July 22, 1958 S. H. KRISTIANSEN 2,844,303

AXIAL BLOWERS OR FANS

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Fig. 1

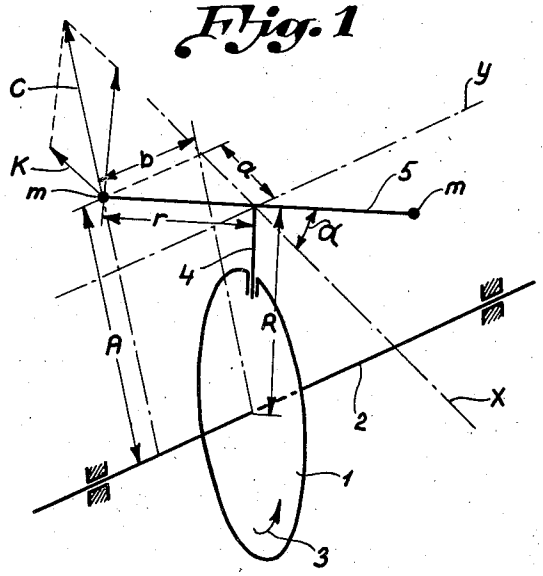
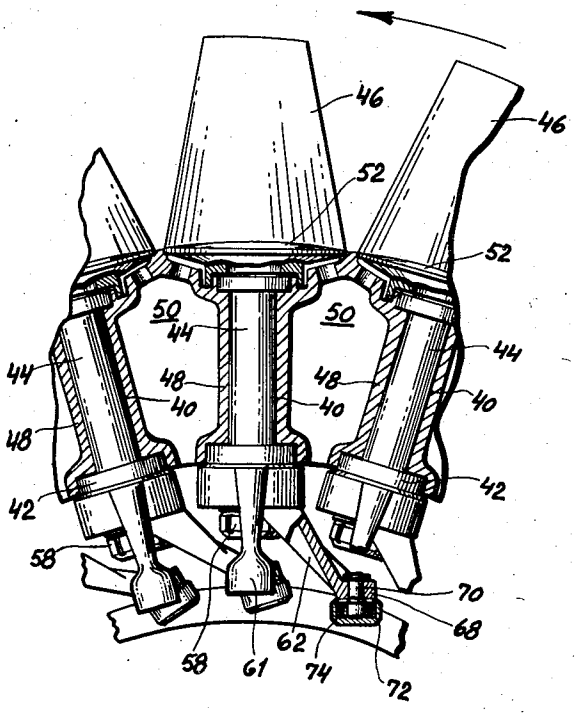


Fig. 3



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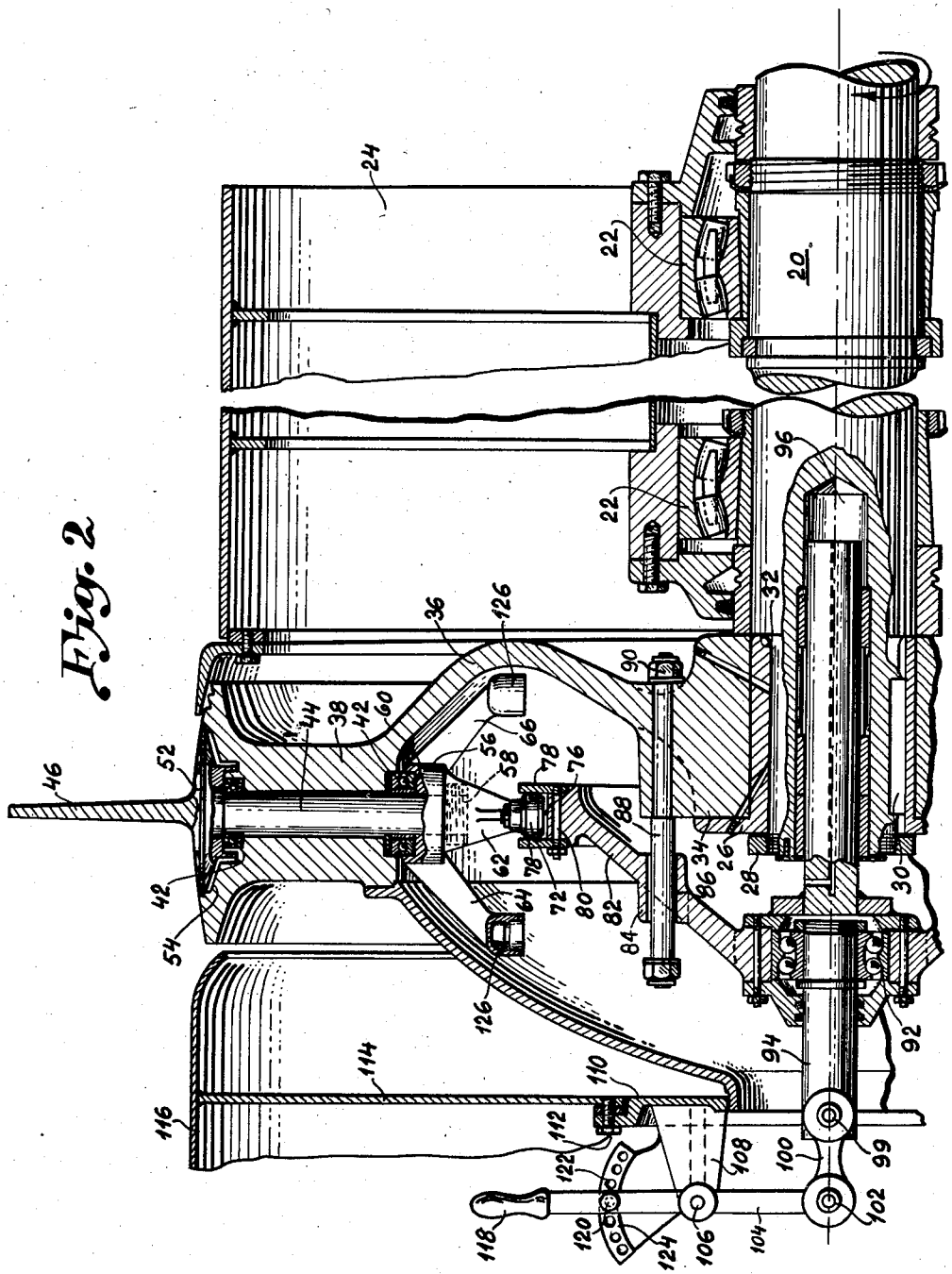
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Fig. 2



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Fig. 4

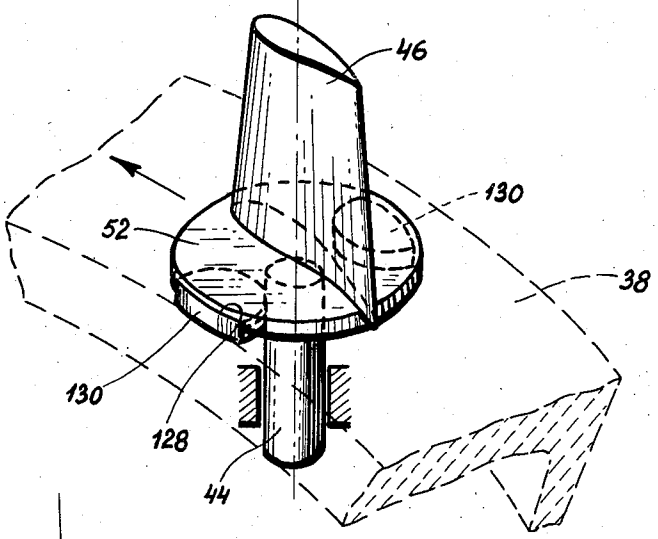
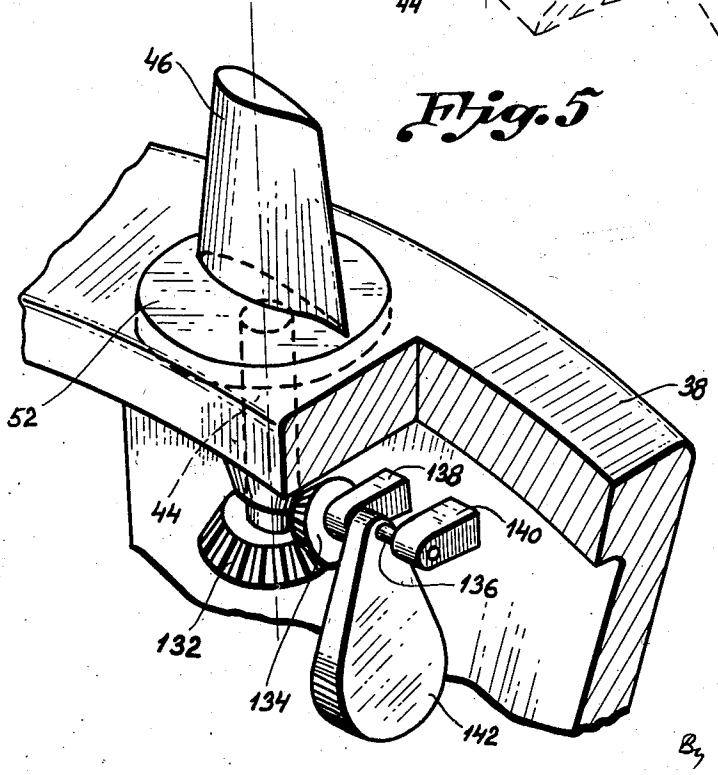


Fig. 5



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2,844,303

AXIAL BLOWERS OR FANS

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Application August 27, 1952, Serial No. 306,669

3 Claims. (Cl. 230—114)

This invention relates to improvements in axial blowers or fans provided with wings or blades which are adjustably rotatable on their longitudinal axes.

The object of the adjustable rotation of the blades in such devices is to render possible an alteration of the output of the axial blower. In normal relatively slow operating axial blowers no great difficulty has been experienced in turning the blades during rotation of the blower and thus adjusting the output. It has, however, been found that when axial blowers of the kind concerned are to be driven at a relatively high rotational speed, the blades are subjected to considerable resistances so that a great consumption of force is required to turn the blades. This resistance, which by far surpasses the resistance due to air resistance, is due to the fact that besides radial actuation of the blades, the centrifugal forces acting on each blade produces a torque on the rotation axis of the blade which endeavours to turn the blade to a position in which its main plane coincides with its rotation plane.

An object of the invention is even in rapidly driven axial blowers to make it possible to adjust the blades during rotation of the blower and without for this purpose necessitating a greater power consumption.

Another object of the invention is to provide an axial blower or fan having a rotatable hub ring, at least two blades or wings journalled in said hub ring rotatable on their longitudinal axes and means for adjustably rotating said wings or blades, and further having counterweights connected to each of said blades or wings inside the peripheral surface of said hub, said counterweights being so positioned on either side of the main plane of said blade or wings and so dimensioned that the inertia moments of said wing or blade, including said counterweights, regarding all planes intersecting the axis of rotation of the wing or blade, are approximately equal. In such an axial blower, the counterweights can equalize the torque on the rotation axes of said blades or wings produced by the rotation of the hub ring and due to centrifugal forces.

A further object of the invention is to procure a wing for use in an axial blower having a hub member and at least two blades or wings journalled in said hub members adjustably rotatable on their longitudinal axes, said wing having a wing blade, a root shaft by means of which it is journalled in said hub member, and at least two counterweights attached to said root shaft in such position that when the wing is placed on said hub ring, said counterweights will be situated inside said hub ring; said counterweights further being so disposed on either side of the main plane of the wing and so dimensioned that the inertia moments of the member comprising the said blade or wing, said root pin and said counterweights, as regards all planes through the rotation axis of the blade, are approximately equal.

Further objects and details of the present invention will be further explained with reference to the drawing, in which

Fig. 1 illustrates schematically the forces which act upon the impeller blades of a blower,

Fig. 2 shows a sectional elevation of the upper half of a blower according to the invention,

Fig. 3 shows a transverse section through a part of a hub ring of the blower shown in Fig. 2, and

Figs. 4 and 5 show two different manners of construction of blades or wings provided with equalizing members according to the invention.

In Fig. 1, a disc, indicated by **1**, rotates on its axis **2** in the direction indicated by an arrow **3**, with a rotational speed of ω. In the disc there is rotatably journalled a radially extending shaft **4** carrying a transverse arm **5** (without weight), which at each side of the shaft **4** and at a distance r from shaft **4** carries a mass m. These two masses represent two points of a rotatable blade. The arm **5** forms an angle α to the rotation plane of disc **1** perpendicular to axis **2** and indicated by a line X. In this position the distance of each mass m to line X is equal to b, and its distance from a plane through shaft **4** perpendicular to the rotation plane as indicated by line y, is equal to a. In the position shown the distance of each mass m from the axis of rotation **2** is indicated by A.

During rotation of disc **1** each mass m will be actuated upon by a centrifugal force

$$C=mA\omega^2$$

This centrifugal force C, may, as shown, be dissolved into two forces, one of which is parallel to shaft **4** and produces upon this shaft a radial drag, the other force K being parallel to the rotation plane X and perpendicular to the plane Y, through the rotation axis **2** and shaft **4**. This force K produces a moment of rotation M equal to $K.b$ on shaft **4**, and this moment of rotation will endeavour to rotate the arm **5** to a position coinciding with plane X.

From Fig. 1 it is clearly evident that

$$K/C=a/A$$

From this is obtained

$$M=a.m.A\omega^2.b/A=m\omega^2.a.b \qquad (I)$$

From the diagram it is, however, likewise evident that

$$a=r\cos\alpha, \text{ and } b=r\sin\alpha$$

which gives

$$M=m.\omega^2.r^2.\sin\alpha;\ \cos\alpha=\tfrac{1}{2}\ m.r^2.\omega^2.\sin 2 \qquad (II)$$

The value $m.\ a.\ b.$ expressed in Formula I indicates the centrifugal moment of the mass m as regards lines X and Y. It is further more apparent from Fig. 1 that masses in the 1′ and 3′ quadrant of the co-ordinate system formed by lines X and Y will, owing to the effect of the centrifugal forces, produce uniformily directed moments of rotation, while masses in 2′ and 4′ quadrants will produce moments of rotation which are oppositely directed to the moments of rotation produced by the masses in 1′ and 3′ quadrants. Thus, the above stated expression for M, when a and b are calculated with signs, likewise indicates the direction of the moment of rotation.

Furthermore it is apparent that the moment of rotation acting upon the system shown may be obviated if there is added a new system, the centrifugal moment of which on lines X and Y is numerically equal to the centrifugal moment of the systems shown, but having unlike signs.

This may also be expressed by the combined system, i. e. the mass system shown and the mass system added, having a centrifugal moment of zero in relation to lines X and Y, if the moments of rotation on the combined mass system are to be equalized.

When furthermore, as the case is according to the invention, it is desired that the moment of rotation produced by the action of the centrifugal forces on the combined system shall be zero, or approximately zero, at all angular position of the system on shaft **4**, it must be demanded that the centrifugal moment of the combined system on any relatively perpendicular axes in the X—Y plane shall be equal to, or approximately equal to zero.

If that which is explained above in connection with single masses in a plane is extended to comprise bodies, it will be noted that the moment of rotation due to centrifugal forces and acting on the rotation axis **4** of the body may be equalized by providing the body with counterweights in such a manner that the centrifugal moments of the member comprising the body and the counterweights, as regards any two relatively perpendicular planes through the rotation axis, will be zero.

When, however, the centrifugal moments of a body as regards any relatively perpendicular planes through an axis is zero, the inertia moments of the body as regards any plane through the said axis will be equal, and conversely. By the determination of the size and position of the counterweights it is thus possible to consider the said inertia moments which are much easier to compute than the centrifugal moments.

When the inertia moments of a body as regards two relatively planes through an axis are of equal value, and the centrifugal moment as regards the same two planes at the same time are zero, the inertia moments as regards any other planes through the rotation axis will also be of equal value.

The result of this will be that when determining the size and position of the counterweights, there is first found for the unbalanced body the relatively perpendicular planes through the rotation axis which produce respectively maximum and minimum inertia moment. As regards these planes the centrifugal moment will at the same time be zero. After this it is a simple matter to calculate the size and positioning of the counterweight.

An axial blower in which the impeller blades are balanced as stated above, is shown in Fig. 2. In this figure **20** indicates a shaft rotatably journalled in roller bearings **22** within a housing **24**. On the shouldered front end of shaft **20** an angular ring **26** is secured by means of a key **30** and a nut **28** screwed on a threaded part of shaft **20**. By means of the said nut **28** the ring **26** is pressed against shoulder **32** on shaft **20**.

A hub **34** is welded or soldered to ring **26**. This hub is provided with flange **36** supporting a hub ring **38** having a number of bearing channels **40**, see Fig. 3, within each of which a root shaft **44** of an impeller blade **46** is journalled by means of ball bearings **42**.

Between the walls **48** of channels **40** hollow spaces **50** are formed within the hub ring **38** for reducing the weight of the said ring.

Each blade **46** has a root plate **52** disposed within a recess **54** in the peripherical surface of hub ring **38**.

The root shaft **44** projects outside the inner surface of the hub ring **38** where it carries a supporting member **56** secured to the threaded shaft end by means of a nut **58** and a key and tongue connection (not shown). By means of this nut **58** the supporting member **56** is pressed against the lower ball cage **60** of the innermost bearing **42**.

The supporting member **56** has three arms **62**, **64** and **66**. The one arm **62** is placed in the centre plane of the blade **46** and has at its free end a flange **68**, Fig. 3, in which a pin **70** is secured. Beneath the flange **68** a roller **72** is rotatably journalled on the pin **70** by means of a ball bearing **74**.

Roller **72** engages a groove **76** formed between two rings **78** which by means of bolts **80** are secured to a conical disc **82**. The disc **82** is provided with a number of enlargements **84** each having an axially extending bore for a pin **86**, the disc **82** being slidable on these pins **88**. The pins **88** are secured to the hub **34** by means of nuts **90**, and thus the disc **82** will partake in the rotation of the hub. Further this disc **82** is journalled on a shaft **94** by means of a ball bearing **92**. The shaft is slidably and rotatably journalled and guided in a central bore **96** in the reduced end of shaft **20**. By means of a pin **99** the one end of a connecting link **100** is pivotally connected to the free end of shaft **94**. The other end of said connecting link is by means of a pin **102** pivotally connected to the downwardly extending arm of a double-armed lever **104** fulcrumed on a pivot pin **106** attached to a bracket **108** secured to a cover **110** which by means of bolts **112** is secured to a partition **114** in a housing **116** disposed at the front end of the blower.

The upwardly extending arm of lever **104** is provided with a handle **118** by means of which the lever may be pivoted for adjustable longitudinal displacement of the shaft **94**. A springloaded pin **120** on the upper arm of lever **104** is arranged to engage any one of a number of notches **122** in a plate **124** fixed to the bracket **108** for holding the lever, and consequently the shaft **94**, in an adjusted position.

Upon longitudinal displacement of the shaft **94** the conical disc **82** is also displaced, thereby turning the impeller blades **46** in consequence of the engagement of roller **78** with the groove **76** on disc **82**.

To the free end of each arm **64** and **66** projecting from the supporting member **56** is attached a counter weight **126**. Each of these counter weights **126** is so disposed and has a such mass that for the purpose set forth above, the inertia moments of the member comprising blade **46**, root plate **52**, root shaft **44**, and supporting member **56** with arms **62**, **64** and **66**, roller **78** and counter weights **126**, as regards all planes through the rotation axis of the blade **46** are approximately equal.

In the arrangement shown in Figs. 2 and 3 the counter weights are positioned relatively close to the rotation axis of the blower. It is to be noted that the radial distance of the weights from the rotation axis of the blower as evident from the above stated formula for M, has no influence on their equalizing effect, for which reason it is preferred that they are positioned as closely as possible to the rotation axis in order to reduce as much as possible the centrifugal forces due to the counter weights.

A modified manner of arranging the counter weights on impeller blades or similar wings is known in Fig. 4. In this instance the impeller blade **46** with root plate **52** and root shaft **44** is rotatably journalled in the hub ring **38** in the same manner as shown in Figs. 2 and 3 but only shown schematically in Fig. 4. The root plate **52** has two grooves **128** in each of which a counter weight **130**, preferably made of lead, is secured. By this arrangement the counterweights take up only very little space, but they are positioned a somewhat greater distance from the rotation axis of the blower than in the arrangement shown in Figs. 2 and 3.

It is to be noted that the weights need only be so dimensioned and positioned that they approximately equalize the forces of the moment of rotation mentioned above, since besides these forces other resistances opposing the rotation of the blades may arise, e. g. air resistance, which it is not possible to equalize. For this reason it is only required to equalize forces of the moment of rotation to such an extent that the value of these forces do not essentially exceed other forces opposing the rotation of the blades. The result of this is that in calculating and positioning the weights the necessary practical considerations may be taken.

From the Formula II given above for M it will further be noted that the said moment is only dependent on ω^2 and α, since for a given member the value $m.r^2$ is constant. The forces of the moment of rotation mentioned may therefore be equalized by means of other forms for counter weights than have an effect which is dependent

on α and ω^2. Thus it is possible to employ a counter weight arrangement as the modification shown in Fig. 5.

In this construction the impeller blade **46** with root plate **52** and root shaft **44** is journalled in the hub ring **38** in the same manner as shown in Figs. 2 and 3 but only shown schematically in Fig. 6. The lower end of the root shaft **44** carries a bevel gear **132** meshing with another bevel gear **134** half the size of the gear **132**. The smaller bevel gear **134** is attached to a shaft **136** journalled in bearings **138** and **140** on the hub ring **38** and carrying a counter weight **142**. When the blade **46** is rotated in the manner shown in and described in connection with Figs. 2 and 3, the counter weight **142** will swing outwards an angle which is double the size of the angle at which the blade **46** is turned. This counter weight **142** will be affected by the centrifugal force which is directly proportional to ω^2, and will produce an effect upon the blade **46** which is dependent on as well angle α, or more correctly angles 2α and ω^2, and will thus be able to produce an effect which obviates the effect of the moment of rotation in question.

I claim:

1. In an axial fan, for use in connection with a driving shaft, in combination, a hollow hub member mounted on said driving shaft, said hub including a hub ring, at least two wings journalled in said hub ring rotatably about their longitudinal axes, each wing comprising a wing blade and a root shaft, said hub ring having a through bore for each of said root shafts, each root shaft mounting inside said hub ring a laterally extending adjusting arm, an inwardly extending actuating pin connected to said adjusting arm, an adjusting shaft mounted for reciprocation coaxially with said hub, an adjusting disk member rotatably mounted on said adjusting shaft, means operable for restraining axial displacement of said adjusting disk relative to said adjusting shaft, at least one driving stud interconnecting said hub member and said adjusting disk member for securing the same rotational speed of said two members, said adjusting disk having a peripheral groove opposite each of said actuating pins, each actuating pin engaging said groove, means operable for axially displacing said adjusting shaft thereby to adjust the axial position of said disk and by way of said actuating pin and said adjusting arm to adjust the pitch of each wing, at least two counterweights secured to the root shaft of each wing and disposed inside the peripheral surface of said hub ring, said two counterweights being positioned on either side of the main plane of each wing, and the inertia momentum of each wing with all members secured thereto including the said root shaft and said counterweights being approximately equal with respect to all planes coincident with the axis of rotation of the wing.

2. An axial fan, as claimed in claim 1, said hub ring having for each wing a recess formed in the peripheral surface of the hub ring concentric with the said bore, each wing including a root plate between said wing blade and said root shaft, said root plate being disposed within said recess and having at least two grooves at either side of the main plane of the wing, said two counterweights being secured to said root plate and each disposed within one of said two grooves.

3. An axial fan, as claimed in claim 1, at least two inwardly inclined supporting arms having free ends and being secured to said root shaft inside said hub ring disposed on either side of the main plane of each wing, each counterweight being secured to one of said two supporting arms.

References Cited in the file of this patent

UNITED STATES PATENTS

1,404,403	Parker	Jan. 24, 1922
1,482,690	Lanzius	Feb. 5, 1924
1,761,690	Steinmetz	June 3, 1930
1,967,461	Ballew	July 24, 1934
1,980,272	Havill et al.	Nov. 13, 1934
2,030,953	Gemeny	Feb. 18, 1936
2,054,947	Riddle	Sept. 22, 1936
2,146,334	De Caria	Feb. 7, 1939
2,219,303	Fraser	Oct. 29, 1940
2,225,209	Dewey	Dec. 17, 1940
2,316,940	Dewey et al.	Apr. 20, 1943
2,353,334	Haugh	July 11, 1944
2,407,630	Dewan	Sept. 17, 1946
2,479,668	Brandon et al.	Aug. 23, 1949
2,552,727	Lightfoot	May 15, 1951