

[54] **VARIABLE PUMPING SYSTEM FOR A PROPELLER FAN**

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[57] **ABSTRACT**

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[51] Int. Cl. **F01p 7/12**

[58] Field of Search **415/173, 174, 156, 415/127; 123/41.04, 41.05, 41.06, 41.49**

An inflatable rubber tube is attached to the interior of a fan shroud for the cooling fan of a reciprocating engine where the tube surrounds the rotation envelope of the fan. A temperature sensing mechanism deflates the tube to increase the clearance space of the fan and thereby decrease pumping efficiency when engine temperature is below its normal operating level. The temperature sensing mechanism inflates the tube to increase pumping efficiency if engine temperature rises above its normal operating level.

[56] **References Cited**

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6 Claims, 3 Drawing Figures

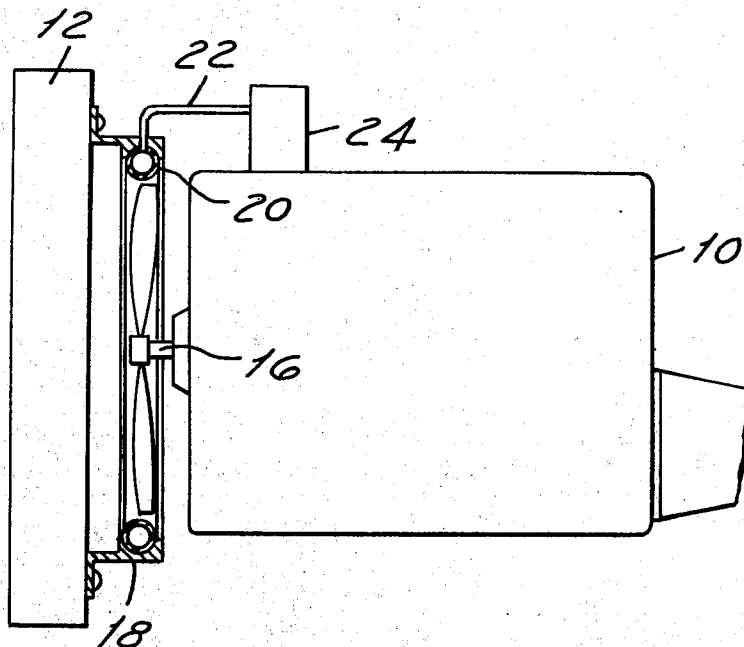


FIG. 1

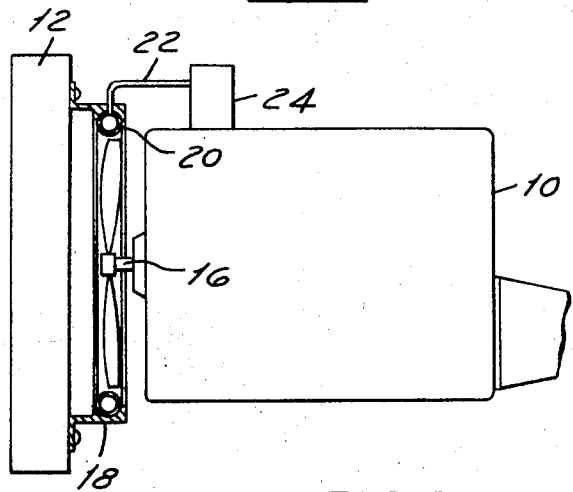


FIG. 2

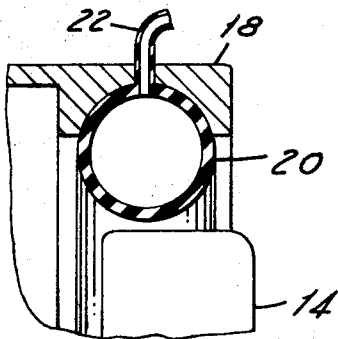
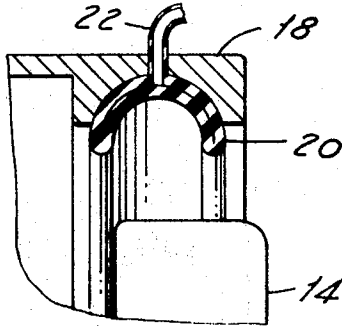


FIG. 3



VARIABLE PUMPING SYSTEM FOR A PROPELLER FAN

SUMMARY OF THE INVENTION

Cooling requirements for vehicle engines vary widely not only because of changing atmospheric conditions but also because of the changing heat rejection rates during various engine operating modes. Numerous mechanisms have been proposed for varying the cooling effectiveness of a vehicle cooling system according to engine requirements. One relatively simple arrangement involves thermally adjustable louvers positioned in front of the vehicle radiator to control air flow through the radiator. Others include thermally responsive clutches for driving the cooling fan at varying rates and thermally responsive mechanisms for varying the pitch of the fan blades. A few of these mechanisms have achieved some degree of commercial success.

This invention provides a relatively inexpensive mechanism for changing the pumping efficiency of a propeller type fan. The invention is useful particularly in an automotive cooling system where it varies the overall effectiveness of the cooling system. In a cooling system for a reciprocating engine including a radiator, a rotatable fan assembly mounted adjacent the radiator for forcing air through the radiator and a shroud mounted radially outward of the fan assembly, the automatic control mechanism of this invention comprises an inflatable member attached to the shroud where the inflatable member surrounds the fan assembly to define the amount of radial clearance between the fan assembly and the shroud. A temperature responsive device that is responsive to the temperature of the engine is capable of deflating the inflatable member to increase the radial clearance space of the fan when engine temperature is below a predetermined value and of inflating the inflatable member to the desired degree when engine temperature reaches its normal operating level. Changing the size of the clearance space changes significantly the pumping efficiency of the fan and thus varies the overall performance of the cooling system.

The inflatable member can be a hollow elastomeric tube having a circular cross section although tubes of numerous other cross sectional shapes and materials also can be used. A neoprene rubber or some other elastomeric material capable of surviving for useful periods in the environment of a vehicle engine compartment typically is used to make the tube. Reinforcement can be included in the tube material to increase flex life. The outer sector of the tube is attached to the inner surface of the fan shroud which in turn is attached to the vehicle radiator or engine, and the inner sector of the tube preferably has a relatively thin wall so generating subatmospheric pressure within the tube collapses the inner sector of the tube against the inner surface of the fan shroud.

Intake manifold pressure of the engine can be used to produce the subatmospheric pressure for the tube interior. A temperature responsive valve mechanism controls the application of the intake manifold pressure to the tube interior according to the temperature of the engine coolant, the engine cylinder head or some other temperature source.

Inflating or deflating the tube can vary the radial clearance between the tips of the fan and the shroud from minimum values commensurate with conventional vehicle assembly tolerances to values several

times larger than the minimum. Such variations in tip clearance for a conventional automotive type cooling fan installation can alter the air flow characteristics of the cooling system by values up to and exceeding 50 percent.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation of an installation of this invention in an engine cooling system. The Figure shows the relationship of the vehicle radiator shroud and fan assembly to the engine and shows the shroud in section to reveal the relative position of the inflatable tube. FIG. 2 is an enlarged sectional view of a portion of the shroud and tube that shows the tube in an inflated condition to minimize the radial clearance at the tips of the fan blades. FIG. 3 is similar to FIG. 2 except that a subatmospheric pressure within the tube has collapsed the tube to increase the radial clearance from the tips of the fan blades.

DETAILED DESCRIPTION

Referring to FIG. 1, a reciprocating internal combustion engine 10 is mounted in a vehicle engine compartment behind a radiator 12. A propeller type cooling fan 14 is positioned between radiator 12 and engine 10 and is mounted rotatably on a shaft 16 that is driven by the engine. A cylindrical shroud 18 is attached to the radiator or radiator support members (not shown) and extends rearwardly from radiator 12 to surround and axially enclose fan 14.

The inner surface of the rearward portion of shroud 18 has a semi-torodial or trough like groove that faces the tip portion of fan 14, and an inflatable tube 20 is positioned in the groove. Tube 20 is made of an elastomeric material such as neoprene rubber and it is located radially outward of the tip envelope of fan 14 to circumferentially surround the fan. A conduit 22 connects the interior of tube 20 through a temperature responsive valve mechanism 24 to the intake manifold (not shown) of engine 10.

When valve mechanism 24 senses an engine temperature within or below the normal operating range, the valve mechanism applies the subatmospheric pressure existing in the engine intake manifold to the interior of tube 20. The subatmospheric pressure within tube 20 collapses the tube to the shape shown in FIG. 3 thereby increasing the radial clearance at the tip portions of fan 14. Fan pumping efficiency and noise are reduced and the ram effect of air through the radiator is maximized.

When engine temperature exceeds the normal operating range, valve mechanism 24 disconnects the interior of tube 20 from the engine intake manifold and applies instead a higher pressure such as atmospheric pressure. Tube 20 expands to the configuration shown in FIG. 2, which decreases the radial clearance of fan 14 and thereby increases the overall performance of the cooling system.

The system of the invention can be used in a variety of different ways to control engine temperature. For example, subatmospheric pressure can be applied to the interior of tube 20 whenever vehicle speed exceeds a predetermined value. At speeds above the predetermined value, the large tip clearance reduces fan noise and maximizes the effect of ram air to produce highly efficient radiator performance. At speeds below the predetermined value, a higher absolute pressure is applied to the interior of tube 20 to inflate the tube to the

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configuration shown in FIG. 2. The resulting increase in fan performance assists in maintaining engine operating temperature within its normal range.

A relatively simple on-off valve mechanism 24 can be used to produce either the fully collapsed or fully inflated configuration of tube 20 as shown in the drawings. If greater control is desired, a valve mechanism 24 that modulates the internal pressure of tube 20 can be substituted to produce a variety of intermediate configurations of tube 20. Interior pressure for tube 20 can be provided by any of several sources such as the power steering system, the engine lubricating system, the automatic transmission fluid or an independent system that is designed specifically to supply the tube interior.

In a typical automotive installation, tube 20 is formed of a reinforced flexible material that biases the tube into a fully formed configuration as shown in FIG. 2 when its internal pressure substantially equals its external pressure. The clearance between the tips of the fan blades and the tube is about three-fourths inch (smaller clearances can be used if the fan shroud 18 is mounted on the engine). When engine temperature is below a predetermined value, engine intake manifold vacuum collapses the tube to the FIG. 3 configuration, thereby increasing radial tip clearance to about 1 1/2 inches. The resulting decrease in fan noise and increased use of ram air greatly improves overall cooling system performance.

Thus this invention provides an automatic control mechanism for varying the performance of a propeller type fan. The invention is useful particularly in vehicle cooling systems but can be applied to other installations of propeller type fans.

I claim:

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1. An internal combustion engine having a propeller type cooling fan driven thereby, a shroud including a generally cylindrical section adapted to surround and axially enclose said fan, said fan being mounted rotatably within the shroud, and a control mechanism for varying the pumping efficiency of the fan comprising inflatable means attached to said shroud between said shroud and said fan to circumferentially surround the fan and define the radial clearance space between the fan and the shroud, and

engine operating condition responsive pressure control means for varying the pressure within said inflatable means to contract or expand the inflatable means and thereby vary the radial clearance space.

2. The engine of claim 1 in which engine temperature responsive means is connected to the pressure control means to reduce the pressure within and deflate the inflatable means and thereby increase the clearance space when a predetermined engine temperature is reached.

3. The engine of claim 2 in which the shroud is mounted adjacent a cooling radiator for the engine.

4. The engine of claim 3 including means connecting engine intake manifold pressure to the pressure control means whereby the latter applies intake manifold pressure to the inflatable means to reduce the pressure within the inflatable means.

5. The engine of claim 4 in which the inflatable means is a hollow elastomeric tube.

6. The engine of claim 5 in which the elastomeric tube is in a fully formed inflated configuration when the pressure within the tube substantially equals the pressure outside of the tube.

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