

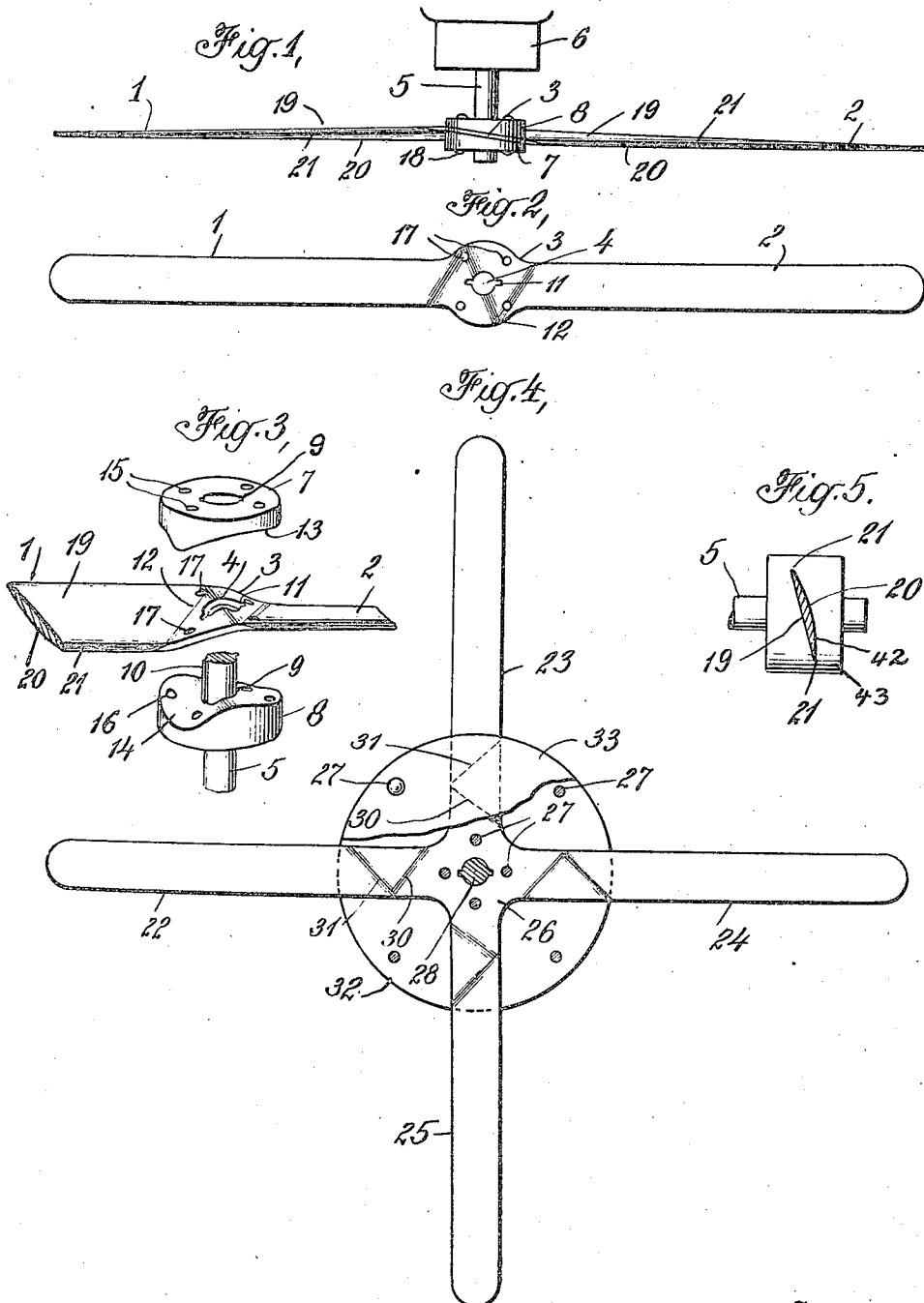
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S. A. REED

AERONAUTICAL PROPELLER

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Inventor
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UNITED STATES PATENT OFFICE.

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AERONAUTICAL PROPELLER.

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To all whom it may concern:

Be it known that I, SYLVANUS ALBERT REED, a citizen of the United States, residing at New York city, in the county of New York and State of New York, have invented certain new and useful Improvements in Aeronautical Propellers, of which the following is such a full, clear, and exact description as will enable any one skilled in the art to make and use the same.

My invention relates to propellers for air craft and flying machines and discloses a novel principle for obtaining the necessary rigidity of the propeller blades to resist the stresses, thereby making possible the use of much thinner blades than heretofore with a gain in efficiency.

Heretofore aeronautical propellers have been made of material such as wood or metal constructed to be structurally rigid against operative stresses, such rigidity usually being substantially sufficient, even when at rest, to resist tangential axial and radial stresses which would occur in full speed operation. It is obvious that when an aeronautical propeller, say eight feet diameter, is operated at say 1200 revolutions per minute, centrifugal force adds to the structural rigidity due to the form of the propeller, a quasi or virtual or dynamic rigidity from the radial tension due to centrifugal force, and this added rigidity is a contingent advantage, but hitherto not regarded as an element which would justify omitting any considerable percentage of the elements providing static or intrinsic rigidity. This has much justification where the rotative speeds do not much exceed 1000 revolutions per minute. If, however, high rotative speeds are used, such for example, as say 5000 to 15000 revolutions per minute, the centrifugal force becomes such a large factor that a progressively less necessity exists for structural or intrinsic rigidity and I have ascertained by many experiments, and as can be easily calculated from well known laws of mechanics, that at certain rotative speeds, a stage or condition is reached where structural or intrinsic rigidity can be largely and to a substantial extent discarded in the design of the propeller and its construction, and reliance placed mainly upon the quasi or virtual rigidity of kinetic character due to centrifugal force.

There are two limiting considerations in

the design or construction and operation of my improved construction of propellers—first, the limit of rupture, and—second, the limit of propeller efficiency measured by the ratio of thrust at stated flying velocities to torque. I have found regarding the first, that by using with propeller blades of thin material the familiar method of tapering the thickness of the blade from hub to tip, very large rotative velocities may safely be used with propellers of diameter sufficient for practical use, and regarding the second, that by substituting thin material blades for blades having the bulky interior portions of structurally or intrinsically rigid propellers, the great reduction in air resistance produces at these high tip velocities efficiencies which compare very favorably with those of the propellers of the customary bulky and massive forms operated at customary speeds.

My invention consists in the various novel and peculiar constructions and arrangements of parts as herein set forth and particularly pointed out in the claims, and I have illustrated types of my invention in the accompanying drawings which are somewhat diagrammatic in parts and wherein I endeavor to clearly show the relatively thin character of the propeller blades the cross-section of which may be varied. In the said drawings;

Fig. 1, is a side view of an aeronautical propeller embodying my invention and secured to a hub mounted on a drive-shaft which is connected with a suitable source of power indicated in said figure, the propeller being a double-bladed one and the view being taken edgewise thereof.

Fig. 2, is a broadside view of the propeller shown in Fig. 1, and shown as detached.

Fig. 3, is an enlarged perspective view of the central part of the two-bladed propeller with the outer portions of the blades broken away, together with two clamping sections of the hub shown as spaced apart in relative clamping positions ready to be assembled.

Fig. 4, is a broadside or face view of a one-piece propeller having four equally spaced radial blades and mounted on the hub of the drive-shaft.

Fig. 5, is an enlarged view of a modified form of the invention, in which separate blades are set or anchored in the hub at a suitable pitch-angle and in any suitable

manner, the blade being shown in cross-section.

Referring to the drawings, in which like numerals of reference designate like parts throughout, 1 and 2 are propeller blades here shown as made integral, that is to say the whole propeller is a single piece though it may be otherwise, with a central connecting or hub part 3, and the blades extend in line with each other in diametrically opposite directions. The hub part 3, is provided with a central orifice 4, for receiving the drive-shaft 5, driven by a suitable source of power indicated at 6, such as an internal combustion engine, or steam-engine or other well known form of motor.

The propeller just described contains its own hub 3, and may be used without additional hub structure, but it may be attached to the usual tubular metal hub member customarily employed with wooden propellers and the same mounted on the propeller shaft. I prefer, however, to provide the propeller hub 3, with additional sectional members made in two clamping sections 7 and 8, each having a central opening for the shaft 5, and each formed with key-ways 9, for receiving the key 10, fixed on the shaft, the central part 3, of the propeller being also formed with key-ways 11, for receiving the shaft key 10, thereby strengthening the assembled parts. In order to give the blades 1 and 2, the necessary pitch-angle, I bend or twist the central connecting part 3 as indicated at 12, in a manner suitable to provide such pitch-angle at the outer part of each blade. Thus a simple twist would accomplish the same result, but in order to avoid possible unequal strain on the material involved by twisting metal cold, I prefer to use the bend 12, which is shown as a geometrical double bend of such shape and character as to provide each blade with the same pitch-angle, and obviously the shape or form of said bend may be varied as desired, so long as the necessary pitch-angle is obtained, as indicated in the drawings.

It will also be noted that each blade has its pitch or blade angles diminishing helically or screw-like from root to tip, as indicated in Fig. 1, which shows an edge view in elevation of my propeller, the said construction giving the effect in said view of a convergence from root to tip of the edges of the blade, which Fig. 2, shows of substantially uniform width.

The clamping-faces 13 and 14, of the respective hub sections 7 and 8, are shaped to conform to and to truly fit the pitch-angle bend 12, upon the opposite sides of the central part 3, and they are counter-parts of each other. The hub-sections are provided with bolt-holes 15 and 16, respectively, which register with a similar set of holes 17, in the hub-part 3, and receive the bolts 18,

by means of which the said parts are securely fastened together, as indicated in Fig. 1. Thus the hub members serve to hold and to assist in retaining in shape the one-piece double-bladed propeller and the blades external to the hub are maintained at the desired pitch-angle.

The blades taper in thickness from hub to tip, as indicated in the drawings, and the rear side is somewhat flat as at 19, while the forward face is slightly bowed or curved as at 20, while the edges are relatively sharp, as indicated at 21, but of course this form may be varied as found expedient.

In Fig. 4, I show a modified form of my propeller in which there are four blades 22, 23, 24 and 25, arranged equal distances apart in radial relation and made in one piece of material. This is secured to a hub 32-33 by means of bolts 27, and the hub is keyed to the shaft 28, which drives the propeller. The pitch-angle is given each blade by bending it near the hub on oblique lines 30, 31, in opposite directions, while the central portion 26 is unbent. The hub is formed in two sections 32 and 33, which are shaped or molded on their inner faces to conform to the series of bends in the respective blades as well as the blades, and are clamped against the blades by the bolts 27, the section 33 being shown as broken away.

Fig. 5, shows a modified form of blade 42, which instead of being integral with its opposite blade, is formed separate and is secured in any suitable manner to the hub 43, at an angle such as to give the blade the requisite pitch-angle.

I make my improved blade relatively thin and thinner than customary throughout, thereby dispensing with a large amount of material which has been required heretofore to give the blade the proper amount of rigidity, and which thin blade when operated at the high speeds herein referred to receives a degree of rigidity imparted thereto by radial tension sufficient to make it practically operative.

By dispensing with the bulk necessary for intrinsic rigidity, my improved propeller wastes less power in friction and air resistance than propellers of the intrinsically rigid type and it is therefore more efficient. By thus providing a propeller which can be operated efficiently at tip velocities much higher than those that have been heretofore employed, the way is opened for the use of motors of higher rotational speed, without the necessity of gearing down to a hitherto limited rate of rotation for the propeller shaft or for propellers of greater diameter at customary rotative speeds. With this limitation removed motors of higher efficiency, that is greater power per unit of weight, can be used, and my improved propeller is especially suited for direct con-

nection to a steam turbine engine which is thereby better adapted for use as a direct-drive aerial motor.

The thinness of the blades of my propeller also affords an advantage over propellers of the intrinsically rigid type, in respect to their superior adaptability to assemblage as multi-blade propellers—either radial or tandem on the same shaft. Thus two two-blade propellers may be crossed at right-angles quite close together on the same shaft, or three or more assembled in a similar way to produce a multi-blade propeller. Or propellers may be strung one in front of the other at intervals, that is to say in tandem, without occupying as much of the length of the propeller shaft as would be required for a similar arrangement with propellers of the intrinsically rigid type.

I have found that by the assemblage of my propellers in both the radial and tandem manner I obtain an increased absorption of the motor power and delivery of same in the form of useful thrust, without any decrease of efficiency and with the occupation of much less space than would be the case with a similar grouping of propellers of the intrinsically rigid type.

My improved propeller may have its blades made of metal, or alloy of metal, or wood, or a suitable composition, and the material used may be flexible, pliable, ductile or malleable, the important requisite being that when made of the required thinness the blade will fulfill the essential requirements herein stated. I have used flat steel and also aluminum in making my improved propellers.

My improved propeller may be made from suitable sheet metal, or by forging or casting the same, and it can be manufactured at a lower cost than other forms of aeronautical propellers. It can be rapidly and cheaply made by stamping it directly from the sheet-metal in completed form except for minor finishing.

It will be observed that while, for the purposes of illustration, I have herein set forth specific embodiments of my invention for utilizing a high degree of radial tension due to centrifugal force as means for creating and maintaining sufficient virtual rigidity in thin propeller blades to make them practically operative, I am aware that many changes and modifications may be made in the different features thereof, without, however, departing from the spirit of my invention.

The term relatively thin as used herein, is intended to define a body whose maximum thickness is that of a metal plate as distinguished from the thinness of a metal sheet, on the one hand, and the thickness of a metal bar or like bulky body, on the other.

It is to be noted that the flexing stresses

of operation are slight at slow rotative speeds, as while getting up speed, the centrifugal force being also slight, but the degree of flexibility of my blades at various points is so proportioned that at every speed the centrifugal force supplements the intrinsic rigidity sufficiently for the necessary actual rigidity to meet the stresses at that speed.

While I have herein described my invention as particularly applicable for use in connection with aeronautics, it is obvious that the same is applicable for use in any field in which air propulsion or blasts can be used.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. An aeronautical propeller having single piece blades constructed of material of such thinness as to require dependence partly but mainly upon the radial tension exerted by centrifugal force to maintain the blades in operative form or shape.

2. An aeronautical propeller having single piece blades of material which is flexible and dependent partly but mainly upon centrifugal force to give the blades sufficient rigidity to substantially overcome lateral deflecting forces tending to reduce efficiency.

3. An aeronautical propeller having single piece blades dependent for resistance to flexure caused by air partly but mainly upon the virtual rigidity imparted by radial tension due to centrifugal force.

4. An aeronautical propeller having one-piece blades dependent for resistance to flexure caused by air partly and substantially upon the virtual rigidity imparted by radial tension due to centrifugal force, and means combined therewith for rotating the propeller at a rate adequate to cause centrifugal force of the degree necessary for sufficient virtual rigidity.

5. An aeronautical propeller the thickness of whose blades does not exceed substantially one-seventy-fifth of their lengths, the propeller being so bent or twisted that the said blades are bodily deflected pitch-wise.

6. An aeronautical neckless propeller whose blades have a ratio of thickness to length not exceeding substantially one-seventy-fifth and have a relatively thin root portion sufficiently rigid to withstand deformation and a relatively elastically flexible outer portion and with blade pitch-angles diminishing helically from root to tip.

7. A one-piece aeronautical neckless propeller made of metal and whose blades are relatively thin throughout their lengths and have a progressively increasing elastic flexibility from root to tip.

8. A one-piece aeronautical propeller having a relatively thin and wide and rigid central connecting portion and relatively

flexible outer portions, said central portion being rigid independently of its mounting-means.

9. A metal aeronautical propeller whose blades are relatively thin throughout their lengths and have as great a width at the axial region as at any other point throughout their lengths and with blade pitch-angles diminishing helically from roots to tips.

10. A metal aeronautical propeller whose blades are relatively thin throughout their lengths and whose outer portions are of no greater width than the axial region and with blade pitch-angles diminishing helically from roots to tips.

11. A metal aeronautical propeller whose blades are relatively thin throughout their lengths and substantially wide and non-cylindrical at the axial region and are no narrower at the axial region than at any part of the outer portions and with blade pitch-angles diminishing helically from roots to tips.

12. A one-piece aeronautical propeller whose blades are relatively thin with a root portion sufficiently rigid to withstand deformation by air during rotation and with the outer portion relatively flexible and dependent mainly upon centrifugal force for sufficient rigidity against deforming stresses during operation.

13. A metal aeronautical propeller whose blades are relatively thin and taper in thickness from root to tip and which depend for resistance to axial and tangential flexure by air during rotation mainly upon virtual rigidity imparted thereto by centrifugal force.

14. An aeronautical propeller whose blades have as great a width at the axial region as at any other point throughout their lengths and are so constructed and proportioned that their structural or intrinsic rigidity for resisting axial and tangential flexure during operation bears to the kinetic or virtual rigidity due to centrifugal force a ratio which is large at or near the axis and diminishes progressively to a small figure at the tips and with blade pitch-angles diminishing helically from roots to tips.

15. An aeronautical propeller whose blades have as great a width in the axial region as at any other point throughout their lengths and are so constructed and proportioned that their structural or intrinsic rigidity for resisting the deforming stresses

of operation bears to the kinetic or virtual rigidity due to centrifugal force a ratio which is large at or near the axis and diminishes progressively towards the tips to a small figure thereat.

16. A single piece metal aeronautical propeller twisted or formed to give its blades a screw-pitch and whose blades are tapered in thickness substantially from the axial region to the tips to a thinness increasing to such a degree of resilient flexibility beyond substantially half-blade length as to depend for their rigidity against deflecting forces mainly upon centrifugal force during operation.

17. A one-piece aeronautical propeller made of metal and relatively thin throughout and having a rigid central or blade-connecting portion and relatively flexible outer portions, whose pitch-angles diminish progressively from roots to tips.

18. An aeronautical propeller having blades shaped to a definite pitch and tapered in thinness towards the tips to such a degree of resilient flexibility that the propeller relies for adequate rigidity during operation partly but mainly upon centrifugal force, and whose opposite blades are rigidly united centrally by extending one through the axis of rotation to continuation of the other with a reversal of blade-angle with the radial plane effected by compound bends equivalent to a twist continuing the leading edge of each blade as the trailing edge of the other.

19. An aeronautical propeller having blades shaped to a definite pitch and tapered in thinness towards the tips to such a degree that they rely for adequate rigidity during operation partly but mainly upon centrifugal force, and whose opposite blades are rigidly united centrally by extending one through the axis of rotation to continuation of the other with a reversal of blade-angle with the radial plane effected by distortion so as to continue the leading edge of each blade as the trailing edge of the other, the blade extension crossing the radial plane and having a section wide in said plane in comparison with the thickness in said plane, for effective transmission of torque.

In testimony whereof, I have hereunto set my hand in the presence of the two subscribing witnesses.

S. ALBERT REED.

Witnesses:

GEORGE C. KOBBE,
LEON MALRAISON.