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3,490,686

FAN DRIVE

Filed March 14, 1968

2 Sheets-Sheet 1

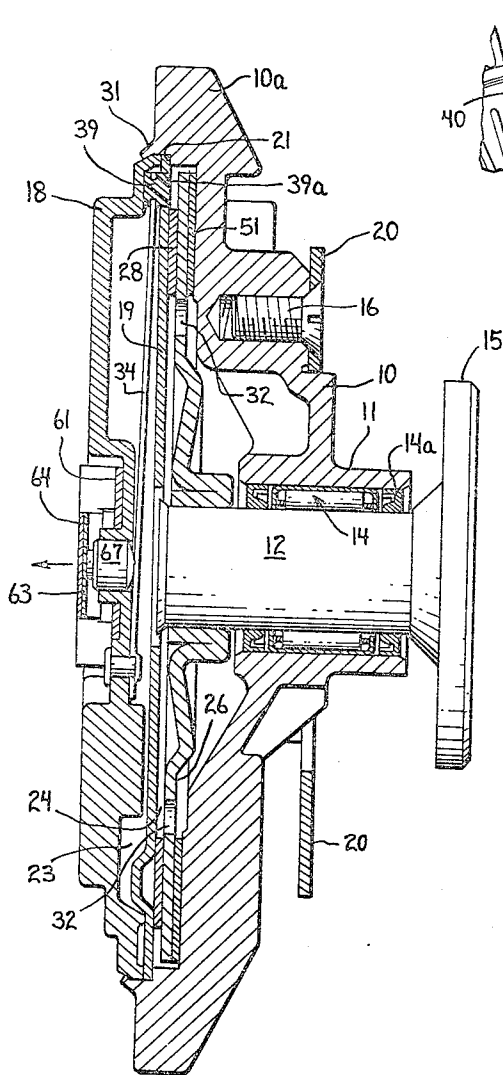


Fig. 1.

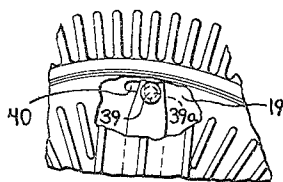


Fig. 5.

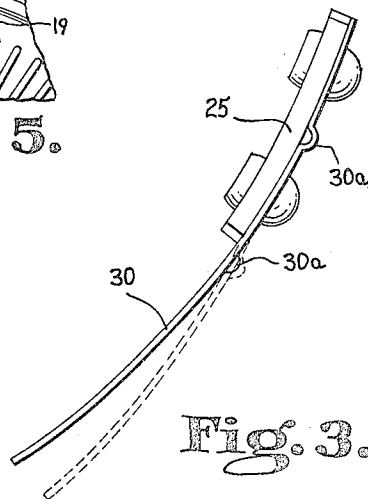


Fig. 3.

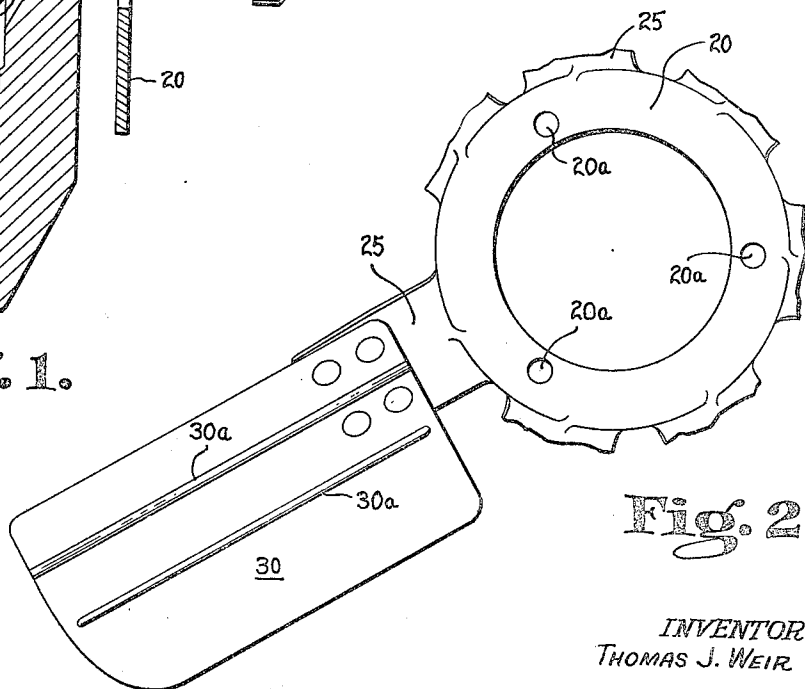


Fig. 2.

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2 Sheets-Sheet 2

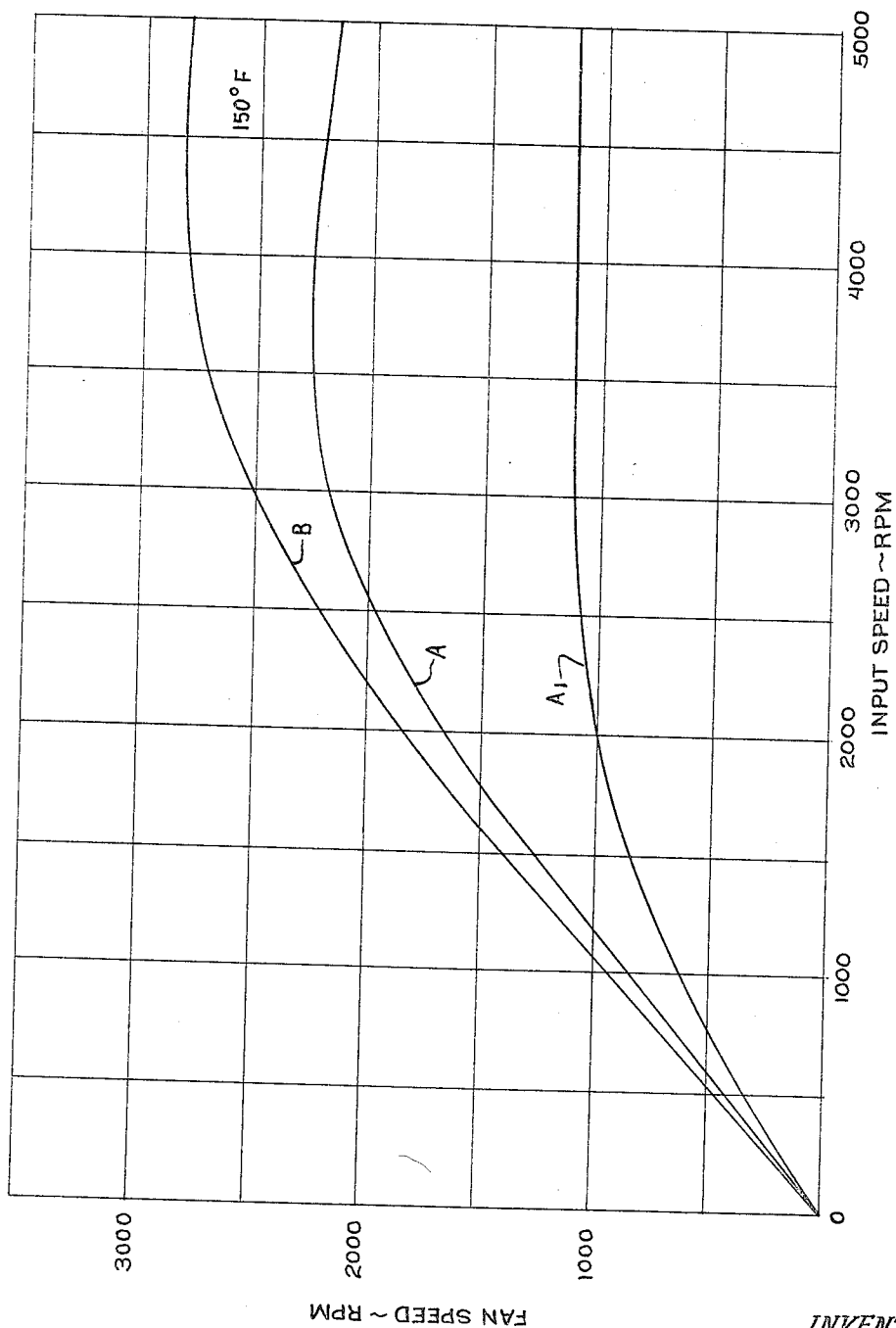


FIG. 4.

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FAN DRIVE

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2 Claims

ABSTRACT OF THE DISCLOSURE

A fan drive structure of the type wherein a shear fluid connects the driving and driven elements and the driven element incorporates flexible fan blades which modify the slip characteristic between the driving and driven members.

BACKGROUND OF THE INVENTION

Field of the invention

The invention relates to fans for cooling internal combustion engines. Automotive vehicles, such as passenger automobiles, buses and trucks, are now being provided with air conditioning equipment, the condensing element of such equipment being mounted in front of the engine cooling radiator. The air flowing through the condensing element is heated by it and then flows through the cooling radiator of the engine, thereby influencing the cooling characteristics of the radiator. The size of the cooling fan and its speed of rotation have been increased to provide the additional volume of cooling air required. As a result, the parasitic load on the engine and the noise level have been increased substantially. Minimizing the parasitic load and noise level become important objectives.

Description of the prior art

In the past, to reduce the parasitic load, the cooling fan of the engine has been provided with a fluid coupling device having temperature responsive means controlled either by the temperature of the air flowing through the radiator or by the temperature of the water circulating through the engine cooling system. Such temperature responsive means are, of course, mounted externally with relation to the coupling housing itself. The degree of coupling between the fan and the engine is controlled by the temperature responsive means to provide substantially direct coupling of the fan to the engine when the air or the cooling water is at relatively high temperatures and to effect a certain degree of slip within the coupling to drive the fan at lower than normal speeds when the temperature of the air or cooling water is relatively low. These temperature variable couplings have the advantage of decreasing the power supplied to the fan by the engine when less air is needed for cooling purposes. Typical fluid drives for fans are disclosed in U.S. Patents Re. 25,481 and 3,191,733.

When, however, a high performance fan, one moving a maximum amount of cooling air even at low speed, is utilized to provide enhanced cooling for idling engine speeds, slip, or the difference between input and output speeds of the fan drive, must increase sharply at higher input speeds to prevent the fan from moving more cooling air than is necessary, assuming generally uniform ambient temperature conditions. This lowering of the rate of change of fan speed with drive input speed does, as the prior art indicates, have the advantage of decreasing the power supplied to the fan by the engine when less air is needed for cooling purposes.

The difficulty is that not all of this power saving resulting from less rapid fan speed increase is a net gain. In

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fluid fan drives of the type under discussion, since heat generated in the drive or coupling is directly proportional to slip in the coupling, under high drive input speed-low fan (output) speed conditions, that is, high slip conditions, some of the power input to the drive is utilized in generating heat in the shear fluid which is, of course, a detriment in that it must be dissipated by the cooling air. Some of the power saved by slowing the fan must be utilized to unproductively raise the temperature of the drive coupling.

Fans, particularly engine cooling fans, having flexible blades are not unknown in the prior art. Flexible blade fan structures are disclosed in U.S. Patents 2,032,224 and 3,289,924. These fan blades distort with increasing fan speed to a shape of reduced pitch and thus unload the fan, that is, they decrease the rate at which the fan volumetric output follows fan speed.

SUMMARY OF THE INVENTION

The concept of the present invention utilizes this unloading characteristic of flexible fan blades to reduce the power loss under high slip conditions. The flexible fan blades are carried by the driven element of the fan drive structure and under what would otherwise be the high slip condition referred to above, the fan (output) speed is increased, with slip and consequently heat generated in the drive coupling reduced. The flexing of the fan blades permits the fan speed increase without a corresponding increase in the amount of air moved by the fan. The fluid drive can thus be utilized to cause its characteristic power-saving decrease of the air moved by the fan under high input (engine) speed conditions, without the characteristic increase in slip in the drive coupling and consequent generation of heat in the coupling representing wasted power. Combining the fluid fan drive with flexible blades thus permits use of a high performance fan contour for low input (engine idling) speeds without suffering the heretofore inherent high slip, high heat generation in the drive because of the necessity to drastically lower the rate of speed increase of the high performance fan. The amount of power which is wasted and the heat that must be dissipated in the fan drive is thus reduced, with attendant design advantages, while the flexibility of control which is an advantage of the temperature responsive fluid fan drive structure is retained.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side sectional view of a thermostatically actuated fluid fan drive structure.

FIG. 2 is a fragmentary end view of a fan spider assembly adapted for mounting on the structure.

FIG. 3 is a side view of one of the spider arms and attached, flexible fan blades shown in FIG. 2.

FIG. 4 is a visual showing of the relationship between input to the fan drive and fan (output) speed at a substantially uniform ambient temperature of 150° F. for both the assembly of the present invention and a prior art, rigid fan blade assembly.

FIG. 5 is a fragmentary, front view of the coupling of FIG. 1 with a portion broken away to illustrate the internal construction.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring initially to FIGS. 1 and 2, a fluid fan drive or coupling assembly identical to that disclosed in Weir U.S. Patent 3,191,733 is illustrated, the assembly, however, incorporating the flexible blade fan spider assembly of FIG. 2. The assembly comprises a casing member 10 having a hub 11 for rotatably mounting the casing on a

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drive shaft 12, there being a bearing 14 and seals 14a for supporting the casing on the shaft. Shaft 12 may be integrally connected with a coupling flange 15 for coupling the drive shaft 12 to any conventional rotating part of an internal combustion engine.

Fastened to the casing 10 screws 16 is the central, annular portion 20 of the flexible blade spider assembly of FIG. 2. Three spaced threaded bosses on the casing 10 accommodate the machine screws extending through the mounting apertures 20a (FIG. 2) of the fan spider. The coupling flange 15 may be connected to the pulley which conventionally drives the engine water pump.

Casing 10 is provided with a cover member 18, the peripheral edges of which engage the peripheral edges of a divided plate 19 seated on an annular surface 21 formed adjacent the periphery of the casing 10. Cover member 18 and plate 19 may be clamped to the casing member 10 by means of an annular flange member 31 swaged or otherwise formed into pressure engagement with the outer peripheral surface of the cover 18. The outer face of cover 18 is provided with heat dissipating ribs or projections and the peripheral portion of the casing 10 may be provided with heat dissipating vanes 10a.

The casing 10 is formed to provide a recess inwardly of plate 19 to thereby define a drive chamber 24 within which is mounted the drive disc 26 press fitted or otherwise fixed upon the shaft 12. The peripheral portions of the disc 26 may be covered with arcuate facing members 28 and 51. Located adjacent the inner margins of the facing members 28 are a series of uniformly distributed ports 32 which extend completely through the disc 26, these ports providing a toroidal circulation of fluid about the peripheral portion of the plate 26.

A pump means for transferring fluid between the reservoir 23 and the drive chamber 24 includes an abutment member 39. The abutment member 39 is cylindrical in configuration and extends into but is movable within an aperture 39a in the plate 19. The aperture 39a has a portion 40 (FIG. 5) which extends ahead of (in the direction of rotation) the abutment 39. The position of the abutment 39 in the aperture 39a, that is, its extension into the chamber 24, is controlled by a resilient element taking the form of the blade 34 rigidly attached to the inner face of the cover 18.

Mounted on the exterior face of the cover 18 is a bracket 61 carrying a thermally responsive means in the form of the bimetal strip 63. The bimetal strip is arranged so that its high expansion side 64 faces outwardly away from the cover 18.

When so arranged, it will be evident that upon an increase in temperature ambient to the bimetal strip, the central portion of the strip will bow outwardly as indicated by the arrow in FIG. 1. Beneath the center of the bimetal strip the cover 18 is apertured and the area surrounding the aperture is flanged outwardly to accommodate a thrust member 67 which at one end bears against the inner face of the bimetal strip 63 and at its other end engages the blade 34.

In the operation of the coupling, the reservoir 23 is filled with a shear fluid to a degree sufficient to fill the spaces in the chamber 24 between the opposing surfaces of the facings 28 and 51 and the adjacent walls of plate 19 and casing 10. With the casing rotating, centrifugal force will distribute the fluid to a uniform level within the reservoir 23 and the drive chamber 24, the fluid passing freely through that portion 40 (FIG. 5) of the port 39a adjacent to and ahead of the abutment 39. It will be understood that rotational speed of the casing 10 as compared to the rotational speed of the shaft 12, that is, the degree of coupling between the two, is dependent upon the amount of fluid in the chamber 24.

When the temperature ambient to the bimetal member 63 is relatively high, indicating that a maximum degree of coupling between the casing and the shaft 12 is desirable, the bimetal 63, member 67 and, consequently,

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the abutment 39 will be in the position shown in FIG. 1. Under these conditions, the face of the abutment 39 does not extend beyond the rightward (as viewed in FIG. 1) face of the plate 19 and does not extend into the path of fluid in the drive chamber. The pumping abutment 39 is thus in an inactive position, and centrifugal force maintains the fluid level within the chamber 24 and the reservoir 23; the chamber 24, under these conditions, contains a maximum amount of fluid and the degree of coupling between the shaft 12 and the casing 10 is relatively high.

Should the temperature ambient to the bimetal member 63 decrease, indicating that a decreased degree of coupling between the shaft 12 and the casing 10 is desirable, the central portion of the bimetal strip 63 will move rightwardly (as viewed in FIG. 1), thereby moving the thrust member 67 and the abutment 39 rightwardly. This motion of the abutment 39 positions it so that it extends from the surface of plate 19 into the drive member 26 and into the path of the fluid in the drive chamber. Under these conditions, the abutment will act as an impact type pump and will raise the fluid pressure in the area just ahead of, or leading, the abutment 39. The consequent increase in pressure in this area will drive or pump fluid from the drive chamber 24 through the port portion 40 (FIG. 5) ahead of the abutment 39 and into the reservoir 23. The volume of fluid in the drive chamber 24 will thus be reduced and, as a result, the degree of coupling between the shaft 12 and the casing 10 will also be reduced. It will be understood that this thermally responsive variation of the shear fluid level in the drive chamber 24 is well known in the prior art and disclosed in detail in U.S. Patent 3,191,733. When the driven member portion (casing 10) of the fluid fan drive structure described carries the rigid fan blades of the prior art, and when the ambient temperature is relatively high (150° F.) the fan (output) speed varies with input speed as shown in curve A of FIG. 4. The slope of the curve, at higher input speeds, reaches a maximum and then the curve flattens out and its slope decreases for higher input (engine) speeds. For lower ambient temperatures the curve has less slope and flattens out at a fan speed correspondingly less as indicated in curve A₁.

Referring to FIGS. 2 and 3, the fan spider 20 carries a plurality of arms 25 (only one of which is shown in FIG. 2) which have riveted thereto flexible fan blades 30, the blades having longitudinal ribs 30a to provide lateral stiffness without interfering with the blade's ability to flex transversely. With increases in speed, the blades 30 deflect, as shown in broken lines in FIG. 3, to assume a shape of reduced pitch thereby lowering the volume of air displaced per fan revolution, that is, unloading the fan.

When the flexible blade spider is mounted on the fan drive, the resulting assembly, in operation, exhibits a characteristic input (engine) speed versus fan (output) speed curve indicated at B in FIG. 4, the ambient temperature being substantially constant at 150° F. as in the case of curve A previously mentioned.

The flexible blade fluid drive fan assembly (curve B) may be designed so that its capacity to move air at relatively low speeds is equivalent to the standard, conventional rigid blade fluid drive fan assembly (curve A). In such a flexible blade fan assembly, as the fan speed increases the fan pitch and consequently the ability of the fan to propel air is reduced. This also reduces the torque required by the fan and therefore the driving torque. Since the coupling torque capacity is fixed, because of the deflecting fan blades the fan speed for a given input (engine) speed for the flexible blade assembly is greater than that for the standard rigid blade assembly as will be evident by comparing curves A and B of FIG. 4. Since the fan speed, in the case of the flexible fan blade assembly is higher, the air flow induced by the fan is approximately unchanged from what it would be if the fan blades were of the standard, rigid type because of the reduction in pitch of the flexible fan blades. Thus, the same air flow

is obtained with the flexible blade fluid drive assembly as with a standard, rigid blade fluid drive assembly at approximately the same torque level, however, the fan speed, for a given input (engine) speed is substantially greater than is the case for the standard rigid blade assembly.

The heat load that is generated in the coupling assembly, and hence the heat that must be dissipated from it, may be expressed as follows:

$$\text{Heat load HP} = \frac{\text{Torque} \times (\text{Input r.p.m.} - \text{Output r.p.m.})}{5252}$$

It will be evident that the heat load is directly proportional to the slip or difference between input and output speeds. Therefore, comparing the two drive structures exhibiting the characteristics indicated in curves A and B of FIG. 4, since the fan speed, for a given input speed and air flow, is higher for the flexible blade fluid drive assembly, the slip is lower and the heat generated in this assembly is less as compared to the standard rigid blade fluid drive assembly, thus providing the design advantages and power saving referred to initially above.

It will be understood that the flexible blade fan structure could be designed to produce a relatively high air flow at low speeds and the flexing rate so determined (by proper choice and shape of the blade material) that the heat generated in the fluid drive would remain constant over a wide speed range thereby providing increased (as compared to prior art structures) air flow at low input speeds without increasing the power required for the drive at relatively high speeds. With reduction in the fan pitch at the higher input speeds, the noise from the fan is also reduced.

What is claimed is:

1. In combination, a fan drive structure comprising a driving member and a driven fan member wherein torque is transmitted from said driving member to said driven fan member through the shearing action of a fluid interposed between the driving and driven members, said driven fan member comprising a fan having flexible fan blades whose pitch changes by flexing to reduce their pitch as the driven fan member speed increases, thereby resulting in a reduction in the torque required by the driven member and the power loss through heat generation in the shear fluid.

2. A combination as claimed in claim 1 in which an ambient temperature responsive means determines the degree of coupling between the driving member and the driven fan member.

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123—41.49; 170—160.5; 192—58