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(71) Applicant (for all designated States except US): **VOLVO LASTVAGNAR AB** [SE/SE]; S-405 08 Göteborg (SE).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **ADELMAN, Steve** [US/US]; 2903 Latta Drive, US-Summerfield NC 27358 (US). **GULLBERG, Peter** [SE/SE]; Biskopsbogatan 47, S-431 41 Mölndal (SE).

(74) Agent: **FRÖHLING, Werner**; Volvo Technology Corporation, Corporate Patents, 06820, M1.7, SE-405 08 Göteborg (SE).

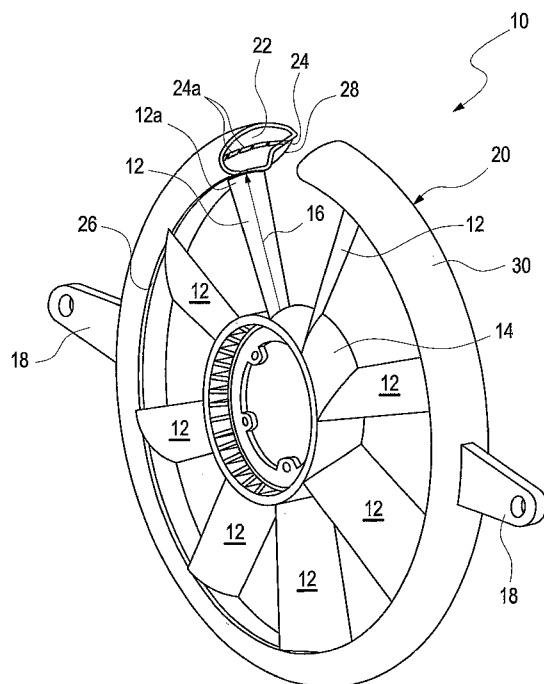
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(54) Title: VEHICLE FAN AND VEHICLE COMPRISING A FAN

Fig. 1



(57) Abstract: The invention relates to a fan (10), particularly a heavy duty vehicle fan, comprising one or more fan blades (12) and a tubular stator ring (20) which encompasses a shell (30) surrounding an interior space (22). The tubular stator ring (20) provides injection air from a position (50) downstream of an intake side of the one or more fan blades (12) to an upstream position (52), wherein a dynamic pressure at a fan exit region (54) enforces the injection air supply pressure inside the tubular stator ring (20).



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DESCRIPTION

Vehicle Fan and Vehicle comprising a Fan

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TECHNICAL FIELD

The invention relates to a vehicle fan and a vehicle comprising a fan according to the preambles of the independent claims.

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BACKGROUND OF THE INVENTION

In modern trucks, particularly medium duty and heavy duty vehicles, cooling of the engine and other aggregates is an important issue. Cooling occurs e.g. by air flowing through a radiator, where the air is forced through by a fan.

15

DE 10 2006 049 076 A1 discloses a fan where a supplied air flow stabilizes the air flow in the blade tip region. A gap is formed between the blade tips and the shroud. In one embodiment an opening in the fan shroud causes recirculation of air from the pressurized side of the fan. In an alternative embodiment, the fan shroud is shaped as a tubular ring. The interior space of the tubular ring acts as a pressure chamber which is pressurized from an external pressurized air source. An opening in the fan shroud supplies pressurized air in the mid blade region at the blade tip.

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SUMMARY OF THE INVENTION

It is an object of the invention to provide an improved fan with a stable air flow at the fan tip. Another object of the invention is to provide a vehicle comprising an improved fan.

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The objects are achieved by the features of the independent claims. The other claims and the description disclose advantageous embodiments of the invention.

In this description, the air flow through the tubular stator ring can be described as an injected air flow, and recirculation is used to describe the detrimental flow at the fan blade tip.

- 5 A fan is proposed, particularly a truck fan, comprising one or more fan blades and a tubular stator ring which encompasses a shell surrounding an interior space. The tubular stator ring provides injection air from a position downstream of an intake side of the one or more fan blades to a position upstream of the fan blades. The static pressure and/or a dynamic pressure at a fan exit region enforces the
10 injection supply pressure inside the tubular stator ring. The injected air flow is used to control the air flow recirculation at the fan blade tips.

- The air flow conditions at the tips of the fan blades have a large influence on the fan performance with respect to pressure rise and efficiency as well as to fan
15 noise. Controlling the fan tip recirculation allows the fan to operate at higher pressure regions in a stable condition more silently.

- Favourably, due to the design according to the invention it is possible to match a recovery of dynamic pressure preferably done by stator vanes and the size of the
20 inlet holes to control the amount of air being recirculated, hence controlling the tip recirculation.

- Favourably, the fan can operate at higher efficiency in a self-regulating way, particularly between an axial flow mode and a radial flow mode. When the fan
25 speed increases, the dynamic pressure in the region around the fan ring can increase if the vehicle is operating at same road speed (the ram-air contribution is constant). Then by increasing the fan speed there will be more radial flow, hence more dynamic pressure going out in a radial manner.

- 30 As the pressure build-up across the fan increases, the fan blade tip recirculation becomes more severe and tends to move towards the leading edge of the fan blade. The recirculating air will in some sense cover the fan blade and minimise its effectiveness. The design according to the present invention allows to delay and to

control this phenomenon in a favourable way, hence increasing the efficiency and expanding the operating range of a fan.

Thus, the dynamic pressure which drives the recirculation of the air passing
5 through the fan blades varies accordingly to the fan speed. Under axial flow mode conditions, i.e. high vehicle speed and/or low fan speed, there is little tip recirculation of the air. In this mode, virtually no high pressure is generated downstream the fan blades because the fan exit flow is axial, flowing rearward from the fan and does not follow the tubular stator ring shape. Under radial flow
10 mode conditions, i.e. low vehicle speed and/or high fan speed, there is a high amount of air recirculation at the blade tips. This recirculating air flows over the tips of the fan blades and reverse direction flowing around the leading edge for the fan at the blade tip region. This recirculation bubble minimizes the effective blade diameter. In this mode, high pressure is generated downstream of the fan because
15 the fan exit flow is highly radial, flowing outward from the fan, following the shape to fan ring. With the addition of the tubular stator ring design some of this flow will be recovered and injected, via the tubular stator ring, in front of the fan to counteract and control the formation of the recirculation bubble as discussed above. This will increase the fan effective diameter and the static pressure rise
20 across the fan.

The fan allows higher pressures and higher flow compared to the solutions known in the art. This allows for a higher tip clearance easing manufacturing and assembly of the fan, while still providing fan flow and efficiency improvements.
25 Advantageously, fuel consumption benefits can be achieved according to the self-regulating operation of the fan. During operation conditions which do not require tip recirculation flow control, no energy is consumed. Further, no additional control device is needed for controlling the proper pressure for the injected air.

30 According to a favourable embodiment of the invention, one or more inlet slits can be provided for air to enter and pressurise the tubular stator ring. Particularly, the inlet slits can be arranged at an output region of the air downstream of the one or more fan blades at the position of the stator blades. This allows making use of the

exit air flow energy (recovery of dynamic pressure) for driving the injection air flow inside the tubular stator ring.

5 According to a further favourable embodiment of the invention, one or more circumferential outlet slits can be provided for air to exit the tubular stator ring. In a favourable improvement, the one or more circumferential outlet slits can be directed radially towards the one or more fan blades in a position along the axial extension of the one or more fan blades. It is also possible to direct the one or more outlet slits axially or tangentially oriented to the stator ring surface. In a 10 favourable improvement, the air can exit the one or more outlet slits tangentially in front of the fan. The air can also be released tangentially or radially upstream of the fan. The design of the fan is improved. The fan design can be improved particularly by making use of the coanda effect.

15 Particularly, the one or more outlet slits can be arranged not in the mid blade region but more to the front side, preferably in the first half, more preferably in the first third of the blade with respect to the air flow through the one or more blades.

20 According to a further favourable embodiment of the invention, the one or more inlet slits can be arranged downstream of the one or more outlet slits with respect to the air flow through the one or more fan blades. This allows making use of the exit air flow energy for driving the injected air flow and providing a source of pressurized air needed to control and stabilize the recirculating air flow in the fan blade tip region.

25 According to a further favourable embodiment of the invention, one or more vanes directing downstream of the one or more fan blades can be arranged on the tubular stator ring. "Downstream" means generally behind the fan blades and can be in axial as well as in radial flow direction, depending on the current flow 30 direction. Favourably, the vanes can provide de-swirling of the flow. The de-swirl vanes can recover some of the swirl energy in the exiting air flow and increase the effective fan system pressure rise. This can increase the air flow through the fan and through a cooling system coupled to the fan and improve the cooling performance.

According to a further favourable embodiment of the invention, a first portion of the shell can be adjacent to the one or more fan blades and extends roughly parallel to the air flow through the one or more fan blades. Preferably, the one or more outlet slits can be arranged in the first portion of the cross section.

According to a further favourable embodiment of the invention, a second portion of the shell can be directing downstream the one or more fan blades. According to an advantageous improvement, the one or more inlet slits can be arranged in the second portion of the shell. Preferably, the S-shaped notch can be arranged in the second portion of the shell upstream of the one or more inlet slits. Favourably, the direction of the air flow exiting the fan system can be an effective driver to reduce recirculation of hot underhood air flow to the inlet of the cooling package. The air flow exiting a fan of modern truck cooling systems according to the art is highly radial. The radial air flow hits the engine tunnel or a corresponding hood/splash shield and becomes a localized high pressure region with some flow directed towards the front of the vehicle. The notch, particularly shaped as a slight S-like recess, can help to minimize this flow impingent at the tunnel region.

According to a further favourable embodiment of the invention, a third portion of the shell can form an outer surface of the tubular stator ring with respect to the one or more fan blades. Favourably, the third portion of the shell is arranged circumferentially around the one or more blades.

According to a further favourable embodiment of the invention, the shell of the tubular stator ring can exhibit a roughly obtuse angled triangle shaped cross section. Preferentially, the first and the second portion of the shell can enclose an obtuse angle.

According to a further favourable embodiment of the invention, the fan can be operable between axial flow and radial flow conditions in a self-regulating way. Favourably, by varying the speed of the fan the flow can be varied from axial flow to radial flow, particularly if the cruising speed of a vehicle supplied with the fan is constant during fan speed variation.

According to a further aspect of the invention, a cooling package is proposed comprising at least one radiator unit and a fan which comprises one or more fan blades and a tubular stator ring which encompasses a shell surrounding an interior space. The tubular stator ring provides recirculation air from a position downstream of an intake side of the one or more fan blades to an upstream position, wherein a dynamic pressure at a fan exit region generates the injection air supply pressure inside the tubular stator ring.

According to a further aspect of the invention, a vehicle is proposed comprising a fan which comprises one or more fan blades and a tubular stator ring which encompasses a shell surrounding an interior space. The tubular stator ring provides injection air from a position downstream of an intake side of the one or more fan blades to an upstream position, wherein a dynamic pressure at a fan exit region generates the injection air supply pressure inside the tubular stator ring.

The invention is not limited to engine mounted fan ring installations, particularly with fan blades with a tight tip clearance to the fan shroud. The invention can also be applied to installations for fans without tight tip clearance engine mounted fan ring.

More particularly, the invention can be applied advantageously in any installations using small diameter fans, such as in medium duty and medium/heavy duty vehicles, any multiple fan installations. The blade tip recirculation turns out to be even more beneficial as the blade diameter decreases and as a pressure rise across the fan blades increases. Any installation where the fan is "highly loaded" can benefit from the invention. Some benefits are that cooling performance can be improved; the fan noise can be reduced; the engine power availability can be increased,

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention together with the above-mentioned and other objects and advantages may best be understood from the following detailed description of the

embodiments, but not restricted to the embodiments, wherein is shown schematically:

- Fig. 1 a perspective view of a preferred embodiment of a fan comprising a tubular stator ring according to the invention;
- Fig. 2a, 2b fan air exit flow paths for different operating conditions;
- Fig. 3a-3c details of embodiments of the tubular stator ring of Fig. 1; and
- Fig. 4 a cooling package of a power source with a fan according to the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

In the drawings, equal or similar elements are referred to by equal reference numerals. The drawings are merely schematic representations, not intended to portray specific parameters of the invention. Moreover, the drawings are intended to depict only typical embodiments of the invention and therefore should not be considered as limiting the scope of the invention.

Fig. 1 depicts schematically a perspective view of a preferred embodiment of a fan 10 comprising a tubular stator ring 20 according to the invention, wherein the tubular stator ring 20 is partially cut for displaying details of the stator ring 20. The fan 10 can be a fan designed for a truck, particularly a medium duty vehicle or medium to heavy duty vehicle. The tubular stator ring 20 provides on its outer circumference mounting brackets 18 for attachment to a cooling package 100 (Fig. 4) or an engine 102 (Fig. 4).

Fig. 2a and 2b illustrates fan air exit flow paths for different operating conditions.

Fig. 2a shows an operating condition with a high vehicle speed and a low fan speed, with an axial flow mode. The exit air flow 42 leaves the fan 10 predominantly in an axial direction.

In Fig. 2b, a radial flow mode is indicated correlated to low vehicle speed and high fan speed. The exit air flow 42 leaves the fan 10 predominantly in a radial direction.

- 5 Fig. 3a-3c illustrates the details of the tubular stator ring 20 of Fig. 1 in more clearness.

The fan 10 comprises a multitude of fan blades 12 having a longitudinal extension 16 extending from a hub 14 in the centre of the fan to fan tips 12a close to the
10 tubular stator ring 20. By way of example, the fan tips 12 have a tight clearance to the tubular stator ring 20.

The tubular stator ring 20 encompasses a shell 30 surrounding an interior space 22. In the shell 30, a multitude of inlet slits 24 are provided for air to enter the
15 interior space 22 of the tubular stator ring 20 downstream of an intake side of the fan blades 12. The inlet slits 24 are abutted by small webs 24a.

A circumferential outlet slit 26 is provided for air to exit the tubular stator ring 20. By way of a first example, the circumferential outlet slit 26 is directed radially
20 towards the fan blades 12 in a position along the longitudinal extension 16 of the fan blades 12.

The inlet slits 24 are arranged downstream of the outlet slit 26 with respect to the air flow 40 through the fan blades 12. The inlet slits 24 and the outlet slit 26
25 provide an injection of the air flow which is driven by the static and recovered dynamic pressure downstream of the blades 12.

As can be seen in detail in Fig. 3a-3c, a first portion 32 of the shell 30 is adjacent to the fan blades 12, i.e. the blade tips 12a, and extends roughly parallel to the air
30 flow 40 through the fan blades 12. The circumferential outlet slit 26 is arranged in the first portion 32 of the shell 30.

A second portion 34 of the shell 30 following the first portion 32 in direction of the air flow 40 is directing downstream the fan blades 12. The inlet slits 24 are

arranged in the second portion 34. The second portion 34 exhibits a notch 38 upstream of the one or more inlet slits 26. The notch 38 is S-shaped with a recess inside the shell 30.

- 5 A third portion 36 of the shell 30 forms an outer surface of the tubular stator ring 20 with respect to the fan blades 12 and connects the first and second portions 32, 34. The third portion 36 shows a convex curvature when looked from outside the tubular stator ring 20 which encloses the injected air and maintains the pressure.
- 10 The shell 30 of the tubular stator ring 20 exhibits a roughly obtuse angled triangle shaped cross section, wherein the first portion 32 and the second portion 34 of the shell 30 enclose an obtuse angle.

At each slit 24 a vane 28, by way of example a stator vane, is arranged directing
15 downstream of the fan blades 12, wherein the vanes 28 are positioned below the slits 24, between the interface of the second portion 34 of the shell to the first portion 32 of the shell and the slits 24. The vanes 28 favourably de-swirl the flow and recover swirl energy in the exiting air flow thus increasing the effective fan system pressure rise.

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When the blades 12 are rotating, the air flow 40 is sucked into the fan 10 upstream the blade region and exits the blade region downstream of the blades 12. Downstream the blade 12, a dynamic pressure builds up downstream of the blades 12 influencing the air flow through the fan 10.

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The flow 40 through the fan blades 12 vary depending on the speed of rotation of the blades 12 at constant vehicle speed when employed in a vehicle. When employed in a vehicle, the flow will also be dependent on the vehicle cruising speed. Generally, when the fan speed increases, the dynamic pressure increases
30 in the tip region 12a. When the fan speed decreases, the dynamic pressure decreases. Consequently, the pressure which drives the injection of the air passing through the shell 30 varies accordingly to the fan speed. This effect is enhanced further by the vanes 28 which recover swirl energy from the exiting air flow. The dynamic pressure as well as the de-swirling effect of the optional vanes

28 generate a flow stagnation pressure which can partly be used to drive the injection of air between the inlet slits 24 and the outlet slit 26 which improves the air flow conditions at the fan blade tips 12a.

- 5 The flow through the fan blades 12 can vary between axial and radial flow depending on the fan or blade rotational speed and/or a cruising speed of a vehicle when the fan is employed in the vehicle.

10 Axial flow mode conditions (Fig. 2a) apply with a low fan speed and/or high vehicle speed (when the fan is installed in a vehicle, particularly a truck). In this operational mode, there is little tip recirculation of the air in the tight clearance between the blade tips 12a and the radially inner side of the tubular stator ring 20. In this mode, virtually no high pressure is generated downstream the fan blades 12 because the fan exit flow is axial, flowing rearward from the fan 10 and does not
15 follow the shape of tubular stator ring 20.

Radial flow mode conditions (Fig. 2b) apply with high fan speed and/or a low vehicle speed (when the fan 10 is installed in a vehicle, particularly a truck). In this operational mode, there is a high amount of tip recirculation of the air in the tight
20 clearance between the blade tips 12a and the radially inner side of the tubular stator ring 20. In this mode, a high pressure up to a maximal high pressure is generated because the fan exit flow is highly radial, flowing outward from the fan 10, following the shape to the tubular stator ring 20.

- 25 Figs. 3a-3c depict some embodiments of the tubular stator ring 20, where the air flow and recirculation in a radial operation mode is indicated.

The air flow 40 through the fan blades 12 is deflected downstream the fan blades 12 providing an radially flowing air stream 42 in a region 54 downstream the fan
30 blades 12. A partial air flow 44 enters the tubular stator ring 20 through the inlet slits 24. In the interior space 22 of the tubular stator ring 20 a high pressure air flow 46 moves towards the circumferential outlet slit 26. An air flow 48 exits the tubular stator ring 20 in an upstream position 52 and is directed towards the fan blades 12. This stimulates and controls the tip recirculation hence allowing this

system to operate with a higher efficiency compared to other designs in this art.

"Injection" is used to describe the air flow 46 through the tubular stator ring 20.

"Recirculation" is used to describe the detrimental flow at the fan blade tip 12a.

- 5 The tubular stator ring 20 provides injection of air from a position 50 downstream of the fan blades 12 to a position 52 close to the front of the blades 12. The static and dynamic pressure at the fan exit region 54 generates the injection supply pressure inside the tubular stator ring 20. As described above, the pressure inside the tubular stator ring 20 is variable dependent on the operation conditions of the
10 fan 10. Consequently, the fan 10 can operate in a self-regulating way.

- As can be seen in Fig. 3a, the circumferential outlet slit 26 is directed radially towards the fan blades 12 in a position along the axial extension 16 of the one or more fan blades 12. By way of example, in order to describe the difference
15 between blade tip recirculation and injected air that controls the tip recirculation a blade tip recirculation area 60 is indicated at the outlet slit 26.

- Fig. 3b shows an alternative embodiment, wherein the circumferential outlet slit 26 is arranged in front of the fan blades 12 and directed tangentially towards the fan
20 blade tip 12a. The air exits the outlet slit 26 tangentially. The blade tip recirculation area 60 is not explicitly shown.

- Fig. 3c shows an alternative embodiment wherein the circumferential outlet slit 26 is arranged in front of the fan blades 12 and directed inclined towards the fan
25 blades 12. The air exits the outlet slit 26 facing the fan blade tips 12a slantwise. The blade tip recirculation area 60 is not explicitly shown.

- Fig. 4 shows a cooling package 100 of a power source 102, e.g. a combustion engine, more particularly a diesel engine, with a fan 10 according to the invention.
30 The cooling package 102 comprises one or more radiators and the fan 10 as described in the preceding Figures.

The power source 102 is cooled with a cooling circuit 104 which is illustrated in an oversimplified manner. The fan 10 sucks in air through the one or more radiators of the cooling package 102.

- 5 Particularly in modern trucks the cooling packages 100 are nearly exhausted in design with respect to maximum cooling capacity and minimum installation space.

The use of the fan 10 can favourably divert the fan air flow rearward in the vehicle (not shown) in direction of the power source 102, helping to minimize the
10 recirculation issues and also improve hot spot issues in the power source compartment. By using the swirl energy recovered by the vanes 28 and the dynamic pressure of the air flow exiting the fan blades 12 as a pressure source allows injecting a controlled air flow in the fan tip region that improves the performance of the fan 10.

15

The hot air flow exiting the fan 10 is diverted in such a way as to reduce the recirculation flow to the inlet of the cooling package 102 and increases the power-source compartment flow to control hot spot regions in the compartment of the power source 102.

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The invention is not limited to engine mounted fan ring installations. The invention can be used in electric as well as hydraulic fan drive systems where the fan drive is mounted directly to the cooling package 102.

25

C L A I M S

1. A fan (10), particularly a heavy duty vehicle fan, comprising one or more fan
5 blades (12) and a tubular stator ring (20) which encompasses a shell (30)
surrounding an interior space (22), characterized in that the tubular stator
ring (20) provides injection air from a position (50) downstream of an intake
side of the one or more fan blades (12) to an upstream position (52),
wherein a dynamic pressure at a fan exit region (54) enforces the injection
10 supply pressure inside the tubular stator ring (20).
2. The fan according to claim 1, characterized in that one or more inlet slits
(24) are provided for air to enter the tubular stator ring (20).
- 15 3. The fan according to claim 1 or 2, characterized in that one or more
circumferential outlet slits (26) are provided for air to exit the tubular stator
ring (20).
4. The fan according to claim 3, characterized in that the one or more
20 circumferential outlet slits (26) are directed radially towards the one or more
fan blades (12) in a position along the axial extension (16) of the one or
more fan blades (12).
5. The fan according to claim 3, characterized in that the one or more
25 circumferential outlet slits (26) are arranged in front of the of the one or
more fan blades (12).
6. The fan according to claim 3 or 4, characterized in that the one or more
circumferential outlet slits (26) are directed tangentially towards the one or
30 more fan blades (12) in front of the of the one or more fan blades (12).
7. The fan according to one of the preceding claims, characterized in that the
one or more inlet slits (24) are arranged downstream of the one or more

outlet slits (26) with respect to the air flow (40) through the one or more fan blades (12).

8. The fan according to one of the preceding claims, characterized in that one or more stator vanes (28) directing downstream of the one or more fan blades (12) are arranged on the tubular stator ring (20).

9. The fan according to one of the preceding claims, characterized in that a first portion (32) of the shell (30) is adjacent to the one or more fan blades (12) and extends roughly parallel to the air flow (40) through the one or more fan blades (12).

10. The fan according to claim 9, characterized in that the one or more outlet slits (26) are arranged in the first portion (32) of the shell (30).

11. The fan according to one of the preceding claims, characterized in that a second portion (34) of the shell (30) is directing downstream the one or more fan blades (12).

12. The fan according to claim 11, characterized in that the one or more inlet slits (24) are arranged in the second portion (34) of the shell (30).

13. The fan according to claim 11 or 12, characterized in that the notch (38) is arranged in the second portion (34) of the shell (30) upstream of the one or more inlet slits (24).

14. The fan according to one of the preceding claims, characterized in that a third portion (36) of the shell (30) forms an outer surface of the tubular stator ring (10) with respect to the one or more fan blades (12).

15. The fan according to one of the preceding claims, characterized in that the shell (30) of the tubular stator ring (20) exhibits a roughly obtuse angled triangle shaped cross section.

16. The fan according to claim 15, characterized in that the first and the second portion (32, 34) of the shell (30) enclose an obtuse angle.
- 5 17. The fan according to one of the preceding claims, characterized by being operable between axial flow and radial flow conditions.
18. A cooling package (100) comprising at least one radiator unit (102) and a fan (10) according to one of the preceding claims.
- 10 19. A vehicle comprising a fan (10) according to one of the claims 1 to 17 and/or a cooling package (100) according to claim 18.

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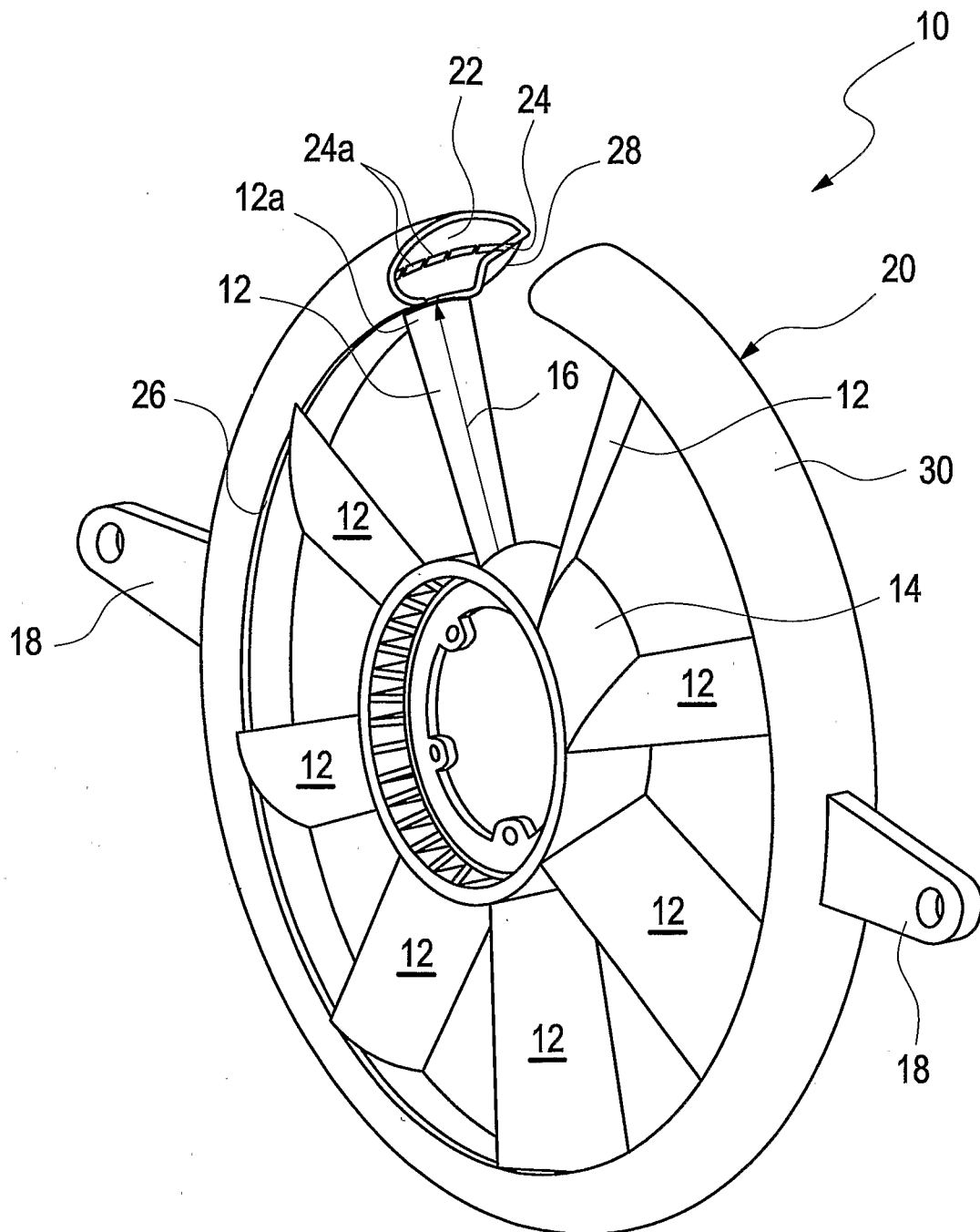


Fig. 1

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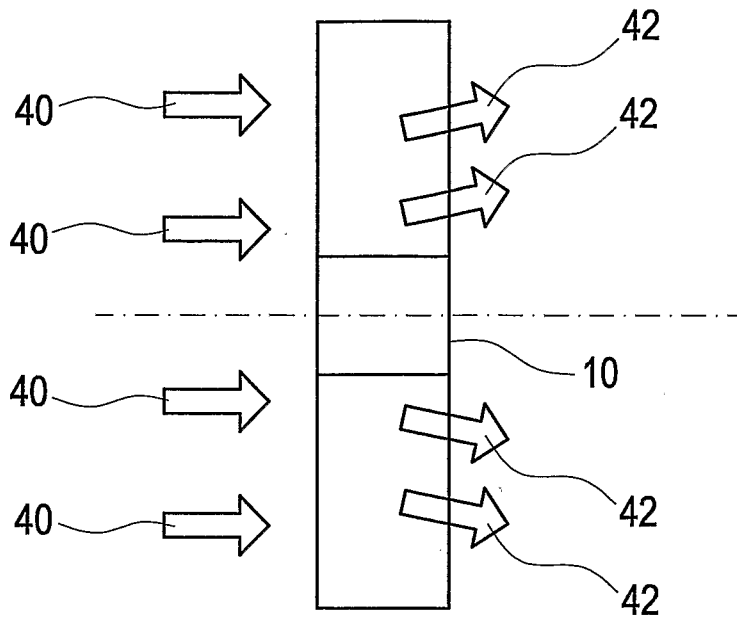


Fig. 2 a

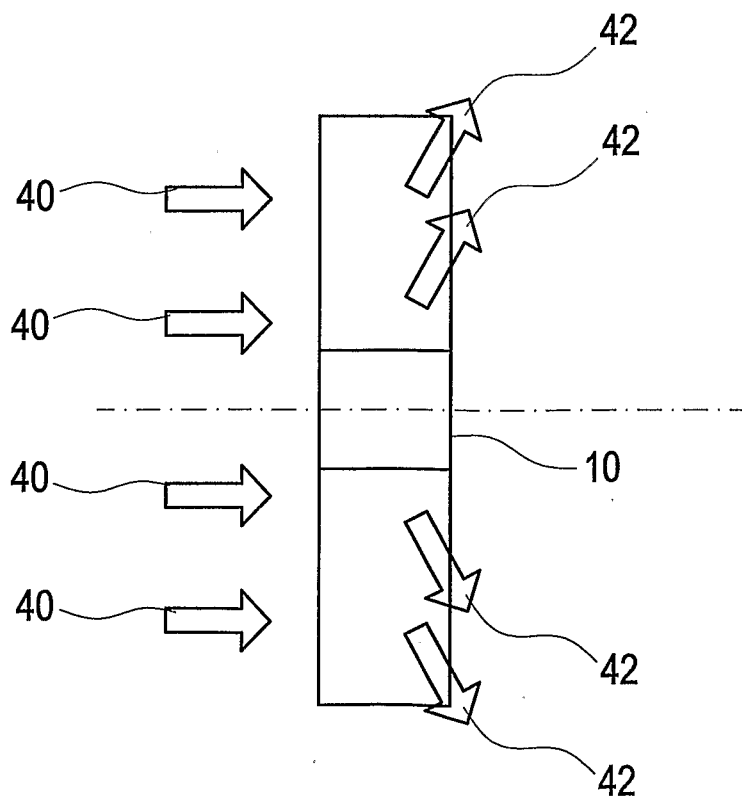


Fig. 2 b

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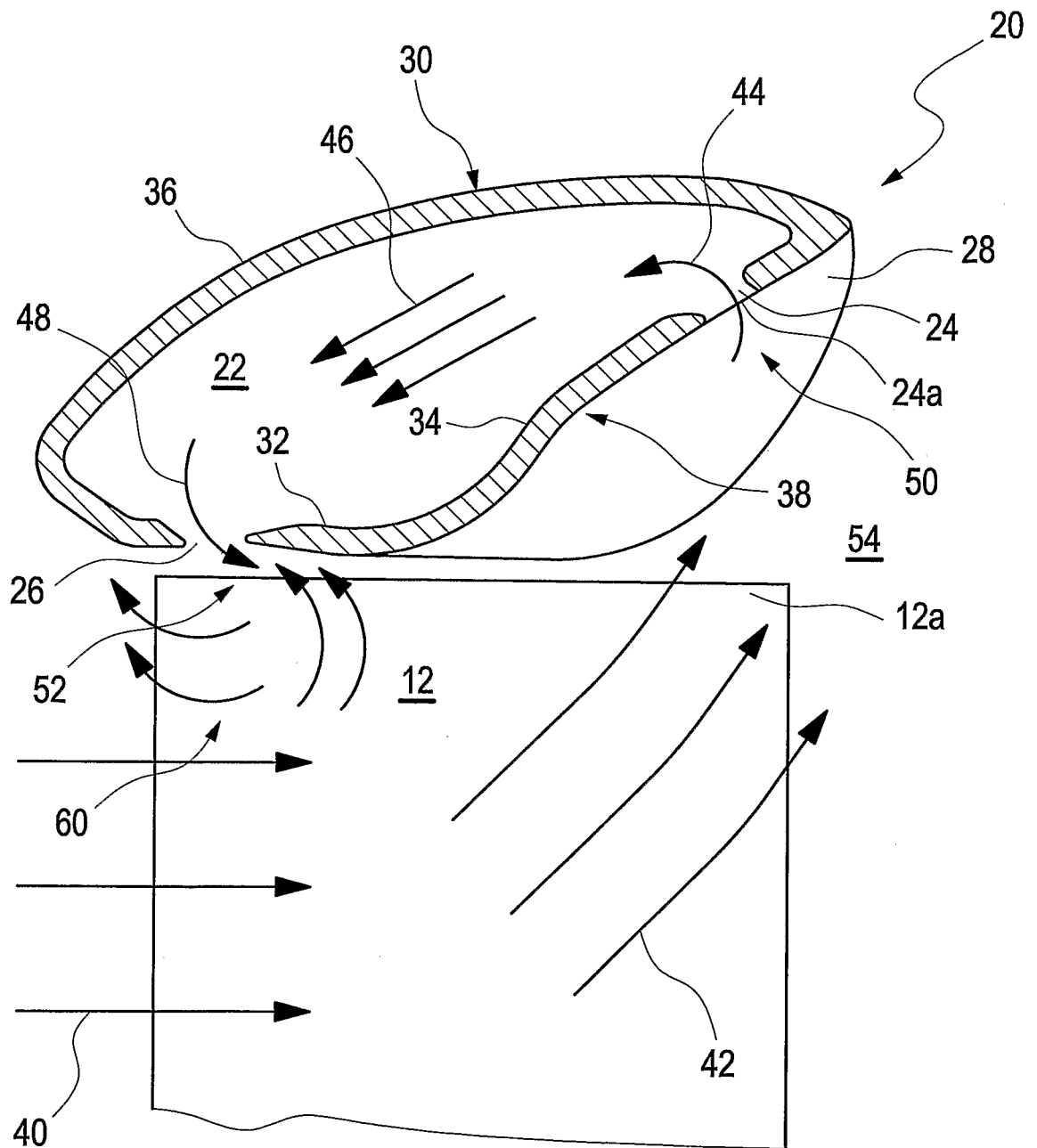


Fig. 3 a

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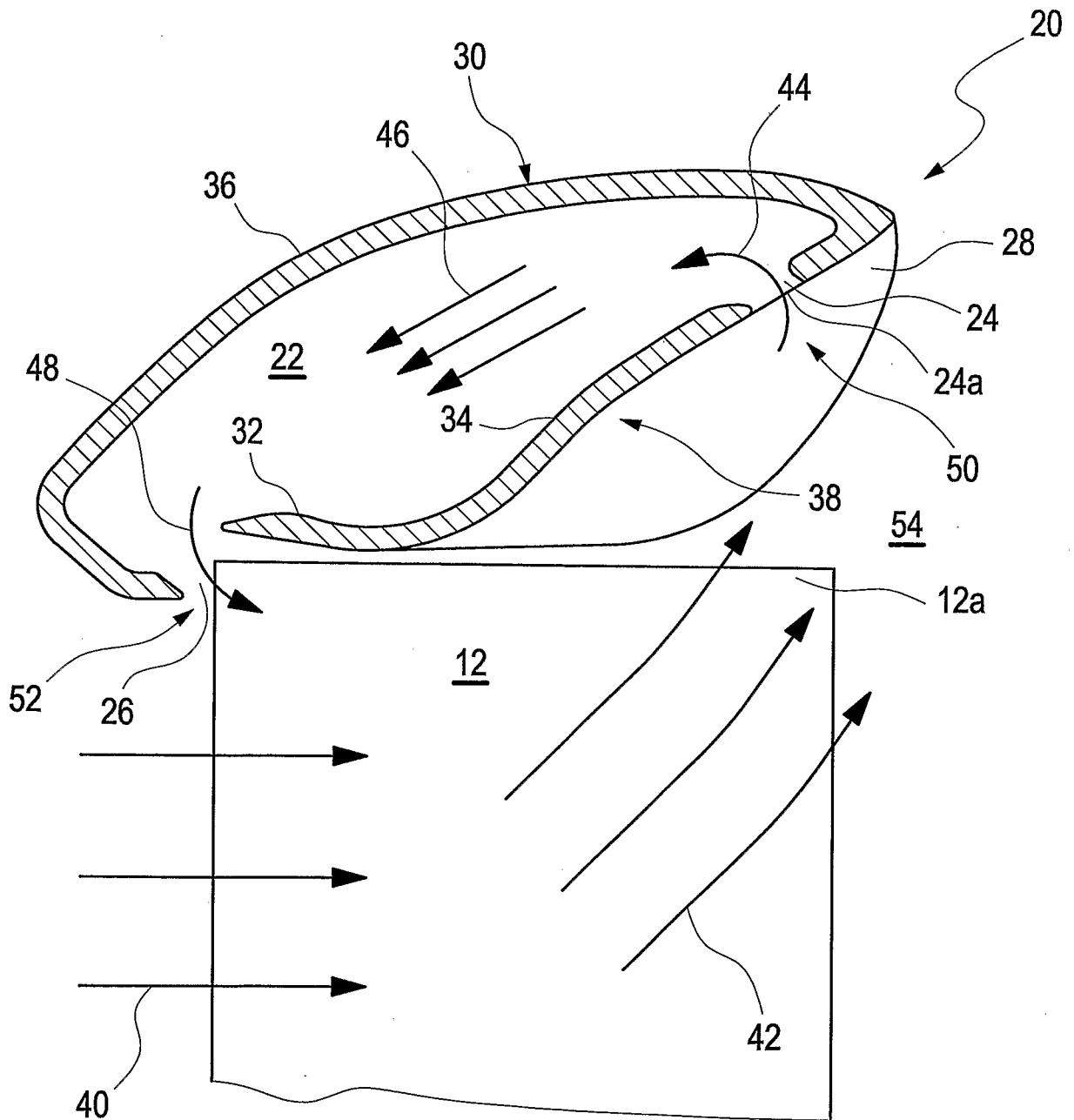


Fig. 3 b

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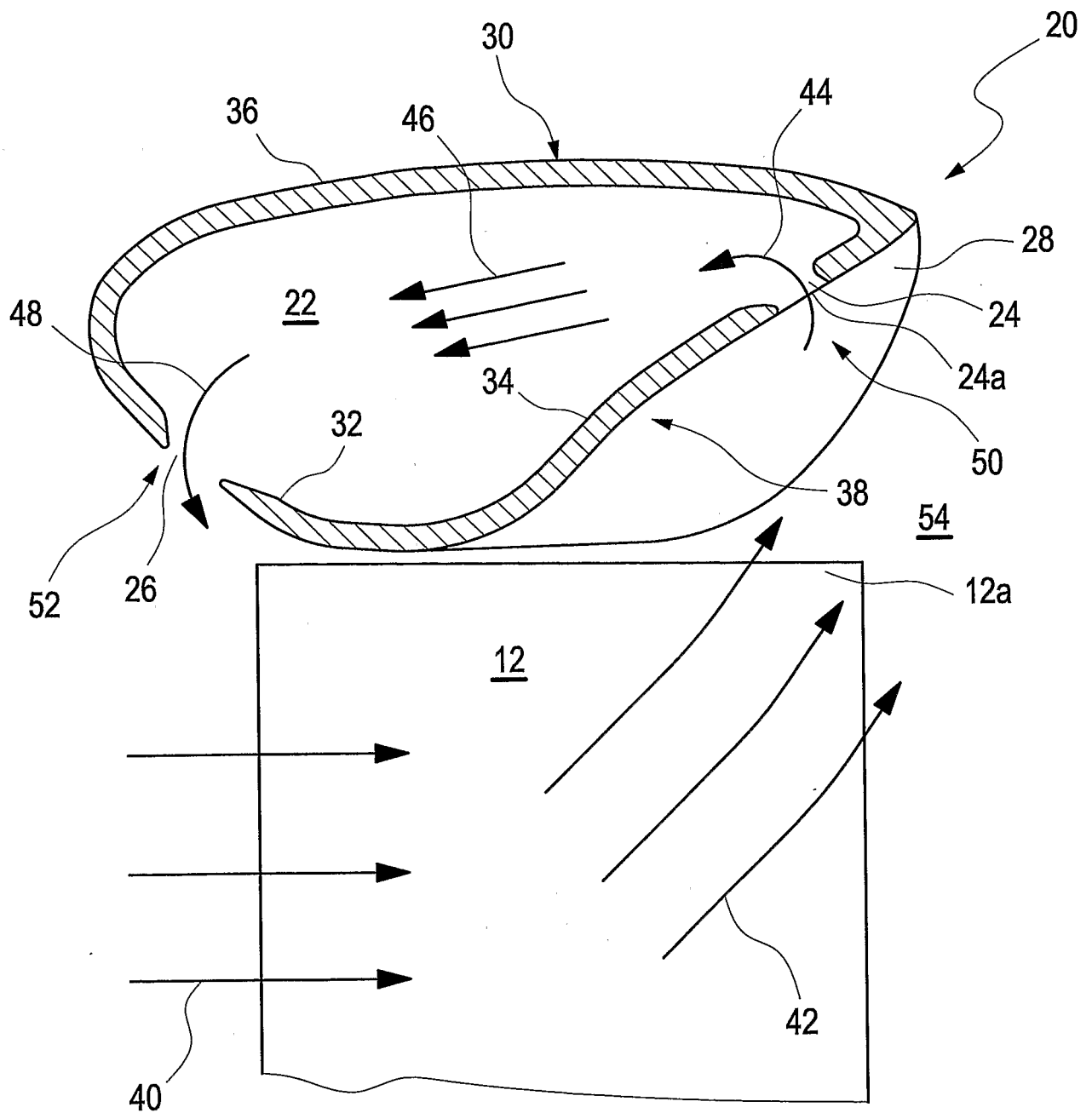


Fig. 3 c

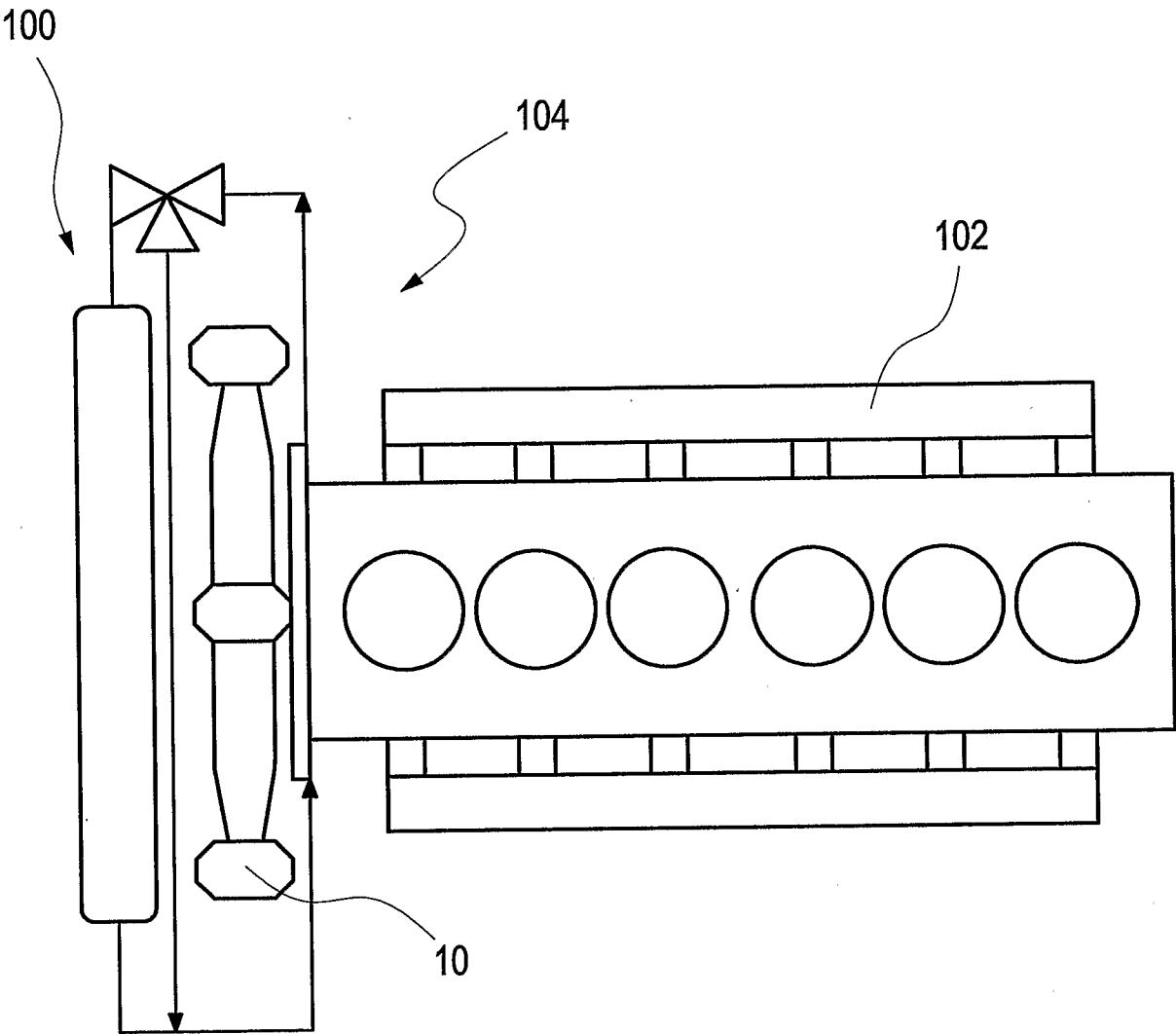


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE2008/000715

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: F01P, F04D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 1086558 B1 (WIEBE DRAIJER), 4 August 1960 (04.08.1960), column 5, line 32 - line 39; column 6, line 3 - line 6, figure 7 --	1-19
A	DE 4438184 C1 (BEHR GMBH & CO.), 11 April 1996 (11.04.1996), figures 1-4, abstract --	1-19
A	DE 102006049076 A1 (BEHR GMBH & CO. KG), 17 April 2008 (17.04.2008), figure 4, paragraph (0026) --	1-19

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
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Date of the actual completion of the international search

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Name and mailing address of the ISA/
Swedish Patent Office
Box 5055, S-102 42 STOCKHOLM
Facsimile No. +46 8 666 02 86

Authorized officer

Lena Nilsson / JA A
Telephone No. +46 8 782 25 00

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5489186 A (YAPP ET AL), 6 February 1996 (06.02.1996), column 7, line 34 - line 59, figure 11 -- -----	1-19

International patent classification (IPC)

F01P 5/06 (2006.01)
F04D 27/02 (2006.01)
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