Aug. 9, 1966 A. E. H. ELMER 3,265,047

COOLING FANS

Filed May 14, 1964 4 Sheets-Sheet 1

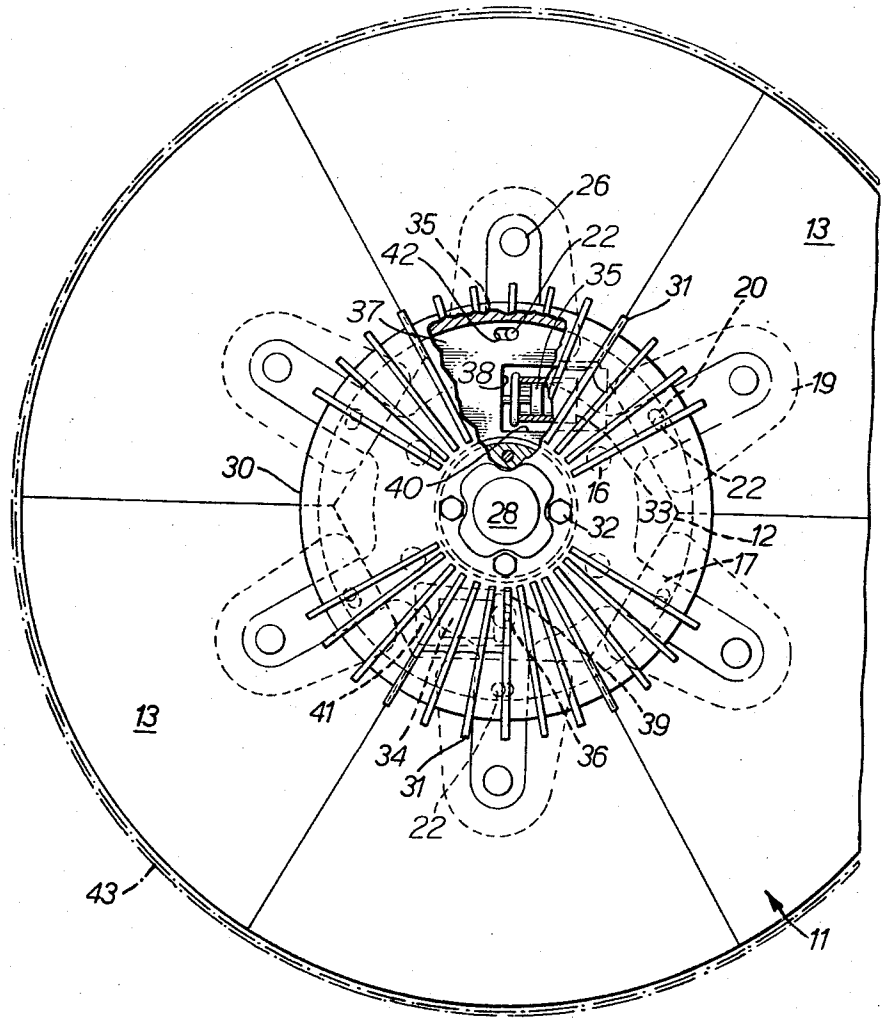


FIG. 1.

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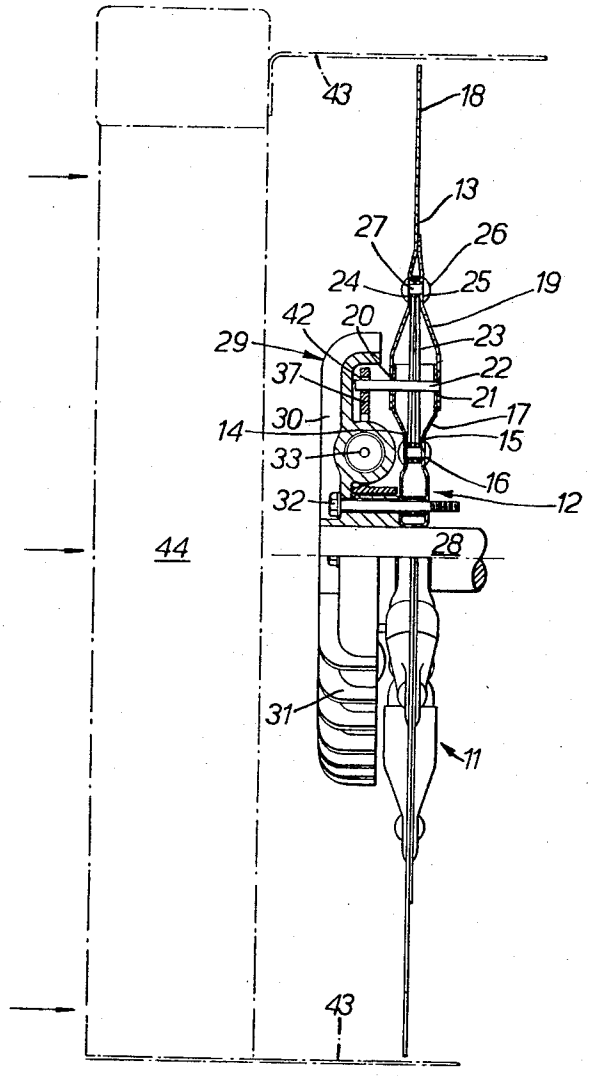


FIG. 2.

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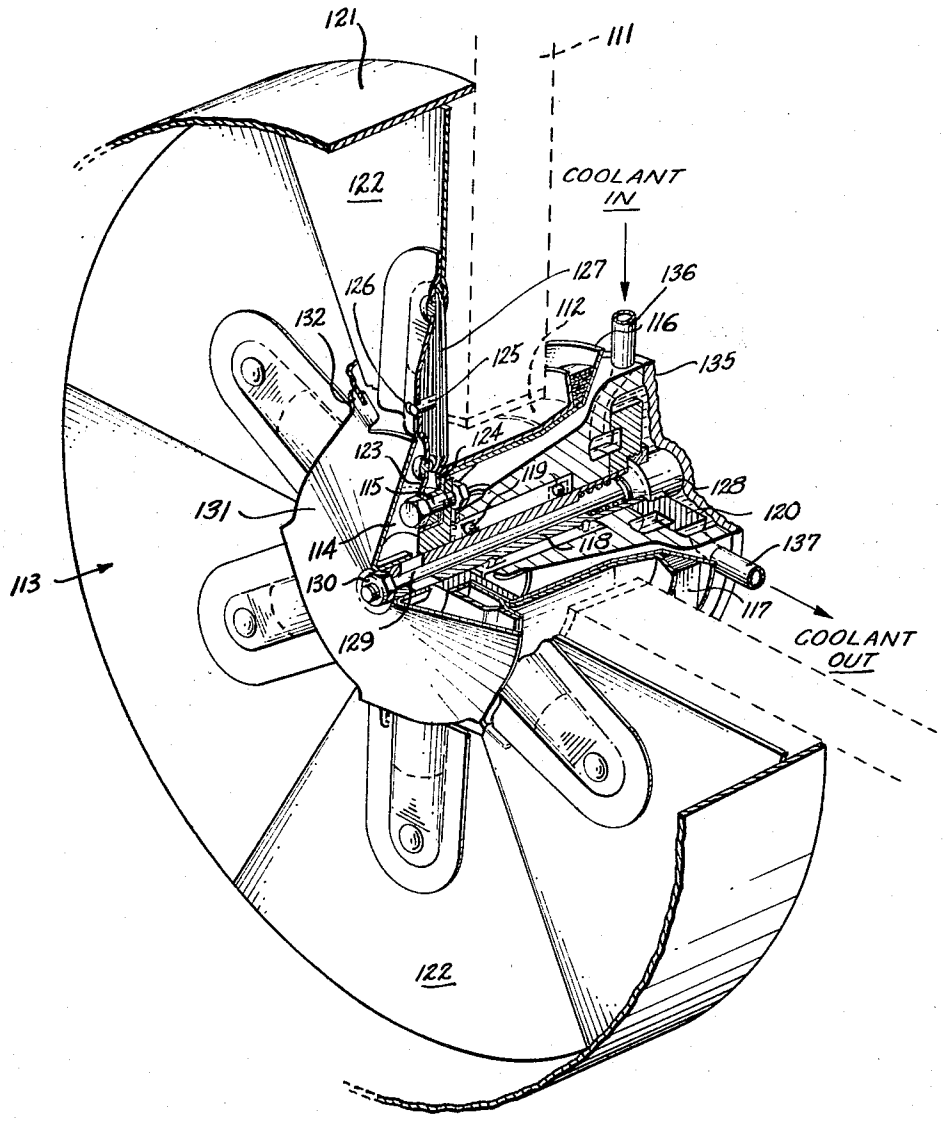


FIG. 3.

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COOLING FANS

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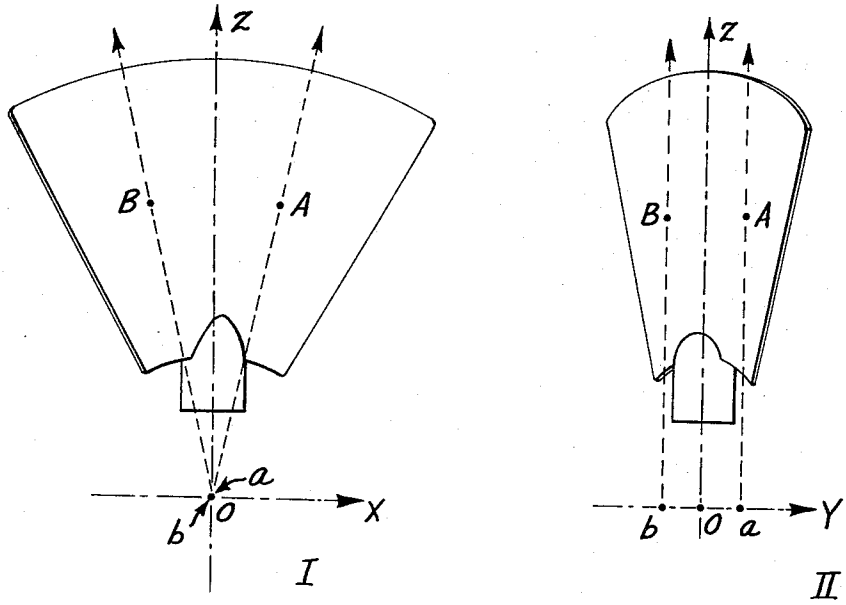
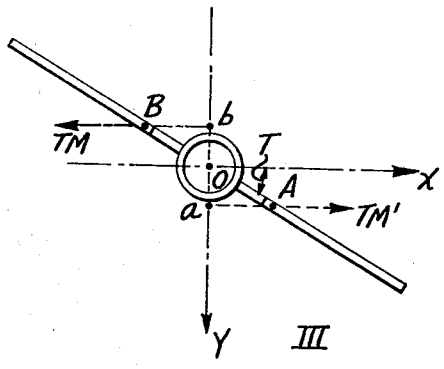
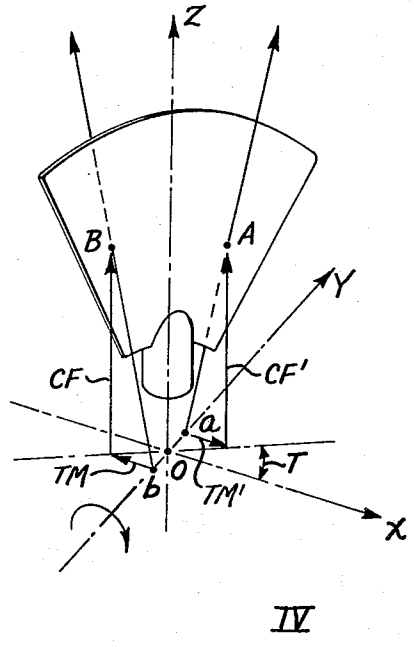


Fig. 4.





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3,265,047

COOLING FANS

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Claims priority, application Great Britain, May 16, 1963, 19,553/63
8 Claims. (Cl. 123—41.12)

This invention relates to cooling fans suitable for use in a vehicle, arranged to cool the engine of the vehicle during normal operation.

According to the invention a cooling fan suitable for use in a vehicle is arranged to be driven by the engine of the vehicle for rotation in a duct disposed adjacent the radiator of the engine, or speaking more generally, adjacent the cooling system of the engine, the blades of the fan being automatically adjustable as to their pitch under the control of thermo-responsive means so that under low temperature operating conditions of the engine, i.e., when the engine is cold, the blades are in fine pitch position, thereby substantially to close the duct, and to prevent or diminish cooling of the engine, but upon increase in the operating temperature of the engine, the pitch of the blades is coarsened to induce flow of cooling air through the radiator and the duct to an extent necessary to maintain the engine within a predetermined operating temperature range. By so doing there is no necessity to provide a radiator grill shutter to assist in warming the cold engine, in addition to a cooling fan. The fan of this invention serves both purposes.

The thermo-responsive means may be secured to the hub of the fan and be operably connected to the roots of the blades. The operation of the thermo-responsive means may be reacted by spring devices associated with the blades.

The spring devices may also be arranged to react the centrifugal twisting moments inherent in the blades upon operation of the fan thereby to afford automatic pitch control of the blades. In this way the power absorbed by the fan during the range of operating conditions of the engine is substantially only that which is required for the cooling demands of the engine at any given condition. These centrifugal twisting moments on the blades are distinct from the centrifugal force acting radially on the blades, as will appear more clearly hereinafter.

The spring devices may be arranged also to retain the blades in the radial sense with respect to the hub of the fan.

The thermo-responsive means may include at least one wax capsule thermostat device either fitted upon or disposed adjacent the forward face of the hub. The thermo-responsive means may also include a heat sink member arranged in heat conducting relation with the thermostat device or devices and with the air which in operation passes through the fan. The heat sink member may comprise a first disc having a plurality of radially-directed forwardly-extending fins formed integrally therewith.

The thermostat device or devices may be operably connected to the roots of the blades through the intermediary of a second disc interposed between the first disc and the hub. The second disc may be angularly adjustable with respect to the first disc and the hub upon expansion and contraction of the thermostat device or devices to transmit pitch adjusting movement to all the blades in unison.

Certain details of the spring devices, of the thermo-responsive means, and of the operative connection of the latter to the blades, although shown herein, are also shown in some detail in my copending application Ser. No. 355,768, filed Mar. 30, 1964, now Patent No. 3,220,484.

One embodiment of the invention will now be particularly described with reference to the accompanying drawings, of which,

FIGURE 1 is a front elevation, partly broken away, of an engine cooling fan which is rotatable within an air duct, and,

FIGURE 2 is a side elevation of the cooling fan of FIGURE 1, shown partly in cross-section and adjacent the engine radiator.

FIGURE 3 is an isometric view, partly broken away, of a further embodiment.

FIGURE 4 is a series of diagrams illustrating the source of the centrifugal twisting moments acting upon each fan blade during rotation of the fan, and the result thereof, such as tends to rotate each radially directed blade about its longitudinal axis, towards its fine pitch position, with increase in the fan's rotational speed.

Referring to FIGURES 1 and 2 of the drawings, a cooling fan **11** suitable for use in a vehicle for cooling the engine of the vehicle, comprises a hub **12** which can be fixed to a pulley (not shown) mounted so that the fan may be driven through belt or other means by the engine.

The hub carries several blades **13**, six for example, of sector-like shape, which are each mounted for pitch change movement about their longitudinal axes, which by reference to FIGURE 4 may be designated the z axis.

The hub comprises two steel pressings **14** and **15**, these pressings being of such shape that when they are secured together by four rivets **16** and spot-welding (not shown) they define a hub with six radially-outwardly directed tubular projections **17**. These projections each carry a blade **13** in a manner hereinafter described, each blade being angularly adjustable as to pitch with respect to its supporting tubular projection **17**. Each blade comprises a sheet metal working portion **18** of suitable camber and a pivot portion **19** which is spot-welded to the portion **18** and shaped so as to define at the radially inner end of the blade a root socket whereby the blade is mountable upon the tubular portion **17** of the hub with the desired amount of clearance for low friction pitch change movement.

Each tubular projection **17** is provided with a pair of circumferentially-directed slots **20**, **21**, stop means in the form of a pin **22** secured to the blade root passing through these slots. Thus the pin **22** in association with the slots **20**, **21** limits the available range of pitch change adjustment of its associated blade **13**.

For each blade **13** a double-looped torsion spring **23** is anchored at its radially-inner end portion to the associated rivet **16**, and thus to the hub **12**, while at its radially-outer end portion this spring is anchored upon engaging portions **24** and **25** of the pressings of the working portion **18** and the portion **19** respectively. A rivet **26** passes through the aperture **27** defined by the portions **24** and **25** to provide a firm anchorage for the outer end portion of the torsion spring.

The torsion spring thus provided for each blade **13**, as well as retaining the blade in the radial sense with respect to the hub, provides a spring device which reacts the centrifugal twisting moments inherent in operation in the respective blade.

These centrifugal twisting moments are generated in the manner shown diagrammatically in FIGURE 4. In that figure the views I, II, III show the geometrical position of a blade turned at an angle T from the plane of rotation when fan rotation is about the y axis. The forces then acting are represented by the arrows aA, bB, where A and B are the centres of inertia of each half of the blade. These forces can be analyzed into components of which the sum of those two (CF and CF') acting parallel to the z axis (the longitudinal pitch change axis of the blade) is commonly called the centrifugal force, while those (TM and TM') acting parallel to the x axis form a

couple acting about the z axis and tending to reduce the angle T. This couple is commonly called the centrifugal twisting moment and is proportional to the product of the mass of the blade, the square of the radius of gyration of the blade about the z axis, the square of the fan rotational speed, and also the sine of twice the angle T.

In FIGURE 4 (IV) these forces are shown in perspective.

In addition to operating as means for limiting the pitch change range of the blades, each pin **22** in association with its slots **20, 21** forms a safety stop in the radial sense for its blade **13** to prevent shedding of the blade from the hub in the event of fracture of the associated torsion spring **23**.

A stub shaft **28** extends forwardly from the drive pulley (not shown), this stub shaft locating the hub **12** and also carrying temperature-responsive means generally indicated at **29**. The temperature-responsive means includes a heat sink member in the form of a first disc **30** having a series of radially-directed forwardly-extending fins **31**. This disc is rigidly secured by set bolts **32** to the forward face of the hub **12**, these bolts serving also to mount the fan upon its associated pulley. The disc **30** is so shaped near its centre portion as to be spaced somewhat forwardly of the hub **12**.

The rearward face of the disc **30** carries two wax-capsule thermostat devices **33** and **34**. The plungers **35** and **36** respectively of these two devices are engageable with a second disc **37** which is so mounted with respect to the first disc **30** as to be capable of limited angular adjustment about the rotational y axis of the fan and with respect to the first disc. The plungers **35** and **36** respectively engage the edges **38** and **39** of suitably cut-away portions **40** and **41** formed in the second disc **37**.

The second disc **37** is provided with four apertures **42**, each stop pin **22** engaging within one such aperture.

The cooling fan above described is arranged to be rotatable within an air duct **43** positioned immediately adjacent and rearward of the conventional water radiator **44** of the engine, or adjacent some other element of the engine's cooling system.

Thus, by the arrangement the heat sink member or disc **30** is positioned in heat conducting relationship with respect to the two wax capsule thermostat devices **33** and **34**, and as the temperature of the air passing through the honeycomb of the radiator **44** and entering the fan increases as the coolant water circulates through the radiator, the heat sink member transmits this to the two devices **33, 34**, and in consequence the plungers **35** and **36** are adjusted so as to cause angular displacement of the second disc **37** about the rotational axis of the fan. Since the disc **37** is in engagement with the pins **22** this movement of the disc causes pitch adjustment of the blades **13** in unison. In this way since the temperature of the air passing through the radiator honeycomb is indicative of the engine operating temperature, the pitch setting of the blades is automatically adjustable in response to this temperature.

The air duct **43** is of circular cross-section, only a relatively small running clearance being provided between the tips of the blades **13** and the wall of the duct.

In operation of the cooling fan when the engine is at a low operating temperature when use of the fan is not required, the temperature-responsive thermostat devices **33** and **34** are in a condition such that the blades of the fan are in their fully fine position, having been moved into such position by action of the springs **23**. In this position the blades, being of sector-like shape, together effectively constitute a continuous "disc" such that, apart from the very small running clearance around the periphery of the "disc" so formed, the air duct **43** is substantially closed by the rotating fan. In this way the blades form a series of radial shutters for the duct.

As the operating temperature of the engine increases, the thermostat devices **33** and **34**, being sensitive to the increasing temperature of the air passing through the engine radiator **44**, operate to coarsen the pitch of the blades so that the "shutters" commence to open and air is permitted to flow through the duct **43**. Thus the flow of air through the radiator and the duct induced by the rotation of the fan blades in the new pitch setting gives rise to cooling of the engine to an extent necessary to maintain the engine within a predetermined operating temperature range. If the engine's temperature decreases, the same mechanism can be arranged to adjust the blades to a finer pitch position.

Movement of the blades in the pitch-coarsening direction under the control of the thermostat devices is reacted by the torsion springs **23** associated with the blades. It is these springs which actually effect finer pitch adjustment when the engine's operating temperature decreases, in the embodiment shown.

Since the torsion springs **23** are also provided to react the centrifugal twisting moments inherent in the fan blades, automatic pitch control of the blades is provided so that the power absorbed by the fan during the range of operating conditions of the engine is substantially only that which is required for the cooling demands of the engine at any given condition. Thus with increase in rotational speed of the engine automatic tendency to pitch fining of the blades is always occurring so that only the necessary cooling requirements are afforded at any given engine rotational speed and thus excessive power absorption by the fan under conditions where the amount of cooling actually necessary is becoming less, is avoided.

However, regardless of this automatic control in dependence upon engine rotational speed, if for some other operating condition the engine temperature rises so that the temperature of the water passing through the radiator **44** rises, the temperature-responsive means **29** is effective to override the automatic fining effect caused by the inherent centrifugal twisting moments, thereby to coarsen the pitch of the blades and produce such cooling as to maintain the engine within the predetermined operating temperature range.

An alternative embodiment of the invention, is shown in FIGURE 3. Herein the air duct and fan are arranged forward of the engine radiator, a drive shaft for rotation of the fan passing through a suitable aperture formed in the radiator. In this way the "shutter" effect afforded by the fan is provided forward of the engine radiator, but since the pitch adjustment of the blades must be in dependence upon the temperature of the water circulating through the radiator, the thermo-responsive means is arranged rearward of the radiator upon suitable supporting means, a connecting device being provided to articulate the thermostat device to the blades of the fan, components of this device passing through the aperture of the radiator. Moreover, in this embodiment the thermo-responsive means, instead of being subjected to the temperature of the air passing through and from the engine radiator, is subjected to the coolant temperature within the conventional coolant pump of the engine, the thermo-responsive means being in fact incorporated within the pump structure. Its incorporation in the pump structure is not essentially related to the location of the cooling fan and of the thermo-responsive means respectively ahead of and behind the radiator, for either such form can be used independently of the other.

In detail, in the embodiment shown in FIGURE 3, the honeycomb of an engine radiator is shown at **111** and is provided with a circular aperture **112**. The cooling fan **113** comprises a hub **114** which is bolted at **115** to a pulley **116**. The fan is mounted ahead of the radiator **111**, the pulley **116** being disposed rearwardly of the radiator and having a portion which extends through the aperture **112** thereby to connect with the fan. The pulley is driven by a belt **117** from the engine (not shown).

The fan **113** and pulley **116** are together mounted upon a shaft **118** itself mounted for rotation in ball bearings **119**. The shaft **118** is connected to the rotor **120** of a

water pump forming part of the cooling system of the associated engine. A rear closure plate **135** houses in the pump chamber, and inlet and outlet ducts **136** and **137** respectively admit and discharge coolant therefrom. Other parts of the water pump are omitted.

The cooling fan **113**, which is rotatable within a duct **121**, includes six blades **122** of sector-like shape and which are mounted for pitch change movement about their longitudinal axes, in substantially the same manner as in the embodiment previously described. Thus, the hub **114** comprises two steel pressings **123** and **124**, these pressings being of such shape that when they are secured together by rivets and spot-welding in a manner similar to the construction of FIGURES 1 and 2, they define a hub with six radially-outwardly-directed tubular projections. These projections each carry a blade **122**, each blade being angularly adjustable as to pitch with respect to its supporting tubular projection. Each blade is of similar construction to those of FIGURES 1 and 2 and each has stop means in the form of a pin **125** secured to the blade root passing through a pair of slots **126** provided in the respective tubular projection of the hub. Again, as with the construction of FIGURES 1 and 2, for each blade **122** a double-looped torsion spring **127** is anchored at its radially-inner end portion to the associated rivet and thus to the hub **114**, while at its radially-outer end portion this spring is anchored to the blade structure.

A wax capsule thermostat device **128** is provided coaxially within the pump rotor **120**. This device has an output rod **129** which extends forwardly of the assembly, through the aperture **112** in the radiator, and is secured by a nut **130** to an axially-displaceable disc **131**. The periphery of this disc is provided with six fork-like projections **132** each of which straddles a blade **122**, hence is in operable engagement with the root end portion of its respective blade. The position of engagement of the fork-like projection with the blade is somewhat displaced from the longitudinal axis of the blade so that with movement of the disc **131** axailly, pitch change adjustment of the blade occurs about its longitudinal or *z* axis.

In operation of the fan, when the temperature of the cooling water of the engine is below a predetermined value, the wax capsule thermostat device **128**, which is affected by the temperature of the coolant passing through the pump, is fully contracted so that the blades are held in the fully fine position. In this position, the blades, being of sector-like shape, together effectively constitute a continuous "disc" such that, apart from the very small running clearance around the periphery of the "disc" so formed, the air duct **121** is substantailly closed by the rotating fan. In this way the blades form a series of radial shutters for the duct.

As the operating temperature of the engine and consequently of the coolant increases, the thermostat device **128** commences to expand, to move the blades, in opposition to the force of the torsion springs **127**, in the pitch coarsening direction, so that the shutters commence to open and air is permitted to flow through the duct **121**. Thus the flow of air through the radiator from the duct, induced by the rotation of the fan blades in the new pitch setting, gives rise to cooling of the engine to an extent necessary to maintain the engine within a predetermined operating temperature range. If the engine's temperature decreases, the wax capsule thermostat device **128** contracts so that the disc moves rearwardly axially to effect a fining off in the pitch of the blades. Such pitch decreasing movement is assisted by the effort of the torsion springs **127**.

A cooling fan in accordance with the present invention, in providing a "shutter" effect is an alternative to the radiator grill shutter systems hitherto provided ahead of the engine radiator in road vehicles, the arrangement of this invention compactly providing an automatic shutter system and cooling fan in one.

Although in the embodiments above described the thermo-responsive means has included wax-capsule thermostat devices, in alternative embodiments of the invention other suitable and known devices are used in substitution for wax-capsule thermostat devices.

Again, in other alternative embodiments instead of subjecting thermo-responsive means to the temperature of the air passing through and from the engine radiator it is instead subjected to the coolant temperature within the conventional coolant pump of the engine, a part at least of the thermo-responsive means being incorporated within the pump structure.

I claim:

1. A combined warm-up shutter and cooling fan for use in conjunction with a duct in the cooling system of a motor vehicle's engine, and arranged to be driven by such engine, said shutter and fan comprising a hub rotative in the duct, a plurality of blades mounted upon said hub for change of their pitch between fine and coarse pitch limit positions, and so shaped that in their fine pitch limit position cooperatively they substantially close the duct, spring devices disposed generally radially between the hub and each blade and biased to urge said blades to their fine pitch limit position, and means responsive to engine-operating temperature and operatively connected to the blades for adjustment of their pitch, said temperature-responsive means being arranged to increase the pitch of the blades automatically from fine pitch limit position, in opposition to said spring devices, upon increase of the engine's operating temperature from cold to a warmer operating temperature, and conversely to permit decrease in the pitch of the blades by said spring devices, upon decrease of the engine's operating temperature below a predetermined value, thereby to maintain the engine's temperature within an optimum range during its operation.

2. A combined warm-up shutter and cooling fan for use in conjunction with a duct positioned in the cooling system of a motor vehicle's engine ahead of a radiator forming part of such cooling system, said fan being arranged to be driven by such engine, said shutter and fan comprising a hub rotative in the duct, a plurality of blades mounted upon said hub for change of their pitch between fine and coarse pitch limit positions, and so shaped that in their fine pitch limit position co-operatively they substantially close the duct, yieldable means to urge said blades to their fine limit position, and means responsive to engine-operating temperature and operatively connected to the blades for adjustment of their pitch, said temperature-responsive means being positioned rearward of the radiator, and connecting means which pass through an aperture in the radiator and operatively connecting said temperature-responsive means to the blades to increase the pitch of the blades automatically from fine pitch limit position, in opposition to said yieldable means, upon increase of the engine's operating temperature from cold to a warmer operating temperature, and conversely to permit decrease in the pitch of the blades by said yieldable means, upon decrease of the engine's operating temperature below a predetermined value, thereby to maintain the engine's temperature within an optimum range during its operation, said yieldable means comprising spring devices disposed generally radially between the hub and each blade to retain the blades in the radial sense with respect to the hub.

3. A combined warm-up shutter and cooling fan as claimed in claim **2**, wherein the said means responsive to engine temperature is positioned in direct heat-exchange relation with the coolant of the cooling system.

4. A combined warm-up shutter and cooling fan as claimed in claim **3**, wherein the said means responsive to engine temperature is housed within a coolant pump forming another part of said cooling system, the connecting means including a rod member and a disc-like member coupled to the rod member and to the blades, adjustment in the pitch of the blades occurring upon displace-

ment of the rod member and disc-like member in response to changes in temperature of said coolant.

5. A fan for warming the cold engine of a motor vehicle and for preventing overheating of the engine during normal operation, arranged within a duct for passage of coolant air, and to be driven by such engine, said fan comprising a rotative hub, a plurality of blades mounted upon said hub for change of their pitch between fine and coarse pitch limit positions, and means responsive to change in the engine's operating temperature, and operatively connected to said blades to adjust the blades automatically upon increase in the engine's operating temperature, from fine pitch position wherein they substantially close the duct and induce heating of a cold engine, to a coarser pitch position to maintain the engine's operating temperature within an optimum range, spring devices which are disposed generally radially between the hub and each blade, to retain the blades in the radial sense with respect to the hub, reacting the operation of the means responsive to engine operating temperature and also reacting centrifugal twisting moments inherent in the blades upon operation of the fan.

6. A fan as claimed in claim 5, wherein the means responsive to engine operating temperature includes a thermostat device and two discs relatively rotatable, one of which discs is secured to the hub of the fan, and the other of which is operatively connected to the blades for pitch change thereof, and the thermostat device being interposed between said two discs to effect their relative rotative adjustment, and being arranged in heat-conducting relation with the air which in operation passes through the fan.

7. A fan as claimed in claim 5, wherein the means responsive to engine operating temperature is secured to the hub of the fan and includes a thermostat device and a heat-sink member arranged in heat-conducting relation therewith, and with the air which in operation passes through the fan, the heat-sink member including a first disc having a plurality of radially-directed, forwardly-extending, fins formed integrally therewith and including a second disc interposed between the first disc and the hub and operatively connected to the blade roots, whereby the thermostat device is operably connected to the roots of the blades through the intermediary of said second disc.

8. A fan as claimed in claim 6, wherein stop means are provided in association with the roots of the blades to limit the range of pitch change movement of the blades, said stop means including pins, one secured to each blade root and in engagement with the second disc, blade pitch adjustment thereby occurring upon angular displacement of the second disc, and the hub is formed with circumferentially-directed slots through which the pins pass, and by which adjustment of the pins is limited.

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