Jan. 24, 1967 | K. S. LOWE | 3,299,963

VARIABLE-PITCH FAN

Filed Oct. 11, 1965 | 4 Sheets-Sheet 1

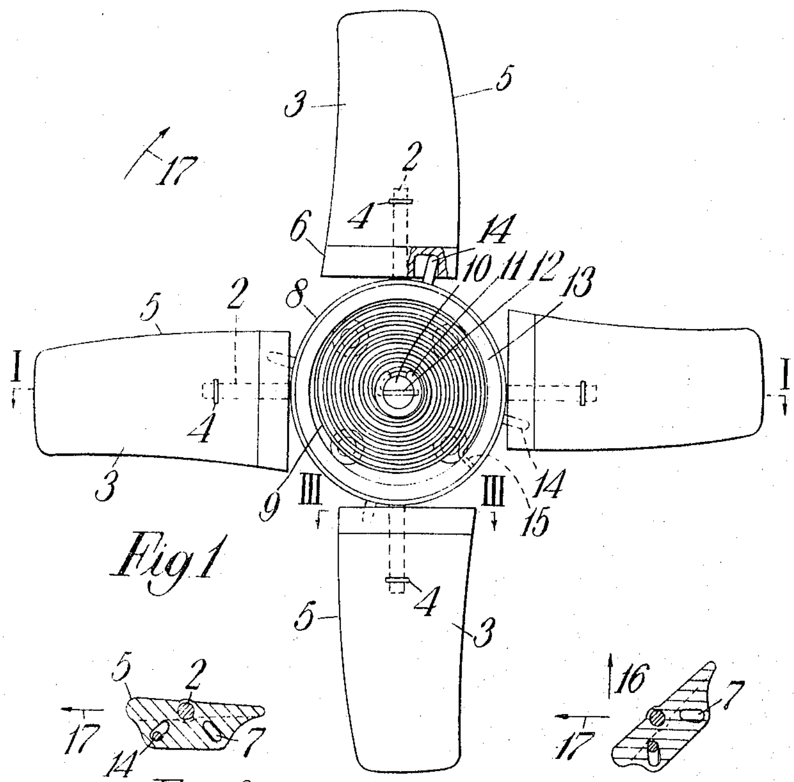


Fig 1

Fig 3a

Fig 3

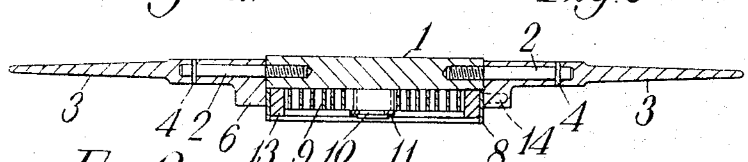


Fig 2

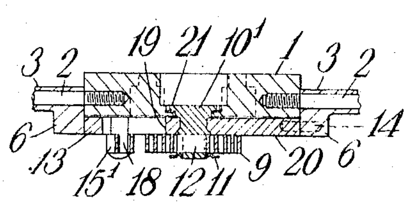


Fig 4

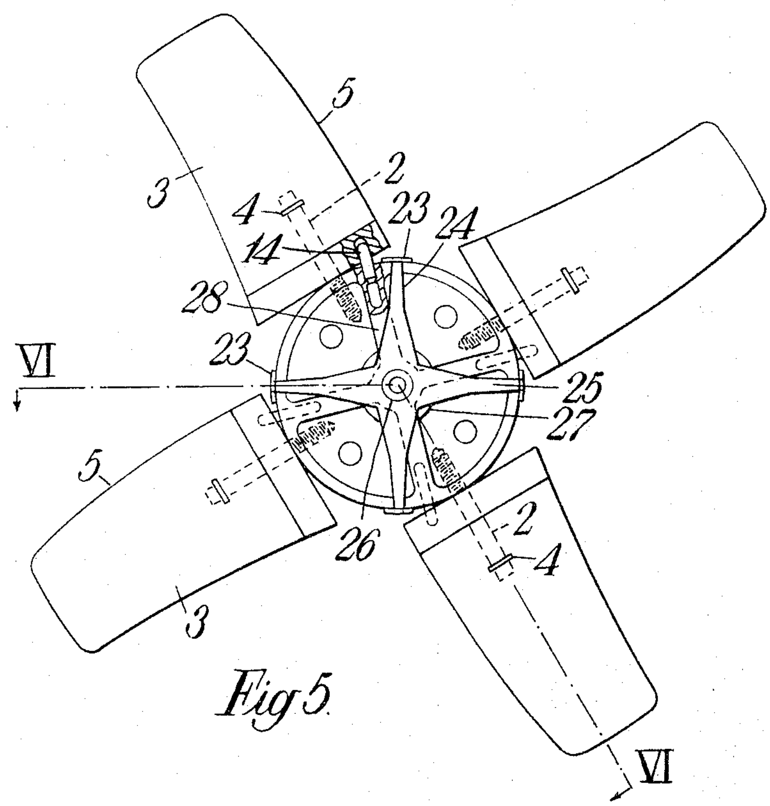


Fig 5.

Fig. 6a

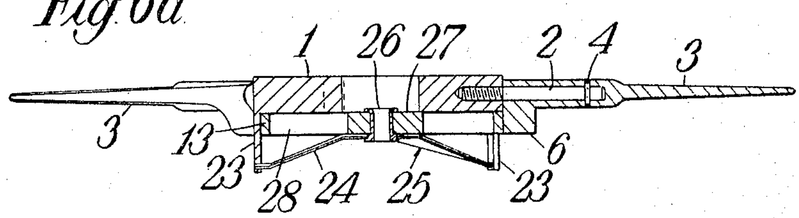
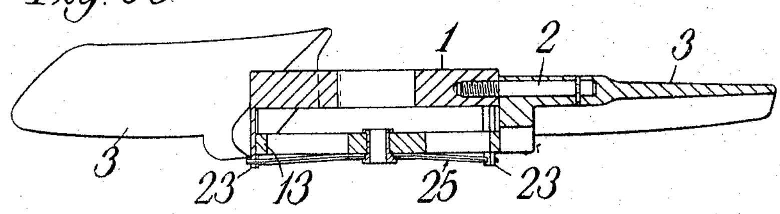


Fig. 6b



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VARIABLE-PITCH FAN

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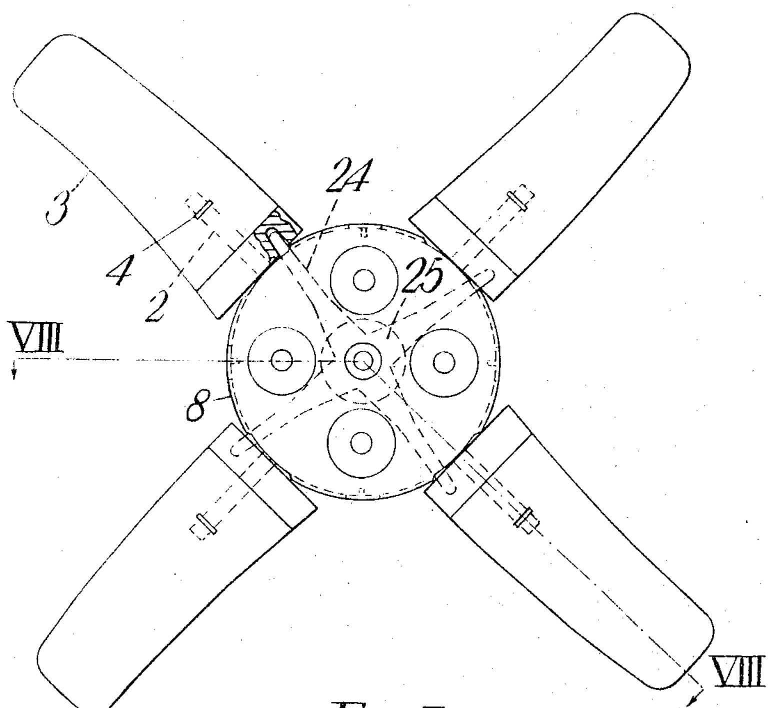
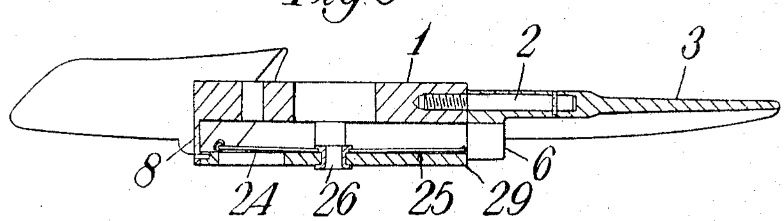


Fig 7

Fig 8



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VARIABLE-PITCH FAN

Filed Oct. 11, 1965 4 Sheets-Sheet 4

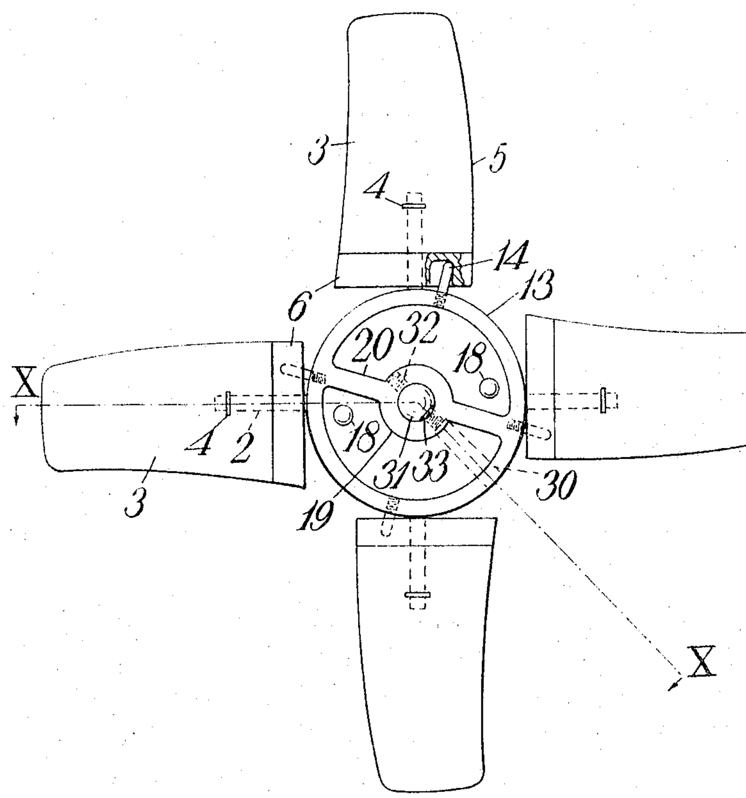

Fig 9

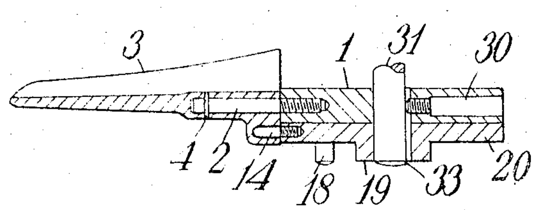

Fig 10

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VARIABLE-PITCH FAN

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5 Claims. (Cl. 170—160.13)

This invention relates to variable-pitch fans, and more particularly but not exclusively has reference to cooling fans for automobile and other internal combustion engines.

It is well known that liquid cooled and air cooled internal combustion engines of all types tend to run too hot during operation in slow running congested conditions when fitted with a conventional cooling fan of fixed pitch.

In order to overcome this disadvantage, it has been proposed to fit a variable pitch fan normally, but not exclusively, driven by the engine and to control the pitch of the fan blades by a heat responsive means, the temperature of which is governed by the air surrounding the engine or radiator or other form of heat exchanger such as the cooling fins of an air cooled engine.

By this means, it is arranged for the pitch of the fan blades to be increased as the temperature of the air rises and decreased as the temperature of the air falls, respectively, thereby maintaining the temperature of the engine substantially at its optimum running temperature despite the changes of the conditions under which it is operated.

It has also been proposed to fit a variable-pitch fan driven by the engine and control the pitch by the speed of rotation of the fan. By this means, it is arranged for the pitch of the fan blades to be at a maximum at zero to a given r.p.m., and progressively decreased as the r.p.m. rises, with zero pitch being obtained at any set maximum r.p.m.

It is also well known that air impellers of fixed pitch absorb a certain amount of power dictated by the pitch of the fan blades, the amount or number of blades, and the total diameter of the impeller, if the driving member or driving medium is limited in power such as an electric motor, small internal combustion engine or hydraulic or air motor then it is necessary to ensure that the pitch of the blades and diameter of the impeller etc. allows the driving medium to attain a rotational speed that is not so slow that it places a strain on the driving medium owing to too much power being absorbed by the impeller or a rotational speed so fast that the impeller is in the stall condition. In either case, the impeller is not working at its greatest efficiency. Attempts to overcome the necessity of making an impeller specifically for each different application have been limited to making impellers in which the blades can be located in the center hub at two or three different angles of pitch, with one such angle of pitch being nearer the ideal than would apply for a given application with a fixed pitch impeller not specifically designed and manufactured for that application but in most cases still far from the ideal.

It is an object of the invention to overcome these disadvantages and to provide a variable pitch fan of cheap, simple, and efficient design.

According to the invention the variable pitch cooling fan comprises a driven member, a plurality of fan blades, radially positioned pins rotatably supporting the fan blades upon the driven member for changing the pitch of the fan blades, a pitch controlling member positioned

coaxially with respect to the axis of rotation of the fan and rotatable with respect to the driven member, a plurality of finger-like members equal in number to the fan blades positioned radially about the pitch controlling member, and the root of each fan blade having a pair of slots arranged at an angle to one another and defining equal angles to the surface of the fan blade engageable alternatively by the cooperating finger-like member when the fan blades are assembled upon the driven member to adapt the position of the fan blades for the motion of air in the desired axial direction for the same direction of rotation.

Means may be provided for locking the further member in a desired position and the blade pitch will then be fixed during operation but adjustable to suit different circumstances of use.

Alternatively, the pitch may be made temperature dependent if a bimetallic element, preferably one or more spiral coils, acts between the members so as to move the further member relative to the driven member in response to ambient temperature changes.

Alternatively or in addition, the pitch may be made speed sensitive if movement of the further member is resisted by one or more resilient members so that the tendency of the blades to feather as a result of the reaction of air or other gas passing through the fan is resisted and feathering thus increases as speed increases.

Several exemplary embodiments of the invention will now be described with reference to the accompanying drawings, in which:

FIG. 1 is a front view of a speed or temperature sensitive fan, fully feathered;

FIG. 2 is a sectional view of the fan taken on line I—I of FIG. 1;

FIGS. 3*a* and 3*b* are sectional views on line III—III of FIG. 1, showing a blade in positions of minimum and maximum pitch respectively;

FIG. 4 is part sectional view, corresponding to FIG. 2, of a modified construction;

FIG. 5 is a front view of a speed sensitive fan, fully feathered;

FIGS. 6*a* and 6*b* are sectional views on line VI—VI of FIG. 5, showing the blades in positions of minimum and maximum pitch respectively;

FIG. 7 is a front view of another speed sensitive fan, with the blades at maximum pitch;

FIG. 8 is a section on line VIII—VIII of FIG. 7;

FIG. 9 is a front view of a fan of adjustable pitch; and

FIG. 10 is a part sectional view on line X—X of FIG. 9.

In the drawings, corresponding parts are identified by the same reference numerals.

FIGS. 1 and 2 show a fan having a driven member in the form of a base plate **1**, which in use is suitably secured to a shaft or motor, and which carries four equally spaced blade pivot pins **2**, a molded plastic blade **3** being secured on each pin by a clip **4**. Each blade has a leading edge **5** and an enlarged root part **6** containing two slots **7** defining with the pin **2** a right angle and set at 45° to the chord of the blade. The slots have the same radial size and spacing relative to the pin **2**.

Plate **1** has an edge wall **8** defining a cup in which is housed a spiral element **9** retained on a boss **10** of plate **1** by a circlip **11**. The element **9** has an inner tongue **12** slotted in boss **10** and an outer tongue **15** located in a ring **13** which fits in wall **8** and carries four thrust pins **14** projecting through slots in wall **8** into one slot **7** of each blade. Pins **14** are at at small angle relative to pins **2** (15° in the fully feathered position of FIG. 1).

It will be readily seen that the pitch of the blades depends on the position of ring **13** relative to plate **1**. In

FIG. 1, ring **13** is shown at the limit of its clockwise displacement relative to plate **1** and the blades are in the plane of plate **1**. If ring **13** is turned relatively anticlockwise its pins **14** engaging blade recesses **7** it will turn the blades about pins **2** (pins **14** being axially offset from pins **2**: see FIG. 3*a*) to increase the pitch. The clockwise rotation of ring **13** relative to plate **1** will again decrease the pitch.

If element **9** is a spiral spring, the fan is speed sensitive. At zero speed the blades are at maximum pitch namely, 45°, as shown in FIG. 3*b*. As the speed increases, the reaction of the air passing through the fan tends to feather the blades, i.e. to turn them from the position shown in FIG. 3*b* towards the fully feathered position shown in FIG. 3*a* in which the pitch is zero and flow is also zero. Air flow and direction of rotation are indicated by arrows **16** and **17** respectively. Feathering involves rotation of ring **13** relative to plate **1** and is therefore resisted by spring **9**. As the speed rises the pitch will therefore decrease and so will the air flow. By suitable choice of the strength of spring **9**, the feathering force can be resisted fully up to a certain speed so that maximum pitch is kept up to, say 600 r.p.m. (i.e. at idling speed) but the pitch then decreases, reaching zero at high speeds of rotation when the air pressure on the blades holds the blades against a stop, e.g. the ends of the slots in wall **8**.

If element **9** is a bimetal spiral, the fan is temperature sensitive, because any change in ambient temperature will cause bimetal element **9** to expand or contract and thus rotate ring **13** thereby changing the pitch of the blades. In this case, it is usually desired to increase the pitch with temperature so that, in the case of an internal combustion engine, the engine temperature is kept close to the optimum value. Thus, at low temperatures (cold engine), the pitch is zero as shown in FIGS. 1 and 3*a*, and as the temperature rises the bimetal coil **9** expands, thereby turning ring **13** anticlockwise and increasing the pitch.

It will be seen that the bimetal spiral will act like a coil spring to oppose feathering caused by air reaction on the blades. Thus, by suitably choosing the thermal and mechanical characteristics of the bimetal, the fan can be made responsive to both speed and ambient temperature. For example, it could be arranged that in an internal combustion engine heating increases the pitch as engine speed rises to a certain point above which further speed increase reduces the pitch by the reaction of the air on the blades as already described.

FIGS. 1 to 3*b* show the pins **14** engaging the leading edge slots **7**. This corresponds to the use of the fan as a suction fan and for use as a blower, the pins would engage the trailing edge slots **7**.

In the modified construction of FIG. 4, outer end **15**[1] of the spiral element **9** is secured to a post **18** on the base plate **1** and the inner tongue **12** is secured in a pin **10**[1] fast with a hub **19** connected to ring **13** by spokes **20** (only one being shown). Pin **10**[1] is journaled in plate **1** and is secured by flange **21**. The operation is exactly as described above with reference to FIGS. 1 to 3*b* and in the absence of edge wall **8** with its guide slots for the pins **14**, post **18** and spokes **20** co-operate to limit the rotation of ring **13** and hence the change of pitch of blades **3**.

Other modifications of the above and subsequently described fans are of course possible. In particular, pins **14** or their equivalent could be provided on plate **1**, with the blades being pivoted on ring **13**. Pins **14** could be fixed in the blades and engage grooves or holes in ring **13**. The slots **7** could be curved to provide a desired variation of pitch as a function of speed or temperature. The direction of the variation of pitch may be the opposite of that described above (i.e. increasing with speed or decreasing with temperature) and the initial value and range of variation of the pitch can be varied to suit a particular application and may be made variable, e.g. by provision of variable stops.

The fan shown in FIGS. 5 to 6*b* is only speed sensitive. In this case, the ring **13** can move axially. It will be clear that such axial movement, with pins **14** engaging blades **3** as above mentioned, will pivot the blades on pins **2**. When ring **13** lies against plate **1** (FIG. 6*a*) the pitch is zero and as ring **13** moves away from the plate the pitch increases (FIG. 6*b*). The ring is guided by four arms **23** of plate **1** in whose ends are slidably supported arms **24** of a star-shaped spring **25** whose center is staked by a rivet **26** to a hub **27** connected to ring **13** by spokes **28** in which pins **14** are set. The zero- and low-speed position (maximum pitch) is shown in FIG. 6*b* and the maximum pitch is fixed by the length of arms **23**, since ring **13** cannot pass the fixing points of spring arms **24**. As the speed rises the air exerts feathering forces on the blades tending to turn them to the feathered position of FIG. 6*a* and accordingly move ring **13** towards plate **1**. This movement is resisted by spring **25** so that the pitch decreases as the speed rises, as decribed in connection with FIGS. 1 to 3*b*. Axial movement of ring **13** and pivoting of blade **3** involves some rotation of ring **13**, which is therefore left free to rotate relative to spring **25**.

Alternatively, the feathering action of the blades could be controlled by an adjustable stop or the like which in turn is controlled by centifugal forces, and this stop or stops or the like could take the form of a wedge or the like running up an inclined plane situated between the base plate and a front plate. The centrifugal force would tend to move the wedge or the like outwards to the periphery of the front and rear, thus allowing the two plates to approach each other when the fan is rotating at a high speed thereby allowing the blades to feather. The wedges or the like are returned by a springing medium to the center of the plate, thereby increasing the pitch. Alternatively wedges or the like could incorporate a hole or the like into which inclined pins or the like ensure adequate and correct location for the wedges or the like to slide outwards.

FIGS. 7 and 8 show a modification of the fan of FIGS. 5 to 6*b* in which ring **13** is omitted and spring arms **24** are coupled directly to blades **3**. In other words the ends of the blades may carry pins or may themselves project into recesses in the blades. The spring **25** is pivoted by rivet **26** on a fixed front plate **29**, which with plate **1** and walls **8** of the latter, defines a substantially closed chamber. The zero-speed position is shown in FIG. 8. As speed rises, the feathering forces pivot the blades, and this pivoting is resisted by flexing of the arms **24** of spring **25** so that the pitch decreases as speed rises.

FIGS. 9 and 10 show a fan whose pitch is fixed during operation but can be adjusted to suit the circumstances of use. Its construction is similar to the fan of FIG. 4 but the spiral element **9** is omitted and the hub **19** is provided with means for clamping it to plate **1**. The fan shown is intended for shaft mounting and plate **1** therefore has an access hole **30** for a grub screw to fix plate **1** on a shaft **31**. In hub **19** is a hole **32** for a screw to fix hub **19** to the shaft and fix the relative positions of hub **19** and plate **1** and hence the pitch of the blades. Normally, shaft **31** will have a flat **33** to receive the screw in hole **30** and the screw in hole **32** for fixing the hub **19** must not engage this flat (since if it did the position of hub **19** could not be adjusted) and hole **32** is therefore on the opposite side to hole **30** relative to the shaft. In use, plate **1** is fixed to shaft **31**, with hub **19** being turned on the shaft to set the blades to the desired pitch, and hub **19** is then fixed to the shaft. Posts **18** serve as stops in cooperation with spokes **20**.

The fan shown in FIGS. 9 and 10 is for shaft mounting. For flange mounting (like the fans of FIGS. 1 to 8), the central shaft hole would be replaced by a bolt or stud with an associated nut to clamp hub **19** against plate **1**.

It will be understood that the arrangements described in detail above are merely exemplary and constructional details may be modified within the scope of the invention. For example, the single spiral elements **9** could be replaced by two or more smaller spiral elements. This may be advantageous if the fan is to be mounted on a shaft and central fixing of the element is thereby made impossible. The blades can have any convenient form and it is not essential that they be pivotable as a whole. For example, the blades may have fixed leading edge parts and pivotable or flexible trailing edge parts with only the trailing edge parts being varied in pitch. The speed sensitive arrangement shown in FIG. 5 could be made temperature sensitive if the star spring were replaced by an axially expansible temperature sensitive element such as a wax bulb arranged to expand and contract axially.

I claim:

1. A variable pitch cooling fan comprising a driven member, a plurality of fan blades, radially positioned pins rotatably supporting said fan blades upon the driven member for changing the pitch of the fan blades, a pitch controlling member positioned coaxially with respect to the axis of rotation of the fan and rotatable with respect to the driven member, a plurality of finger-like members equal in number to the fan blades positioned radially about the pitch controlling member, and the root of each fan blade having a pair of slots arranged at an angle to one another and defining equal angles to the surface of the fan blade engageable alternatively by the cooperating finger-like member when the fan blades are assembled upon the driven member to adapt the position of the fan blades for the motion of air in the desired axial direction for the same direction of rotation.

2. A variable pitch cooling fan comprising a bush constituting a driven member, a plurality of fan blades, radially positioned rods rotatably supporting said fan blades upon the perimeter of the driven member for changing the pitch of the fan blades, a pitch governing member positioned coaxially with respect to the axis of rotation of the driven member and rotatable with respect to the latter, a plurality of pins equal in number to the fan blades and positioned radially outwardly about the pitch governing member, the root of each fan blade having a pair of slots arranged at an angle to one another and at equal angles to the surface of the blade engageable alternatively by the coacting radial pin when the fan blades are assembled upon the radially positioned rods upon the driven member to adapt the general position of the fan blades to produce the required axial direction of the air for the particular direction of rotation of the fan, and spring means acting between the driven member and the pitch governing member to urge the fan blades in the direction of one of their extreme positions.

3. The variable pitch cooling fan as claimed in claim **2** in which the spring means is a spiral spring.

4. The variable pitch cooling fan as claimed in claim **2** in which the spring means is a spiral bi-metallic heat responsive member, the spring action of which acts in the direction to decrease the pitch while the thermal action acts to increase the pitch of the fan blades.

5. The variable pitch cooling fan as claimed in claim **1** in which both the driven member and the pitch controlling member are provided with coaxial bores for attachment of the fan upon a driving shaft, and fixing means for rigidly attaching the driven member and the pitch controlling member to a driving shaft in a variety of different relative circumferential positions for varying the pitch of the fan blades.

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