Feb. 1, 1949. F. A. HOFFMAN ET AL 2,460,351

ROTOR BLADE

Filed Nov. 30, 1945 3 Sheets-Sheet 1

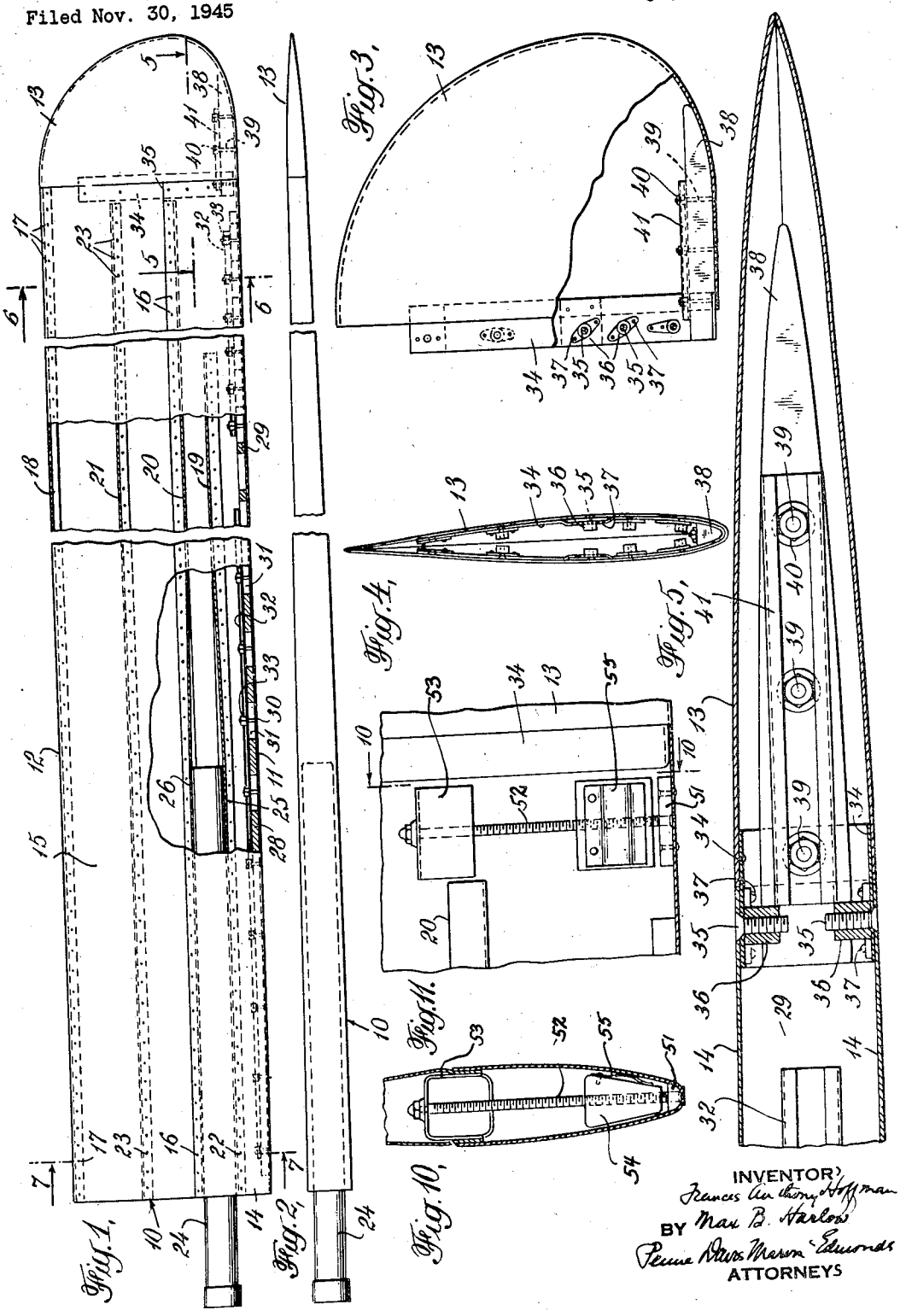


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 10.

INVENTORS
Frances Anthony Hoffman
Max B. Harlow
BY Pennie Davis Marvin & Edmonds
ATTORNEYS

Feb. 1, 1949. F. A. HOFFMAN ET AL 2,460,351

ROTOR BLADE

Filed Nov. 30, 1945

3 Sheets-Sheet 2

Fig. 6.

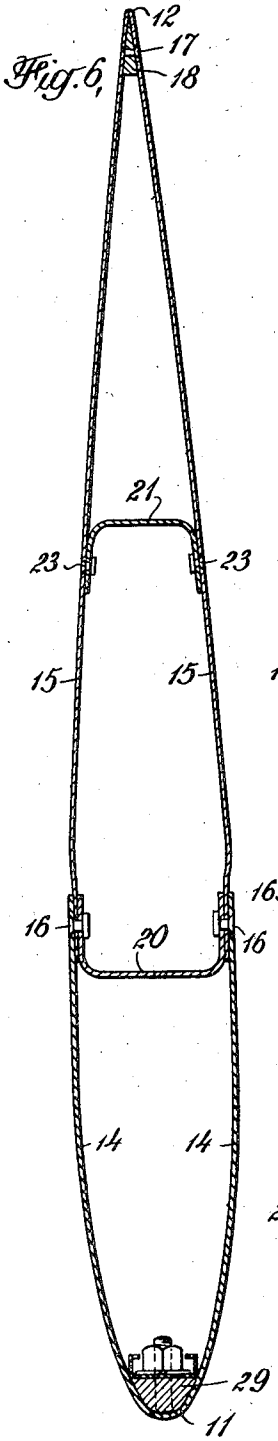


Fig. 7.

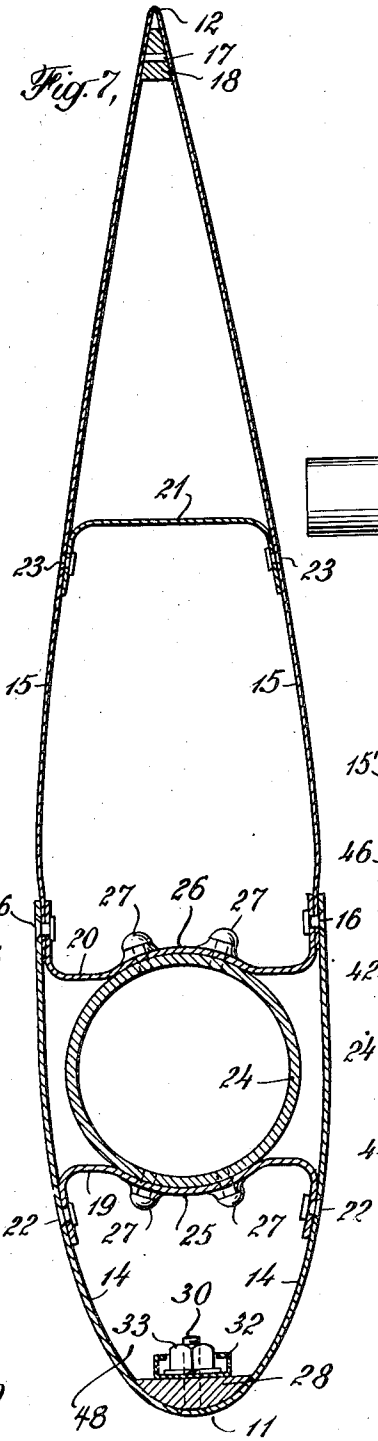


Fig. 9.

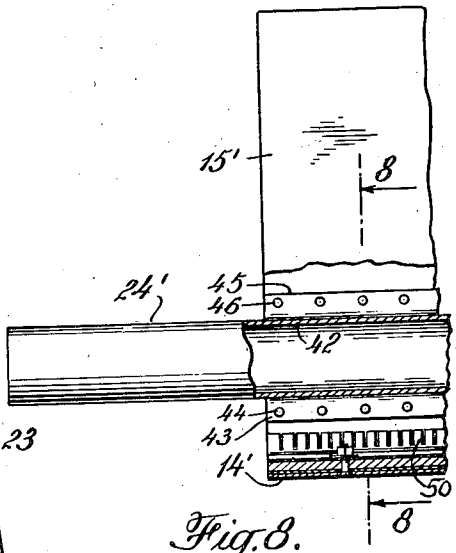
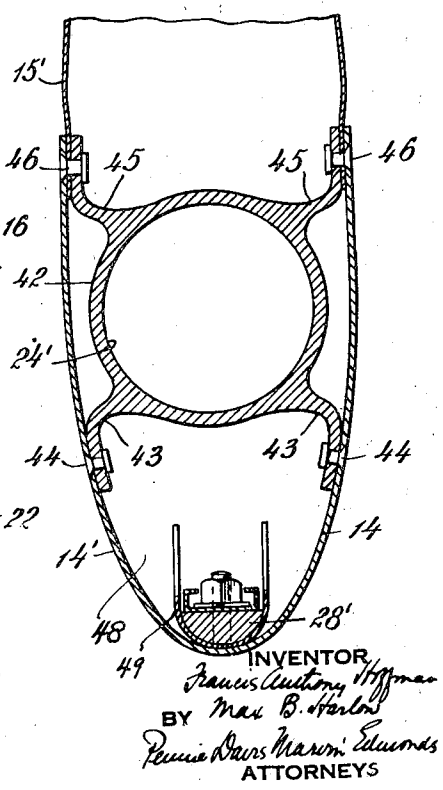


Fig. 8.



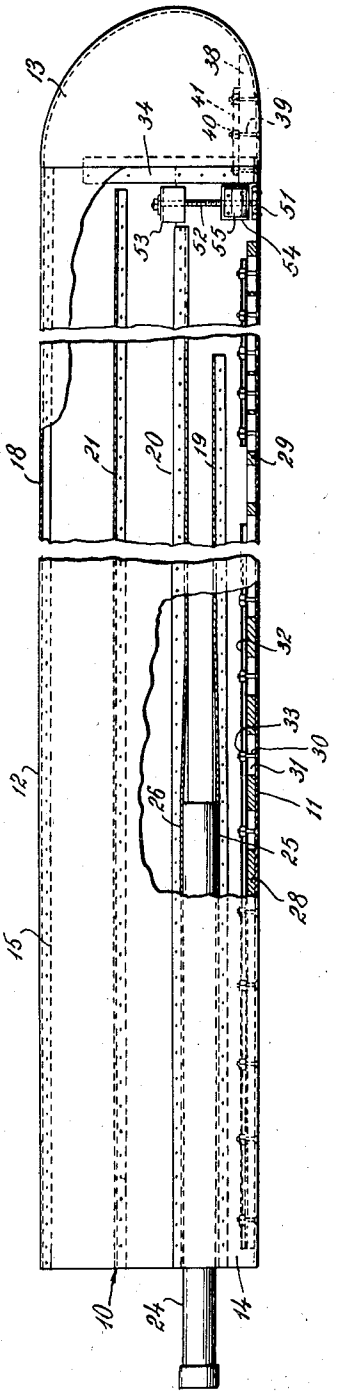
INVENTOR
Francis Anthony Hoffman
BY Max B. Harlow
Pennie Davis Marvin Edmonds
ATTORNEYS

Feb. 1, 1949. F. A. HOFFMAN ET AL 2,460,351

ROTOR BLADE

Filed Nov. 30, 1945 3 Sheets-Sheet 3

Fig. 12.



INVENTORS
Frances Anthony Hoffman
Max B. Harlow
BY
Pennie Edmonds Morton Barrows
ATTORNEYS

Patented Feb. 1, 1949

2,460,351

UNITED STATES PATENT OFFICE

2,460,351

ROTOR BLADE

Francis Anthony Hoffman, Glendale, and Max B. Harlow, Pasadena, Calif., assignors to Rheem Manufacturing Company, New York, N. Y., a corporation of California

Application November 30, 1945, Serial No. 631,986

7 Claims. (Cl. 170—159)

1

This invention relates to aircraft, such as helicopters, in which a set of rotor blades is employed instead of fixed wings. More particularly, the invention is concerned with a novel rotor blade structure for use in such aircraft, which is light in weight, capable of withstanding the bending and other stresses to which it is subjected in service with an ample factor of safety, and can be readily fabricated to the close tolerances that are imposed on such structures. The new rotor blade is of all-metal construction and of relatively few parts and it includes adjustable weighting means by which its chord-wise and span-wise balance and the location of its center of percussion can be varied. By the provision of such weighting means, it is possible to balance one of the new blades, so that it will be interchangeable for others of the same design in the same rotor set, so far as static, pendular, and aerodynamic balance is concerned. The blade of the invention includes various novel features of construction, such as the attachment of the mounting tube, the internal bracing, etc., which will be pointed out in the following description.

For a better understanding of the invention, reference may be had to the accompanying drawings, in which

Fig. 1 is a top plan view of one form of the new rotor blade, certain parts being broken away or shown in section;

Fig. 2 is a view of the blade in front elevation;

Fig. 3 is a plan view of the blade tip with parts broken away;

Fig. 4 is an end view of the blade tip looking from the left in Fig. 3;

Fig. 5 is a longitudinal sectional view on line 5—5 of Fig. 1;

Figs. 6 and 7 are transverse sectional views on lines 6—6 and 7—7, respectively, of Fig. 1;

Fig. 8 is a transverse section, similar to Fig. 7, on line 8—8 of Fig. 9;

Fig. 9 is a fragmentary plan view of a modified construction;

Fig. 10 is a sectional view on the line 10—10 of Fig. 11;

Fig. 11 is a bottom plan view with parts broken away of a modified construction; and

Fig. 12 is a top plan view, with parts broken away or shown in section, of another form of the new rotor blade.

The rotor blade assembly illustrated in Figs. 1 and 12 comprises a wing-like sheet metal member or shell 10 having a leading edge 11 and a trailing edge 12. The shell has upper and lower surfaces of suitably curved airfoil form extending

2

chord-wise from the leading edge to the trailing edge and the shell gradually tapers in thickness from its inner or root end to its outer or tip end, the outer end of the shell being closed by a tip 13 of suitable contour and construction. The shell 10 in divided into a leading or nose section 14 and a rear or trailing section 15 joined together in overlapping relationship with the forward edges of the trailing section 15 telescoped within or butt joined to the nose section 14 and riveted or otherwise secured thereto at spaced points 16 (Figs. 6 and 7).

The nose section 14 is the main structural member of the assembly and it is formed of sheet metal, such as stainless steel, aluminum alloy, or other similar metals or alloys. The trailing section 15 is then preferably made of lighter sheet metal, such as magnesium alloy, so as to decrease the blade weight and obtain proper weight distribution. Section 14 is preferably formed of a metal sheet folded back upon itself longitudinally and section 15 is preferably made of two metal sheets riveted or otherwise secured together at spaced points 17 with a narrow wedge-shaped metal strip 18 between the sheets and serving as a filler which extends the entire length of the shell 10. Section 14, if desired, may be made of a single sheet of metal folded back upon itself, in which event, the strip 18 may be eliminated.

The blade is internally braced by means of spar channels only and without the use of ribs, and two of these channels are utilized, as will be described, as a means of attachment of the blade to the mounting tube. The number of spar channels used will vary in different blades and the construction illustrated includes a front channel 19, a central channel 20, and a rear channel 21, of which channels 20 and 21 extend substantially the entire length of the blade except for the tip and channel 19 extends only a portion of the length of the blade from the root end thereof. The front channel 19 lies within the nose section 14 and its upper and lower flanges extend forwardly in contact with the inner surface of the metal sheet forming the wall of the section and are riveted or otherwise secured thereto at spaced points 22. The central spar channel 20 also lies within the nose section adjacent the overlapping joint between that section and the trailing section. The flanges of channel 20 extend rearwardly and are secured to the telescoped edges of the two sections by rivets 16. The rear channel 21 together with any additional channels that may be required lies within the trail-

ing section 15 and its flanges extend forwardly and are riveted to the walls of section 15 at spaced points 23.

The mounting tube 24, by which the blade is attached to the usual hub, extends into the interior of the blade at its root end between channels 19 and 20, and these channels are centrally curved at 25, 26, respectively, to conform to the outer surface of the mounting tube. The tube is held in place by being riveted or otherwise secured to channels 19, 20 at spaced points 27. The mounting tube extends only a part of the length of the blade and, beyond the outer end of the tube, the curved portions of channels 19, 20 gradually flatten out.

Rotor blades employed in a set must be balanced against any other blade in the set within close tolerances with respect to the locations of the span-wise center of gravity, the chord-wise center of gravity, and the center of percussion. In the new blade, adjustable weighting means are provided, so that the location of the centers referred to can be varied as may be necessary for balancing purposes.

The weighting means comprises a pair of weights 28, 29, preferably of lead, disposed in closely spaced end to end alignment within the leading edge of nose section 14. The forward faces of the weights are suitable curved and tapered, so that they fit snugly against the inner surface of section 14, and they are held in place by a number of bolts 30 which extend through openings in the wall of section 14 and pass through slots 31 in the weights. A channel member 32 lies against the rear surface of each weight for substantially the entire length of the weight, and the inner threaded ends of the bolts 30 pass through openings in the channel members and are threaded into nuts 33 seated within the channel 32.

With this construction, the location of the chord-wise center of gravity is adjusted by removal of portions of the weights or by substituting other weights for those originally employed. The location of the span-wise center of gravity is adjusted by moving both weights lengthwise of the blade in the same direction and the location of the center of percussion is varied by movement of the weights relative to one another lengthwise of the blade.

The tip 13 may be formed either as a hollow casting or as a sheet metal assembly having upper and lower surfaces of suitably curved airfoil form. The tip has an inner open end conforming to the outer open end of the shell 10 and a closed outer end of any suitably curved design, such as that shown.

A metal connecting strip 34 is secured to the interior of the tip by welding or otherwise along a portion of the open end of the tip, the strip projecting outwardly beyond the edge of the tip and being of such shape as to fit snugly within the outer end of shell 10. When the strip has been inserted within the end of shell 10, the tip 13 is secured in position by screws 35 threaded through registering openings in the wall of shell 10 and the strip and into lock-nut 36 secured to the inner surface of strip 34 by rivets 37 or otherwise. The strip 34 is suitably formed to accommodate the overlapping joints between sections 14, 15. A weight 38 is disposed within the leading edge of tip 13 and it is secured in place by bolts 39 extending through openings in the wall of the tip and through the weight. The inner ends of the bolts are threaded into nuts

40 lying within a channel member 41 which extends along the back of the weight.

In the construction above described, the spar channels 19 and 20 are separate members and the mounting tube 24 lies between and is secured to them, but these channels and the tube may, if desired, be replaced by an extruded member 42 of suitable section, as shown in Figs. 8 and 9. The extruded member has a tubular portion 24' serving as the mounting tube and it is formed with flanges 43 extending forwardly and riveted or otherwise secured at spaced points 44 to the walls of the nose section 14' of the blade. The extruded member also has flanges 45 which extend rearwardly and are riveted or otherwise secured at spaced points 46 to the edges of section 14' and the trailing section 15'. The tubular portion of the extruded member extends inboard of the end of the blade to form a mounting tube of the desired length, and it extends into the shell the distance necessary for adequate strength. The flanges 43 and 45 do not extend past the inboard end of the blade but run toward its outer length such distances as are necessary for the required strength.

In the new blade, the space 48 in the nose section forward of the front spar channel 19 or the extruded member 42 may be employed as a duct into which hot air may be introduced at the inboard end of the blade for de-icing purposes. When the blade is provided with means for supplying hot air to it, it is desirable to form the weight 28' with a curved surface on a somewhat smaller radius than is used in forming the curved surface of weight 28. A U-shaped sheet of metal 49 is then mounted to straddle the weight and lie between the weight and the front end of the nose section. The legs of the member 49 extend backward into the duct 48 a substantial distance and they are slotted as indicated at 50. The member 49 transmits heat from the air flowing past it to the forward wall of the nose section, where the heat is desired for de-icing purposes, and the slotting makes the legs effective to produce turbulence in the air flow.

In the construction illustrated in Fig. 1, the location of the chord-wise center of gravity is adjusted by removing portions of the weights 28, 29 or substituting other weights of different sizes. The location of this center of gravity may be varied in the Fig. 12 construction without changing the weights and, for this purpose, a weight adjustable chord-wise is used, the construction and mounting of the weight being shown on an enlarged scale in Figs. 10 and 11. In the construction there shown, a small bearing member 51 is riveted or otherwise secured within the forward end of the nose section at its outer end close to tip 13, and a bolt 52 is passed through an opening in the member 51 and through a channel member 53, which is secured in any suitable manner within the trailing section 15. A weight 54 is threaded on the bolt and may be moved back and forth lengthwise of the bolt by turning the latter in the desired direction. A leaf spring 55 is attached to the under surface of the bolt and makes continuous contact with the inner wall of the nose section to hold the weight steady. The assembly described provides for a micrometer type of adjustment, which can be easily made and takes care of small deviations from chord-wise balance that may appear after the blade has been put into service.

In the blade assembly illustrated, the internal bracing is effected without the use of ribs and

that construction is preferred because assembly of the parts is simplified and a structure of suitable strength is obtained by the use of the spar channels alone. Ribs, however, may be employed to provide additional bracing, if desired.

In the foregoing, the parts have been described as being secured together by riveting, but it will be apparent that ordinary welding, spot welding, cycle welding, and other methods of attachment may be used with equal advantage.

We claim:

1. A rotor blade for use in aircraft which comprises a hollow wing-like metallic member, a mounting element extending into the inner end of the member, supporting means in the member including a longitudinally extending sleeve encircling the mounting element and having outwardly projecting flanges arranged in pairs and secured to the walls of the member, and longitudinally adjustable weighting means mounted within and extending along the leading edge of the member for balancing the latter.

2. A rotor blade for use in aircraft, which comprises a nose section and a trailing section, the sections being made of metal and extending lengthwise of the blade and being secured together, a mounting element extending into the nose section from the root end of the blade, internal reinforcing means for the sections, including a plurality of spar channels extending lengthwise of the sections, substantially from end to end thereof, each channel having upper and lower flanges throughout its length engaging the inner surfaces of the sections and secured thereto, a pair of the channels within the nose section forming a socket in which the inner end of the element is received and secured, the flanges of one channel of the pair being secured to the sections along their lines of junction, the trailing section containing at least one channel, and weighting means mounted within the nose section and adjustable longitudinally thereof for balancing the blade, said means including a pair of elongated weights disposed end to end and together extending substantially the entire length of the nose section and bolts passing through slots in the weights for holding them adjustably in place.

3. A rotor blade assembly for use in aircraft which comprises a hollow wing-like sheet metal member formed of a nose section and a trailing section extending longitudinally of the member and joined together, a longitudinally extending supporting sleeve within the nose section and having outwardly projecting longitudinal flanges arranged in pairs along its outer surface, one pair of flanges extending along the joint between the nose and trailing sections and secured to the united edges thereof and another pair secured to the walls of the nose section, a tubular shank secured within the sleeve and projecting outwardly beyond the inner end of the member, and a pair of weights mounted within the leading edge of the nose section and together extending substantially the entire length thereof, the weights being longitudinally adjustable for balancing the blade.

4. A rotor blade assembly for use in aircraft which comprises a hollow wing-like member formed of a nose section and a trailing section extending lengthwise of the member and joined together in overlapping relationship along their edges, the nose section being made of a sheet of metal folded to define the leading edge of the member and the trailing section being made of two sheets of metal joined together at the trailing edge of the member, a tip closing the outer end of the member, a plurality of spar channels mounted in and extending lengthwise of the member including one in the nose section, another adjacent the joint between the nose and trailing sections, and a third in the trailing section, the spar channels having flanges secured to the walls of the sections, the first and second channels being formed with oppositely disposed recessed portions providing a socket, a tubular shank mounted in the socket and projecting outwardly beyond the inner end of the member, and balancing means in the leading edge section including a pair of weights mounted in the leading edge of the nose section and together extending substantially the entire length thereof, the weights being longitudinally adjustable to balance the blade.

5. A rotor blade for use in aircraft which comprises a hollow wing-like metallic member, reinforcing means within the member providing a plurality of longitudinally extending internal supports for the member, a mounting element connected to an adjacent pair of the supports within the member and projecting out of the member at its inboard end, longitudinally adjustable weighting means mounted within and extending along the leading edge of the member, said means including a pair of weights disposed end to end and together extending substantially the entire length of the member and bolts passing through slots in the weights for holding them adjustably in place, and chord-wise adjustable weighting means mounted within the member and including a weight and a bolt mounted chordwise within the member and threaded through the weight.

6. A rotor blade for use in aircraft which comprises a hollow wing-like metallic member, reinforcing means within the member providing a plurality of longitudinally extending internal supports for the member, a mounting element connected to an adjacent pair of the supports within the member and projecting out of the member at its inboard end, longitudinally adjustable weighting means mounted within and comprising a pair of weights disposed end to end and extending along the leading edge of the member throughout substantially the entire length thereof, a weight mounted within the nose section of the member near its outboard end, and a bolt extending chordwise through the leading edge of the member and threaded through the weight, the bolt being rotatable to shift the weight chord-wise of the member.

7. A rotor blade for use in aircraft, which comprises a nose section and a trailing section, the sections being made of metal and extending lengthwise of the blade with their edges secured together, a plurality of spar channels mounted within the blade and extending substantially the entire length thereof, each channel having upper and lower flanges throughout its entire length, one channel lying within the nose section with its flanges secured to the upper and lower parts thereof, a second channel lying adjacent the connected edges of the sections with its flanges secured to those edges, the third channel lying within the trailing section with its flanges secured to the upper and lower parts thereof, the portions of the webs of the first and second channels adjacent the inboard end of the blade being formed concave to one another to provide a socket, and a cylindrical mounting element extending through the inboard end of the blade into the

socket in engagement with and secured to the concave portions of the channels.

FRANCIS ANTHONY HOFFMAN.
MAX B. HARLOW.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,501,606	Leitner	July 15, 1924
2,111,975	Larsen et al.	Mar. 22, 1938
2,362,301	Pecker	Nov. 7, 1944
2,380,583	Cierva	July 31, 1945
2,430,948	Platt	Nov. 18, 1947

FOREIGN PATENTS

Number	Country	Date
369,478	Great Britain	Mar. 24, 1932
452,611	Great Britain	Apr. 9, 1936