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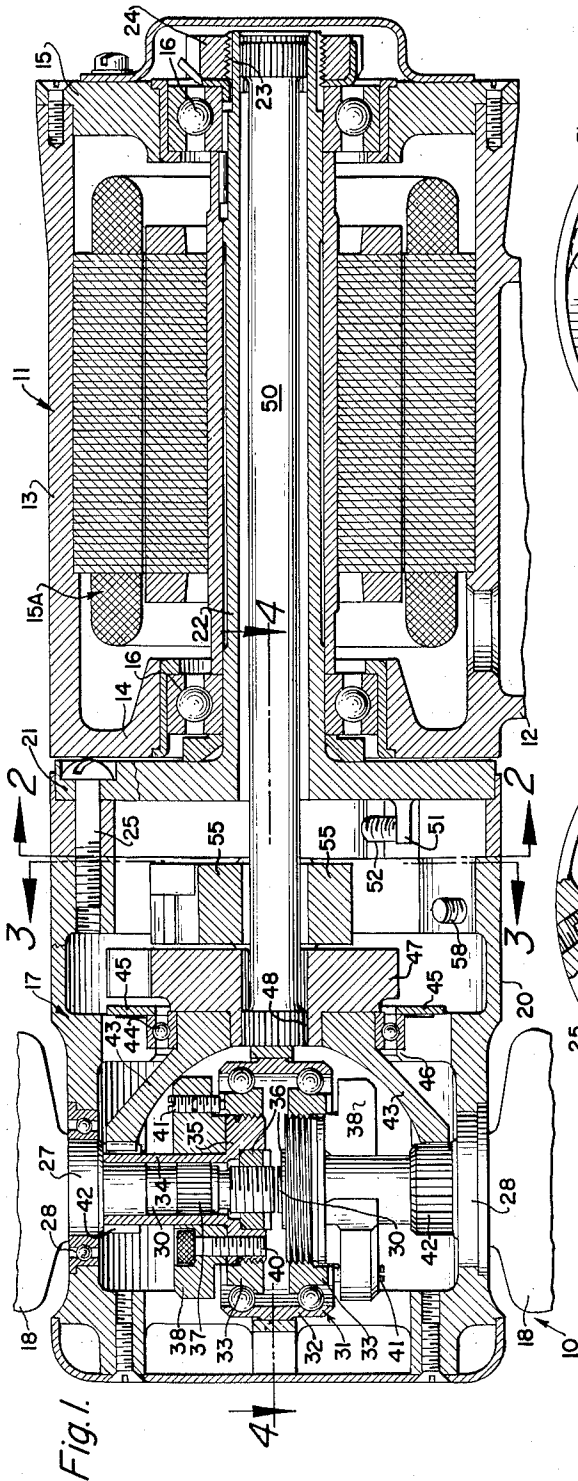
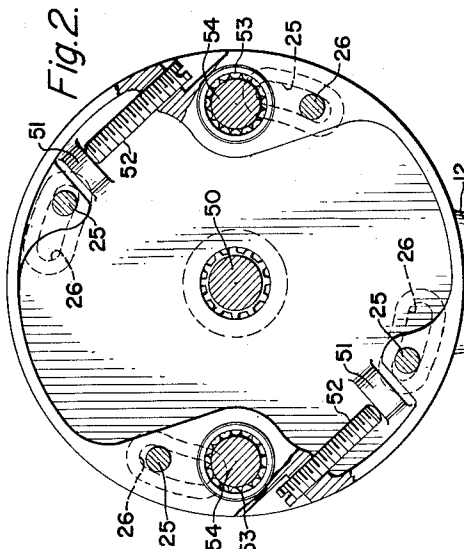
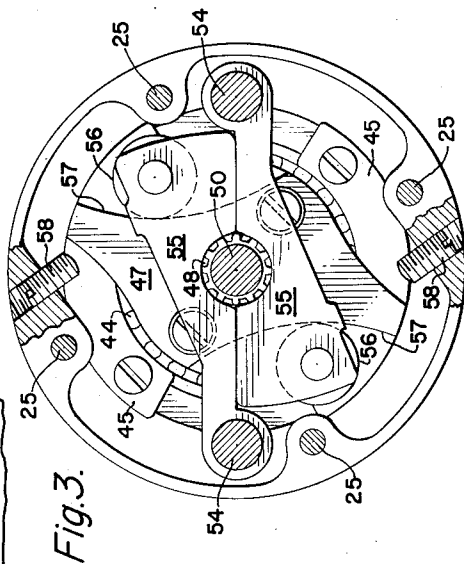
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2,967,572

RAM AIR TURBINE

Filed April 11, 1957

2 Sheets-Sheet 1



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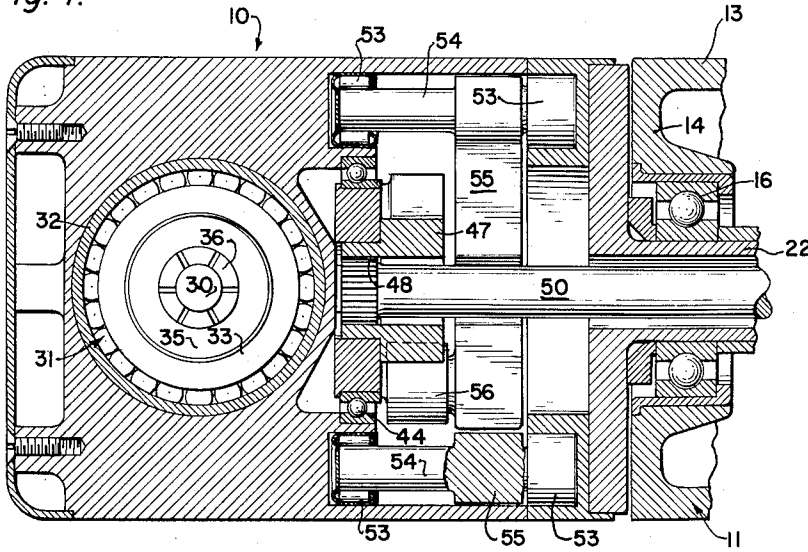
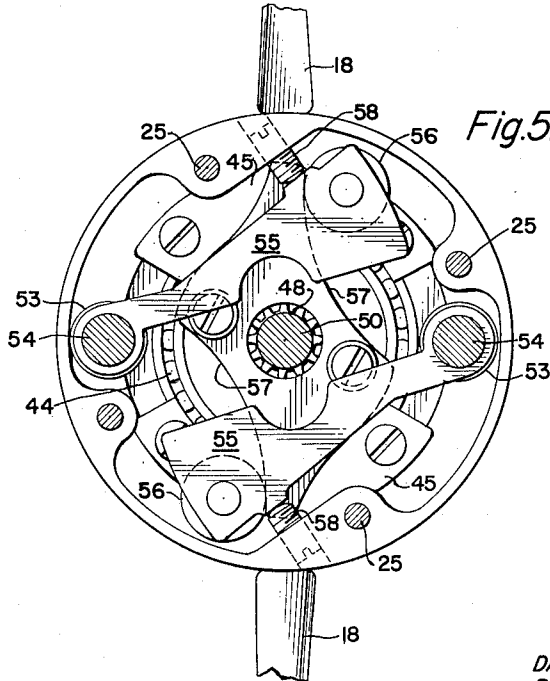
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Fig. 4.



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RAM AIR TURBINE

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9 Claims. (Cl. 170—68)

This invention relates generally to auxiliary or emergency power equipment for use on airplanes or similar craft and is more particularly directed to turbines adapted to be supported in an air stream and driven by the ram air to translate the force thereof into electric, hydraulic or other power.

One of the objects of this invention is to provide a simple compact auxiliary power device having a relatively small number of parts and being capable of dependable operation while requiring a minimum amount of attention.

Another object of the present invention is to provide an auxiliary power unit of the ram air operated type having a plurality of blades and a relatively simple means for utilizing centrifugal force to adjust the pitch of the blades and govern the rate of operation of the unit, a uniform rate being desirable to maintain a steady flow of auxiliary power.

A further object of the invention is to provide an auxiliary power unit having a ram air operated driving turbine with a plurality of adjustably pitched blades and a governor mechanism for controlling the pitch of the blades, such governor mechanism including flyweight means and cam means, operated by the flyweight means in response to centrifugal force, to adjust the blades and impart torque to a torsion device which yieldably opposes the centrifugal force and serves to return the blades toward their initial pitch when the rate of flow of the ram air decreases in order to maintain the rate of operation of the turbine.

A still further object of the invention is to provide an auxiliary power unit having a ram air turbine with means responsive to centrifugal force to govern the rate of operation of the turbine, the governing means having a torsion type resistance element to oppose centrifugal force and return portions of the governing mechanism to starting positions, the unit also being provided with power generating means disposed in telescoping relationship with the resistance element to reduce overall size of the unit and yet make use of a single element which will be sufficiently sturdy and of a size to have the required life.

Another object is to provide the auxiliary power unit mentioned in the preceding paragraph with novel means for adjusting the resistance element to secure the initial torsion thereof and preset the rate of operation of the ram air turbine.

It is also an object of the invention to provide a ram air turbine with a speed governing means having flyweight members responsive to centrifugal force to adjust the pitch of the turbine blades, resistance means being employed to oppose movement of the flyweight members and return them to starting positions, and a novel cam and follower mechanism being utilized to transmit the movement of the flyweight members to the resistance means and the turbine blades, the cam being so calculated as to vary the effective leverage developed thereby as the force

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of the resistance means changes between minimum and maximum loadings.

An object of the invention, also, is to provide a ram air turbine having a frame supported for rotation about an axis and equipped with blades disposed on diametrically opposite sides of the axis, the frame being provided with a novel bearing assembly for the inner ends of the blades, whereby the centrifugal load imparted to the bearing assembly by one blade will be counteracted by the corresponding load imparted by the opposite blade and premature deterioration of the device will thus be prevented.

A more specific object of the invention is to provide the ram air turbine mentioned in the preceding paragraph with an inner blade bearing assembly, having an external double row race mounted in the rotor frame with the axis of rotation of the frame bisecting the race, the bearing assembly having a pair of inner races disposed equidistantly from the axis of rotation and each having the inner end of a blade secured thereto. The centrifugal force developed by each blade will be transmitted by the ball bearings to the outer race and will counteract the similar force transmitted thereto by the opposite blade.

Other objects and advantages will be apparent from the following description of one form of the invention which has been illustrated in detail in the accompanying drawings.

In the drawings:

Fig. 1 is a longitudinal sectional view taken through an emergency power unit formed in accordance with the present invention.

Figs. 2 and 3 are vertical transverse sectional views taken on planes indicated by lines 2—2 and 3—3, respectively, of Fig. 1.

Fig. 4 is a detailed horizontal sectional view taken on the plane indicated by the line 4—4 of Fig. 1, and

Fig. 5 is a view similar to Fig. 3 showing parts of the governor mechanism in different positions of operation.

To secure the objects outlined above, the power unit shown in the drawings has been provided. This power unit includes two main parts 10 and 11, the first being a ram air turbine which is employed to operate the second main part which in this instance is illustrated as an electric generator. It should be obvious that other types of power generators, such as a hydraulic pump, could be employed instead of the electric generator.

The emergency power unit includes a support 12 which may be rigidly or movably attached to an airplane so that the unit may be disposed in an air stream as the airplane moves through the air. In the form of the invention shown the support 12 includes a generally tubular portion 13 having end walls 14 and 15, the latter being removably attached to the portion 14 to permit parts of the electric generator 15A to be inserted therein. The end walls 14 and 15 receive anti-friction bearings 16 for the rotatable support of the ram air turbine 10.

This turbine includes a frame 17 on which a pair of blade elements 18 are mounted, these elements being so formed that when the device is supported in a stream of air, the frame 17 will be caused to revolve in the bearings 16 and drive the generator 15A. The frame 17 includes two parts 20 and 21, the latter having a tubular projection 22 extending therefrom to be supported in the bearings 16. The rear end of the projection 22 is threaded as at 23 to receive a nut 24 employed to lock the frame 17 in the bearings. The parts 20 and 21 of the frame are secured together by screws 25, part 21 having slots 26 through which the screws 25 extend to permit relative movement between the frame parts for a purpose which will be set forth hereinafter.

The blades 18 project from the frame 17 at right angles to the axis of rotary movement of the frame. These

blades are supported for adjustment about the longitudinal axes thereof, the axes, in the present instance, being aligned with one another. To support the blades for such adjustment they are provided with hubs 27, which are received in outer bearings 28, and shafts 30, the inner ends of which are supported in inner bearings 31. As pointed out in the objects, one of the features of this invention lies in providing a novel bearing structure at the inner ends of the blades.

This bearing structure, indicated by the numeral 31, includes an outer race 32 which is supported in the frame with the axis of rotation of the frame bisecting the race, the latter being formed to receive two rows of ball bearings. Each of these rows of ball bearings rotatably supports a separate race 33 to which the inner end of the shaft 30 of the respective blade is connected. The manner of connection is not particularly important, one form of connection being shown for purposes of illustration only. The form of connection shown includes a sleeve 34 which receives the blade shaft 30 and is provided with a head 35 threaded into the inner race 33. The shaft is threaded on its inner end to receive a nut 36 which retains the blade in connection with the sleeve 34. Relative rotation between the sleeve and the shaft is precluded by the engagement of splines 37 formed on these elements.

It will be obvious from the foregoing that when the frame is revolved due to air flow across the blades, the centrifugal force generated by the blades will be transmitted through the blade shafts and sleeves 34 to the inner races 33 and from these elements through the ball bearings to the outer race 32. Since the rows of ball bearings are spaced equidistantly from the axis of rotation of the frame 17, the centrifugal force of each blade will be transmitted to the outer race and counteracted by the corresponding force of the other blade.

Since the blades normally have positions disposed at an angle to the plane of rotation, some torque will be generated as the frame revolves. To counteract this torque, counterweights 38 are secured to the sleeve 34, these counterweights being fastened to the enlarged portions of the sleeve by screws 40. The entire blade assemblies may be maintained in position relative to the inner race by set screws 41 extending through the counterweights and into recesses formed in the inner race 33.

To adjust the blades about their axes to secure a uniform rate of rotation of the turbine, each blade is provided with a gear portion 42 which consists of teeth cut in the sleeves 34 or otherwise provided thereon. These gear teeth are arranged to mesh with teeth formed in a face or ring gear 43 or segments of a gear of such type. This gear is supported in the frame by an anti-friction bearing 44 which is held in the frame by clamp plates 45 and shoulders 46 formed in a web provided in the frame. The face gear 43 is secured to a cam element 47 which is also supported for rotary movement in the bearings 44. Cam element 47 is splined as at 48 to one end of a torsion bar 50 which extends axially through the hollow shaft projection 22 provided on the frame 21. This torsion bar 50 is also splined at its opposite end to the rear end of the hollow projection 22 so that the torsion bar will be anchored at one end to the frame 17. Initial torque may be imparted to the torsion bar by adjusting the frame section 21 in one direction relative to the section 20. This adjustment is made possible by the screw and slot arrangement 25 and 26 previously mentioned. To facilitate this adjustment the section 21 is provided with lugs 51, while the section 20 is equipped with set screws 52. When these screws are adjusted in the section 20, the inner ends engage and move the lugs 51 which in turn transmit movement to the section 21 relative to the section 20. The degree of torque initially imparted to the torsion bar 50 is thus varied.

The blades 18 are adjusted in response to centrifugal force generated when the ram air turbine is revolved.

To effect this adjustment the section 20 is provided with two sets of bearings 53 on diametrically opposed sides of the axis of rotation of the frame. These bearings receive stub shafts 54 on which flyweights 55 are provided. These flyweights extend across the turbine and are so formed that in their idle positions they engage one another, as shown in Fig. 3, on a plane extending through the axes of the shafts 54 and the axis of rotation of the frame 17. When initial torque is imparted to the torsion bar 50 these flyweights will be in engagement as shown in Fig. 3 and will determine the initial pitch of the blades.

Each flyweight has a roller 56 supported for rotation thereon, these rollers being disposed in engagement with cam surfaces 57 provided on the cam element 47. The surfaces 57 are so arranged that when the flyweights swing outwardly due to the centrifugal force caused by the rotation of the frame 17, the rollers will traverse the cam surfaces and impart additional torque to the torsion bar 50. This torque will tend to resist outward swinging movement of the flyweights, and when the centrifugal force decreases due to a decrease in the rate of rotation of the frame, the torque will return the flyweights toward their initial positions. The degree of outward swinging movement of the flyweights is determined by set screws 58 threaded into the frame section 20. When the flyweights swing in an outward direction and motion is imparted to the cam 47 the face gear or segments 43 will also be rotated causing rotary adjustment to be transmitted through the gears 42 to the blades 18. The degree of adjustment of the blades 18 will be proportional to the degree of movement of the flyweights. This degree of movement is determined by the resistance offered by the torsion bar 50.

It will be obvious from the foregoing that the rate of rotation of the frame 17 will be controlled by the governor mechanism, any variation from a predetermined rate causing the blades 18 to be adjusted to compensate therefor. If the rate of rotation tends to increase above the predetermined rate, the flyweights will cause the cam 47 to move and adjust the blades toward a feathered position which will in turn tend to decrease the rate of operation. If the rate of operation tends to decrease, a converse operation will take place.

Fig. 1 shows the armature of the generator 15A, previously mentioned, fixed on the projection 22 of the frame section 21. When the frame 17 revolves the armature will be rotated relative to the field portion of the generator, and electric current will be produced. As previously pointed out, the tubular portion of the frame 13 could receive pump means, a movable part of which may be secured to the projection 22.

We claim:

1. In a ram air turbine: a support; a rotor journaled in said support, said rotor having a frame; blade means disposed on said frame for pitch adjustment about axes extending angularly to the axis of rotation of said rotor; flyweight means mounted on said frame for pivotal movement about a pair of axes parallel to and disposed on diametrically opposite sides of the axis of rotation of said rotor, said flyweight means being movable in response to centrifugal force resulting from the rotation of said rotor; torsion bar means disposed on the axis of rotation of said rotor and anchored at one end to said frame; a cam element secured to the opposite end of said torsion bar means, movement of said flyweight means causing said cam element to impart torque to said torsion bar; and motion transmitting means operatively connecting said cam element and said blade means to adjust the latter in response to movement of said cam element.

2. In a ram air turbine: a support; a rotor journaled in said support, said rotor having a frame; blade means disposed on said frame for pitch adjustment about axes extending angularly to the axis of rotation of said rotor; flyweight means mounted on said frame for pivotal move-

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ment about a pair of axes parallel to and disposed on diametrically opposite sides of the axis of rotation of said rotor, said flyweight means being movable in response to centrifugal force resulting from the rotation of said rotor; torsion bar means disposed on the axis of rotation of said rotor and anchored at one end to said frame; a cam element secured to the opposite end of said torsion bar means; cam engaging rollers carried by said flyweight means to impart movement to said cam when said flyweight means moves, said cam element transmitting torque to said torsion bar means; and motion transmitting means operatively connecting said cam element and said blade means to adjust the latter in response to movement of said cam element.

3. In a ram air turbine: a support; a rotor journaled in said support, said rotor having a frame; blade means disposed on said frame for pitch adjustment about axes extending angularly to the axis of rotation of said rotor; flyweight means mounted on said frame for pivotal movement about a pair of axes parallel to and disposed on diametrically opposite sides of the axis of rotation of said rotor, said flyweight means being movable in response to centrifugal force resulting from the rotation of said rotor; torsion bar means disposed on the axis of rotation of said rotor and anchored at one end to said frame; a cam element secured to the opposite end of said torsion bar means, said cam element having cam surfaces for developing variable lever moments; roller means carried by said flyweight means to traverse said cam surfaces upon movement of said flyweight means and impart torque to said torsion bar means through said cam element; and motion transmitting means operatively connecting said cam element and said blade means to adjust the latter in response to movement of said cam element.

4. In a ram air turbine: a support; a rotor journaled in said support, said rotor having a frame; blade means disposed on said frame for pitch adjustment about axes extending angularly to the axis of rotation of said rotor; flyweight means mounted on said frame for pivotal movement about a pair of axes parallel to and disposed on diametrically opposite sides of the axis of rotation of said rotor, said flyweight means being movable in response to centrifugal force resulting from the rotation of said rotor; torsion bar means disposed on the axis of rotation of said rotor and anchored at one end to said frame; a cam element secured to the opposite end of said torsion bar means, said cam element having cam surfaces for developing lever moments which compensate for changes in effective leverage of said flyweight means resulting from movement thereof; roller means carried by said flyweight means to traverse said cam surfaces upon movement of said flyweight means and impart torque to said torsion bar means through said cam element; and motion transmitting means operatively connecting said cam element and said blade means to adjust the latter in response to movement of said cam element.

5. In a ram air turbine: a support; a rotor journaled in said support, said rotor having a frame; blade means disposed on said frame for pitch adjustment about axes extending angularly to the axis of rotation of said rotor; flyweight means mounted on said frame for pivotal movement about a pair of axes parallel to and disposed on diametrically opposite sides of the axis of rotation of said rotor, said flyweight means being movable in response to centrifugal force resulting from the rotation of said rotor; torsion bar means disposed on the axis of rotation of said rotor and anchored at one end to said frame; a cam element secured to the opposite end of said torsion bar means, said cam element having cam surfaces on opposite sides of the axis of rotation of said rotor; roller means on said flyweight means to traverse said cam surfaces upon movement of said flyweight means and impart torque to said torsion bar means through said cam ele-

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ment; and motion transmitting means operatively connecting said cam element and said blade means to adjust the latter in response to movement of said cam element.

6. In a ram air turbine: a support; a rotor having a frame with a pair of relatively adjustable pieces, one of said pieces forming a hollow shaft disposed on the axis of rotation of said rotor and journaled for rotation in said support; blade means disposed on said frame for pitch adjustment about axes extending angularly relative to the axis of rotation of said rotor; flyweight means mounted on said frame for pivotal movement about an axis eccentric to the axis of rotation of said rotor, said flyweight means being movable in response to centrifugal force resulting from the rotation of said rotor; torsion bar means telescoping the hollow shaft on said frame piece and anchored at one end thereto, relative adjustment of said frame pieces serving to turn the anchored end of said torsion bar; cam means secured to the opposite end of said torsion bar means, movement of said flyweight means causing said cam means to impart torque to said torsion bar means; and motion transmitting means operatively connecting said cam means and said blade means to adjust the latter in response to movement of said cam element.

7. In a ram air turbine: a support; a rotor journaled in said support, said rotor having a frame; blade means disposed on said frame for pitch adjustment about axes extending angularly to the axis of rotation of said rotor; a pair of flyweights mounted on said frame for swinging movement about axes disposed on diametrically opposed sides of and extending parallel to the axis of rotation of said rotor, said flyweights being movable between first positions adjacent the axis of rotation of said rotor and second positions disposed outwardly from said axis of rotation; a torsion bar disposed on the axis of rotation of said rotor and anchored at one end to said frame; a cam element secured to the other end of said torsion bar and disposed adjacent said flyweights, said cam element having cam surfaces on opposite sides; a cam follower mounted on each of said flyweights and engaging a cam surface on said cam element, movement of said flyweights in response to centrifugal force imparting torque to said torsion bar; and motion transmitting means operatively connecting said cam element and said blade means to adjust the latter in response to movement of said cam element.

8. In a ram air driven auxiliary power generating mechanism: a support; rotor means having a frame with a hollow shaft journaled in said support, said hollow shaft being disposed on the axis of rotation of said rotor means; blade means carried by said frame for rotation with said rotor means, said blade means being adjustable about axes extending angularly to the axis of rotation of said rotor means to vary the pitch of said blade means; flyweight means supported on said frame for pivotal movement about an axis parallel and eccentric to the axis of rotation of said rotor means; a torsion bar telescoping said hollow shaft and anchored at one end thereto; cam means secured to the opposite end of said torsion bar, movement of said flyweight means in response to centrifugal force imparting torque to said torsion bar; motion transmitting means operatively connecting said cam means and said blade means to adjust the latter in response to movement of said cam means; and a rotary element of the generating mechanism surrounding said hollow shaft and secured for rotation therewith.

9. In a ram air driven auxiliary power generating mechanism: a support; rotor means having a frame with a hollow shaft journaled in said support, said hollow shaft being disposed on the axis of rotation of said rotor means; blade means carried by said frame for rotation with said rotor means, said blade means being adjustable about axes extending at an angle to the axis

of rotation of said rotor means to vary the pitch of said blade means; a torsion bar telescoping said hollow shaft and anchored at one end thereto; a first means carried by said frame and responsive to centrifugal force to impart torque to said torsion bar; and a second means operatively connecting said first means to said blade means and said torsion bar to adjust said blade means in proportion to the degree of torque imparted to said torsion bar.

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References Cited in the file of this patent

UNITED STATES PATENTS

1,401,651	Scharnagel	Dec. 27, 1921
2,530,520	Hackethal et al.	Nov. 21, 1950
2,550,229	Cotton	Apr. 24, 1951
2,652,123	Kearns	Sept. 15, 1953
2,704,129	Cushman	Mar. 15, 1955
2,777,524	Chapman et al.	Jan. 15, 1957