

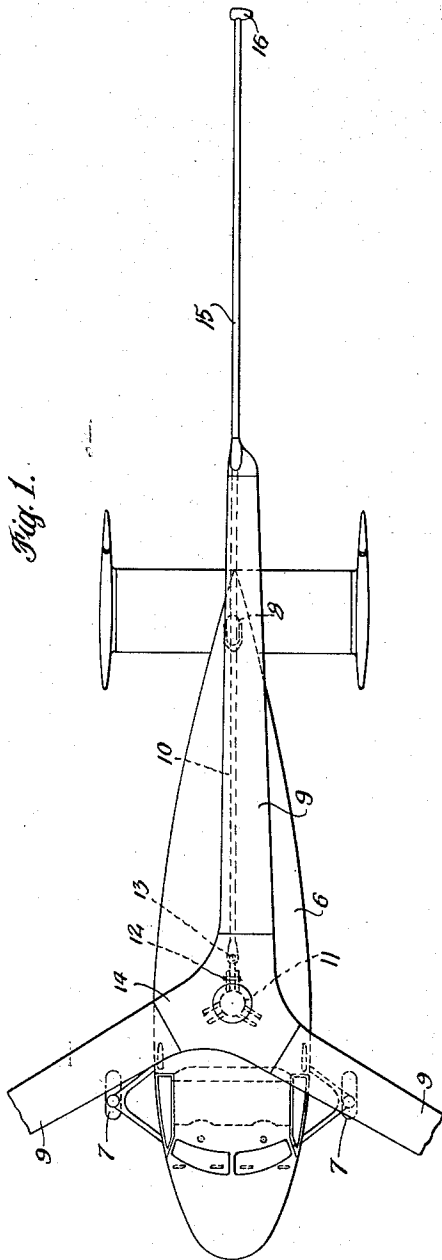
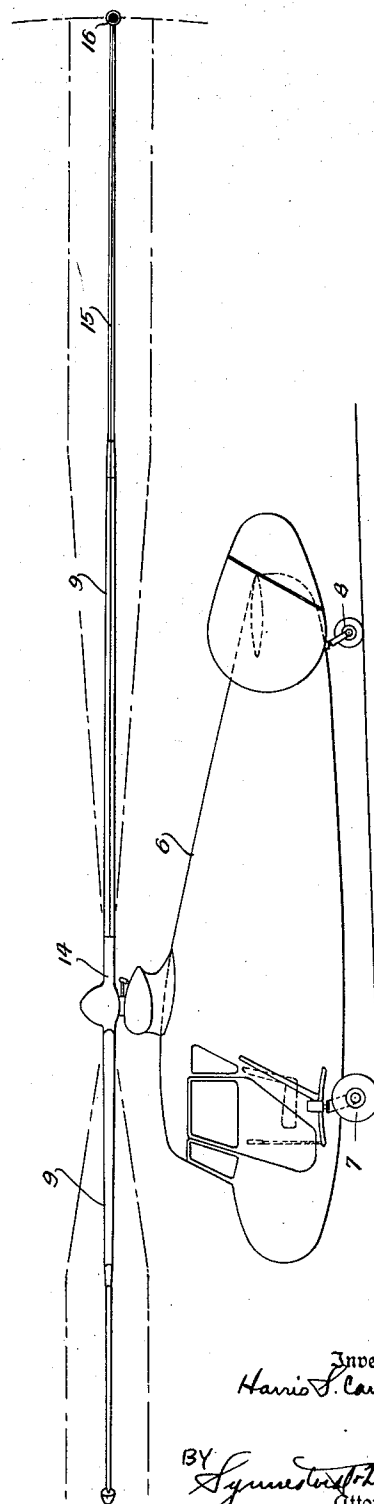
Jan. 1, 1957

H. S. CAMPBELL
JET DRIVEN SUSTAINING ROTOR

2,776,016

Filed June 9, 1948

2 Sheets-Sheet 1



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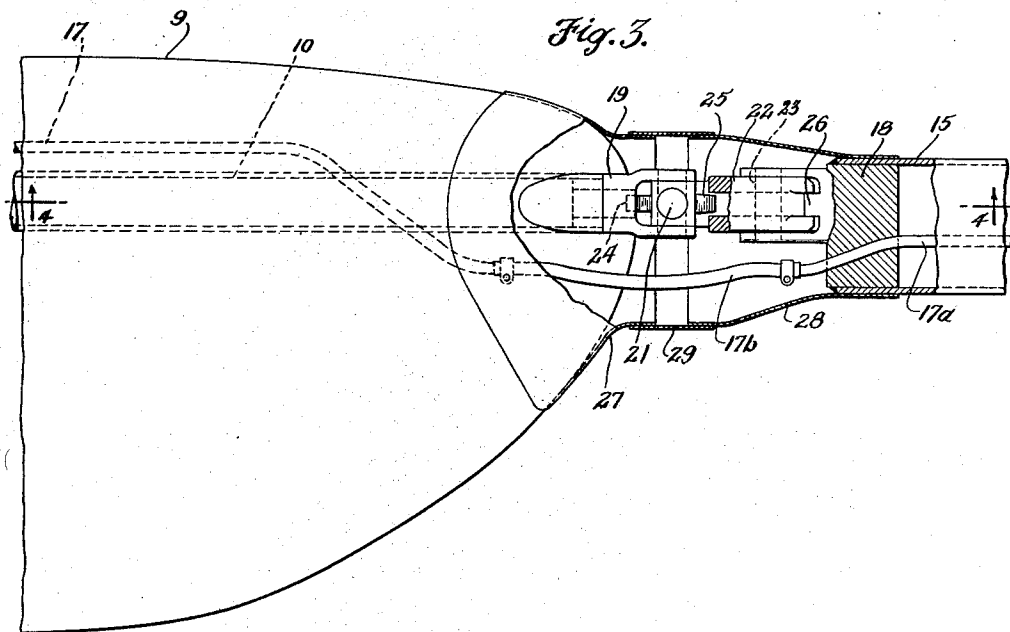
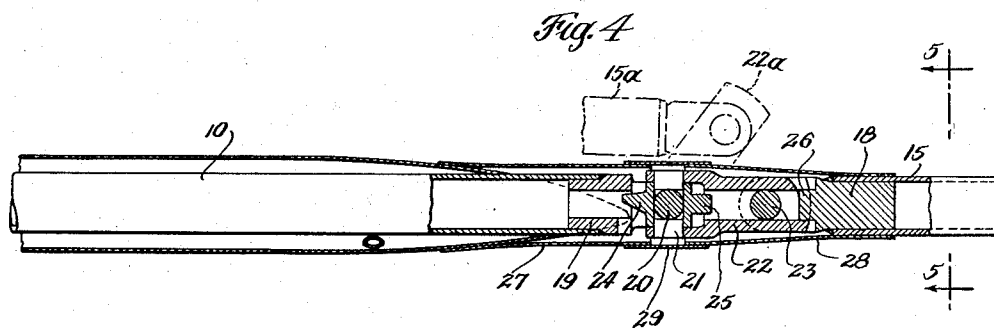
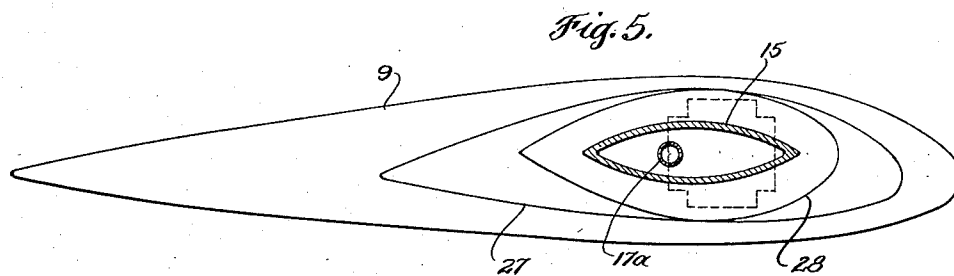
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JET DRIVEN SUSTAINING ROTOR

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8 Claims. (Cl. 170—135.4)

This invention relates to rotative winged aircraft, and especially to such aircraft incorporating a bladed sustaining rotor with jet driving devices carried by the blades.

As is known, efficiency of jet operation requires a relatively high velocity of movement of the jet. On the other hand, for various reasons, it is advantageous to avoid an excessively high rotor blade tip speed.

One of the principal objects of the present invention is to provide an arrangement in which both of the considerations just referred to are satisfied, the arrangement providing for high velocity movement of the jet, while at the same time avoiding excessively high blade tip speed.

Briefly, this is accomplished according to the invention by providing extended supports projecting radially from the tips of the rotor blades and carrying the jet driving devices toward the outer ends thereof.

In considering another aspect of the invention, attention is first directed to the fact that because of various considerations, it is desirable to avoid excessively large blade swinging movements, either in the flapping sense or in the lag-lead sense, about the flapping and drag pivots frequently employed for mounting sustaining rotor blades. It is an object of the invention to reduce such blade swinging movements about the root end mounting pivots, and this is accomplished, in the arrangement of the invention, by virtue of the location of a weight or mass, advantageously the jet device itself, at the outer ends of the extensions above mentioned, which project radially beyond the blade tips. Because of the relatively great radius of rotation of such weights, even a relatively small weight will exercise a substantial influence tending to restrict the extent of blade swinging movements.

In accordance with another feature of the invention, various bending moments in the blades and extensions are relieved by the provision of a pivotal connection between the tips of the blades and the extensions projecting radially therefrom. This is of particular importance in the preferred arrangement of the invention, according to which, although the radial extensions are of aeroform section, they are so mounted as to operate at substantially zero effective lift incidence, whereas the blades themselves are, of course, normally set to operate at an appreciable positive effective lift incidence.

In accordance with still another feature of the invention, it is contemplated that the blade tip speed be kept below the transonic range, while at the same time using radial extensions of sufficient length to cause the jet devices carried at the outer ends thereof to operate at a supersonic speed. At the same time, the preferred arrangement of the invention contemplates employment of a blade section of appropriate shape for operation below the transonic speed range, the transverse section of the extension, however, at least in the outer region thereof, being "wedge shaped" or sharp edged, as is required for low drag characteristics at supersonic velocities.

Still another object of the invention is the provision of means for folding the radial extensions, whereby to reduce the overall diameter of the rotor system, for instance for purposes of storage or parking.

How the foregoing and other objects and advantages are attained will appear more fully from the following description referring to the accompanying drawings, in which:

Figure 1 is an outline plan view of the aircraft equipped

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with a sustaining rotor, according to the present invention;

Figure 2 is an outline elevational view of the aircraft of Figure 1;

Figure 3 is an enlarged plan view, partly in horizontal section, of the junction between one of the blade tips and the radial extension projecting therefrom;

Figure 4 is a vertical sectional view taken as indicated by the section line 4—4 in Figure 3; and

Figure 5 is a transverse sectional view through the radial extension, taken as indicated by the line 5—5 on Figure 4, this view being on a still further enlarged scale.

As seen in Figures 1 and 2, the aircraft comprises a body 6 having appropriate landing gear including wheels 7 and 8. In the particular embodiment illustrated, the aircraft is provided with a single sustaining rotor incorporating three blades 9. Each blade may be built up in any suitable known manner, preferably incorporating a primary longitudinal strength structure such as the spar indicated at 10. The root end of the spar is advantageously connected with a rotative hub member such as indicated at 11 by means of a flapping pivot 12 and a drag pivot 13. The entire hub assembly, including the root end mounting pivots for the several blades, may be enclosed within a streamlined fairing 14. If desired, a pitch mounting bearing may also be provided at the root end of the blade, so as to permit the blades to change their pitch angle about the longitudinal blade axis, for instance, for control purposes, in a manner understood in this art.

Each blade is provided with a spar-like extension 15, desirably of length equal at least to one-half of the blade radius, for instance, from 50% of the blade radius to 100% of the blade radius. At its outer end, the extension 15 carries a jet-driving device 16.

The jet-driving device may take any one of a variety of forms, and since the details thereof form no part of the present invention per se, they are not described herein. It may be mentioned, however, that with certain types of jet devices, it is desirable to continuously feed fuel thereto, and for this purpose, a fuel feed line such as shown at 17 may be extended radially outwardly through the blade 9 from the hub, the line 17 being coupled with an extension line 17-a in the radial extension 15 by means of a flexible tube 17-b.

As best seen in Figures 3 and 4, the extension 15 is of hollow spar-like construction, having a root end fitting 18 adapted to be connected with the tip end of the blade spar 10 by means of flexible or pivot joints. Thus, a forked fitting 19 is secured to the blade spar 10 and this fitting cooperates with a universal joint incorporating flapping and drag pivots 20 and 21. The drag pivot in turn cooperates with the forked link 22 which is pivotally connected by the horizontal pivot 23 with the root end fitting 18 of the extension 15.

Various of the swinging movements provided by the pivotal connections just described are limited by stops including a droop stop 24 projecting into the fitting 19 at the tip of the blade spar 10 and serving to prevent excessive downward swinging movement of the extension 15 about the horizontal pivot 20. The lower portion of the fitting 19, however, is cut away so that the stop 24 will not interfere with upward swinging movement of the link 22, for instance, to the position indicated at 22-a in Figure 4. Lag-lead movement of the extension 15 is limited by a stop 25 which projects into the link 22, as clearly appears in both Figures 3 and 4. This stop has clearance providing free movement within predetermined limits, but comes into engagement with the link 22 upon excessive lag-lead swinging of the extension 15, for instance under the influence of initiation

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of jet drive. Excessive downward drooping of the extension 15 about the pivot 23 is restrained by a stop 26, which projects into link 22. The upper portion of link 22 is cut away so as to permit upward swinging movement of the extension 15 through a large angle. This latter freedom, and also the freedom provided for upward swinging movement of link 22 on the pivot 20, permits the extension 15 to be brought to the position indicated at 15-a in Figure 4. In this way, the extension may be folded over the top of the blade, to thereby extensively reduce the overall diameter of the rotor system for purposes of storage of the aircraft.

Attention is now called to the fact that the flexible tube 17-b between the jet feed lines 17 and 17-a is arranged at the blade tip in the region of the pivot joints, so as to accommodate the various pivotal movements of the extension 15 with reference to the blade 9.

The various parts of the junction between the extension 15 and the blade tip are surrounded and enclosed by fairing members, including a fairing member 27 secured to the blade tip and a fairing member 28 secured to the extension 15. Still another fairing member 29 is provided as a junction between the members 27 and 28. Member 29 is adapted to be displaced radially outwardly when it is desired to swing the extension 15 upwardly and fold the same over the blade. Members 27 and 28 may be rigid and member 29 advantageously flexible, for instance in the form of a piece of rubber tubing so that in normal flight operation the member 29 will accommodate the pivotal movements occurring between the extension 15 and the blade tip.

Referring now to Figure 5, it will be seen that the airfoil contour of the blade 9 is of a rounded nose type, appropriate for efficient operation at speeds below the transonic range. As above mentioned, it is contemplated that this blade section shall be set at a positive lift incidence in normal flight operation, for instance in a range from about 4° to about 6°.

As is also shown in Figure 5, the extension 15 is of relatively narrow chord dimension in relation to the chord dimension of the blade itself, preferably being only a minor fraction of the chord dimension of the blade.

Moreover, in the preferred arrangement, the extension 15 is of substantially wedge-shaped section, being sharp edged at both the leading and the trailing edges, as is required for low drag characteristics at supersonic velocities. This extension 15, moreover, is preferably set at substantially zero lift incidence, so that it does not contribute appreciable lift during operation of the rotor. Because of the zero lift setting of the extension 15, this extension will retain a substantially horizontal position when viewed as in Figure 2, notwithstanding flapping movements of the blade 9, the relative angling of the blade and extension being accommodated by the pivotal connection of the extension with the blade tip, as fully described above with reference to Figures 3 and 4. This action, during flapping of the rotor blade, is indicated by dotted dash lines in Figure 2. A similar action occurs with reference to lag-lead movements of the blade and of the extension 15 with respect to the blade. Thus, the mass of the jet device at the outer end of the extension 15, acts to restrain both flapping and lag-lead movements of the blade and to reduce the overall extent of such blade swinging movements. In securing the action just described it is preferred that the outboard pivot 20 be arranged with its axis substantially parallel to the axis of the flapping pivot 12. Similarly, the outboard pivot 21 preferably parallels the drag pivot 13.

In a typical aircraft according to the invention, the rotor is adapted to be driven by the jet devices at a blade tip speed of the order of from 600 to 750 feet per second; and with an extension 15 equal to about three-fourths of the blade radius, as shown in the typical system illustrated in Figures 1 and 2, the jets will be op-

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erating at relatively high speed, under many conditions at a supersonic speed, such as to provide efficient jet operation.

I claim:

1. In an aircraft sustaining rotor, a rotor blade of elongated plan form, a spar-like extension of aeroform contour projecting radially from the blade tip and connected with the blade by pivot means providing for angling movement of the longitudinal axis of said extension relative to the longitudinal axis of said blade, and a jet driving device carried by said extension toward the outer end thereof, said pivot means including a pivot having its axis extended generally perpendicular to the blade axis.

2. A construction according to claim 1 in which said pivot provides freedom for movement of the jet device in a plane parallel to the rotor axis.

3. A construction according to claim 1 in which said pivot provides freedom for movement of the jet device in a plane transverse the rotor axis.

4. In an aircraft sustaining rotor, a rotor blade of elongated plan form and having a primary longitudinal spar extended substantially throughout the length of the blade and by which the blade is mounted at its root end, a spar-like extension projecting radially from the blade tip, a pivot having an axis which transects the blade axis interconnecting the spar and said extension, and a jet driving device carried by said extension toward the outer end thereof.

5. In an aircraft sustaining rotor, a rotor blade of elongated plan form and having a primary longitudinal spar extended substantially throughout the length of the blade, a pivotal connection mounting the blade at the root end thereof providing freedom for swinging movements of the blade, an extension projecting radially from the blade tip, a weight carried by the extension toward its outer end, and a pivotal connection interconnecting the outboard end of the blade spar and the inboard end of said extension and defining a pivot axis providing for swinging movement of the extension with respect to the blade substantially in the same plane as said blade swinging movements provided by the blade mounting pivot.

6. A construction according to claim 5 in which the weight carried by said extension is a jet driving device mounted thereon toward the outer end thereof.

7. A construction according to claim 5 in which the pivotal connection at the root end of the blade and the pivotal connection between the blade and the extension each includes flapping and drag pivots.

8. A construction according to claim 5 in which the pivotal connection at the root end of the blade and the pivotal connection between the blade and the extension each includes a flapping pivot.

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