Oct. 7, 1930. S. P. VAUGHN 1,777,630

LIFTING AIR SCREW FOR AIR VEHICLES

Filed March 8, 1929

FIG. 1

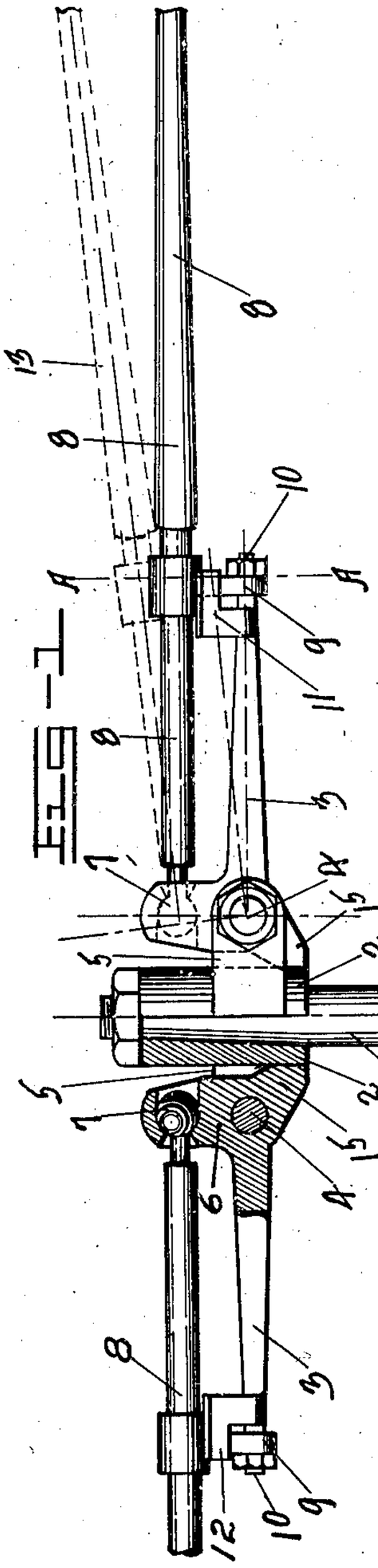


FIG. 2

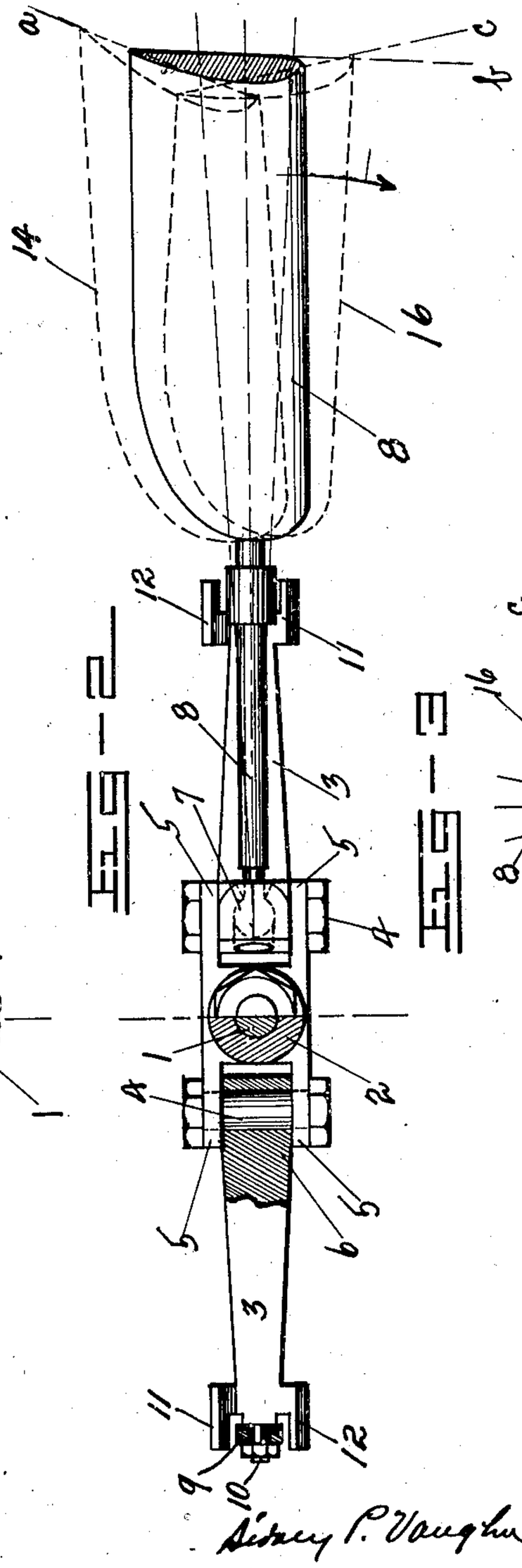
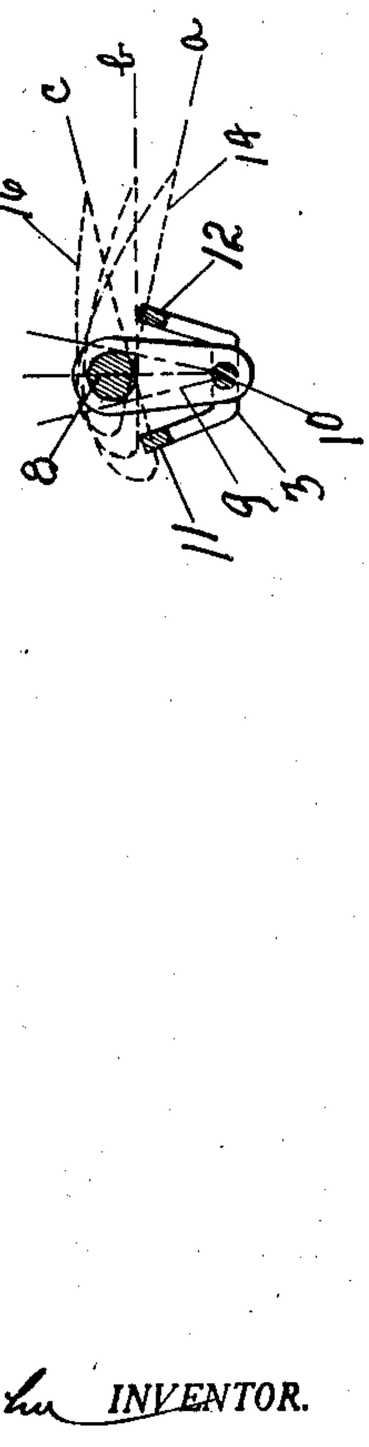


FIG. 3



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LIFTING AIR SCREW FOR AIR VEHICLES

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(GRANTED UNDER THE ACT OF MARCH 3, 1883, AS AMENDED APRIL 30, 1928; 370 O. G. 757)

This invention refers to lifting air screws for air vehicles such as helicopters, and the principal object is to provide an air screw having blades hinged to the hub in a manner that the blades automatically attain a positive pitch when a torque is applied to the driving shaft and automatically attain a negative pitch when the torque is removed, thereby providing at will a lifting air screw for vertical ascent and a windmill for descent and forward flight.

Another object is to provide an air screw for supporting air vehicles in the air that is inherently stable under all conditions of flight.

Another object is to provide in an air screw having hinged blades, whereby centrifugal force is utilized to assist the thrust force in causing the blades to attain a negative pitch when the torque or driving force is removed.

With the above and other objects in view the invention consists in the construction, combination and arrangement of parts as will be more fully described hereinafter.

Reference is to be had to the accompanying drawings forming part of this specification in which like reference characters indicate corresponding parts throughout the several views and in which—

Fig. 1 illustrates a side elevation of the air screw partially in section to better illustrate the details. Fig. 2 is a plan view of the air screw illustrated in Fig. 1 and is cut away in section to better illustrate the details. Fig. 3 is a sectional view on line A—A Fig. 1 looking toward the hub.

The drive shaft 1 of the air screw carries a hub 2 to which radial arms 3 are hinged by hinge pin 4 passing through forks 5, extending from the hub 2, and the bases 6 of the arms 3, whereby the arms are pivotally held to the hub and are swingable in an upward direction or in the direction of thrust. The bases of the arms 3 extend upwardly and have the roots of air screw blades 8 attached thereto by ball and socket joints 7 which permit the blades to swing a limited distance in all directions. The upward swing of the blades with reference to the arms 3 is restrained by cranks 9 secured to the blades a short distance away from the ball and socket joints and loosely hinged to the end of the arms 3 by hinge pins 10. The side swing of the blades 8 is restricted by stops 11 and 12 which intercept the cranks 9 and limit the movement of the cranks through an arc equal to the difference between the maximum negative and positive pitch desired in the blades.

Normally the arms 3 and the blades 8 attached thereto are held in a right angle position to the axis of the hub by stops 15, formed by downward extensions on the bases of the arms, which rest against the hub 2. The position of the blades is indicated by the full lines and the blade pitch is indicated by the pitch lines (*b*) Figs. 2 and 3. From the above it is obvious that the blades are free to move with the hinged arms in an upward direction and are free to swing a limited distance with reference to the arms in a conical path around the ball and socket joints. Such an arrangement permits the pitch of the blades to be changed from a negative pitch to a positive pitch when a torque is applied to the drive shaft and from a positive pitch to a negative pitch when the torque is removed, also the blades are free to attain a radial position corresponding to the resultant of the thrust and centrifugal forces acting upon the blades.

Since the pivotal points 7 of the blades 8 are above the pivotal points 4 of the arms, any centrifugal force acting upon the blades is transmitted to the hub through the pivotal points 7 and tends to swing the arms 3 downwardly and away from the blades. Since the downward movement of the arms is restrained by the cranks 9, the axes of the blades tend to attain a position above and in the same radial planes as the axes of the arms when no torque is acting upon the blades, as illustrated by the full lines in the drawings. In the drawings the chords of the blades are shown at right angles to the longitudinal axes of the cranks and the full lines show the pitch "*b*" of the blades as zero, but it will be understood that the angle formed between the chords of the blades and the longitudinal axes of the cranks 9 may be either greater or less than 90 degrees depend-

ing upon the extent to which it is desired to utilize centrifugal force in causing the blades to attain a negative pitch when no torque is applied.

When the angle between the chords of the blades and the longitudinal axes of the cranks 9 is 90 degrees it is best to have the center of thrust or lift between the longitudinal axes of the cranks and the trailing edges so that these forces will cause the blades to swing in the direction of the leading edges around the axes of the arms and attain a negative pitch when no torque is applied as illustrated by the dotted lines 16. The blades must be so designed that the tendency to swing forward and attain a negative pitch, due to the fact that the center of thrust or lift is in the rear of the longitudinal axes of the blades, is not so great as to prevent the blades swinging backward and attaining a positive pitch when a torque is applied as illustrated by the dotted lines 14.

In describing the operation of the air screw assume that it is operating as the lifting air screw of a helicopter and is driven by a motor (not shown) which may be disconnected at will by the use of a clutch placed between air screw and the motor. When a torque is applied to the drive shaft of the air screw for vertical ascent, the drag on the air screw blades causes them to swing backward against the stops 12 and attain a positive pitch (*a*) as illustrated by the dotted lines 14 in Figures 2 and 3. When rotating with a positive pitch a lift force or upward thrust is obtained which causes the blades to swing in an upward direction around the hinge pin 4 until the centrifugal force balances the lift force as illustrated by the dotted lines 13 in Figure 1. The blades will then assume an angular position relative to a plane at right angles to the axis of the hub which is the resultant of the thrust and centrifugal forces. When sufficient altitude has been obtained for forward flight, or when it is desired to descend, the clutch is thrown out and the air screw disconnected from the motor which removes the torque from the air screw drive shaft. The blades still sustain the vehicle and the upward thrust and the centrifugal force acting upon the blades instantly causes them to swing forward against the stops 11 and attain a negative pitch (*c*) as illustrated by the dotted lines 16 in Figure 2. When the blades attain a negative pitch they will continue to revolve in the same direction and will act as a windmill due to the passage of the air through the blades from below. When the air screw is revolving freely as a windmill the vehicle may be propelled forward by another propeller attached to the motor in the same manner as an airplane or the Cierva autogyro.

It is apparent from the above description that many modifications in structural arrangement may be made without departing from the principles described and the spirit of the following claims, and all such modifications I claim.

I claim:

1. In an airscrew, a drive shaft, a hub mounted thereon, arms pivotally carried by the hub, and blades carried by the arms, said blades being free to swing in a conical path relative to a radial line extending from the hub through the axis of the cone and also to swing in a radial plane parallel to the axis of the hub.

2. In an airscrew, a drive shaft, a hub mounted thereon, laterally extending forks supported by the hub, arms pivotally connected to the forks and movable in a radial plane parallel to the axis of the hub, and blades supported by the arms, said blades having a movement in a conical path relative to a radial line extending from the hub through the axis of the cone.

3. In an airscrew, a drive shaft, a hub mounted thereon, laterally extending forks supported by the hub, arms pivotally connected to the forks and movable in a radial plane parallel to the axis of the hub, means carried by the arms for restricting their movement in an upward direction, and blades supported by the arms and movable with respect thereto.

4. In an airscrew, a drive shaft, a hub mounted thereon, arms pivotally carried by the hub and having a movement in a radial plane parallel to the axis of the hub, blades supported by the arms and having a movement whereby their pitch is varied, and means carried by the arms for limiting the amount of said last movement.

5. In an airscrew, a drive shaft, a hub mounted thereon, forks extending laterally from the hub, arms pivotally connected to the forks, blades supported by the arms, the inner ends of the roots of the blades being attached to the arms by ball and socket joints and the intermediate portions by cranks.

6. In an airscrew, a drive shaft, a hub mounted thereon, arms connected to the hub, blades movably carried by the arms, and means connecting the blades to the arms whereby the blades attain a positive pitch when a torque is applied to the drive shaft and attain a negative pitch when the torque is removed.

7. In an airscrew, a drive shaft, a hub mounted thereon, arms pivotally connected to the hub, blades movably supported by the arms, and means connecting the blades to the arms to permit the blades to swing through a conical path relative to a radial line extending from the hub through the axis of the cone to change the pitch of the blades, and to attain a radial position corresponding to the resultant of the thrust and centrifugal forces acting upon the blades.

8. In an airscrew, a drive shaft, a hub mounted thereon, arms pivotally connected to the hub, and blades carried by the arms, said blades and arms having a movement in a radial plane parallel to the axis of the hub, and the blades having an independent movement in a conical path relative to a radial line extending from the hub through the axis of the cone.

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