March 1, 1955 E. J. SANDERS 2,703,075

FLUID CIRCULATING APPARATUS

Filed March 23, 1951

Fig. 1.

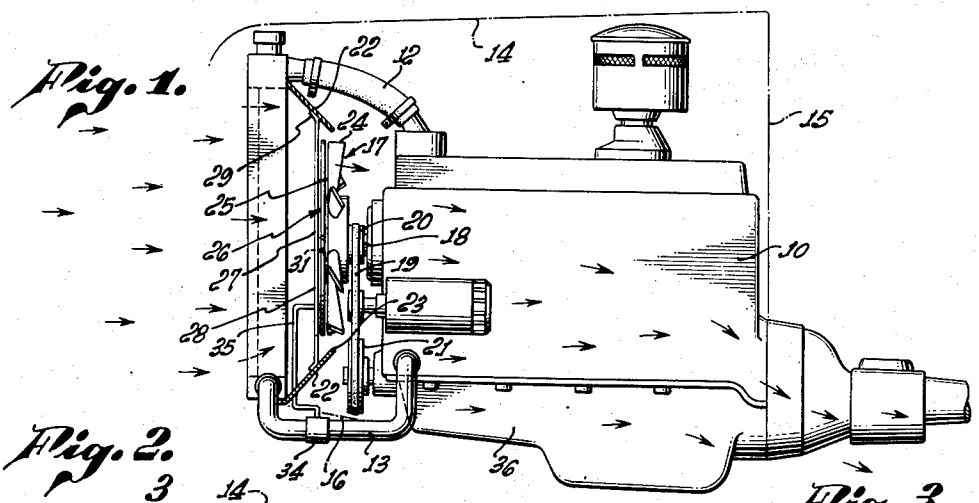



Fig. 2.

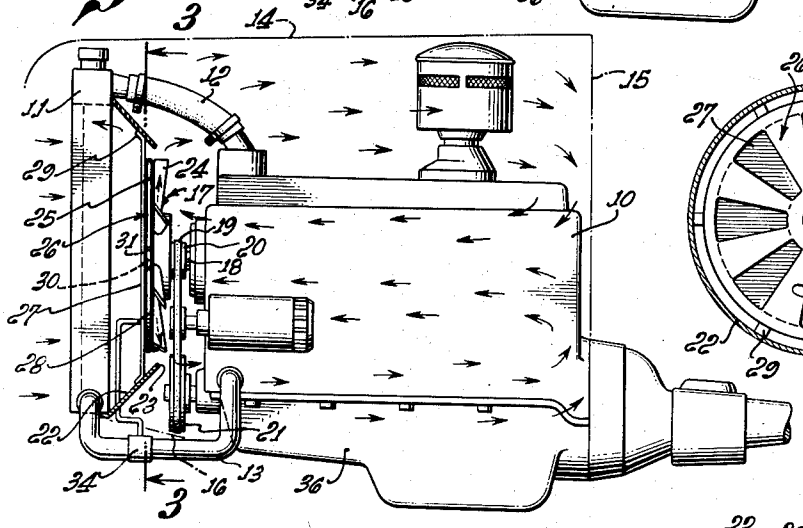



Fig. 3.

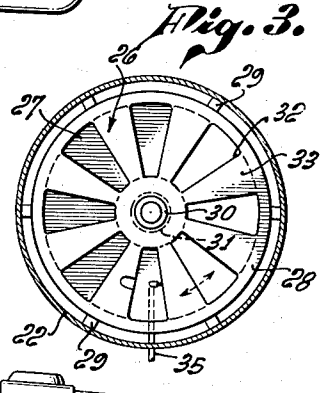



Fig. 4.

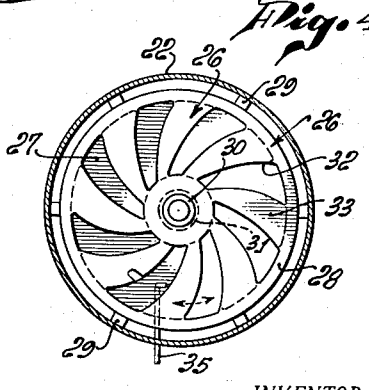



Fig. 5.

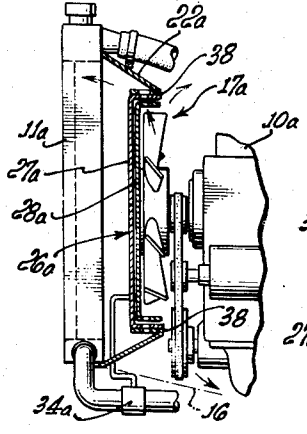
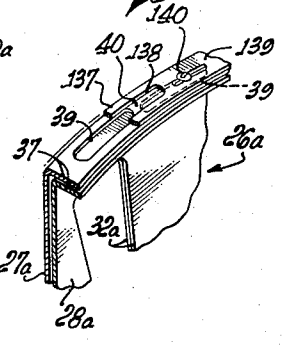



Fig. 6.




INVENTOR.
ELMORE J. SANDERS,
BY Hoskin & White
ATTORNEY.

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# FLUID CIRCULATING APPARATUS

Elmore J. Sanders, San Gabriel, Calif.

Application March 23, 1951, Serial No. 217,251

11 Claims. (Cl. 123—41.49)

The invention has to do with improved fluid circulation systems especially adapted for various temperature controlling uses, as for instance in circulating temperature controlling air in an internal combustion engine installation. More particularly the invention is concerned with circulating systems of the type shown in my co-pending application Serial No. 217,253, filed March 23, 1951, on "Fluid Circulation Systems."

In internal combustion engine installations and other fan cooled equipment, it has in the past been extremely difficult to effectively maintain such parts as the radiator and crankcase at proper operating temperatures. Particularly difficult has been the problem of preventing undue cooling of the radiator under low load conditions or during periods when little or no water circulation is required. To provide for a more effective temperature control in such installations, my above application discloses certain unique air circulation systems operable not only to create the usual cooling air draft when required, but also to create a circulation of warm air about the various engine parts and accessories during non-cooling periods. This circulation of warm air protects the entire equipment against undesired ambient temperatures, and against the adverse effects which have heretofore been caused by such temperatures. Structurally, the above application employs for creating both the cooling and warming air streams a specially constructed fluid displacing rotor or fan convertible between an axial flow cooling condition and a second non-cooling condition in which the fan acts as a centrifugal impeller picking up air from a warm air source and discharging it radially outwardly. For effecting the conversion between these conditions, the rotor includes shutter means rotatable with the fan and adapted to close off one side of the fan to change it to a centrifugal impeller. A baffle or shroud positioned in the path of the radially discharged warm air deflects the air axially toward the radiator and the engine compartment to warm both.

The present invention contemplates the provision of temperature controlling systems of the above general type but in which, instead of using a specially constructed rotor having a rotating shutter section, I employ a conventional axial flow fan in combination with a stationary or non-rotating shutter assembly. The use of such a stationary shutter is highly advantageous in certain situations where maximum ruggedness and ability to withstand relatively rough treatment are of prime importance. For instance, the present stationary shutter arrangements are more desirable than the rotating shutter systems for use in the engines of military vehicles, since a stationary shutter is less susceptible than a rotating shutter to derangement as a result of enemy fire.

The stationary shutter assembly in its closed condition is positioned in such proximity to one face of the rotating fan as to close off axial flow at that side of the fan and thereby effect the desired conversion to a centrifugal impeller. When used for controlling the temperatures of an internal combustion engine, the fan and shutter may be positioned between the usual radiator and engine, the fan normally drawing cooling air through the radiator but acting when the shutter is closed to instead draw warm air forwardly from over the engine and discharge it radially outwardly. Baffle means are provided about the fan for dividing the radially discharged warm air into two distinct streams, a first one of the streams being deflected forwardly toward the radiator, and the second stream being deflected rearwardly to circulate and warm the engine compartment. These baffle means may include a tubular shroud converging rearwardly from about the radiator to a position about and axially overlapping the fan.



When the shutter and fan are positioned between the engine and radiator, the forwardly deflected stream of radiator warming air flows forwardly along a path at the outer edge of the shutter and directly at the inside of the tubular shroud. A further object of the invention is to provide means for positively preventing the reverse passage of air along this outer path and about the main portion of the shutter in the normal axial flow condition of the apparatus. For this purpose, I may provide valve means at the outer edge of the shutter adapted to be automatically actuated from an open condition to a closed condition when the fan is converted to axial flow condition. These valve means may comprise a pair of rims formed about the outer edges of the two sections of the shutter assembly and having openings moving into and out of registry in response to relative rotary adjustment of the sections.

The above and other features and objects of the present invention will be better understood from the following detailed description of the typical embodiments illustrated in the accompanying drawing, in which:

Fig. 1 is a side view of an internal combustion engine installation embodying the invention, showing the cooling air flow when the shutter assembly is in open condition;

Fig. 2 is a view corresponding to Fig. 1 but showing the air flow pattern when the shutters are closed;

Fig. 3 is a fragmentary vertical section taken on line 3—3 of Fig. 2 and showing the rear side of the shutter assembly;

Fig. 4 is a view corresponding to Fig. 3 but showing a variational type of shutter;

Fig. 5 is a fragmentary vertical section through a variational form of the invention; and

Fig. 6 is an enlarged fragmentary perspective view of the shutter rims in the Fig. 5 arrangement.

Referring first to Figs. 1 and 2, I have represented at **10** a conventional water cooled internal combustion engine, forwardly of which is mounted the usual water cooling radiator **11**. Water flows between the water jacket of the engine and the radiator through an upper hose **12** and a lower line **13**. The engine is housed within a compartment defined at its top and sides by a hood **14**, at its rear by upstanding partition **15**, and at its bottom by a wall **16** extending partially across the underside of the engine.

The engine carries at its forward end an axial flow cooling fan **17**, mounted on a shaft **18** and driven by the engine through belt **19** and pulleys **20** and **21**. Fan **17** is positioned opposite the radiator, and normally creates a draft of cooling air rearwardly through the radiator and past the engine to discharge at the underside of the engine. This rearward flow of air, and a reverse forward flow later to be described, are directed between the radiator and fan by a tubular rearwardly converging shroud **22**. At its forward edge, the shroud extends about the air passing portion of the radiator and is suitably mounted to the radiator. From this forward edge, the shroud converges rearwardly to a circular rear edge portion **23**, which partially axially overlaps the fan blades **24** and is positioned relatively close to the outer ends of the blades.

Extending across the forward side of fan **17**, and in very close proximity to the leading edges **25** of the fan blades, I provide a shutter assembly **26** for closing off the normal suction to the fan. This shutter assembly comprises a pair of circular relatively rotatable sheet metal disks or sections **27** and **28**, of a diameter approximately equal to or slightly greater than the fan. Shutter disks **27** and **28** are annularly spaced from shroud **22** at their outer edges, except at the location of a number of circularly spaced outwardly extending tabs **29**, by which the forward shutter disk is fastened stationarily to the shroud. At its rear side, the forward shutter disk **27** has a central hub projection **30** about which the rear shutter disk is rotatably mounted, as by ball bearings **31**.

Referring to Fig. 3, each of the two shutter disks contains a series of circularly spaced radially extending and enlarging apertures **32**, between which the disk forms a series of correspondingly spaced and shaped shutter surfaces **33**. The rear shutter disk is rotatable relative to the forward disk between the Fig. 3 closed condition and an open condition in which the apertures **32** of the two shutter disks are in registry. The rear disk is actuated between these two conditions, in accordance with changes in engine water temperature, by a thermostat **34**, connected into water line **13**. The thermostat actuates the shutter through any suitable type of operative connection, diagrammatically represented at **35**.

When engine **10** is in operation, fan **17** is continuously driven, and the cooling effectiveness of the fan is regulated by opening and closing of shutter assembly **26**. Whenever the cooling water temperature rises to a predetermined value, as for instance 160° F., thermostat **34** actuates the shutter assembly to its open condition, in which the fan draws air rearwardly through the radiator to flow past the engine and then discharge from the underside of the engine compartment (see Fig. 1). This flow of air through the radiator cools the engine water in the same manner as in the conventional internal combustion engine. When the water has been cooled to a second predetermined temperature, as for instance 155° F., the thermostat closes the shutter assembly, to shut off the flow of cooling air through the radiator. The engine water temperature is thus maintained at all times between the two predetermined upper and lower temperatures.

When the shutter is closed (see Fig. 2), it forms a closure extending across the entire suction side of the fan **17**, which converts the fan to a centrifugal impeller drawing air forwardly to its center and discharging it radially outwardly. In order that the fan may thus serve as a centrifugal impeller, it is desirable that shutter assembly **26** be positioned as close as practically possible to the leading edges **25** of the fan blades. The air drawn to the center of the fan when serving as a centrifugal impeller is warmed by passage forwardly over the engine, and is then circulated by the fan in a manner maintaining the entire underhood compartment and the radiator against sharp drops in temperature. Specifically, the warmed air discharged radially outwardly by fan **17** is divided by shroud **22** into two streams for warming the radiator and circulating the underhood compartment respectively. The forward stream is deflected forwardly by the shroud about the shutter assembly and toward the radiator. As a result, the radiator is pressurized with warm air, which slowly flows outwardly through the radiator in a manner effectively protecting the radiator against external temperatures. When the engine is used to drive an automobile or other vehicle, this slow forward flow of warm air through the radiator prevents the forcing of cold air through the radiator as a result of the forward motion of the vehicle.

That portion of the radially discharged air not deflected forwardly by shroud **22** is confined within the engine compartment for flow rearwardly along the outer portions of the compartment, after which it reverses its flow to pass forwardly over the engine and back to the fan. Such circulation of air within the underhood compartment maintains all parts of the engine at a warm temperature, to assure maximum efficiency from the engine. In particular, it is noted that the lower crankcase portion **36** of the engine, the crankcase breather system, and the engine air induction system are all kept warm.

Fig. 4 represents a variational type of shutter assembly, in which the shutter apertures and intermediate shutter surfaces extend angularly rather than directly radially outwardly, and are slightly curved as shown. As will be appreciated, the shutter apertures and intermediate surfaces may of course assume any of numerous other shapes.

Figs. 5 and 6 represent a variational form of the invention in which the engine **10***a*, radiator **11***a*, fan **17***a*, and shroud **22***a* are all substantially the same as in Figs. 1 and 2, but in which the shutter assembly **26***a* is specially formed to positively control the flow of air at its outer portions. Specifically, the two relatively rotatable shutter sections **27***a* and **23***a* are provided about their outer edges with a pair of circular rearwardly extending rims **37**. The forward shutter section **27***a* is stationarily mounted to shroud **22***a* by welding or other attachment of rim **37** of that shutter section to the shroud as at **38**.

The rims **37** of the two shutter sections have elongated openings **39** and intermediate shutter surfaces **40** spaced alternately about their entire circular extent, for controlling the air flow at the outer edge portion of the shutters. One of the rims **37**, typically the outer one as shown, carries an annular ring **137**, having apertures **138** and shutter surfaces **139**, which ring is rotatably adjustable relative to the associated rim to vary the effective size of its apertures. Ring **137** may be retained in any desired position by any suitable fastening means, as for instance by means of a screw **140**.

When the shutter assembly is in its open axial flow condition corresponding to Fig. 1, the openings **39** in the two shutter section rims are moved out of registry (see Fig. 6), so that substantially no air can flow through the rims, the entire rearward flow of air being directed through openings **32***a* in the face of the shutter sections. When, however, thermostat **34***a* actuates the shutter to a closed condition corresponding to Fig. 2, in which the fan commences to function as a centrifugal impeller, rim openings **39** move into registry to permit a portion of the radially discharged air from the fan to flow outwardly through the rims for deflection forwardly toward the radiator.

The amount of air thus discharged radially outwardly is varied to meet specific operational conditions by adjustment of ring **137** relative to the outer rim **37**.

I claim:

1. Fluid circulating apparatus comprising a rotatable fan having blades normally taking suction and discharging axially, shutter means at a side of the fan and operable between open and closed conditions, said shutter means having a main portion extending transversely across said side of the fan in closed condition and converting the fan to a centrifugal impeller discharging fluid radially outwardly, baffle means positioned outwardly of the fan in the path of said radially outward flow of fluid and deflecting a portion thereof in an axial direction past the outside of said main portion of the baffle means, and adjustable valve means between said baffle means and said main portion of the shutter means for controlling the passage of fluid therebetween.

2. Fluid circulating apparatus comprising a rotatable fan having blades normally taking suction and discharging axially, shutter means at a side of the fan and operable between open and closed conditions, said shutter means having a main portion extending transversely across said side of the fan in closed condition and converting the fan to a centrifugal impeller discharging fluid radially outwardly, baffle means positioned outwardly of the fan in the path of said radially outward flow of fluid and deflecting a portion thereof in an axial direction past the outside of said main portion of the baffle means, adjustable valve means between said baffle means and said main portion of the shutter means for controlling the passage of fluid therebetween, and means for actuating said valve means in accordance with the actuation of said shutter means between open and closed conditions.

3. Fluid circulating apparatus comprising a fan normally taking suction and discharging axially, shutter means at a side of the fan and including a pair of relatively rotatable sections having disk portions containing registerable apertures, said disk portions of the shutter sections being adjustable between open and closed conditions by relative rotation and in said closed condition being disposed across said side of the fan in close proximity thereto to convert the fan to a centrifugal impeller discharging fluid radially outwardly, a tubular converging shroud positioned about the fan and deflecting a portion of said radially outward flow of fluid in an axial direction about the outside of said disk portions of the shutter sections, and said shutter sections having circular rims carried at the outer edges of said disk portions and extending between said disk portions and the shroud, said rims containing registerable ports for controlling the passage of fluid between the shroud and said disk portions of the shutter means, said ports registering in the closed condition of said disk portions and moving out of registry to close off fluid flow between the shroud and disk portions in the open condition of said disk portions.

4. Fluid circulating apparatus comprising a rotatable fan having blades normally taking suction and discharging axially, shutter means at a side of the fan and operable between open and closed conditions, said shutter means having a main portion extending transversely

across said side of the fan in closed condition and converting the fan to a centrifugal impeller discharging fluid radially outwardly, baffle means positioned outwardly of the fan in the path of said radially outward flow of fluid and deflecting a portion thereof in an axial direction past the outside of said main portion of the baffle means, valve means between said baffle means and said main portion of the shutter means for controlling the passage of fluid therebetween and operatively connected to said shutter means for actuation to open and closed conditions in response to actuation of said shutter means to closed and open conditions respectively, and means for regulating the air passing area of said valve means in open condition.

5. Fluid circulating apparatus comprising a rotatable fan having blades normally taking suction and discharging axially, first shutter means at a side of the fan and operable between relatively opened and closed conditions, said first shutter means extending across said side of the fan in said closed condition and converting the fan to a centrifugal impeller discharging fluid radially outwardly, second shutter means extending about said fan and operable between relatively opened and closed conditions to control said radially outward flow of fluid, and means operatively interconnecting said first and second shutter means to actuate said second shutter means to opened and closed conditions respectively in response to actuation of said first shutter means to closed and opened conditions respectively.

6. Temperature control apparatus comprising a radiator, a fan opposite said radiator operable to create a flow of air therethrough, a shroud extending between said radiator and fan to direct air therebetween and extending to a location about a portion of the fan, shutter means in said shroud between the fan and radiator and operable between an open position for passing air axially through the radiator and fan, and a closed position closing off said axial flow, there being an air flow passage through the shroud past said shutter means when the shutter means are closed, said fan being constructed to create a flow of air through said passage toward the radiator when said shutter means are closed, and valve means positioned in said air flow passage and near the periphery of said shutter means and operable to close off said air flow passage past the shutter means.

7. A fluid circulation system comprising a radiator, a rotatable fan opposite said radiator normally taking suction and discharging axially and having angular fluid displacement blades, shutter means at the suction side of said fan operable between open and closed conditions while the fan is in operation, said shutter means in closed condition being disposed across said suction side of the fan in close proximity to said blades and acting to convert the fan to a centrifugal impeller discharging fluid



radially outwardly, baffle means positioned in the path of said radially outward flow of fluid and deflecting a portion thereof axially toward the radiator, and valve means positioned near the periphery of said shutter means and in the path of the fluid which is directed toward the radiator by said baffle means and operable to close off said air flow axially toward the radiator.

8. A fluid circulation system as recited in claim 7, in which said shutter means in closed condition are of an extent to shut off the fluid flow to said blades across substantially the entire normal suction side of the fan so that the fan when acting as a centrifugal impeller takes suction from its normal discharge side, and the axial distance between said shutter means and said fan blades is less than the axial extent of said blades.

9. Temperature control apparatus as recited in claim 6, including means for actuating said valve means to closed condition in response to actuation of said shutter means to open condition.

10. Temperature control apparatus as recited in claim 6, in which said shutter means comprise a pair of discs rotatably adjustable between open and closed conditions, and said valve means comprise rims on said discs containing ports which register in closed condition of the shutter discs and move out of registry to close off air flow through the ports in open condition of the discs.

11. Temperature control apparatus as recited in claim 6, in which said shutter means is constructed and positioned to convert said fan to a centrifugal impeller creating a radially outward flow of air when the shutter means is closed, and said shroud and valve means are constructed to direct a portion of said radially outward flow of air axially toward the radiator and allow a second portion of the air to flow in the opposite axial direction, there being an internal combustion engine driving said fan and positioned along the path of said second portion of the air, and a hood enclosing said engine and said second portion of the air flow.

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