Oct. 22, 1968 S. E. V. BOOTH 3,406,898

AXIAL-FLOW AIR-MOVING DEVICES

Filed July 12, 1966 2 Sheets-Sheet 1

Fig. 1

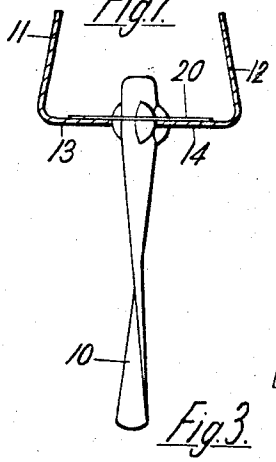


Fig. 2

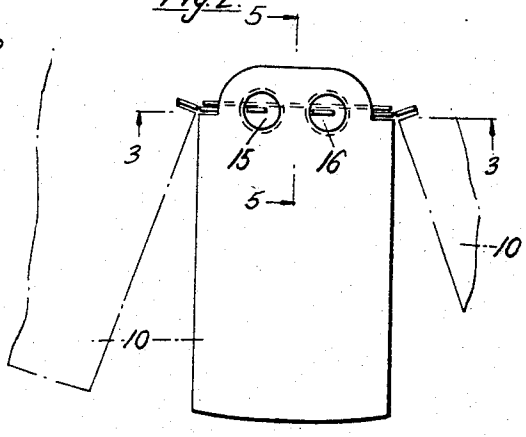


Fig. 3

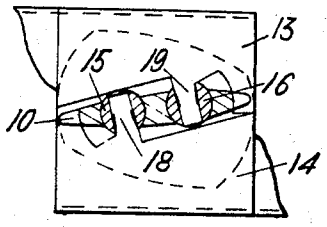


Fig. 4

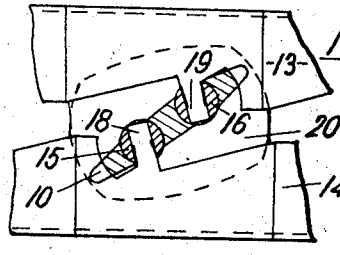


Fig. 8

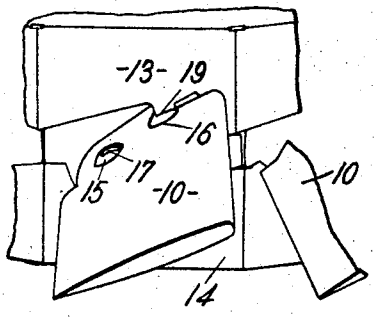


Fig. 5

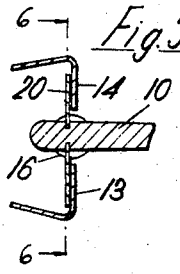


Fig. 6

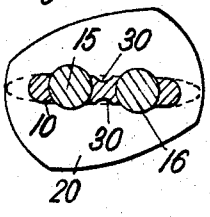


Fig. 7

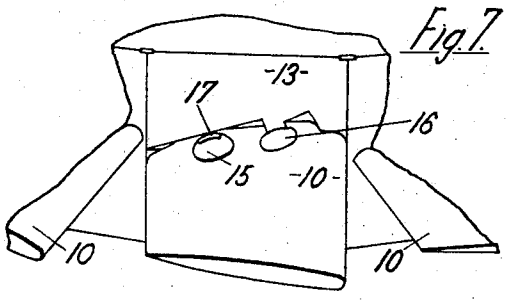
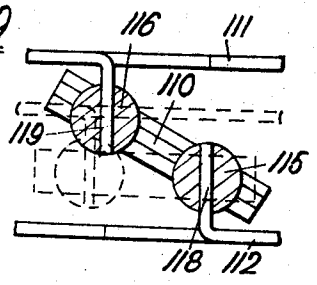


Fig. 9



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AXIAL-FLOW AIR-MOVING DEVICES

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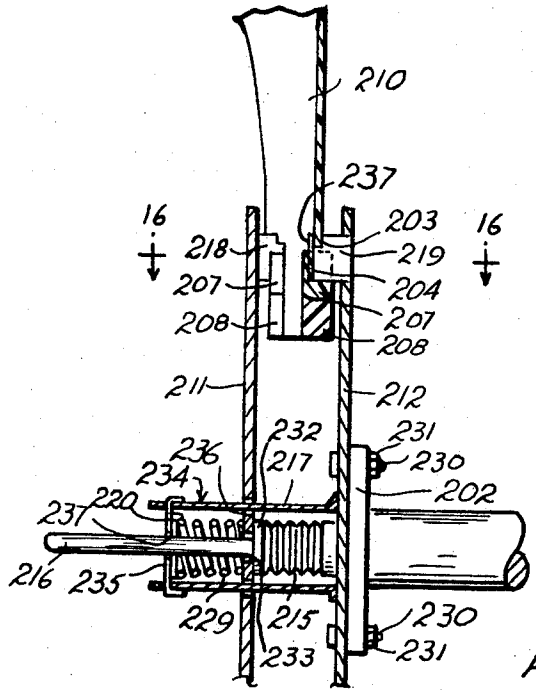

FIG. 10

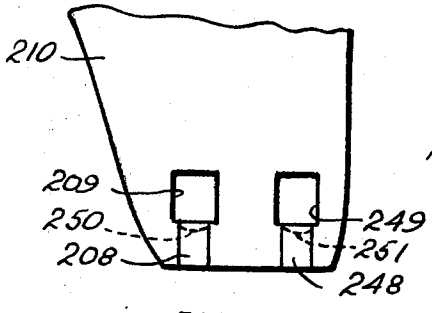

FIG. 11

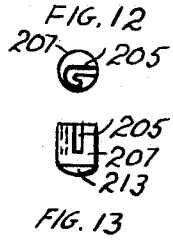

FIG. 12

FIG. 13

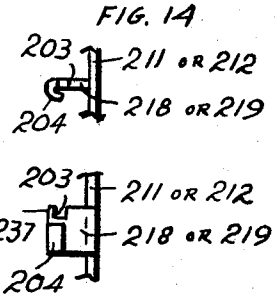

FIG. 14

FIG. 15

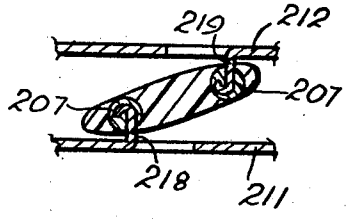

FIG. 16

United States Patent Office

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Patented Oct. 22, 1968

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AXIAL-FLOW AIR-MOVING DEVICES

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15 Claims. (Cl. 230—270)

ABSTRACT OF THE DISCLOSURE

A fan or other axial-flow fluid-moving device having blades with adjustable pitch and means responsive to the temperature of the fluid flowing through the device for controlling the pitch.

An object of the invention is to provide an axial-flow fluid-moving device comprising simple and nevertheless effective means for adjusting the pitch of the blades.

Another object of the invention is to provide an axial-flow fluid-moving device having a hub comprising two parts which are axially displaceable relative to each other and which are connected with the blades of the device by means simultaneously serving as supporting means for the blades and as means for providing for adjustment of the pitch thereof.

A further object of the invention is to provide a fan to be used with automobile engines and other fluid cooled internal combustion engines, which fan is by simple and cheap means adapted both simply and economically to have the pitch of the blades adjusted in accordance with the temperature of the cooling fluid in such a manner that the pitch is at a minimum and thereby the power consumption of the fan at a minimum when the cooling water is cold and until the temperature of said water rises above a predetermined value, so that the fan is effective only at temperatures of the cooling fluid above the normal or prescribed working temperature.

Three embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings which illustrate axial-flow fans in accordance with the invention and in which:

FIG. 1 is a fragmentary side elevational view of a blade mounted between two plates;

FIG. 2 is a plane view of a blade;

FIG. 3 is a section on the line 3—3 of FIG. 2 with the blade in fine pitch;

FIG. 4 is a section on the line 3—3 of FIG. 2 with the blade in coarse pitch;

FIG. 5 is a section on the line 5—5 of FIG. 2;

FIG. 6 is a section on the line 6—6 of FIG. 5;

FIG. 7 is a fragmentary perspective view of a blade in fine pitch corresponding to FIG. 3;

FIG. 8 is a fragmentary perspective view of a blade in coarse pitch corresponding to FIG. 4;

FIG. 9 is a similar view to FIG. 4 showing a modification of the invention;

FIG. 10 is a radial section through one blade and mounting parts therefor according to a third embodiment of the invention;

FIG. 11 is a side elevation of the root part of the blade;

FIGS. 12 and 13 are, respectively, end and side elevations of a bearing member;

FIGS. 14 and 15 are, respectively, end and side elevations of tongues cooperable with the bearing members, and

FIG. 16 is a section on line 16—16 of FIG. 10.

Referring to the drawings, FIG. 1 shows one blade **10** of a fan having a plurality of radially-disposed blades mounted between two plates **11** and **12** together forming a hub and mounted on a shaft (not shown) in such manner as to be relatively movable both axially and rotationally of the shaft. The plates are of polygonal shape in the described embodiment but they could be circular, and they are mounted in spaced parallel relationship. The plates are relatively movable to vary the distance between them and to vary their rotational relationship.

The plate **11** has a flange **13** around its perimeter and plate **12** has a similar flange **14**, said flanges being directed one towards the other and being shaped so as to allow the blade root to pass between them at any angle of pitch between prescribed limits.

In the root of each blade at two transversely-spaced locations are two seats holding captive balls **15**, **16** each having slots **17** therein. On the flanges **13**, **14** are barbed tongues **18**, **19** which serve as pivot means for the blade **10** and engage in the slots **17** in the balls **15**, **16** respectively which serve as bearing members.

A plate **20** (see FIGS. 5 and 6) engages flexibly in slits **30** in the blade **10** and abuts lightly against the inside surface of the flanges **13** and **14**.

In the present embodiment the blade **10** may be made of polypropylene, the plates **11** and **12** may be made of steel, the balls **15** and **16** may be made of nylon and the plate **20** may be made of nylon or polyvinyl chloride.

To alter the pitch of the blades **10**, the plate **11** is moved towards or away from plate **12** and rotated slightly relative thereto. The balls are thus rotated in their seats and the pitch of the blades is consequently altered. The blade is shown in fine pitch in FIG. 3 with the plates **11**, **12** close together, and in coarse pitch in FIG. 4 with the plates **11**, **12** moved apart. Temperature-responsive means of known construction may be disposed between the plates **11** and **12** mounting each blade **10** and be coupled to the plates in order automatically to vary the pitch of the blades in accordance with variation in the ambient temperature.

The plate **20** occludes air from circulation through and around the blade root and also acts as resilient means to restrain the blade from swinging freely on its ball joints, but allowing the blade to take up a position under the influence of the centrifugal force and the air load so that minimal blade-root bending moments are generated.

Referring now to FIG. 9 there is shown a second embodiment of the invention in which parts are indicated by reference numerals increased by 100 over those used for like parts in FIGS. 1 to 8. Tongues **118** and **119** are formed integrally with plates **111** and **112**, no flanges being present. Each tongue is cut and bent out from the edge of one of the plates. No plate such as plate **20** is provided in this embodiment, but plates **111** and **112** are set close together and there is thus little space for undue recirculation of fluid around the roots.

In FIGS. 10 to 15 illustrating a third embodiment of the invention, parts already described are indicated by reference numerals increased by 200 over those used for

like parts in FIGS. 1 to 8. In this embodiment there is shown the shaft **201** on which the hub is mounted. The shaft **201** has an end flange **202** on which the plate **212** on the hub is secured by bolts **230** and cooperating nuts **231**. There is also shown, disposed between the plates, temperature-responsive means comprising a thermostat **215** from whose end **232** remote from plate **212** extends a feeler **216** which passes through an opening **233** therefor in the plate **211** and through a cage **234** to atmosphere there to be subject to the ambient temperature. The cage **234** mounts a seat **220** for a spring **239** serving to urge the plate **211** towards the plate **212** in opposition to the thermostat **215**. The spring **229** is rated to coact with the thermostat in varying the inter-plate spacing in response to changes in the ambient temperature. The cage **234** is made up of an end disc **235** through a central opening **237** in which the feeler **216** passes and rods **217** which pass through openings **236** therefor in the plate **211** and are secured to the plate **212**.

This embodiment of the invention differs from those already described in the blade-mounting arrangement. In this embodiment, the tongues **218** and **219** extend radially of the axis of the shaft **201** and each has a notch **203** in its outer side edge at a short distance from its radial edge **237**. Said radial edge **237** is foreshortened by a length slightly greater than the depth of the notch **203** and is reversely bent to provide a barb **204** which does not extend as far as the base of the slot in the radial direction. A roller-shaped bearing member **207** of resilient material has therein a slot **205** which corresponds in shape to the barb and part of the tongue **218** or **219** from which it extends so that the bearing member can be snap-fitted to the tongue. The bearing member **207** is part-spherical at its inner end **213**.

Each of the blades **210** has two-transversely-spaced rectangular bearing slots **209** and **249** in the root thereof, and, below the slots and between same and inner edge of the blade is locally thickened at both sides to provide cylindrical seating members **208** and **248** having part-spherical dished outer surfaces **250** and **251** facing the slots.

In mounting the blades **210**, the bearing members **207** are snap-fitted on to the tongues and are then fitted to the blades, firstly by engaging the notches **203** on the blades at the upper ends of the bearing slots and then pressing the bearing members into the position wherein their part-spherical inner ends **213** seat in the part-spherical dished outer surfaces **250** and **251** of the seating members **208** and **248**.

In a modification of the invention the plates **11** and **12**, or **111** and **112**, or **211** and **212**, are fixed relative to one another, whereby the fan is a fixed pitch fan.

It will be manifest that the invention is applicable to axial-flow fluid-moving devices other than fans, for example, it is applicable to turbines.

Among the advantages of the invention are that it provides axial-flow fluid-moving devices enabling hinging movements of the blades or vanes which obviates a common cause of failure due to bending moments at the roots of the blades or vanes.

Among the further advantages of devices according to the invention are that they can be cheap; easy to operate; require little or no maintenance or lubrication; and have an intrinsically reliable structure. Devices like those described as the first embodiment are also aerodynamically efficient as air is prevented from recirculating at the blade or vane root.

I claim:

1. An axial-flow fluid-moving device comprising:
(a) a hub;
(b) a plurality of blades; and
(c) two swivel joints connecting each blade to the hub to extend radially therefrom and to rotate therewith, the centres of which joints are at fixed positions relative to said blade and are spaced apart circumferentially relative to said hub; each said blade being free to move about an axis extending between the centres of said two joints.

2. A device as set forth in claim **1**, wherein said blades are movable relative to each other on the hub axis and are relatively rotatable on the hub axis.

3. A divice as set forth in claim **2**, and further comprising temperature-responsive means adapted to effect said relative axial movement.

4. A device as set forth in claim **3**, comprising:
(a) a shaft;
(b) said hub consisting of two parts,
(c) means mounting said parts on said shaft in spaced-apart relationship to define a space and in such manner as to be relatively movable both axially and rotationally of said shaft;
(d) circumferentially-spaced tongues on each said part extending in the direction of the other said part, the tongues of one said part being offset circumferentially to the tongues of the other said part to provide pairs of oppositely directed tongues in said space;
(e) fan blades disposed radially of said hub and each having a root entering said space; and
(f) means at two transversely-spaced locations on each said root engaged by and cooperable with a said pair of tongues to permit rotational displacement of the appertaining blade about two axes at each said location.

5. A device as set forth in claim **4**, wherein said parts are substantially flat plates mounted in parallel relationship and each tongue is formed by a portion of one plate, said portion being cut and bent out from the edge of said plate to extend perpendicular to the plane of the plate.

6. A device as set forth in claim **5**, in which each blade root has two transversely-spaced openings therein and is locally thickened radially inwards of said openings, each said local thickening being shaped to present to the appertaining opening a part-spherical seating surface; and in which each said swivel joint comprises a bearing member entered into a said opening to be captive therein and seating on the seat presented to said opening and means mounting said bearing member on a said tongue.

7. A device as set forth in claim **5**, in which each swivel joint comprises a ball, means on a said root holding said ball captive against axial displacement but free to rotate, said ball having a slot therein, and a said tongue engaged in said slot.

8. A device as set forth in claim **7**, including means resiliently restraining the blades from swinging and preventing air recirculating around said roots.

9. A device as set forth in claim **8**, wherein said means comprise a plate secured to each said root, each plate extending in a plane perpendicular to the long axis of its associated blade, and wherein said two parts each have peripheral flanges extending towards one another and having inner faces, said plates being disposed to engage said inner faces.

10. An axial-flow fluid-moving device comprising a hub rotatable about an axis, the hub comprising two parts extending radially of said axis with a space therebetween, said parts having limited relative movement both axially and circumferentially, each of said parts having a tongue extending toward the other part in said space, the tongues being circumferentially offset relatively to each other, a blade, and bearing members interconnecting the blade with said tongues respectively, said members being rotatably mounted in the blade and the blade being supported on said hub parts solely by said members.

11. A device according to claim **1** wherein the offset of said tongues is substantially 180°.

12. A device according to claim **1** wherein said bearing members have spherical surfaces.

13. A device according to claim **1** wherein the inner

end of each bearing member is spherical and seats in a spherical cup in the blade, each bearing member has a slot to receive said tongue, and the outer end of each bearing member having a notch to receive an edge of the hub.

14. A device according to claim **13** wherein the blade is made of yielding plastic material.

15. A device according to claim **1** further characterized by temperature-responsive means for producing said axial movement.

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HENRY F. RADUAZO, *Primary Examiner.*