



(51) International Patent Classification:

F01P 1/02 (2006.01)

F01P 5/06 (2006.01)

F01P 5/02 (2006.01)

(21) International Application Number:

PCT/IN2020/050221

(22) International Filing Date:

09 March 2020 (09.03.2020)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

201941010996

21 March 2019 (21.03.2019)

IN

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ,

(54) Title: A COOLING SYSTEM FOR A POWER UNIT

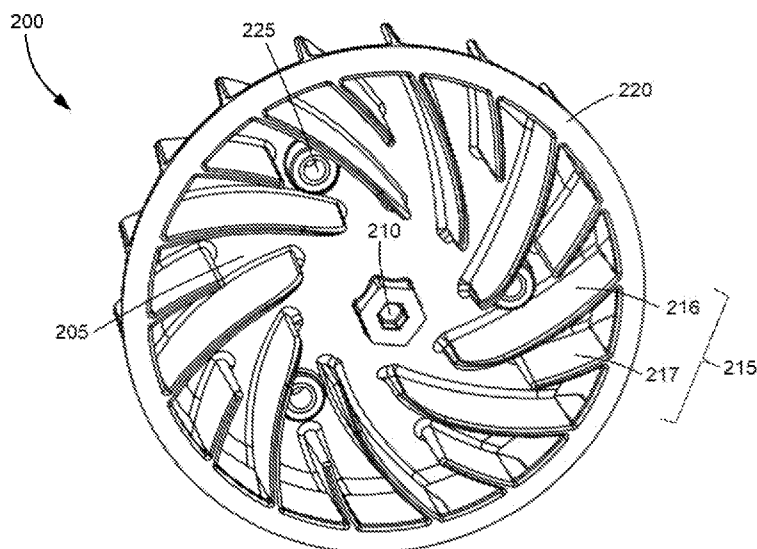


Fig. 2

(57) Abstract: The present subject matter provides a power unit (100) for a motor vehicle (10). A cooling fan (200) mounted to a rotating member (120) of said power unit (100). The cooling fan (200) includes a plurality of primary vanes (216) and a plurality of secondary vanes (217). Each secondary vane of the plurality of secondary vanes (217) is disposed between two consecutively disposed primary vanes (216). The plurality of secondary vanes (217) are having a length smaller than a length of said plurality of primary vanes (216, 316, 416). The cooling fan (200) offers streamlined and attached flow with reduced power consumption thereby improving performance of the power unit (100).



UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to the identity of the inventor (Rule 4.17(i))*
- *of inventorship (Rule 4.17(iv))*

Published:

- *with international search report (Art. 21(3))*

A COOLING SYSTEM FOR A POWER UNIT

TECHNICAL FIELD

[0001] The present subject matter relates generally to a power unit for a motor vehicle. More particularly, the present subject matter relates to a forced air cooling system engaged to cool the power unit.

BACKGROUND

5 [0002] Generally, power units like an internal combustion (IC) engine converts one form of energy, which is chemical energy into mechanical energy, which can be employed to do a wide variety of mechanical work. To be specific, combustion of the chemical (air-fuel mixture) generated thermal energy that is used to generate the mechanical work, in the IC engine. Whereas, in case of an electric
10 motor, the electrical energy is converted into mechanical energy. In case of electric motors also, heat is generated due to the resistance to flow of currents and also due to friction. In both the aforementioned systems, a rotating member, as per the design requirement, is provided that undergoes a rotational motion.

[0003] Further, considering the IC engine, a reciprocating piston is present that
15 undergoes translational motion within a cylinder portion of a cylinder block. A connecting rod connects the piston to the rotating member like a crankshaft. In addition to the thermal energy generated due to combustion process, presence of multiple components and interaction therebetween also causes friction between the elements resulting in generation of heat. When heated up, the mechanical
20 properties and frictional properties of the components vary and this may affect the performance of the system. For example, heat causes expansion of the components that may affect the clearance between components by which friction may be increasing. Hence, it is necessary to have a cooling system for dissipation of heat.

25 [0004] Generally, some vehicles have the power unit exposed to the atmosphere and the cooling happens naturally due to the flow of wind during operation of the vehicle. However, some vehicles require forced air cooling due to the power unit either being at least partially covered by panels of the vehicle or due to the excess

heat generated by the power unit thereby requiring forced cooling in addition to natural cooling. The excess heat generation can arise owing to various factors like engine performance enhancement, environmental conditions, variance in user driving conditions & driving pattern, etc. In known forced cooling systems, a forced-air cooling is one of the most cost effective cooling system when compared to other cooling systems in the art like the liquid cooling that requires circulating system, fans, control unit etc. In case of a forced air cooled system, a cooling fan is used and the cooling fan is mechanically driven by the rotating member of the power unit itself.

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BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The detailed description is described with reference to the accompanying figures. The same numbers are used throughout the drawings to reference like features and components.

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[0006] Fig. 1 (a) illustrates a right side view of an exemplary motor vehicle, in accordance with an embodiment of the present subject matter.

[0007] Fig. 1 (b) illustrates a side perspective view of a portion of a power unit, in accordance with an embodiment of the present subject matter

[0008] Fig. 2 illustrates a perspective view of a cooling fan, according to an embodiment of the present subject matter.

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[0009] Fig. 3 illustrates an axial view of the cooling fan, according to the embodiment of the present subject matter.

[00010] Fig. 4 depicts a perspective view of a cooling fan, in accordance with another embodiment of the present subject matter.

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[00011] Fig. 5 illustrates a sectional view of the cooling fan taken along axis X-X' as shown in Fig. 4, according to an embodiment of the present subject matter.

[00012] Fig. 6 depicts a perspective view of a cooling fan, in accordance with yet another embodiment of the present subject matter.

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[00013] Fig. 7 illustrates a cross-sectional view of the cooling fan taken along axis Z-Z' as shown in Fig. 6, according to an embodiment of the present subject matter.

[00014] Fig. 8 illustrates a schematic view of the power unit depicting flow, according to the embodiment of the present subject matter.

[00015] Fig. 9 illustrates a schematic view of flow attachment in a conventional cooling fan.

5 [00016] Fig. 10 illustrates a schematic view of flow attachment in a cooling fan, in accordance with an embodiment of the present subject matter.

[00017] Fig. 11 illustrates a graphical representation of power consumed by the fan versus power unit speed.

DETAILED DESCRIPTION

10 [00018] The power unit generates mechanical energy that is either directly transferred to at least one of the wheels of the motor vehicle or an intermediate transmission system is used for transmitting the mechanical energy to the wheel(s).

[00019] Generally, in the forced air cooling system, atmospheric air is drawn
15 into the cooling system from the atmosphere through an inlet by using a cooling fan. A shroud covers some portions of the power unit that requires cooling. When the atmospheric air drawn by the fan flows over the parts/components, heat transfer occurs from those parts due to convection, because of which the air gets heated and the hot air is scavenged out of the shrouds. Typically, the cooling fan
20 used in such power unit applications draws air in axial direction and directs air in radial direction due to the limitation of engine size in width direction. However, in conventional fans known in the art, the air entering the cooling does not have an attached or streamlined flow. Fig. 9 shows a schematic view of flow attachment in a conventional cooling fan 500. The region marked as A shows that at the entry
25 portion of the vanes, the flow is not attached because of creation of turbulence that would result in disturbed flow. This causes a disturbed flow which may also create resistance on the cooling fan. Moreover, the region marked as B shows that the flow leaving the cooling fan is also not streamlined and disturbed thereby creating turbulence and forming a complex non-smooth / non-laminar flow which
30 is undesired.

[00020] A major downside to use of cooling fans in conjunction with power units is, the power generated by the power unit is partly utilized in operation of the cooling fan, which causes loss of useful brake horse power or drive power that dictates the vehicle performance. The cooling fan being directly mounted to the rotating member of the power unit or to a member that is connected to the rotating member shows the effect of such non-laminar flow on the performance of the power unit. Fig. 11 depicts a graphical representation of the power consumed by the fan against engine speed. Line A shows the power consumed by the fan in a conventional cooling fan. As can be seen, the power consumed by the fan, for rotation of the fan, increases with engine speed (rotations per minute), which essentially shows the amount of power being used to drive the cooling fan. The slope of Line A indicates the effect of running the conventional fan.

[00021] An additional facet of the operation of power units like the IC engines is, the emissions. The emissions, especially associated with the cold start or cold condition/cold running state, are higher, which is undesirable. Thus, a faster warm up time of the IC engine, which includes warming up of engine components and oil, improves the performance. Additionally, faster warm up of the engine also has direct impact on conversion efficiency of the catalytic converter provided in the exhaust system by which emission can be reduced. Also, improper warming up of the engine affects air intake paths/plenum resulting in wall wetting. However, use of a conventional mechanical fan which does not have a controlled cooling performance is a shortcoming that affects quick engine heating. As, the mechanical fan offers cooling from the starting condition of the IC engine because of which the quick warm up thereof is also adversely affected. As per a known art, an external fan or blade type control system is implemented to selectively direct air into the cooling system at different usage conditions & in different desired quantities. However, such systems involve more number of parts, are complex & costly.

[00022] Further, the brake horse power of small capacity engines is about $1/3^{\text{rd}}$ to $1/4^{\text{th}}$ of the total heat energy released during the fuel combustion. Thus,

reduction or optimizing power consumption of ancillary systems like the cooling fans is imperative to improve the overall performance of engine.

[00023] Thus, there is need for a power unit with a cooling system that is capable of offering optimum & efficient cooling according to varying power unit
5 & user operating conditions. Moreover, the cooling system should be capable of offering efficient cooling supporting optimum power unit performance without the need for any external control. Further, the overall performance of the power unit is also to be improved.

[00024] Hence, the present subject matter is aimed at addressing the
10 aforementioned and other problems in the art in relation to the power unit. The power unit of the present subject matter offers an optimum cum efficient cooling system that is capable of offering improved power unit performance and at the same time in IC engine applications, it will be capable of offering optimum engine cooling.

[00025] The present subject matter, according to one embodiment offers, a
15 cooling fan having a base which is a disc shaped member or conical shaped member with larger cone angle. The cooling fan is provided with plurality of vanes provided on one axial face thereof, which is facing laterally outward of the power unit towards an opening of a shroud assembly that at least partially
20 encloses the power unit. The plurality of vanes includes plurality of primary vanes and plurality of secondary vanes spaced annularly. Each of the secondary vane of the plurality of secondary vanes is disposed between two consecutively disposed primary vanes. The vanes can a disposed in a forward direction or rearward direction.

[00026] The cooling fan includes a bore portion provided at a centre portion
25 thereof, wherein the bore portion is formed by the space at the inward radial ends of the primary vanes. Thus, the primary vanes are having an inward end in proximity to the bore portion and the secondary vanes are having inward ends disposed away from the bore portion, with reference to the inward end of the
30 primary vanes. Thus, the cooling fan is of lighter weight due to less material usage due to the provision of bore portion and also due to the smaller length of the

secondary vanes thereby effectively requiring less material compared to a conventional fan. Further, this reduces load on the power unit, which drives the cooling fan.

[00027] The entering of air to the vanes is through the bore portion and through
5 a primary entry portion formed by two consecutively placed primary vanes whereby the air gets attached to the primary vanes. Subsequently, the air passes through secondary entry portions, two in number, formed due to the provision of secondary vane between the consecutively disposed primary vanes. In addition to streamlined flow, the energy is retained due to introduction of the secondary vane
10 whereby the distance between the vanes is reduced (considering distance between a primary vane and a secondary vane when compared to distance between two primary vanes) thereby reducing turbulence. Thus, effectively the portion/area, which is near the primary entry portion, enables entry of larger volume of air. Only subsequently does the secondary vane interact with the air drawn and enable
15 in retaining the streamlined flow and energy.

[00028] Further, a cumulative thickness/ projected area occupied by the primary vanes is substantially less when compared with a conventional fan with all full length vanes. The air that enters substantially in axial direction exits the cooling fan through exit paths formed at the radial ends thereof.

20 [00029] The air flow entering the two secondary entry portions gets attached with a set of three consecutive vanes formed by two primary vanes and an interposed secondary blade disposed therebetween causing improved attached flow of air with the vanes.

[00030] The secondary vanes are oriented in substantially the same orientation
25 as that of the primary vanes whereby air passing through the primary vanes even after passing through the secondary entry portion, retains the momentum efficiently and provides a streamlined and attached air flow. Thus, a high air pressure is maintained offering attached flow, whereby an optimum flow pattern is obtained, which is with reduction or elimination of losses.

30 [00031] The pressurized air exiting the cooling fan is directed towards the components of the power unit that require cooling. For example, in a power unit

formed by an IC engine, the shroud assembly directs the pressurized air towards the cylinder block and the cylinder head for cooling. Moreover, the attached flow of air reduces losses at exit due to reduced flow separation.

[00032] In one embodiment, the primary vanes define a primary pitch for entry of air into the primary entry portion formed between the vanes and provision of the secondary vane between the two adjacently disposed primary vanes creates a first secondary pitch and a second secondary pitch for entry of air therethrough. In a preferred embodiment, a sum of a first secondary pitch and the second secondary pitch is at least equal to a primary pitch. This enables in retaining the streamlined flow with minimum flow separation by effectively accommodating the volume entering the cooling fan till the exit thereby reducing or eliminating losses.

[00033] Further, the streamlined flow exiting the cooling fan enables optimum cooling of the parts of the system/power unit, as the vanes of the cooling fan offers attached flow even at a higher pressure.

[00034] In one embodiment, the power unit when undergoing warmup has lower convection due to lower thermal coefficient at that condition as the thermal coefficient is dependent on flow and fluid properties. Thus, heat transfer to the streamlined flow of air by convection is low because of which the power unit gets warmer quickly due to retention of heat.

[00035] Subsequently, when the power unit is operational for certain duration, the part temperatures rises and the heat-transfer coefficient/ film coefficient increases thereby improving convection. Thus, the streamlined air flow directed by the cooling fan offers improved convection thereby offering cooling effect.

[00036] In one embodiment, a cooling fan includes a ring member (also known as shroud) that provides structural support to the vanes from getting deflected even at high speeds of operation. Further, the ring member along with a base and the vanes provides a guided path for the air to be directed in radial direction. Thus, any losses (with respect to air flow) that could occur in axial direction of the cooling fan can be reduced thereby improving flow attachment.

[00037] In one embodiment, the primary vanes in proximity to the bore portion are provided with a height disposed at an elevation from the base when compared to the height of the vanes near to outer periphery thereby improving flow attachment from the time of entry through primary entry portion.

5 [00038] In one embodiment, to attain the effect of elevated vanes, wherein the vanes are provided with uniform height as the base is provided in the form of a cone, with a large cone angle in the range of 100°-170°, whereby the height of vanes tends to be axially outward, in axial direction, enabling improved attachment during entry itself.

10 [00039] However, in another embodiment, the height of the vanes is varied depending on pressure and/or velocity requirements. For example, in one implementation, the height of the vanes at the inlet portion is substantially larger than the height of the vanes at the outlet portion, wherein the height is analogous to area of the vane, which enables improved attachment of air.

15 [00040] In one embodiment, a cooling fan includes a semi-spherical bore/profile portion. In other words, the plurality of vanes is provided with inward ends that is having a curved portion. The curved portion enables improved intake of air in axial direction, or say at primary entry portion, as the curved portion offers improved length for attaching of air to the primary vanes. Moreover, this further
20 provides a lighter fan with desired flow attachment. Thus, smooth entry of air flow at various points, in axial direction, happens due to the curved inward end of the vanes, which offers various attachment points in radial direction and axial direction.

[00041] Various features and embodiments of the present subject matter here
25 will be discernible from the following further description thereof, set out hereunder with an embodiment of a two wheeled saddle type scooter vehicle. Further, the terms "front", "rear", "left" and "right" referred to in the ensuing description of the illustrated embodiment are referred with respect to the power unit or the motor vehicle accommodating the power unit. The detailed explanation
30 of the constitution of parts other than the present subject matter which constitutes an essential part has been omitted at suitable places.

[00042] Fig. 1 depicts an exemplary motor vehicle 10, in accordance with an embodiment of the present subject matter. The vehicle 10 has a frame member 15 that includes a head tube 16, a main frame 17 extending rearwardly downward from the head tube 16. The main frame 17 may comprise one or more main tube(s), and a pair of rear tubes 18 of the frame member 15 are extending inclinedly rearward from a rear portion of the main frame 17. In the present embodiment, the vehicle 10 includes a step-through portion 19 defined by the frame member 15 of the vehicle 10. However, the aspects of the present subject matter are not limited to the depicted layout of the vehicle 10.

10 [0001] Further, a handlebar assembly 20 is connected to a front wheel 25 through one or more front suspension(s) 30. A steering shaft (not shown) connects the handlebar assembly 20 to the front suspension(s) 30 and the steering shaft is rotatably journaled about the head tube 16. A power unit 100 including an internal combustion (IC) is mounted to the frame member 15. The power unit 100 may also include a traction motor either hub mounted or mounted adjacent to the IC engine. In the depicted embodiment, the power unit 100 is disposed below at least a portion of the rear frame(s) 18. However, the power unit may be fixedly disposed below the main tube 17. In one implementation, the power unit 100 includes the IC engine, which is forwardly inclined type i.e. a piston axis (not shown) of the IC engine is forwardly inclined. The power unit 100 is functionally connected to a rear wheel 35 through a transmission system (not shown). The transmission system includes any one of a continuously variable transmission (CVT), a fixed gear ratio transmission, or automatic-manual transmission (AMT) controlled by an AMT control unit. Further, the vehicle 10 includes an air induction system (not shown) that provides air to an air-fuel mixing unit (not shown). A fuel tank (not shown) stores and supplies fuel to the air-fuel mixing unit, wherein the air-fuel mixing unit can be a carburetor or a throttle body with fuel injector. Also, the vehicle 10 includes a discharge system that helps in dissipation of exhaust gasses from the IC engine. The discharge system includes a muffler 45 mounted to the vehicle 10.

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[0002] Further, the rear wheel 35 is connected to the frame member 15 through one or more rear suspension(s) (not shown). In the depicted embodiment, the power unit 100 is swingably mounted to the frame member 15 through a toggle link (not shown) or the like. A seat assembly 50 is supported by the frame member 15 and is disposed rearward to the step-through portion 19 and above the power unit 100.

[0003] Further, the vehicle 10 includes a front fender 55 covering at least a portion of the front wheel 25. In the present embodiment, a floorboard 60 is disposed at a step-through portion 19 and is supported by the main frame 17 and a pair of floor frames (not shown). The user can operate the vehicle 10 by resting feet on the floorboard 60, in a sitting position. In an embodiment, a fuel tank (not shown) is disposed below the seat assembly 50 and behind the utility box. A rear fender 65 is covering at least a portion of the rear wheel 35. The vehicle 10 comprises of plurality of electrical/electronic components including a headlight 75, a tail light (not shown), a battery (not shown), a transistor controlled ignition (TCI) unit (not shown), an alternator (not shown), a starter motor (not shown). Further, the vehicle 10 may include a synchronous braking system, an anti-lock braking system.

[0004] The vehicle 10 comprises plurality of panels that include a front panel 80 disposed in an anterior portion of the head tube 16, a leg-shield 81 disposed in a posterior portion of the head tube 16. A rear panel assembly 82 includes a right side panel, a left side panel, and a central panel disposed below the seat assembly 50 and extending rearward from a rear portion of the floorboard 60 towards a rear portion of the vehicle 10. The rear panel assembly 82 encloses a utility box disposed below the seat assembly 50. Also, the rear panel assembly 82 partially encloses the power unit 100. Also, the muffler 45 of the discharge system is coupled to exhaust side of the IC engine and in an implementation, the muffler 45 is disposed towards one lateral side of the vehicle 10.

[00043] Fig. 1 (b) illustrates a perspective view of an exemplary power unit, according to an embodiment of the present subject matter. The power unit 100 includes a housing 101 that supports various components of the power unit 100.

The housing 101 supports a cylinder block (not shown) and a cylinder head (not shown) supported by the cylinder body. A cylinder head-cover 102 is mounted to the cylinder head. The power unit 100, according to the present embodiment includes an intake port 104 and an exhaust port (not shown) for supply of air-fuel mixture and for passing out exhaust gases, respectively. Further, a piston capable of moving in a reciprocating motion at a cylinder portion defined by the cylinder body. The piston is functionally connected to a primary rotating member 120 (shown as dotted line) of the power unit 100. In the present embodiment, the primary rotating member 120 is a crankshaft and the piston is functionally connected to the primary rotating member 120 through a connecting rod. The housing 101 rotatably supports the primary rotating member 120. In one embodiment, the housing 101 is made up of left-side portion 105 and a right-side portion 106.

[00044] In one embodiment, the power unit 100, which is an IC engine, may include an electric machine like an alternator/ magneto assembly or an integrated starter generator. The electric machine is either directly mounted to the primary rotating member 120 or is mounted to a shaft parallel to the primary rotating member 120.

[00045] Furthermore, the power unit 100 is provided with a forced air cooling system. The cooling system is formed by a shroud assembly 110 acting as an outer shell that is covering at least a portion of the power unit 100 and the shroud assembly 110 includes an air inlet 111 for drawing atmospheric air into the shroud assembly 110. Further, the cooling system includes a cooling fan 200 (shown in Fig. 2), which is mounted on the primary rotating member 120 in the present implementation. The cooling fan 200 is disposed in proximity to the air inlet 111. The cooling fan 200 includes plurality of mounting member 225 for securing the cooling fan 200 to the rotating member 120. In one embodiment, the cooling fan is secured to an alternate current generator (ACG) or to an integrated starter generator (ISG).

[00046] Fig. 2 illustrates a perspective view of the cooling fan, in accordance with an embodiment of the present subject matter. Fig. 3 illustrated another view

of the cooling fan, in accordance with the embodiment of Fig. 2. The cooling fan 200 includes a base 205, wherein the base, in the present embodiment, is disc shaped member. The base 205 includes an adjustment portion 210 disposed substantially at a centre portion, wherein adjustment portion 210 enables
5 adjustment of cam chain timing, valve timing or for tappet noise. For example, for adjusting tappet for reducing tappet noise, in a rocker disengaged condition, an Allen key may be used at the adjustment portion to adjust the tappet. The adjustment portion 210, in the present embodiment, is a hexagonal shaped portion that enables adjustment and servicing of valve train timing. The with the rotating
10 member 120/ a magneto assembly (not shown) by which relative rotation of rotating member 120 with the cooling fan 200 is avoided. The adjustment portion 210 may be any known geometric regular or irregular shape. Further, the cooling fan 200 includes a plurality of vanes 215 provided on one axial face thereof, wherein the one axial face is facing laterally outward of the power unit 100
15 towards the opening 111. The plurality of vanes 215 includes plurality of primary vanes 216 and plurality of secondary vanes 217 spaced annularly. The plurality of vane 215, in accordance with the present embodiment, are disposed rearward. In other words, an outward end of each of the vane 215 is radially lagging with respect to an inward end of the corresponding vane 215. A ring member 220 is
20 provided on an axially outward end of the plurality of vanes 215, wherein the ring member 220 gives structural strength to the vanes as the cooling fan 200 rotates with same speed as speed of the power unit 100.

[00047] Each secondary vane 217 of the plurality of secondary vanes 217 is disposed between two consecutively disposed primary vanes 216. The cooling fan
25 200 includes a bore portion 240 provided at a centre portion and the vanes are disposed outside the bore portion 240. In accordance with one embodiment, the primary vanes 216 are having an inward end in proximity to the bore portion 240 and are extending from a bore portion 240 towards an outer circumference of the cooling fan 200. The bore portion 240 is provided at a substantial axial center
30 thereof, and the secondary vanes 217 are having an inward end away from the bore portion 240 with respect to the inward end of the primary vanes 216. The

bore portion 240, provided at substantial center thereof, formed only by the primary vanes 216 offers flow attachment with the primary vanes with less disturbance to the flow.

[00048] The bore portion 240 acts an axial inlet for the atmospheric air that is drawn into the shroud assembly 110. The air entering the bore portion 240 enters a primary entry portion 250 formed by two consecutively placed primary vanes 216 and subsequently, the air passes through two secondary entry portions 251, 252 formed due to the secondary vane 217 disposed between the consecutively disposed primary vanes 216. Thus, effectively the portion/area for entry air is improved due to reduction in cumulative area. At a primary entry portion 250 for the air on the cooling fan 200, which is in proximity to the inward end of the primary vanes 216, a cumulative thickness of the primary vanes 216 is substantially less when compared with a fan with all full length vanes. The air exits the cooling fan 200 through plurality of exit paths 255 formed at the radial ends of the vanes 215.

[00049] Further, the secondary vanes 217 are oriented along the backward orientation of the primary vanes 216 whereby air passing through the primary vanes 216 even after passing through the secondary entry portion 251, 252 retains the momentum efficiently and provides a streamlined airflow. Thus, a high air pressure is maintained offering attached flow, whereby an optimum & smooth laminar flow pattern is obtained with reduction or elimination of the flow disturbance and turbulence. The pressurized air exiting the cooling fan is directed towards the components of the power unit 100 that require cooling. For example, the shroud assembly 110 directs the pressurized air towards the cylinder block and the cylinder head for cooling. Thus, for the air flow larger entry portion is provided due to the construction of the vanes 215 and the secondary vanes 217 in conjunction with the primary vanes 216 enable flow attachment thereby providing streamlined flow thereby reducing losses at exit due to reduced flow separation.

[00050] Further, the primary entry portion 250 defines a primary pitch 235 for entry of air into the vanes 215 and the provision of the secondary vane 217 creates a first secondary pitch 236 and a second secondary pitch 237. In a preferred

embodiment, a sum of a first secondary pitch 236 and the second secondary pitch 237 is at least substantially equal to a primary pitch 235. This enables in retaining the streamlined flow with minimum flow separation.

[00051] Further, the streamlined flow enables optimum cooling of the system, as the vanes 215 of the cooling fan 200 offers attached flow that is at a higher pressure. Furthermore, the power unit 100 when undergoing warmup, say during starting, the temperature of the cooling surfaces like fins of the cylinder head and the cylinder block are lower, because of which the convection is also less due to lower thermal coefficient. Thus, heat transfer due to convection from the engine parts to air flow is low because of which the power unit 100 gets warmer quickly. Additionally, in conditions like starting of the IC engine, the emission of pollutants is higher due to cold condition and cold running, and also due to parts like catalytic converter not attaining light-off which needs to be overcome by having quick warm-up. Thus, the present subject matter enabling faster warmup aids in reducing the emission as the cold running time is reduced.

[00052] Subsequently, when the part temperatures rise due to the warmup of the power unit 100, the heat-transfer coefficient/ film coefficient of heat transfer increases thereby increasing the heat-rejection to cooling air/air flow. Thus, the streamlined air flow directed by the cooling fan 200 offers improved convection thereby offering cooling effect. Besides, the present subject matter offers streamlined air flow, flowing with high pressure, reducing resistance on the cooling fan 200 due to reduced flow rate.

[00053] Further, as shown in Fig. 3, in one embodiment, a diametrical line D passing through the center of the cooling fan 200 cuts through at least three of the plurality of vanes. Thus, when a sectional portion is considered the vanes are provided such that the air flow gets attached to at least three vanes thereafter providing a streamlined flow of the air.

[00054] Fig. 4 depicts a perspective view of a cooling fan 201, in accordance with a second embodiment of the present subject matter. The cooling fan 201 includes a plurality of vanes 315 provided on one axial face thereof, wherein the one axial face is facing laterally outward of the power unit 100 towards the

opening 111. The plurality of vanes 315 includes plurality of primary vanes 316 and plurality of secondary vanes 317 spaced annularly. Further, a primary pitch 235 enables entry of air into two adjacently disposed primary vanes 316 and the provision of the secondary vane 317 between two consecutively placed primary
5 vanes 316 creates a first secondary pitch 236 and a second secondary pitch 237 through which the air flows with improved attachment to the vanes 316, 317 with reduced distortion in flow. In a preferred embodiment, a sum of a first secondary pitch 236 and the second secondary pitch 237 (similar to as shown in Fig. 3) is at least substantially equal to a primary pitch 235. This enables in retaining the
10 streamlined flow with minimum flow separation. The plurality of vanes 315, in accordance with the present embodiment, are backward type. In other words, an outward end of each of the vane 315 is radially lagging with respect to an inward end of the corresponding vane 315. However, the plurality of vanes can be radial type or forward type. In other words, the plurality of vanes is disposed in at least one of a radial, a forward, and a backward direction. In the present embodiment, a
15 ring member 221 is provided on an axially outward side of the plurality of vanes 315, wherein the ring member 221 covers a at least a portion/length of the secondary vanes 317 when viewed axially. In the depicted implementation, the term 'at least a portion' used herein refers to at least 75% of the secondary vanes
20 317 are covered by the ring member 221. However, the ring member 221 may be adapted to cover at least a 20% of a length of the secondary vanes (317) and a maximum of 90% of a length of the secondary vanes (317) when viewed axially. Thus, in cooling fan requiring a guided region for the air flow without any losses, especially in open axial direction of vanes, the ring member 221 is increased up to
25 90% to of the secondary vane length whereby the ring is rigidly supported by all the vanes of the cooling fan. Further, the structural integrity of the cooling fan is retained. Thus, the present subject matter provides a closed path for the air flow with minimum or no losses from the secondary vanes where the attachment with the secondary vanes also occurs.

30 **[00055]** The ring member 221 provides structural support to the vanes 315 from getting deflected even at high speeds of operation. Further, the ring member 221

along with a base 206 and the vanes 315 provides a guided path for the air to be directed in radial direction. Thus, any losses in axial direction can be reduced and the flow attachment is improved as the ring member 221 also enables guiding of the air. Further, the vanes in proximity to the bore portion 240 are provided with a height elevated when compared to the height of the vanes near to the periphery thereby improving flow attachment.

[00056] Fig. 5 depicts a sectional view of the cooling fan 201 taken along axis X-X', in accordance with an embodiment of the present subject matter. The base 206 is having a conical shape, wherein the vanes 315 are mounted on the outer periphery of the conical shape. In the depicted embodiment, a line 265 passing through the cut section edge of the cooling fan 200 is at angle α , which is the cone-half angle α . The cone-half angle α can be in the range of 30-90 degrees. Thus, the cone-half angle α of the base is adapted to accommodate height of the vanes to have an attached airflow at the entry portion itself thereby reducing disturbance in the flow. Further, in the present embodiment, the height of vanes 315 are maintained substantially uniform, by virtue of the conical profile of the base, the outer edge (axial) of the vanes is at angle/inclination. The inclination is towards axial centre of the cooling fan 201. Thus, air that is drawn into the cooling fan, get attached to the primary vanes and gets guided in radial direction towards the secondary vanes 317. Further, ring member 221 with larger radial surface retains the streamlined flow of the air providing desired pressure.

[00057] Fig. 6 depicts a perspective view of a cooling fan, in accordance with yet another embodiment of the present subject matter. The cooling fan 202 includes a plurality of vanes 415 provided on one axial face thereof, wherein the one axial face is disposed laterally outward with respect to the power unit 100 and towards the opening 111 of the shroud assembly 110 (shown in Fig. 1). The plurality of vanes 415 includes plurality of primary vanes 416 and plurality of secondary vanes 417 spaced annularly on the axial. In one implementation, the cooling fan is made of a polymer and the vanes 415 are integrally formed with a base 205. Further, a primary pitch 235 enables entry of air into two adjacently disposed primary vanes 416 and the secondary vane 417 is disposed between the two

consecutively placed primary vanes 416. Air draws towards the cooling fan 202 in axial direction is directed towards the primary pitch 235 providing a primary entry path. subsequently, the air enters a first secondary pitch 236 and a second secondary pitch 237 formed by the provision of the secondary vane 417 between two consecutively placed primary 416 thereby improving flow attachment to the vanes. In one embodiment, a true length of the secondary vane 417 is a maximum of 75% of the true length of the primary vane 416 whereby the overall material used for the cooling fan is reduced in spite of providing optimum number of vanes 415. The true length of the secondary vane can be 50-75% of the true length of the primary vane, whereby the secondary vane would start. In a preferred embodiment, a sum of a first secondary pitch 236 and the second secondary pitch 237 is at least substantially equal to a primary pitch 235 to enable streamlined flow of the air. Further, in the present embodiment, the bore portion 240 is substantially a semi-spherical portion. Each of the inward end of the vanes 415 is a curved portion to form the semi-spherical bore portion 241.

[00058] Fig. 7 shows a cut-sectional view of the cooling fan 202 taken along axis Z-Z', in accordance with an embodiment of the present subject matter. The inward edge 475 of the vanes 415 are having the curved portion 460, wherein the curved portion 460 enables improved intake of air in axial direction. In one embodiment, the inward edge 475 is having a gradual reduction of a height 470 in a radial inward direction. In another embodiment, the inward edge is having an exponential reduction in the height 470. The curved portion 460 separates attachment points in both radial and axial direction, wherein the curved portion causes flow attachment resulting in streamlined flow. Smooth entry of air flow AF is created due to the outer edges of the vanes 415, especially the inwardly disposed primary vanes 416 are away from the axial centre A-A' and at the same time the lower portion of the vanes 415 is in proximity to the vanes 415. Thus, the primary vanes 416 enable entry of air at the axial centre, which is the bore portion 440, wherein the attachment of air flow AF to the vanes 415 happens on at the bottom portion for the air passing near the axial centre A-A'. Further, air flow AF away from the axial centre A-A', but at the bore portion 440, gets attached along

the curved portion 460 of the vanes. Further, the vanes 415 are disposed at an inclination with respect to an imaginary base plane, wherein a line 203 depicts inclination of the vanes 415 with the imaginary base plane.

[00059] Thus, the pressurized air flow AF with streamlined flow gets directed
5 towards the parts of the power unit viz. the cylinder block, cylinder head, or spark plug for dissipation of heat through convection.

[00060] Fig. 8 shows a side view of an exemplary power unit provided with a cooling fan, in accordance with an embodiment of the present subject matter. Flow is depicted as discrete arrows for brevity and clarity. As shown, substantial
10 amount of air enters from a bore portion 240 formed on the cooling fan 200. The entry of air into the path formed by the primary vanes 216 is depicted as thick arrows at the substantial centre of the cooling fan 200. Further, air entering through the path formed between two consecutively disposed primary vanes 216 gets attached to those primary vanes 216 and the secondary vane 217 provided
15 therebetween. The air entering the secondary paths is depicted as thin arrows that exit the cooling fan 200 enter a volute casing portion 112 of the shroud assembly 110 that gets directed towards the guiding case 113 that substantially encloses at least a portion of the power unit 100.

[00061] The power unit 110 when mounted to the motor vehicle 10 either by
20 fixed mounting or by swingable mounting, the cooling fan 200/201/202 will be capable of providing improved performance & efficiency of the power unit. Even in the motor vehicle 10 as shown in Fig. 1 (a), the power unit 100 will be capable of providing a streamlined flow of air that is utilized for cooling of the components of the power unit 110. For example, the cooling fan 200 would be
25 capable of effectively cooling the cylinder block region in case of an IC engine acting as the power unit.

[00062] Effectively, the streamlined flow of air offered by the cooling fan 200 reduces resistance to the flow of air. At the same time, the vanes of the cooling fan enable in reducing flow rate, across major speeds of operation of the power
30 unit 100. Fig. 10 depicts a schematic view of flow, in accordance with an embodiment of the present subject matter. The region marked as C depicts the

streamlined, smooth & laminar flow at the entry portion, also referred to as primary pitch. Thus, due to the presence of only primary vanes at the entry portion, there is smooth flow/entry at primary pitch. Subsequently, as shown in Fig. 10 at region C, the primary vanes draw air with minimal or no disturbance and subsequently the air flow gets attached to the secondary vane disposed between the two consecutively disposed primary vanes. This creates a smooth flow from entry of the blades and also retains and smooth and attached flow till the exit. Further, as shown in region marked as D, the streamlined flow exits the cooling fan and is directed towards the power unit components. Further, the cooling fan is subjected to low resistance due to undisturbed and streamlined flow. Further, as depicted in Fig. 11, the line B shows a reduced power consumption by the cooling fan due to the streamlined and attached flow. The power consumed by the cooling fan further reduced at higher engine speeds whereby the power can be utilized for other power unit functions. As can be seen, the difference in power ΔP increases at higher even at higher speeds thereby providing improved performance at higher speeds also.

[00063] Also, the heat transfer, which is function of flow rate is reduced by which early heating of the power unit is achieved especially during start. Once the components/parts of the power unit get heated up, due to raise in surface temperature, the heat transfer coefficient increases by which the cooling system works in heat dissipation.

[00064] Many modifications and variations of the present subject matter are possible in the light of above disclosure. Therefore, within the scope of claims of the present subject matter, the present disclosure may be practiced other than as specifically described.

List of reference signs:

10	power unit	30	113	guiding case
15	frame member	120		rotating member
16	head tube	200/ 201/ 202		cooling fan
5	17	203		line
18	rear frame	205/ 206		base
19	step-through portion	35	210	mounting portion
20	handlebar assembly	215/ 315/ 415		vanes
25	front wheel	216/ 316/ 416		primary vane
10	30	217/ 317/ 417		secondary vane
35	rear wheel	220/221		ring member
45	muffler	40	225	bore portion
50	seat assembly	235		primary pitch
55	front fender	236		first secondary pitch
15	60	237		second secondary pitch
65	rear fender	240/ 440		bore portion
75	head lamp	45	250	primary entry portion
80	front panel	251/252		secondary entry portion
81	leg-shield	255		exit path
20	82	260		height
100	power unit	265		line
101	housing	50	460	concave profile
102	cylinder head-cover	470		height
104	intake port	475		inward edge
25	105	500		fan (prior art)
106	right-side portion	α		cone-half angle
110	shroud assembly	55	AF	air flow
111	inlet	D		diametric line
112	casing portion	A-A'		axial center

We Claim:

1. A power unit (100) for a motor vehicle (10), said power unit (100) comprising:
 - a housing (101);
 - 5 a rotating member (120), said rotating member (120) rotatably supported by said housing (101);
 - a shroud assembly (110), said shroud assembly (110) acting as an outer shell with an air inlet (111), said shroud assembly (110) at least partially enclosing at least a portion of the power unit (100); and
 - 10 a cooling fan (200, 201, 202) operably attached to the rotating member (120), and said cooling fan (200, 201, 202) disposed towards one lateral side of said power unit (100), said cooling fan (200, 201, 202) includes plurality of vanes (216, 217, 316, 317, 416, 417), said plurality of vanes (216, 217, 316, 317, 416, 417) being formed by a plurality of
 - 15 primary vanes (216, 316, 416) and a plurality of secondary vanes (217, 317, 417), each secondary vane of said plurality of secondary vanes (217, 317, 417) is disposed between two consecutively disposed primary vanes (216, 316, 416), and said plurality of secondary vanes (217, 317, 417) having a length smaller than a length of said plurality of primary vanes
 - 20 (216, 316, 416).
2. The power unit (100) as claimed in claim 1, wherein said cooling fan (200, 201, 202) comprises a sum of a first secondary pitch (236) and a second secondary pitch (237), corresponding to said secondary vanes (217, 317, 417) disposed between said two consecutively disposed primary vanes (216, 316, 416),
- 25 is at least substantially equal to a primary pitch (235) between two consecutively disposed primary vanes (216, 316, 416).
3. The power unit (100) as claimed in claim 1, wherein said cooling fan (200, 201, 202) includes said plurality of primary vanes (216, 316, 416) extending from a bore portion (240, 440) towards an outer circumference of the cooling fan (200,
- 30 201, 202), and said bore portion (240, 440) is provided at a substantial axial center thereof.

4. The power unit (100) as claimed in claim 1, wherein said plurality of vanes (216, 217, 316, 317, 416, 417) are disposed in at least one of a radial, a forward, and a backward direction, and said secondary vanes (217, 317, 417) are having a true length to be 50-75% of a true length of the primary vanes (216, 316, 416).

5 4. The power unit (100) as claimed in claim 1, wherein said cooling fan (202) includes a bore portion (440) having a semi-spherical profile, and one or more inward edge(s) (475) of said plurality of primary vanes (416) are having a curved portion (460) forming said semi-spherical profile, and wherein an inward edge(s) (475) of said plurality of are having a height (460) receding when moving towards an axial center (A-A') of said cooling fan (202).

6. The power unit (100) as claimed in claim 1, wherein said cooling fan (200) includes a base (206) having a conical shape, wherein said plurality of vanes (316, 317) are mounted on an outer periphery of the conical shape, and said base (206) is having a cone-half angle (α) in a range of 30-90 degrees.

7. The power unit (100) as claimed in claim 1, wherein said cooling fan (200) includes a ring member (221) provided on an axially outward side of the plurality of vanes (315), wherein the ring member (221) covering at least a 20% of a length of the secondary vanes (317) when viewed axially.

20 8. The power unit (100) as claimed in claim 1, wherein said cooling fan (200) includes a ring member (221) provided on an axially outward side of the plurality of vanes (315), wherein the ring member (221) covers a maximum of 90% of a length of the secondary vanes (317) when viewed axially.

9. The power unit (100) as claimed in claim 1, wherein said cooling fan (200, 201, 202) includes a diametric line (D) passing through an axial thereof, and said diametric line (D) passes through at least three vanes of said plurality of vanes (216, 217, 316, 317, 416, 417).

10. A cooling fan (200, 201, 202) comprising:
a base (205, 206);
30 a plurality of vanes (216, 217, 316, 317, 416, 417) disposed on at least one axial face thereof, said plurality of vanes (216, 217, 316, 317, 416, 417) being formed by a plurality of primary vanes (216, 316, 416) and a

plurality of secondary vanes (217, 317, 417), each secondary vane of said plurality of secondary vanes (217, 317, 417) is disposed between two consecutively disposed primary vanes (216, 316, 416), and said plurality of secondary vanes (217, 317, 417) having a length smaller than a length
5 of said plurality of primary vanes (216, 316, 416).

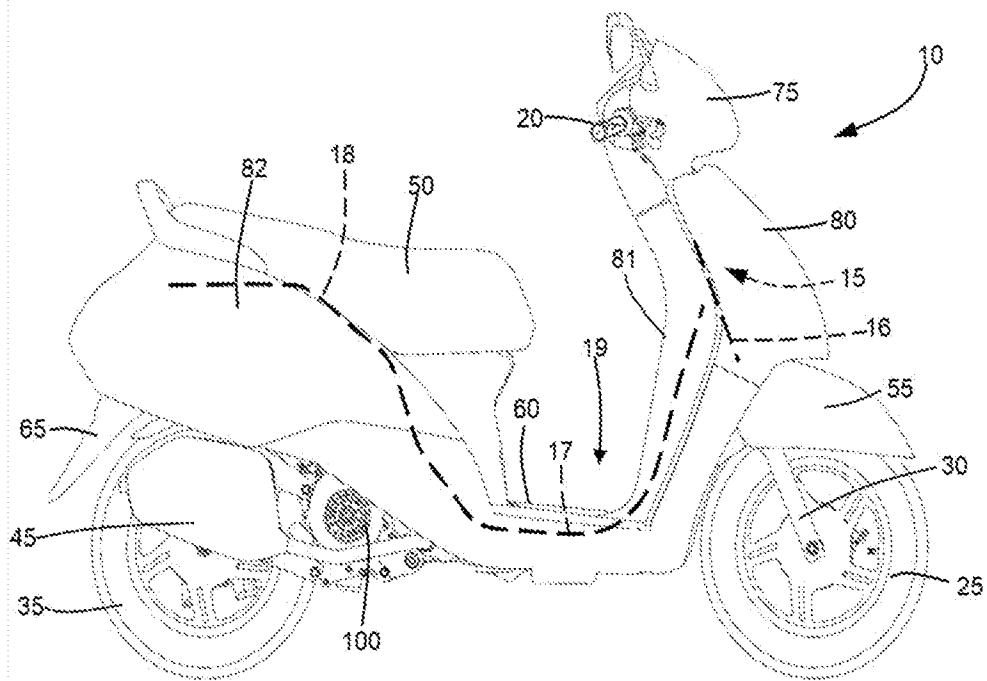


Fig. 1 (a)

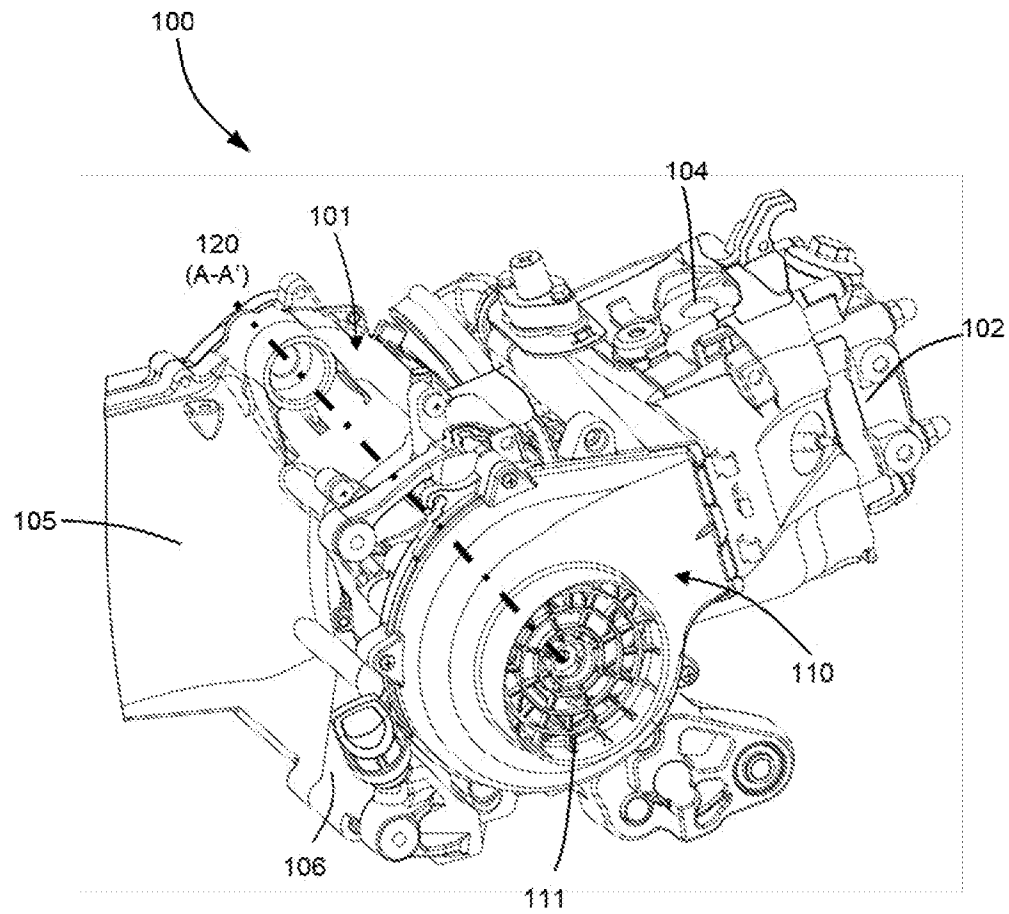


Fig. 1 (b)

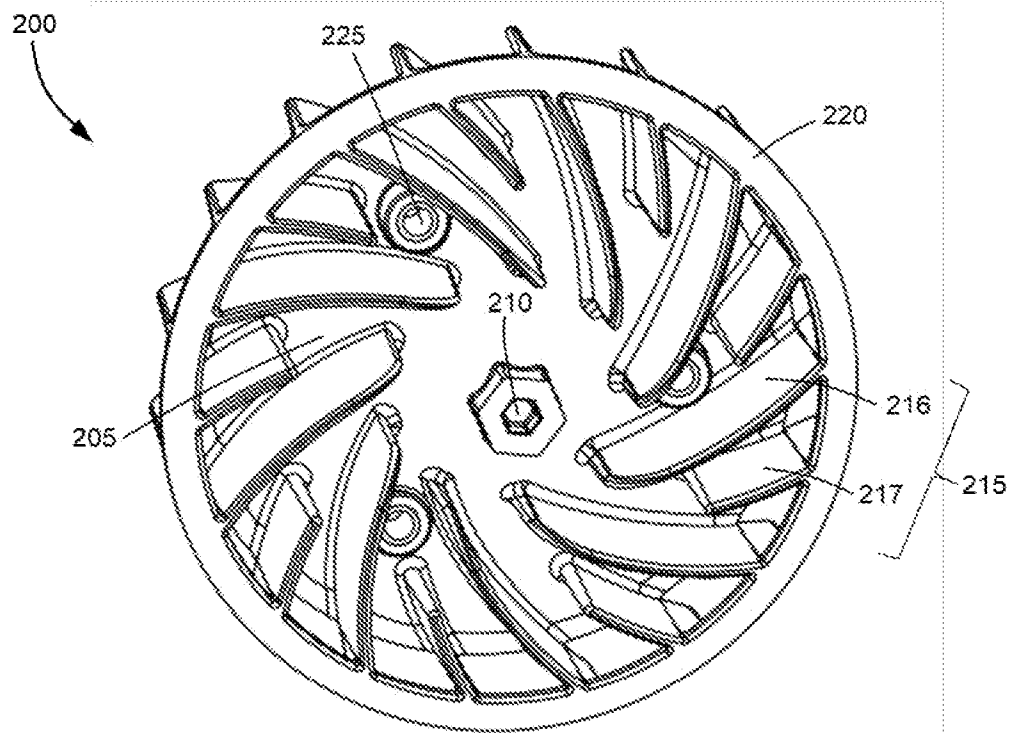


Fig. 2

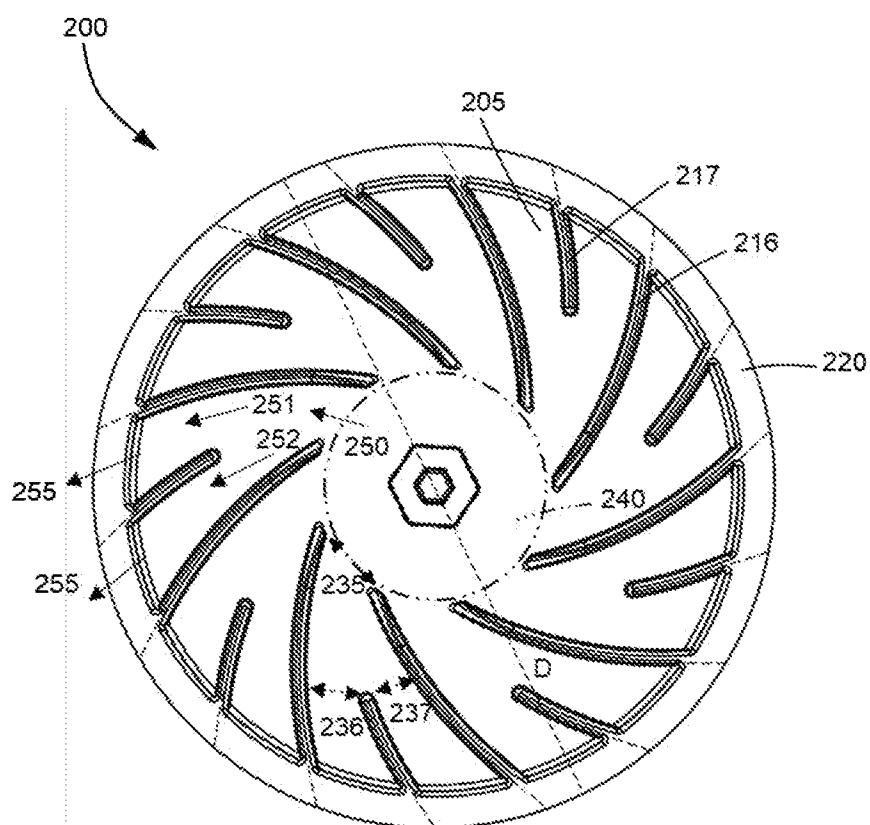


Fig. 3

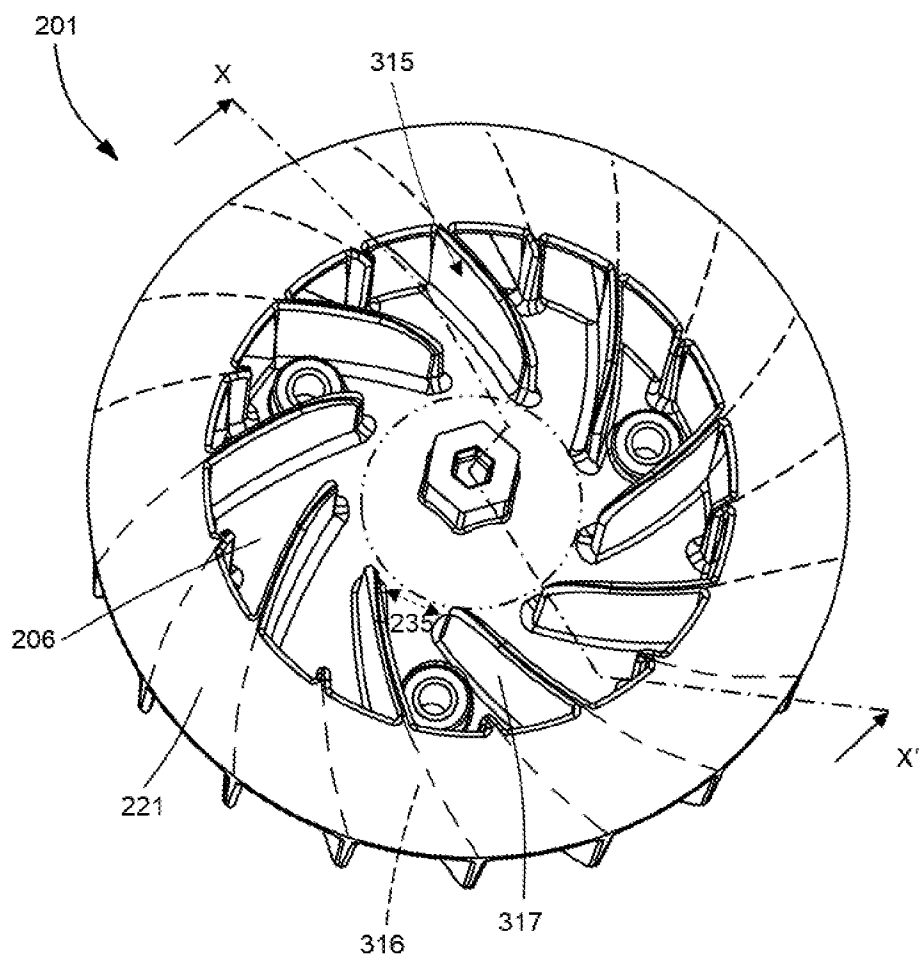


Fig. 4

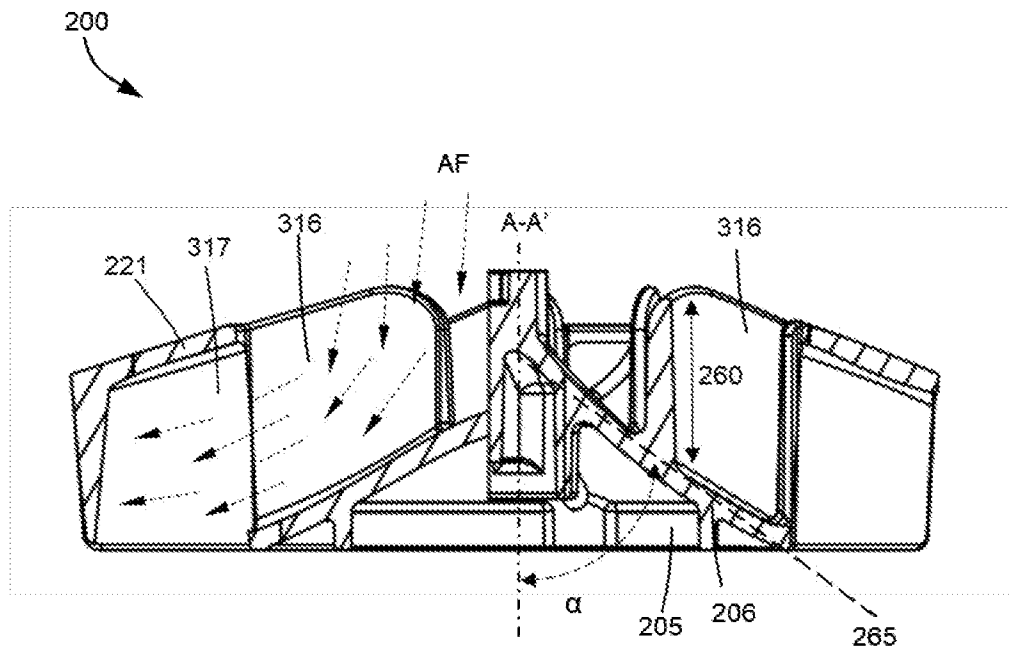


Fig. 5

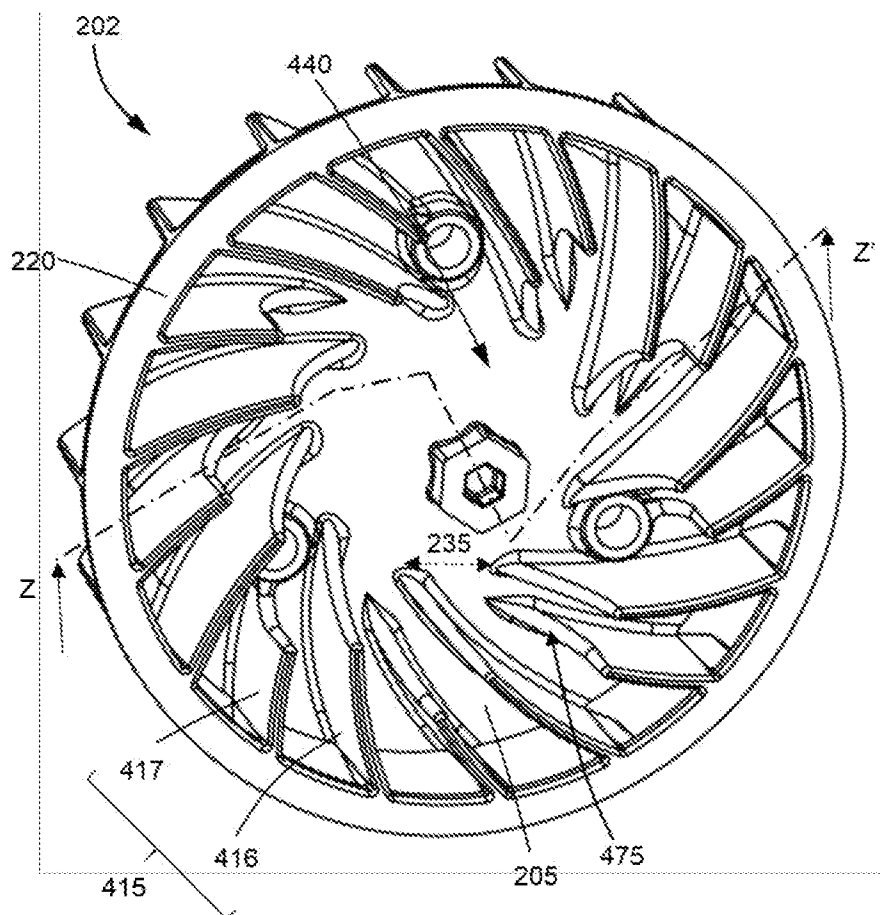
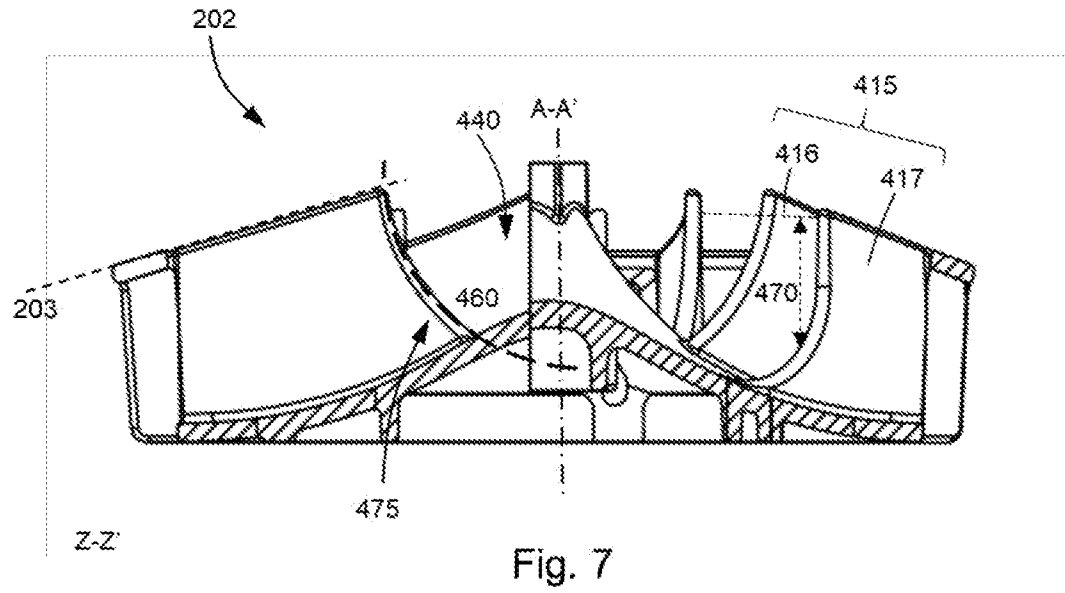


Fig. 6



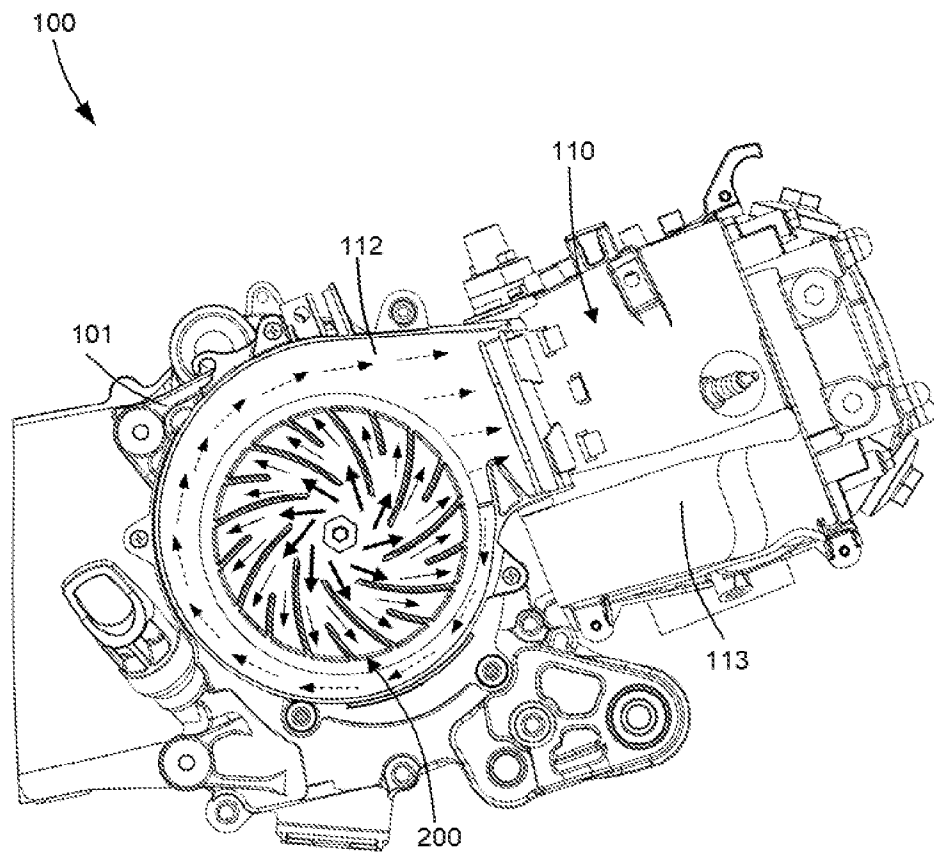


Fig. 8

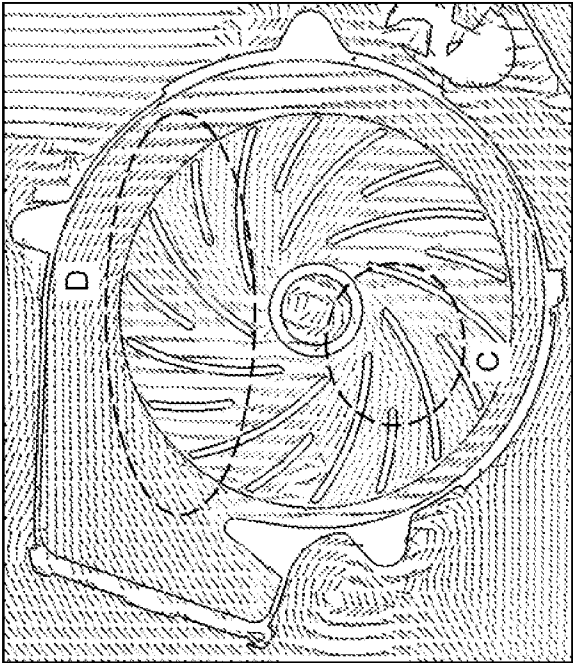


Fig. 10

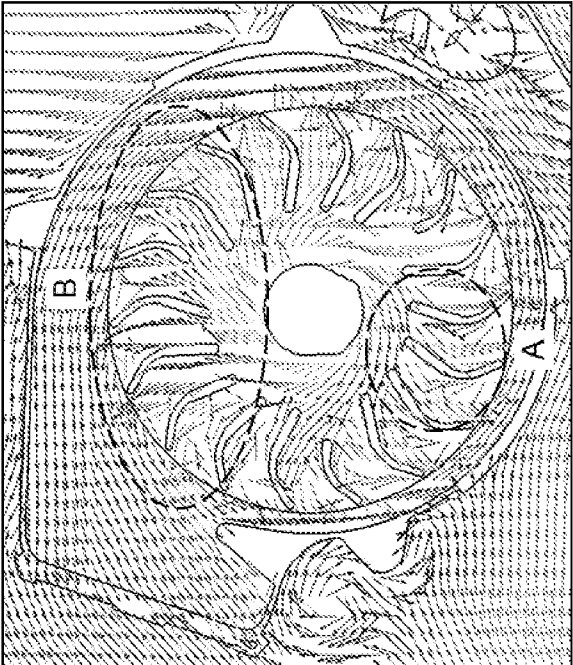


Fig. 9
(Prior art)

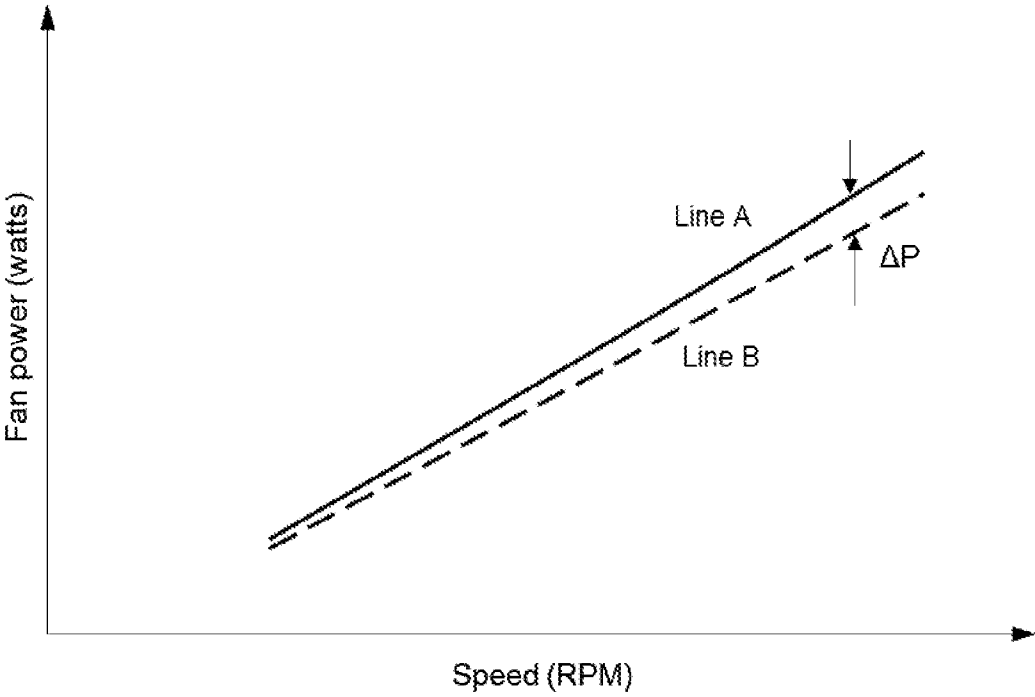


Fig. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/IN2020/050221

A. CLASSIFICATION OF SUBJECT MATTER INV. F01P1/02 F01P5/02 F01P5/06 ADD.		
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) F01P		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 7 484 925 B2 (EMP ADVANCED DEV LLC [US]) 3 February 2009 (2009-02-03)	1-3,10
A	column 1, lines 17-22; figures 1-4 column 3, lines 53-65 column 4, lines 23-39	4-9
A	----- US 5 542 380 A (CHATTEN J KEITH [US]) 6 August 1996 (1996-08-06) column 3, lines 54-65; figures 1,2,5	1-10
A	----- DE 42 03 885 A1 (STIHL MASCHF ANDREAS [DE]) 12 August 1993 (1993-08-12) column 2, lines 16-41; figure 1 -----	1-10
☐ 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) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family	
Date of the actual completion of the international search 28 May 2020	Date of mailing of the international search report 09/06/2020	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Luta, Dragos	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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