus the pitch of the blades is always under control of the pilot through the pilot's control of the throttle, and the changes of pitch necessary in taking-off, cruising and landing are made merely by manipulating the throttle in the same manner as that in which it would ordinarily be manipulated in these maneuvers.

While the airscrew which has been described is entirely adequate for small airplanes, my invention is by no means limited to a two-pitch airscrew. Thus, when my airscrew is used on an airplane of such size that it is desirable to provide three pitch positions, it is necessary merely

to substitute for the two-pitch cam shown in Fig. 7 the three-pitch cam shown diagrammatically in Fig. 10. The three-pitch cam has a step 45x between the steps 45b and 45c to provide a pitch intermediate between high pitch and low pitch and appropriate for climbing. Further such steps may be provided on either of the short sides of the triangular cam groove to provide as many pitch positions as may be desired.

What I claim is:

1. In an airscrew having a relatively fixed hub element, a turnably mounted blade spindle and a controlling element responsive to speed of rotation, an interconnection between the controlling element, the blade spindle and the fixed element comprising a cam follower and a cam having an endless cam groove formed to permit the cam follower to move around the groove in one direction and positively to prevent it from moving around the groove in the opposite direction.

2. In an airscrew having a relatively fixed hub element, a turnably mounted blade spindle and a controlling element responsive to speed of rotation, an interconnection between the controlling element, the blade spindle and the fixed element comprising a spring-pressed cam follower and a cam having an endless cam groove containing ratchet notches permitting the follower to move around the groove in one direction only.

3. In an airscrew having a relatively fixed hub element, a turnably mounted blade spindle and a controlling element responsive to speed of rotation, an interconnection between the controlling element, the blade spindle and the fixed element comprising a cam follower and a cam formed to guide the follower in one direction around the

periphery of a triangular area during one complete reciprocation of the controlling element and to prevent the cam follower from moving around the periphery of said area in the opposite direction.

4. In an airscrew having a relatively fixed hub element and a turnably mounted blade spindle, a centrifugal controlling element slidably mounted on the fixed element for movement parallel to the axis of the blade spindle between inner and outer positions, a spring urging said element towards its inner position, a connection between the controlling element and the blade spindle comprising a spring-pressed cam follower and an endless cam groove in the form of a triangle with a long side parallel to the axis of the blade spindle and short sides inclined to the axis of the blade spindle, the groove containing ratchet notches preventing the cam follower from moving along the long side of the triangle when the controlling element moves inwardly from its outer position and preventing the cam follower from moving along the short sides of the triangle when the controlling element moves outwardly from its inner position.

5. In an airscrew having a relatively fixed hub element and a turnably mounted blade spindle, a controlling element slidably mounted on the fixed element for movement parallel to the axis of the blade spindle, a pair of pinions mounted on the hub element, spiral springs urging said pinions to turn in opposite directions, a double rack connected to the controlling element and engaging said pinions, and a cam connection between said controlling element and the blade spindle.

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