

[54] FAN SHROUD FOR AN ENGINE COOLING SYSTEM

[75] Inventor: David F. Stimeling, Whitehall, Pa.

[73] Assignee: Mack Trucks, Inc., Allentown, Pa.

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123/41.49, 123/41.59, 165/40, 165/98,
415/145

[51] Int. Cl. F01p 7/02

[58] Field of Search 123/41.04, 41.05, 41.06,
123/41.49, 41.59; 415/158, 145, 148, 147,
149; 165/39, 51; 181/35 R, .5 R[56] References Cited
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Primary Examiner—Manuel A. Antonakas

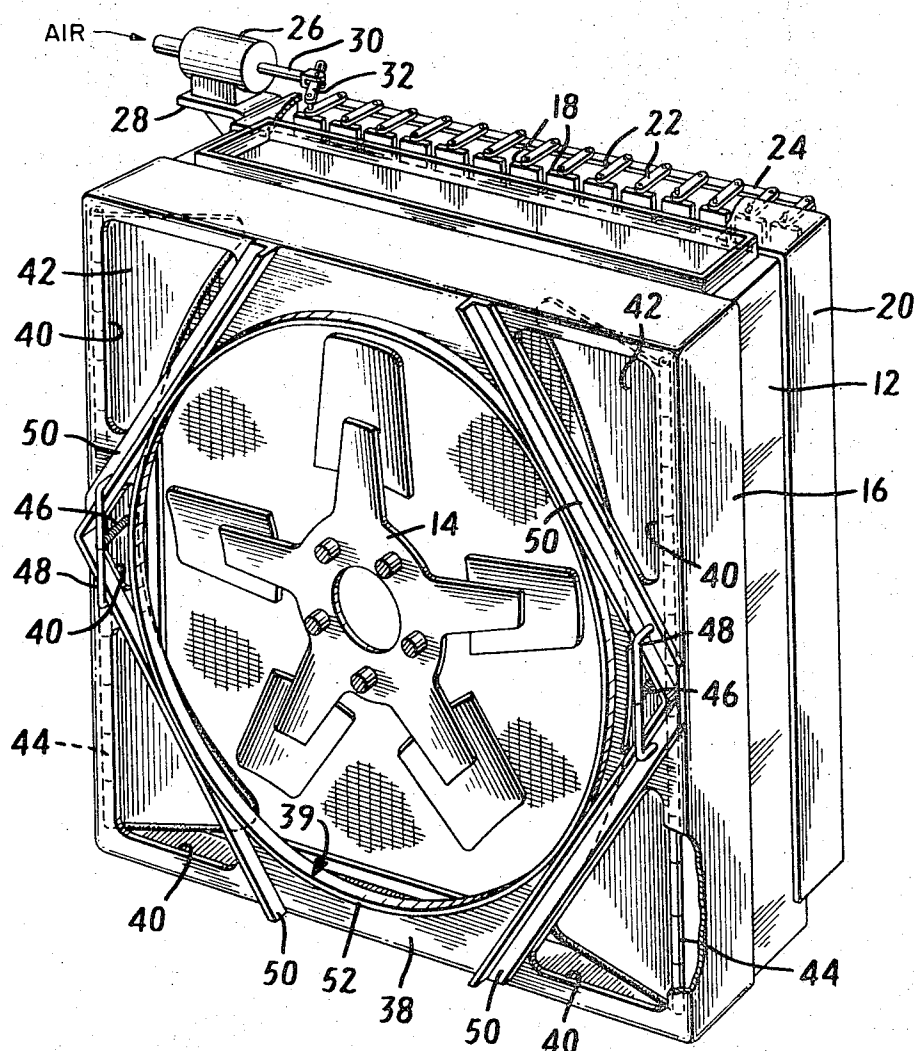
Assistant Examiner—Daniel J. O'Connor

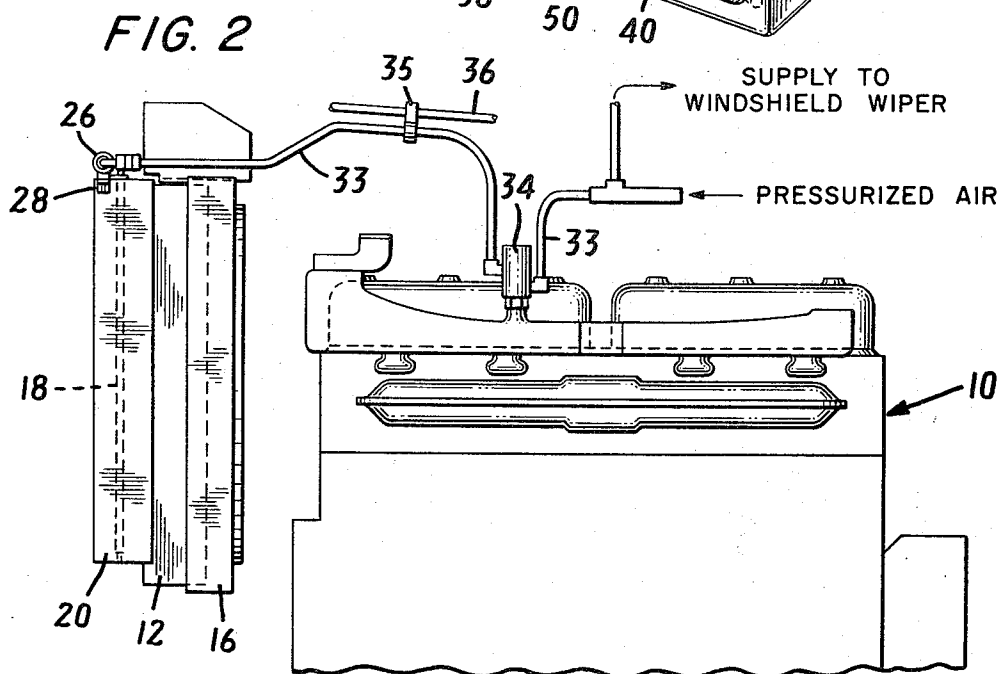
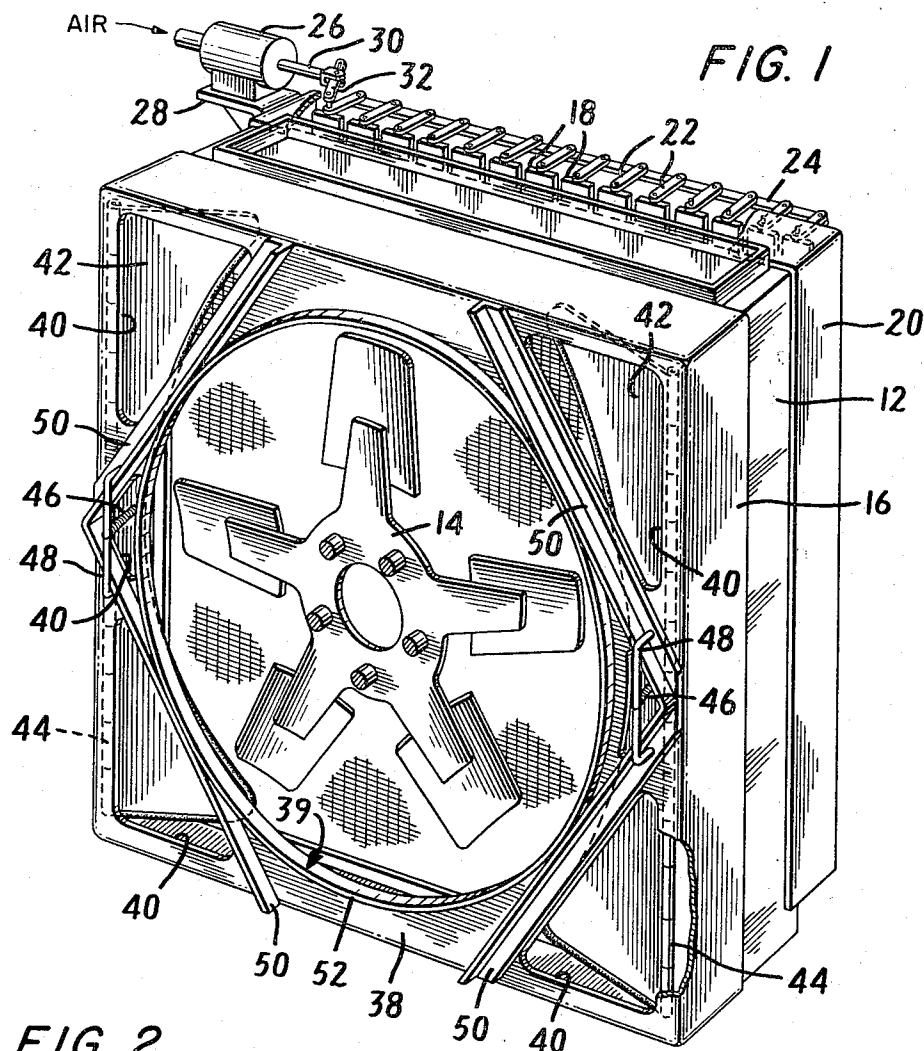
Attorney, Agent, or Firm—Brumbaugh, Graves,
Donohue & Raymond

[57] ABSTRACT

A cooling system for an internal combustion engine includes a radiator, a fan, and a plurality of closable shutters. The shutters regulate the flow of air through the system and thereby control the cooling effected by the system. A shroud encircles the fan and defines at least a portion of a passageway between the shutters and the fan. The shroud has a central opening that affords a free path of flow for air exhausted from the fan after being drawn through the radiator. At least one closable vent formed in the shroud is normally closed when the shutters are open and the fan is operating and normally open when the shutters are closed and the fan is operating. The vent thus reduces the noise generated by the fan in the passageway when the shutters are closed.

12 Claims, 11 Drawing Figures





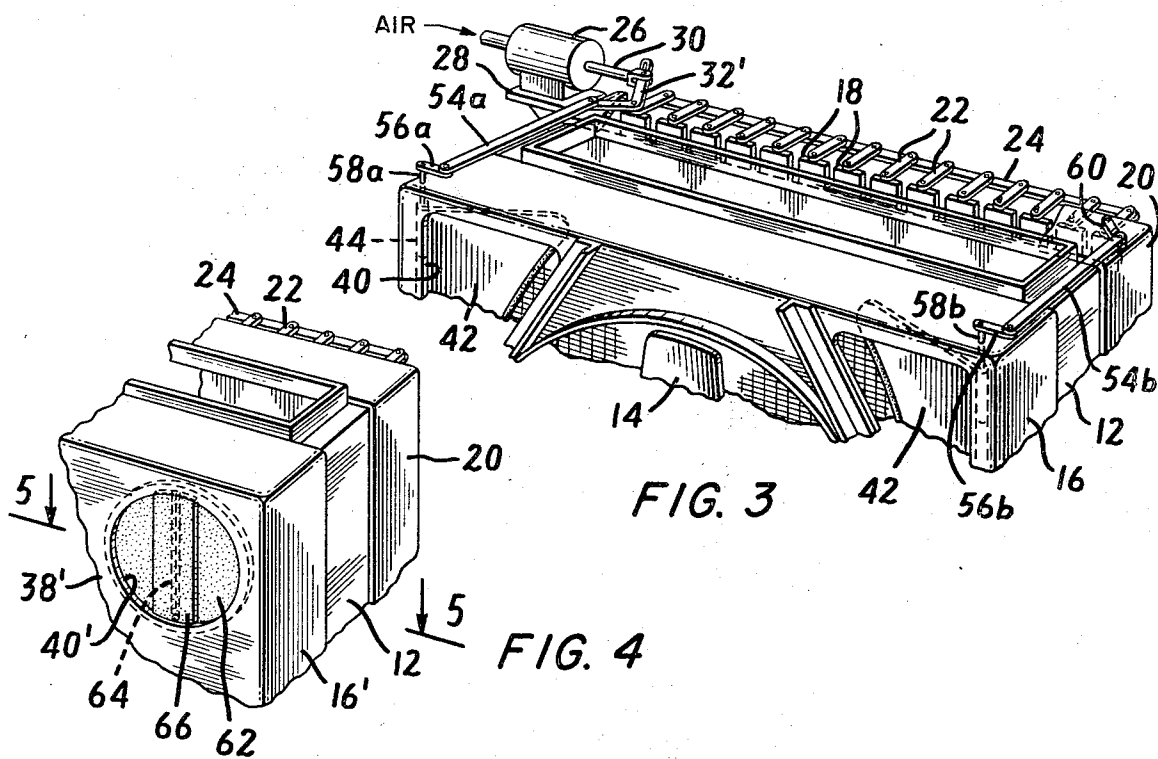


FIG. 5a

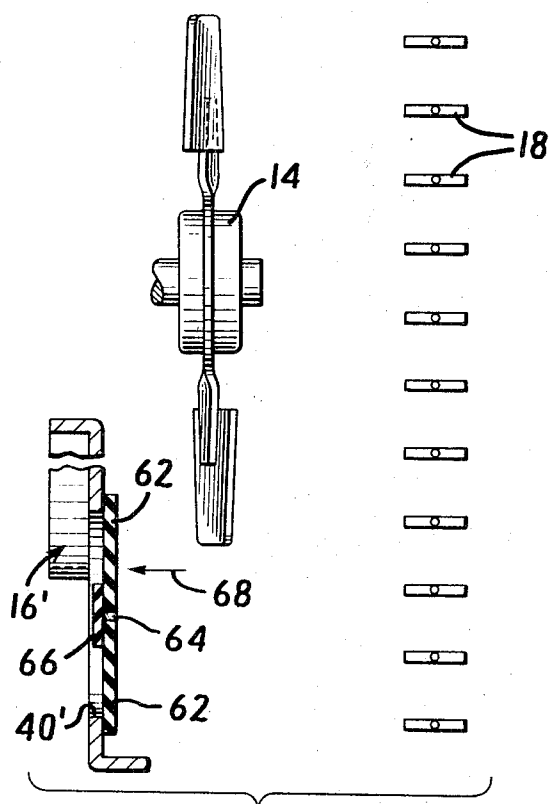
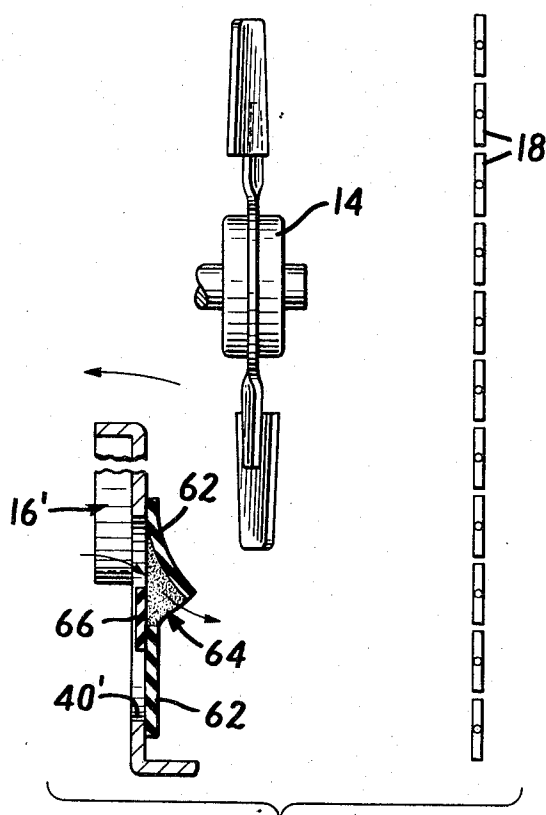


FIG. 5b



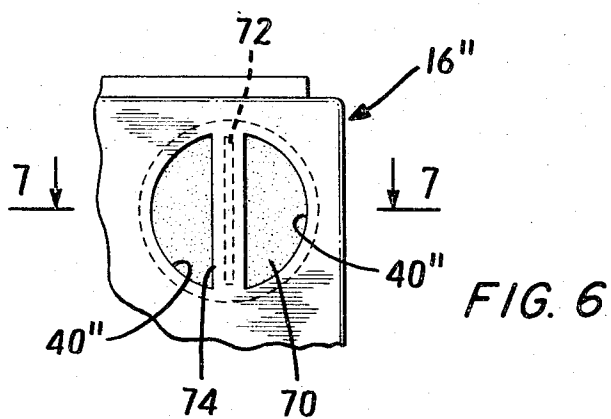


FIG. 7a

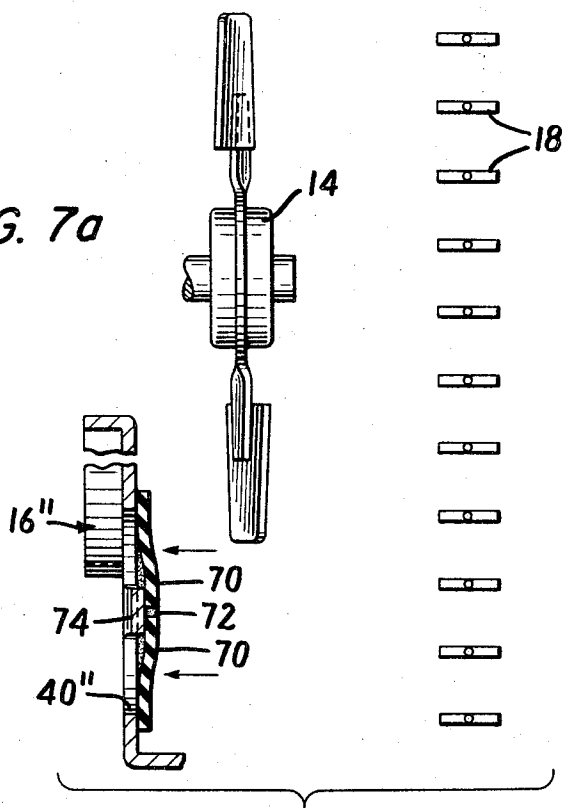
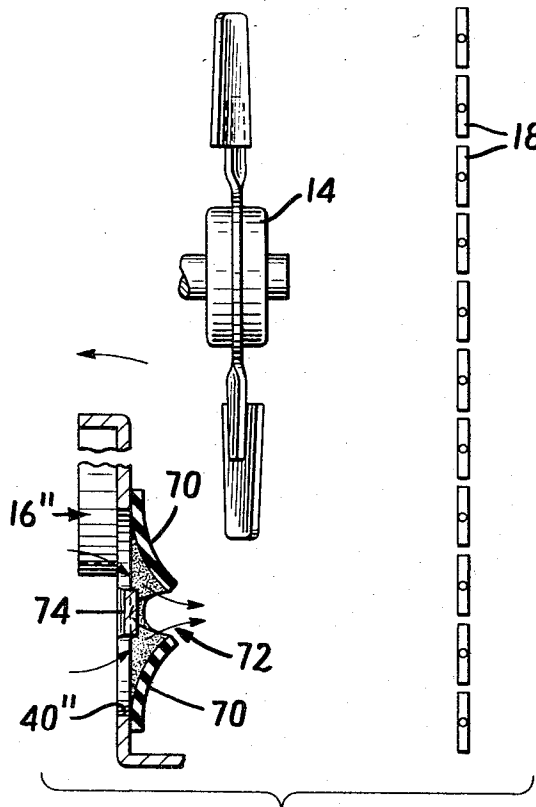


FIG. 7b



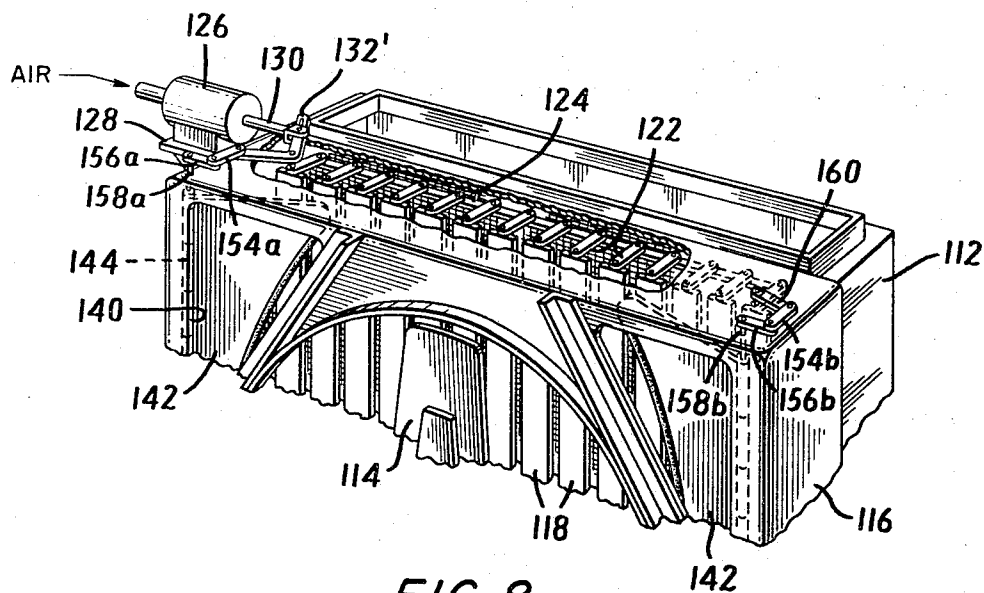


FIG. 8

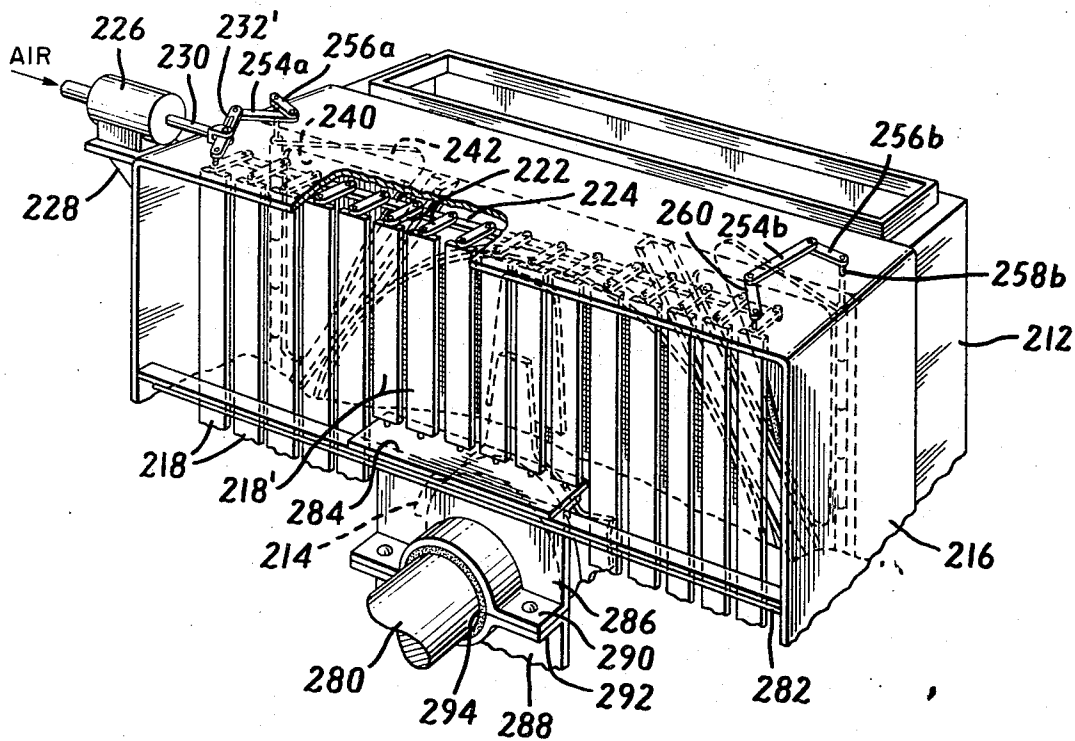


FIG. 9

FAN SHROUD FOR AN ENGINE COOLING SYSTEM

BACKGROUND OF THE INVENTION

In many cooling systems for motor vehicle engines, a shroud extends from the fan for the cooling system to a radiator placed between the fan and an incoming flow of relatively cool air. The shroud improves the effectiveness of the fan and increases the cooling efficiency of the system. An engine cooling system may also include a set of shutters for regulating the flow of cooling air through the system, as illustrated, for example, in Tice U.S. Pat. No. 1,759,527 and Brennan U.S. Pat. No. 2,118,484. Presently manufactured large trucks often have both a set of shutters, mounted either in front of or behind the radiator, and a fan shroud. When the shutters are closed, however, the noise produced by the cooling fan is increased due to air turbulence and resonance in the enclosed passageway defined by the closed shutters and the shroud. Such increased cooling fan noise is a major contributor to excessive vehicle noise, particularly in heavy-duty motor trucks.

SUMMARY OF THE INVENTION

The present invention relates to a noise reducing fan shroud for use with engine cooling systems and similar air moving systems in which the flow of air can not be controlled by interrupting the operation of the fan. According to the invention, at least one closable vent is formed in a shroud extending at least partway between a cooling system fan and a set of closable shutters. The vent is normally closed when the shutters for the cooling system are open and the fan is operating, and is normally open when the shutters are closed and the fan is operating. The vent effectively eliminates the enclosed cavity otherwise formed by the closed shutters and the shroud, thereby reducing the noise generated by the fan to a level generally equivalent to the noise level of a shroudless fan.

In one embodiment of the invention, the portion of the shroud immediately adjacent the fan extends radially outward from the fan and is substantially coplanar therewith. At least one vent is formed on each side of the fan in the coplanar portion of the shroud. The vents are closed by a pair of spring-biased, hinged flaps that are normally biased into a closed position. The vent flaps open inwardly into the shroud cavity, against the forces of the biasing springs, in response to the partial vacuum created inside the shroud between the fan and the cooling system shutters when the fan is operated with the shutters closed. When the vent flaps are open, the resonant cavity defined by the shroud and the closed shutters is disrupted and the noise generated by the fan is reduced without opening the shutters or otherwise substantially influencing the cooling effected by the system. When additional cooling air is required and the shutters are opened, the partial vacuum in the shroud is relieved and the vent flaps are returned to their closed positions by the biasing springs and by the effect of impinging "ram air," if a vehicle on which the cooling system is mounted is in motion.

In another embodiment of the invention, the vent flaps are coupled by appropriate linkage to the shutters. The linkage opens the flaps as the shutters are being closed and closes the flaps as the shutters are being opened.

The vents, in still another embodiment of the invention, are covered by flexible diaphragms. Each diaphragm has in it a slit and a strip of material on the fan shroud or on the diaphragm extends lengthwise of and laterally across the slit. The strip prevents flexing of the diaphragm in one direction beyond the strip. Consequently, the slit can open up to enable a flow of air through the vent only when the diaphragm flexes in the opposite direction. The diaphragms are arranged to open the vents in response to a partial vacuum inside the shroud caused by operating the cooling fan with the cooling system shutters closed.

The closable shutters for an engine cooling system utilizing one of the embodiments of the invention described above may be located in front of both a radiator for the cooling system and the cooling system fan, between the radiator and the fan, or behind both the radiator and the fan. If the shutters are located behind both the radiator and the fan, however, and diaphragms or spring-loaded flaps are used to close the shroud vents, the vents are opened in response to excess air pressure, rather than a partial vacuum, created inside the shroud between the fan and the shutters.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, reference may be made to the following description of various exemplary embodiments taken in conjunction with the figures of the accompanying drawings, in which:

FIG. 1 is a perspective view of a portion of a cooling system, according to the invention, for an internal combustion engine;

FIG. 2 is a side view of the portion of the cooling system of FIG. 1;

FIG. 3 is a perspective view of a portion of a second embodiment of a cooling system according to the invention;

FIG. 4 is a perspective view of a portion of a third embodiment of a cooling system according to the invention;

FIG. 5a is a partial sectional view of the cooling system of FIG. 4, shown generally with the cooling system shutters open;

FIG. 5b is a partial sectional view of the cooling system of FIG. 4, shown operating with the cooling system shutters closed;

FIG. 6 is a front view of a portion of a fourth embodiment of a cooling system according to the invention;

FIG. 7a is a partial sectional view of the cooling system of FIG. 6, shown operating with the cooling system shutters open;

FIG. 7b is a partial sectional view of the cooling system of FIG. 6, shown operating with the cooling system shutters closed;

FIG. 8 is a perspective view of a portion of a fifth embodiment of a cooling system according to the invention; and

FIG. 9 is a perspective view of a portion of a sixth embodiment of a cooling system according to the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

FIGS. 1 and 2 of the drawings illustrate a portion of the cooling system for an internal combustion vehicle engine 10, according to the present invention. The cooling system includes a radiator 12 through which is circulated a liquid coolant for the engine 10. The liquid

coolant absorbs heat from the engine 10 to maintain a proper operating temperature and is cooled in the radiator 12 by a flow of air passing therethrough, from left to right as viewed in FIG. 2. A positive flow of air through the radiator 12 is ensured by a fan 14 placed behind the radiator and operated by the engine 10. A fan shroud 16 encircling the fan 14 and extending between the fan and the radiator 12 enhances the effectiveness of the fan.

In front of the radiator 12, a set of shutters 18 mounted in a frame 20 controls the flow of air to the radiator and the fan. Each of the shutters 18 is rotatable about its longitudinal axis and carries, at its upper end, a connecting arm 22. The arms 22 are also pivotally coupled to a control rod 24 extending across the width of the mounting frame 20. Axial movement of the control rod 24 to the right or left, as viewed in FIG. 1, causes rotation of the shutters 18 into their closed or open positions, respectively.

Axial movement of the control rod 24 is effected by a pneumatically operated piston (not shown) enclosed in a cylinder 26 mounted adjacent one end of the control rod on a bracket 28. A plunger 30 extends from the piston through an end of the cylinder 26 and is pivotally connected to one end of a lever 32, the opposite end of which is rigidly joined to the upper end of the adjacent shutter 18. Axial movement of the plunger 30 pivots the lever 32, which, in turn, rotates the adjacent shutter 18 about its longitudinal axis and also pivots the corresponding connecting arm 22. The pivoting connecting arm 22 moves the control rod 24 axially to the right or left and, thereby, closes or opens all of the remaining shutters 18.

The piston in the cylinder 26, as shown, is single-acting and has a spring return (not shown). The cylinder 26 obtains its air supply through a line 33 from a source of pressurized air (not shown), such as a conventional air compressor. The air source also supplies pressurized air to the windshield wipers (not shown) and other devices, such as air brakes, for the vehicle. A conventional temperature sensitive control valve 34 in the air line 33 is actuated in response to the temperature of the engine 10 so that operation of the shutters 18 is related to the temperature of the engine. The tubing that comprises the air line 33 is supported between the engine 10 and the cylinder 26 by a clamp 35 attached to a tie rod 36 for the radiator 12.

The shutters 18 may be opened and closed by any convenient mechanism and may be operated in response to the pressure in the engine intake manifold. Different shutter assemblies are illustrated both in Tice U.S. Pat. No. 1,759,527 and in Brennan U.S. Pat. No. 2,118,484. The Tice patent also discloses several control devices for operating cooling system shutters in response to intake manifold pressure. The shutters or louvers illustrated in the Brennan patent are operated by a thermostat.

The metal fan shroud 16 is mounted directly behind the radiator 12 to form an enclosed passageway between the radiator and the fan 14. The shroud 16, as shown, is rectangular, but it can be any other convenient shape. The rear surface 38 of the shroud 16 is generally coplanar with the fan 14 and has a circular central opening 39 for the fan exhaust. On opposite sides of the central opening in the shroud 16, the rear surface 38 is cut away to provide a number of vents 40. The vents 40 are closed by a pair of flaps 42 that are

shaped so as not to project into the central opening 39 and are fabricated of any convenient material, such as stiff, molded plastic. Each of the flaps 42 is mounted by a hinge 44 adjacent an outside edge of the rear surface 38 of the shroud 16. The flaps 42 swing inwardly into the shroud 16 to open the corresponding vents 40 and are normally biased into a closed position by springs 46. One end of each spring 46 is secured to the corresponding flap 42 and the other end is anchored to a U-shaped bracket 48 that projects rearwardly from the rear surface 38 of the shroud 16. The bracket 48 is mounted on a pair of metal angles 50 which reinforce the rear surface 38. Reinforcement is also provided about the central opening 39 by an upstanding circular flange 52. The spring arrangement is a matter of choice and other arrangements for spring loading the vent flaps, such as combination hingesprings, may be utilized.

In operation, when the engine 10 is relatively cold and a flow of cooling air through the radiator 12 is not needed, for example when the engine is first being started, the control valve 34 is opened in response to the low engine temperature and the piston in the cylinder 26 closes the shutters 18. With a conventional shroud, closing the shutters would greatly increase the noise produced by the cooling fan due to air turbulence and resonance in the enclosed cavity formed by the closed shutters, the radiator, and the shroud. In the illustrated embodiment of the invention, however, the partial vacuum resulting within the shroud 16 due to closing the shutters 18 causes the vent flaps 42 to be drawn inwardly into the shroud 16, against the forces of the springs 46, opening the vents 40. The open vents 40 effectively open up the enclosed cavity in the shroud 16 and reduce the noise produced by the fan 14 to approximately the level that would be encountered with a fan not equipped with a shroud. When the engine 10 is sufficiently warmed up so that the control valve 34 is closed, the piston and the control rod 24 are positioned by the spring return in the cylinder 26 to open the shutters 18. A flow of cooling air is drawn through the radiator 12 by the fan 14 and is exhausted rearwardly through the central opening 39 in the shroud 16. The flaps 42 are closed by the biasing springs 46 and possibly by impinging "ram air," if the vehicle is traveling at sufficient speed. The amount of the force of the "ram air" flowing through the shutters and impinging on the flaps depends upon the speed of the vehicle.

FIG. 3 of the drawings illustrates a second embodiment of the invention in which the vent flaps 42 are operated by a direct mechanical linkage to the shutters 18. The embodiment of FIG. 3 is generally similar to the embodiment of FIGS. 1 and 2 except that the biasing springs 46 and the U-shaped brackets 48 are eliminated. Instead, the lever 32' that is pivotally connected to the piston plunger 30 is both rigidly joined to the upper end of the adjacent shutter 18 and pivotally coupled to one end of a linkage rod 54a. The linkage rod 54a extends along the side of the radiator 12 and is pivotally connected to one end of an arm 56a. The other end of the arm 56a is carried on the upper end of a shaft 58a that is coaxial with one of the vent flap hinges 44 and is secured to the corresponding vent flap 42 for rotation therewith. A similar linkage arrangement of a linkage rod 54b, an arm 56b, and a shaft 58b is used to couple the second vent flap 42 to the shutters 18. A

lever 60 rigidly joined to the upper end of the shutter farthest from the cylinder 26 is pivotally attached to the adjacent end of the linkage rod 54b to complete the linkage for the second vent flap 42. As the piston plunger 30 moves axially to open or close the shutters 18, the vent flaps 42 are simultaneously closed or opened by their respective linkages.

In the embodiment of FIGS. 4, 5a, and 5b, which is otherwise similar to the embodiment of FIGS. 1 and 2, the vents 40' in the fan shroud 16' are circular in shape and are located in each corner of the rear surface 38' of the shroud. Each vent 40' is closed by a circular, flexible diaphragm 62 made of synthetic rubber, for example, and having a diametral slit 64. The diaphragms 62 are larger than the vents 40' and are cemented about their circumferences to the inside of the shroud 16'. A reinforcing strip 66, which is also fabricated of rubber, is glued to the diaphragm 62 along one side of the slit 64. The strip 66 extends the length of and overlaps the slit 64. As shown in FIGS. 5a and 5b, the fan 14 is not and need not be coplanar with the rear surface of the shroud.

In operation, when the shutters 18 are open, as shown in FIG. 5a (the radiator 12 is omitted from FIGS. 5a and 5b for simplicity), the flow of air, indicated by the arrow 68, pushes the diaphragm 62 on both sides of the slit 64 against the reinforcing strip 66. The stiffening effect of the strip 66 keeps the diaphragm from flexing in response to the air flow and thereby seals the slit 64. When the shutters 18 are closed, as shown in FIG. 5b, the rotating fan 14 produces a partial vacuum in the shroud 16'. The partial vacuum causes the side of the diaphragm 62 to which the reinforcing strip 66 is not glued to flex inwardly into the shroud, against the biasing force generated as that diaphragm side is flexed. The stiffening effect of the strip 66 restrains the other diaphragm side from flexing into the shroud. The flexing of the diaphragm opens the slit 64 and thus the vent 40' to reduce the noise produced by the fan 14 in the shroud 16'.

In an embodiment of the invention similar to the embodiment of FIGS. 4, 5a, and 5b, as shown in FIGS. 6, 7a, and 7b, the vents 40'' in the shroud 16'' are formed as paired semi-circles. A rubber diaphragm 70 closes each pair of vents 40'' and has a diametral slit 72. The portion 74 of the shroud 16'' separating the two vents 40'' of each pair replaces the reinforcing strip 66 of the embodiment of FIGS. 4, 5a, and 5b, and prevents the diaphragm 70 from flexing outwardly of the shroud.

As shown in FIGS. 7a and 7b, in which the radiator 12 is omitted for simplicity, the diaphragms 70 function in a manner similar to the diaphragms 62 of the embodiment of FIGS. 4-5b. Since a reinforcing strip is not glued to each diaphragm 70, however, the diaphragm flexes inwardly on both sides of its slit 72 when the shutters 18 are closed, against the biasing forces generated as the diaphragm sides are flexed.

Although each of the embodiments of the invention described above has been illustrated with the cooling system shutters located in front of the cooling system radiator and fan, the vented fan shroud of the invention can also be used in cooling systems having shutters located either between the radiator and the fan or behind both the radiator and the fan.

An embodiment of the invention used in a cooling system having a set of shutters between a radiator and a fan is illustrated in FIG. 8, while FIG. 9 illustrates an

embodiment of the invention used in a cooling system having a set of shutters located behind a radiator and a fan. Both embodiments are generally similar to the embodiment of FIG. 3 and operate in a similar manner.

In the embodiment of FIG. 8, features corresponding to features of the embodiment of FIG. 3 are designated with reference numerals derived by adding 100 to the reference numerals of FIG. 3. The major difference between the embodiments of FIGS. 3 and 8 is that the fan shroud 116 of FIG. 8 is deeper than the shroud 16 of FIG. 3 so that the shutters 118 can be mounted in the shroud 116. Accordingly, there is no mounting frame in the embodiment of FIG. 8 corresponding to the frame 20 of FIG. 3. In addition, the linkage rods 154a and b of FIG. 8 are shorter than the rods 54a and b of FIG. 3 because of the correspondingly reduced distance between the shutters 118 and the vent flap hinges 144. Although the vent flaps 142 of FIG. 8 are illustrated as being moved by mechanical linkages, spring-loaded flaps or flexible diaphragms could also be utilized to open and close the vents 140.

The features of the embodiment of FIG. 9 corresponding to the features of the embodiment of FIG. 3 are designated with reference numerals derived by adding 200 to the reference numerals of FIG. 3. Again, similar to the embodiment of FIG. 8, the fan shroud 216 of FIG. 9 is extended to mount the shutters 218. The components 232', 254a, 254b, 256a, 256b, and 260 of the linkages for the vent flaps 242 are also arranged differently from their counterparts in FIG. 3 because the shutters 218 are located behind the vent flaps, unlike the shutters 18 of FIG. 3.

The relative orientation of the shutters 218 and the vent flaps 242 of the embodiment of FIG. 9 requires the shutters 218' located above the drive shaft 280 for the fan 214 to be shorter than the remaining shutters. A lateral support 282 extends across the fan shroud 216 above the drive shaft 280 and carries a mounting plate 284 which receives the lower ends of the short shutters 218'. Baffle plates 286 and 288 extend between the mounting plate 284 and the drive shaft 280 and downwardly from the drive shaft, respectively, to block air flow in the area of the drive shaft. The baffle plates 286 and 288 have corresponding flanges 290 and 292 and are formed with corresponding semi-circular offsets so that the plates can be fitted around the drive shaft 280 and fastened together. An annular gasket 294 is fitted between the offset portions of the plates 286 and 288 and the drive shaft 280.

As in the embodiment of FIG. 8, flexible diaphragms or spring-loaded vent flaps can be used to cover the vents 240. In the embodiment of FIG. 9, however, the rotating fan 214 does not create a partial vacuum in the shroud 216 between the fan and the shutters 218 when the shutters are closed, but rather an excess positive pressure. Accordingly, if flexible diaphragms or spring-loaded vent flaps are used in the embodiment of FIG. 9, they are opened by the excess positive pressure created in the shroud 216 between the vents 240 and the shutters 218. The pressure in the shroud would also have to overcome the force of "ram air," if any, impinging on the flaps or diaphragms in order to open the vents 240.

It will be understood that the above-described embodiments are merely exemplary and that those skilled in the art may make many variations and modifications

without departing from the spirit and scope of the invention. All such modifications and variations are intended to be within the scope of the invention as defined in the appended claims.

I claim:

1. In a cooling system for an internal combustion engine including a fan and closable shutter means for controlling a flow of air to the fan, the improvement comprising:

a fan shroud defining at least a portion of a passageway extending from the shutter means to the fan, the shroud encircling the fan and including an opening affording a free path of flow for air moving through the passageway from the shutter means and being exhausted from the fan, at least one vent being formed in the shroud, and automatic means for closing the vent when the shutter means is open and the fan is operating and for opening the vent when the shutter means is closed and the fan is operating.

2. The improvement of claim 1, wherein at least a portion of the shroud extends radially outwardly of the fan and lies in a plane generally parallel to the fan, said portion of the shroud having the vent formed therein.

3. The improvement of claim 1, wherein the cooling system further includes a radiator located between the fan and the closable shutter means.

4. The improvement of claim 1, wherein the closing and opening means includes a pivotable flap for closing the vent and spring means for biasing the flap into a closed position.

5. The improvement of claim 1, wherein the closing and opening means includes a pivotable flap for closing the vent and linkage means coupling the flap to the shutter means.

6. The improvement of claim 1, wherein the closing and opening means includes a flexible diaphragm covering the vent and having a slit therein aligned with the vent.

7. The improvement of claim 6, wherein the closing and opening means further includes stop means disposed on one side of the diaphragm to prevent flexing of the diaphragm in one direction beyond the stop means.

8. The improvement of claim 7, wherein the stop means includes a strip on the shroud and extending across the vent lengthwise of the slit in the diaphragm and laterally across the slit.

9. The improvement of claim 7, wherein the stop means includes a strip on the diaphragm adjacent one side of the slit, the strip extending lengthwise of the slit and laterally across the slit to overlap the diaphragm on the other side of the slit.

10. The improvement of claim 1, wherein the cooling system further includes a radiator located ahead of the shutter means on a side thereof opposite the fan.

11. In a cooling system for an internal combustion engine including a fan and closable shutter means for controlling a flow of air through the system, the improvement comprising:

a. a fan shroud defining at least a portion of a passageway extending from the fan to the shutter means, the shroud encircling the fan and including an opening affording a free path of flow for air moving through the passageway from the fan to the shutter means, a portion of the shroud extending radially outwardly of the fan and lying in a plane generally parallel to the fan, at least one vent being formed in said portion of the shroud; and

b. automatic means for closing the vent when the shutter means is open and the fan is operating and for opening the vent when the shutter means is closed and the fan is operating.

12. The improvement of claim 11, wherein the closing and opening means includes a pivotable flap for closing the vent and linkage means coupling the flap to the shutter means.

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