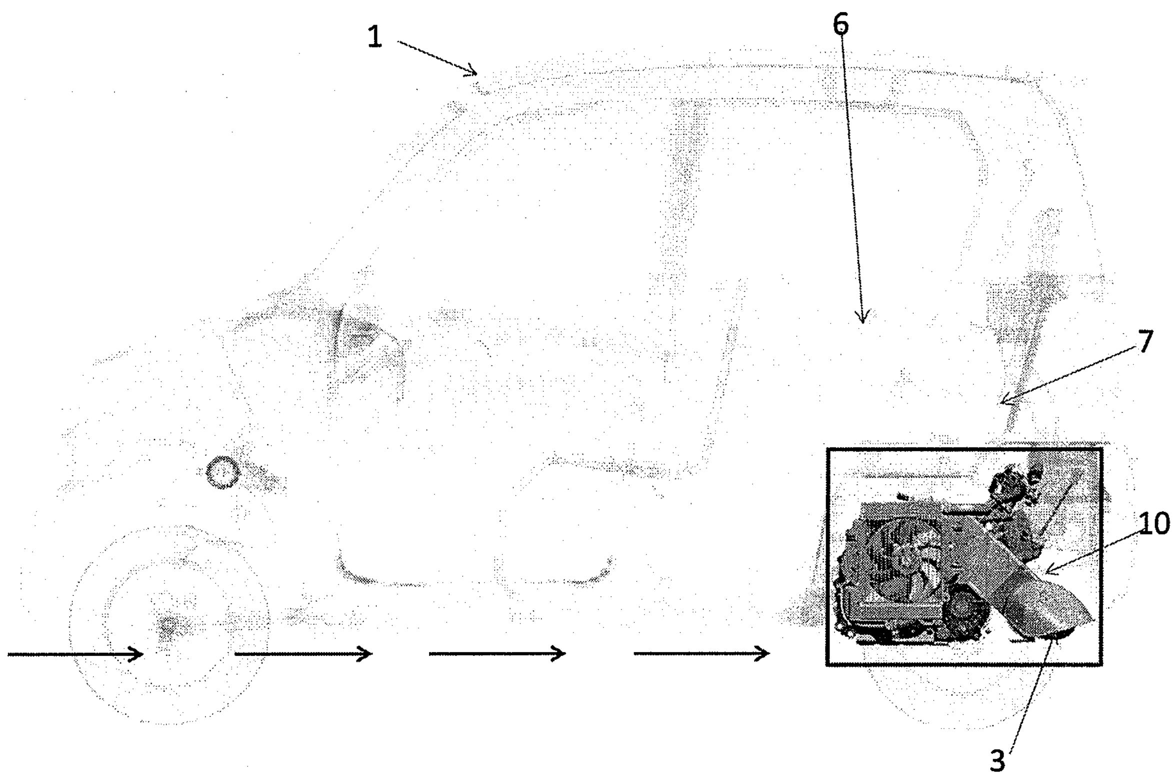


Figure 1

For **BAJAJ AUTO LIMITED**,
By its attorney

(BRINDA MOHAN)

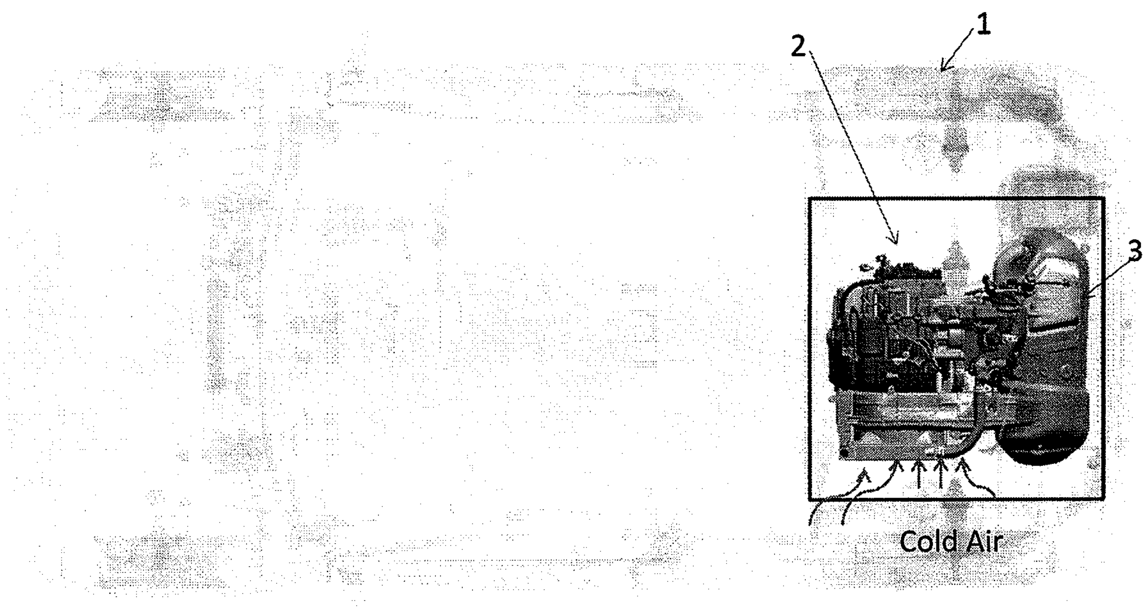


Figure 2

For **BAJAJ AUTO LIMITED**,
By its attorney

(BRINDA MOHAN)

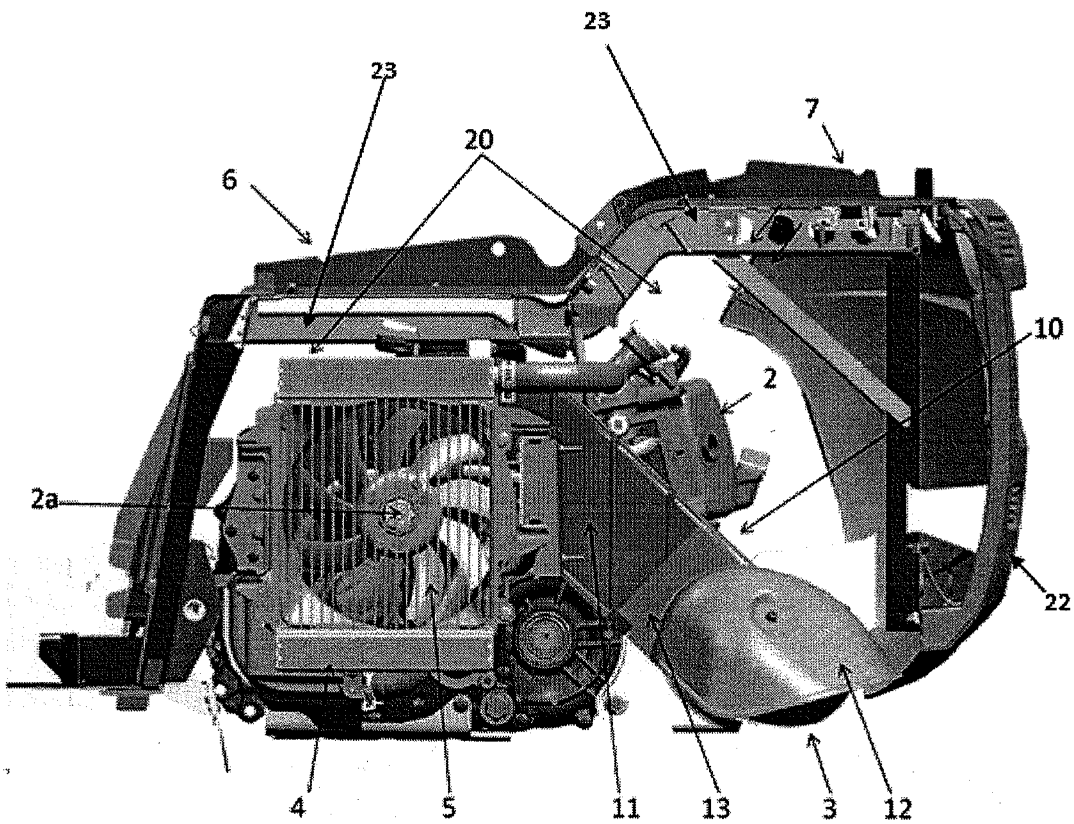


Figure 3

For **BAJAJ AUTO LIMITED,**
By its attorney

(BRINDA MOHAN)

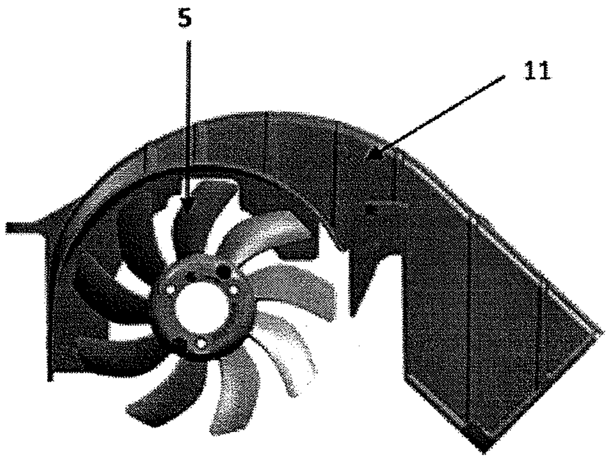
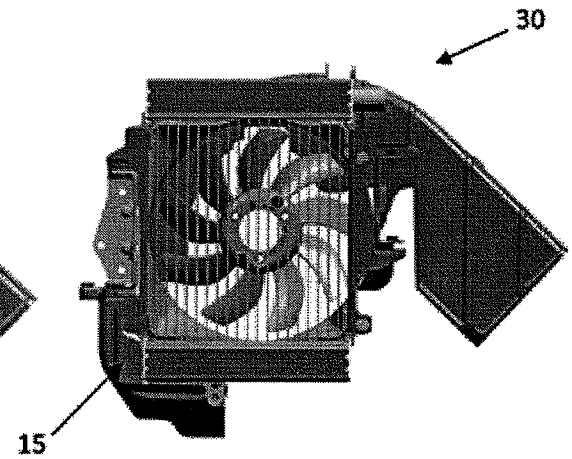


Figure 3a



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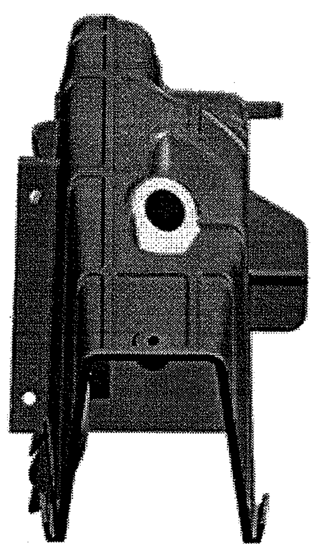

Figure 3c

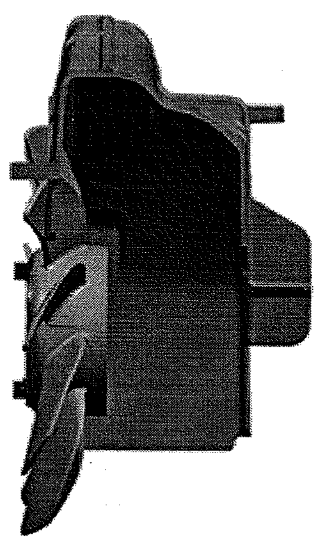

Figure 3d

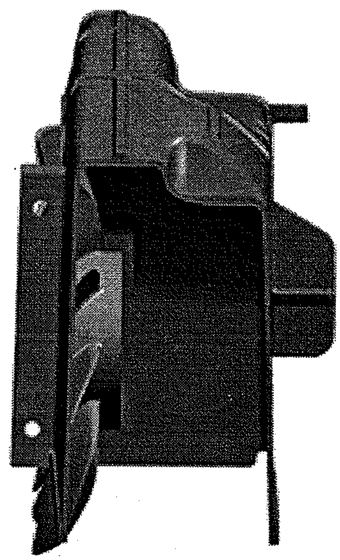

Figure 3e

For **BAJAJ AUTO LIMITED**,
By its attorney

(BRINDA MOHAN)

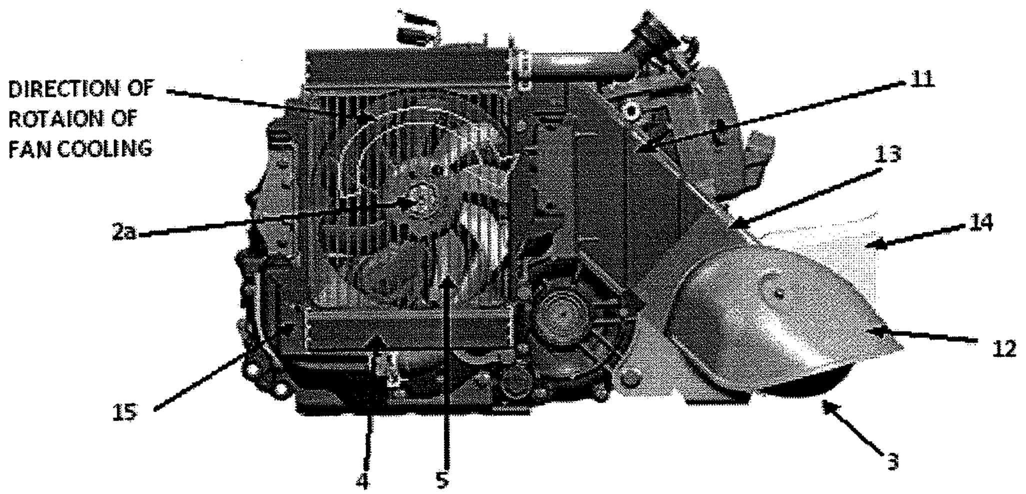

Figure 4a

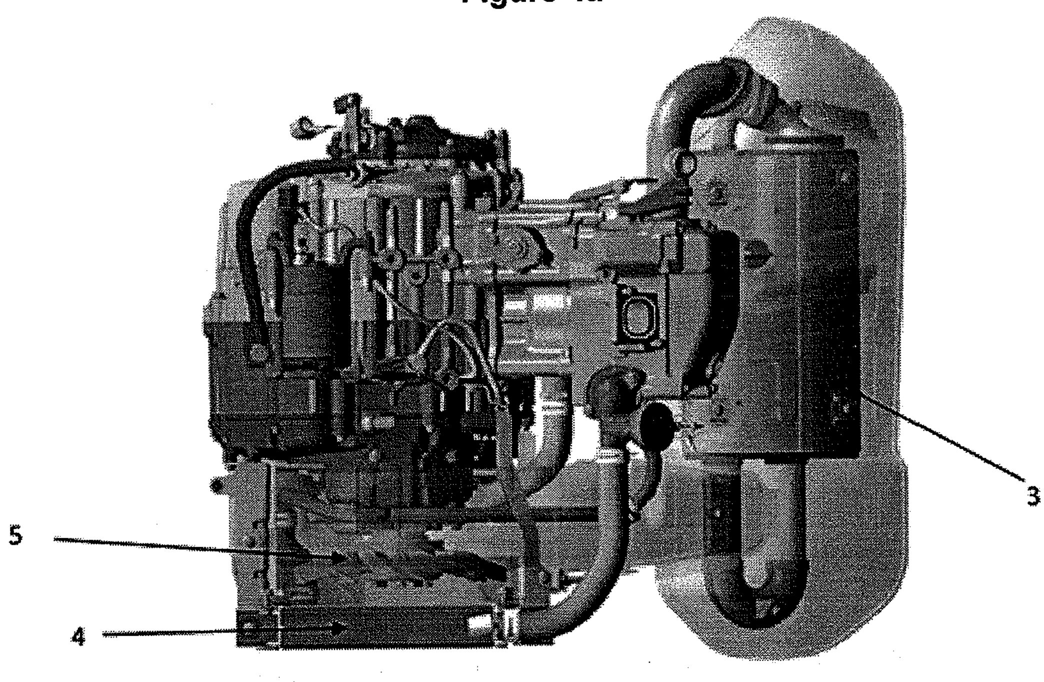

Figure 4b

For **BAJAJ AUTO LIMITED,**
By its attorney

(BRINDA MOHAN)

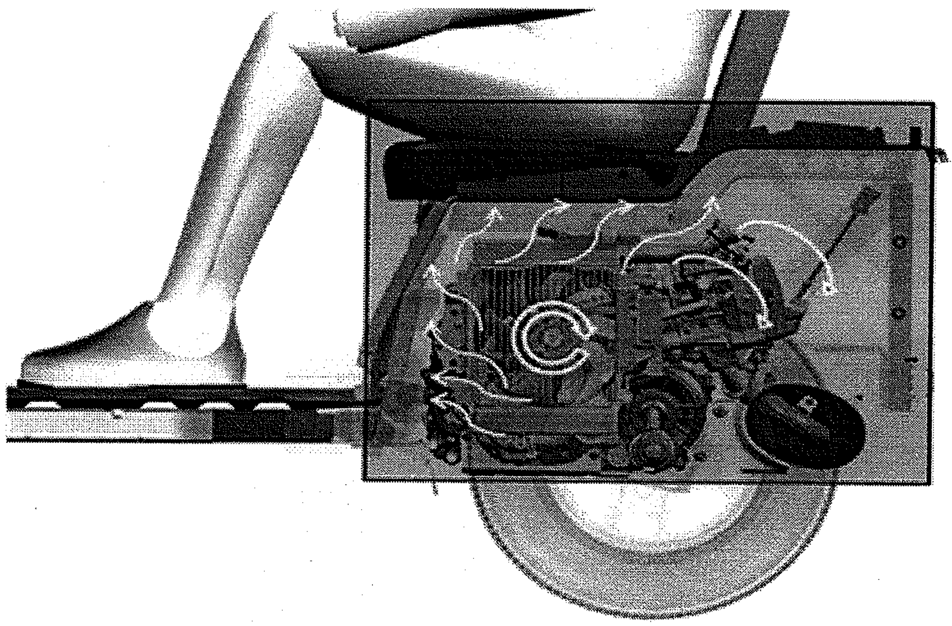

Figure 5a

For **BAJAJ AUTO LIMITED**,
By its attorney

(BRINDA MOHAN)

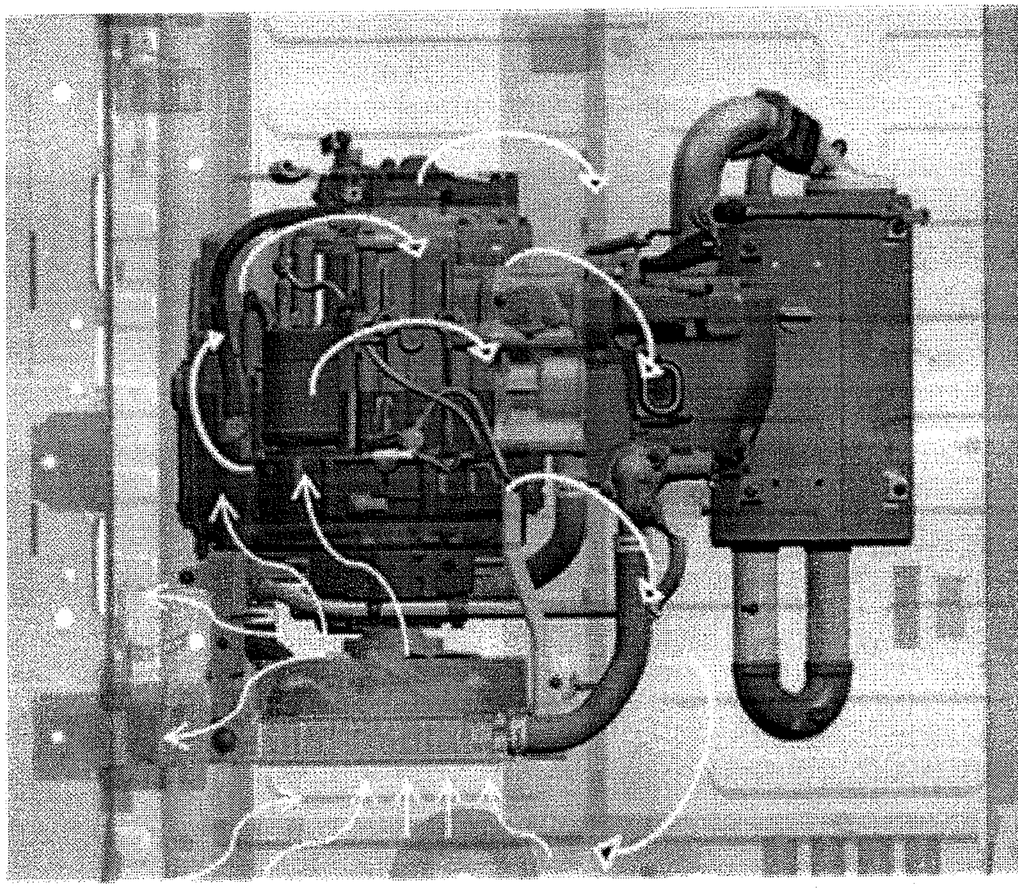

Figure 5b

For **BAJAJ AUTO LIMITED,**
By its attorney

(BRINDA MOHAN)

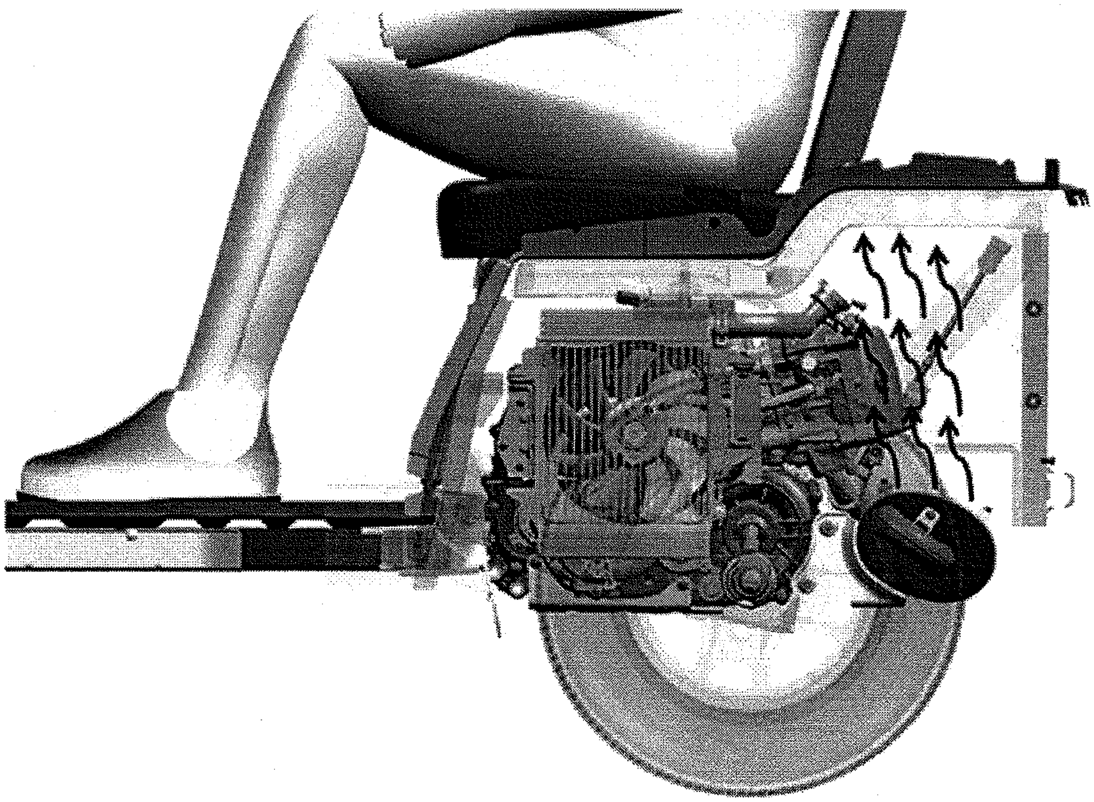

Figure 6

For **BAJAJ AUTO LIMITED**,
By its attorney

(BRINDA MOHAN)

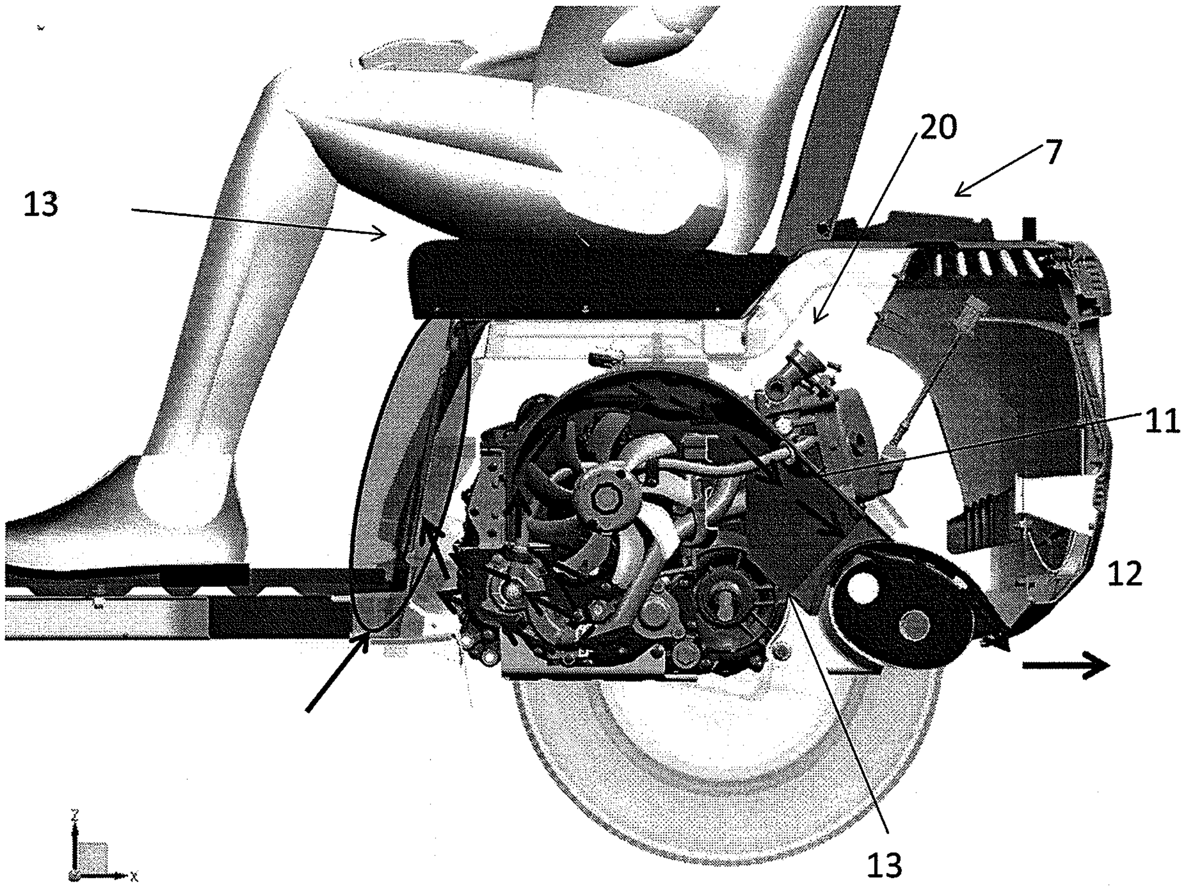

Figure 7a

For **BAJAJ AUTO LIMITED**,
By its attorney

(BRINDA MOHAN)

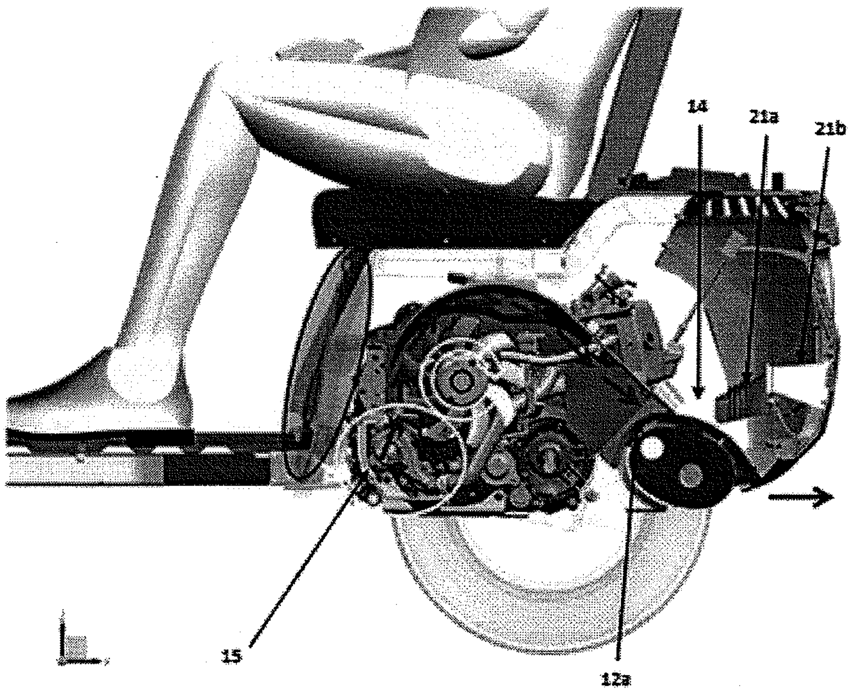

Figure 7b

For **BAJAJ AUTO LIMITED,**
By its attorney

(BRINDA MOHAN)

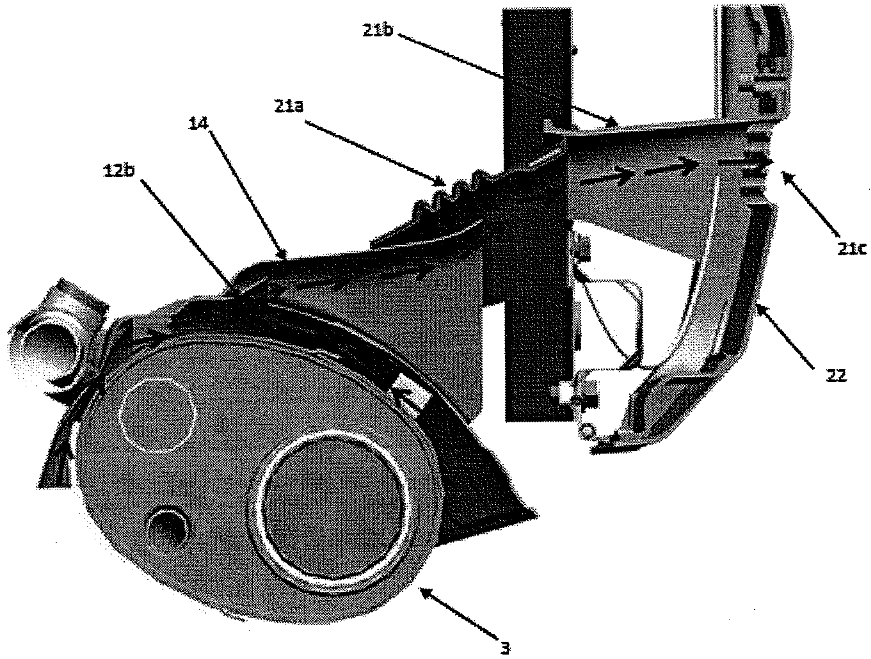

Figure 8

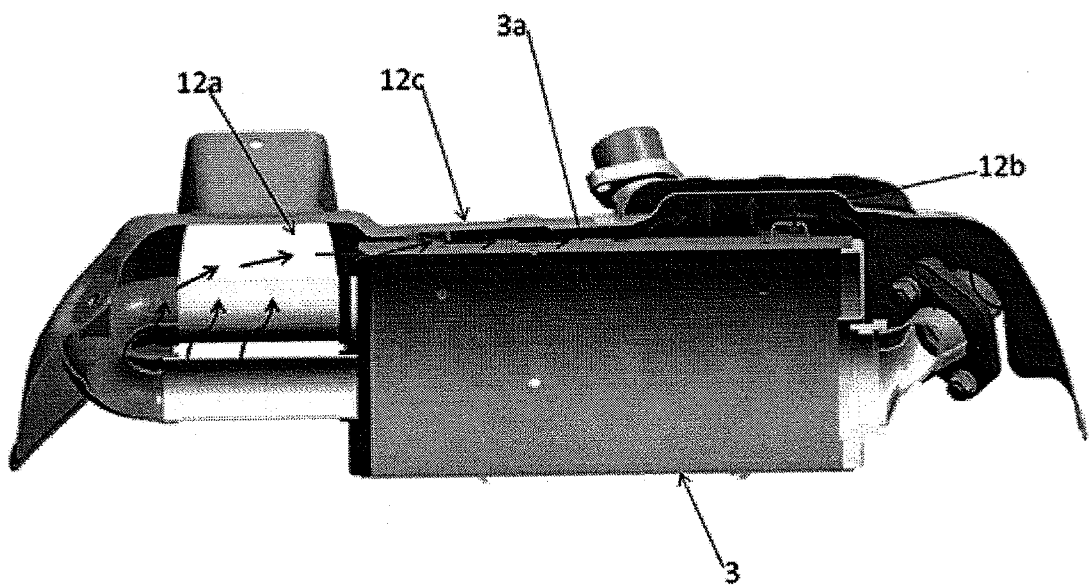

Figure 9

For **BAJAJ AUTO LIMITED,**
By its attorney

(BRINDA MOHAN)

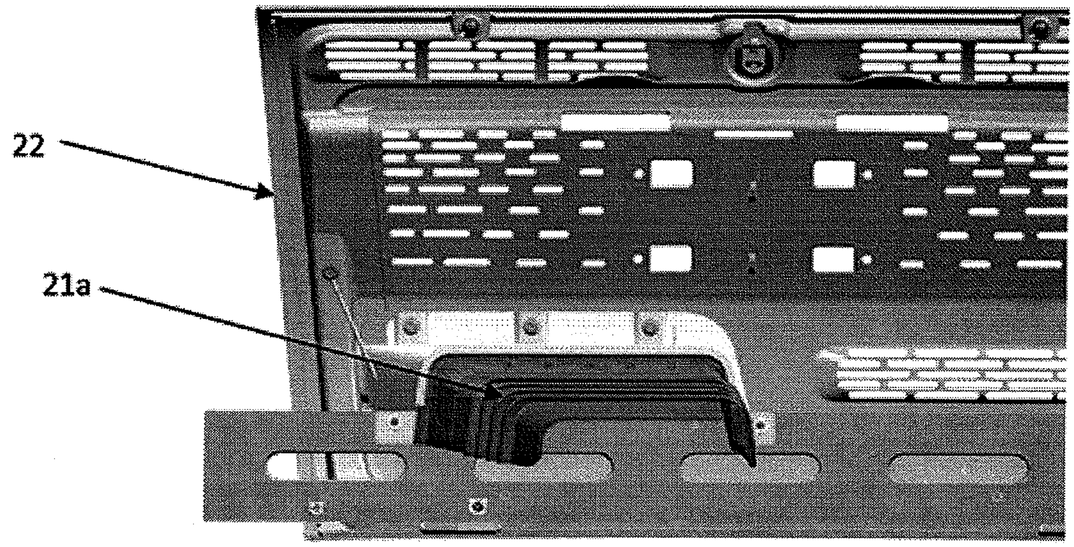

Figure 10

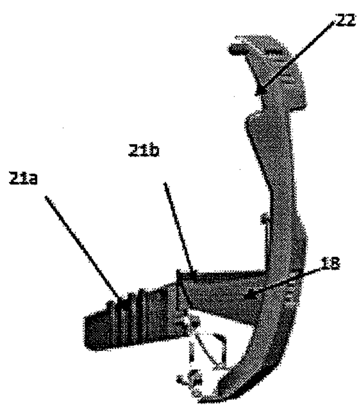

Figure 10a

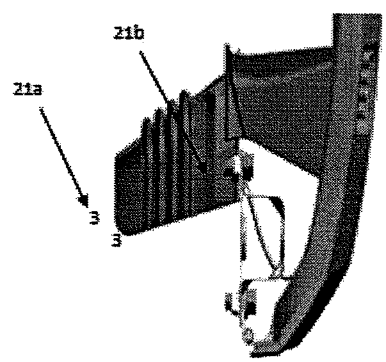

Figure 10b

For **BAJAJ AUTO LIMITED,**
By its attorney

(BRINDA MOHAN)

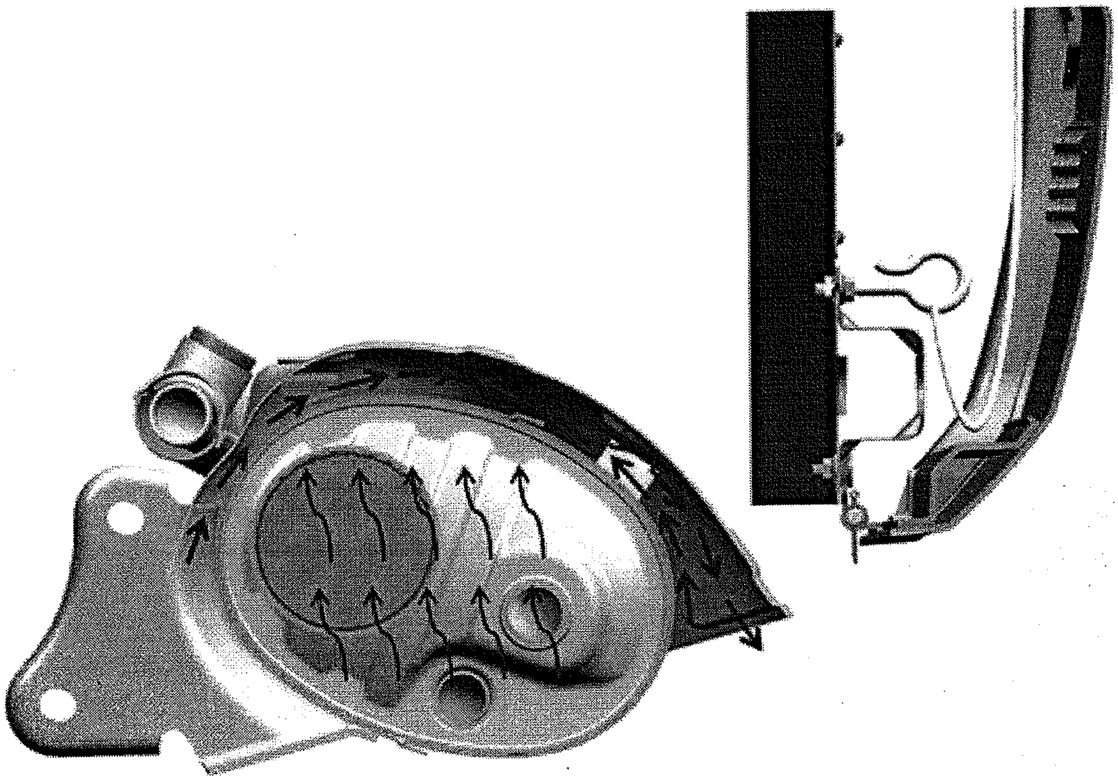

Figure 11

For **BAJAJ AUTO LIMITED**,
By its attorney

Brinda Mohan

(BRINDA MOHAN)

Field of the Invention

This invention relates to a heat or thermal management system for an automotive vehicle, particularly a vehicle with compact layout.

Background to the Invention

Automotive vehicle engines heat up during running conditions. Liquid cooling is one of preferred cooling methods. Basic principle of liquid cooling consist of a coolant which is pumped through passages in the engine block/head (Heat Source) and is subsequently passed through a heat exchanger called radiator (Heat Sink) associated with a cooling fan. Ambient air is passed over the radiator cooling the engine.Thus the heat from the engine is transferred to the atmosphere. Further, liquid cooling should be sufficient so that the metal temperatures of engine and its components are within the operating range for better performance and service life of engine.

The engine needs to be cooled to retain its performance during running conditions. Normally the engine is located in an engine compartment, rearward to the radiator and its associated cooling fan. So when ambient air is passed over the radiator cooling the radiator, the generated heated air moves across the radiator. This creates a problem because this heated air is drawn towards the engine and remains within the engine compartment. This causes heating of the engine compartment and heat or thermal management is required to dissipate hot air away from the engine and engine compartment. Such heat dissipation is essential for better engine performance, protection of the passenger/driver compartment; and heat protection of surrounding engine and vehicle components. Without such heat management, discomfort and unsafe conditions can get created due to excessive overheating.

The heat management problem is particularly severe for vehicles with a compact layout. Compact layout helps in having smaller vehicles and downsized engines in response to the need for radically reducing vehicle emissions. Also ever increasing fuel costs calls for a highly fuel efficient and viable internal combustion engine technology. One way of achieving the above goals is to reduce the vehicle weight.

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Reducing vehicle weight helps to reduce the tractive effort required to accelerate the vehicle and hence reduces the rolling resistance from the tires.

Towards this, placing the engine near the driven rear wheels allows for a physically smaller, lighter, less complex, and more efficient drivetrain, since there is no need for a driveshaft, and the differential can be integrated with the transmission.

In compact vehicles, the exhaust system may also be located within the engine compartment, close to the engine. In this case, significant heat is dissipated by the exhaust system into the engine compartment and also towards the passenger/driver compartment leading to an uncomfortable or unsafe situation. Typically, overheating conditions are most severe when the engine stops running or the vehicle comes to a halt after running for a significant period of time. This situation requires a specific heat management device to dissipate heat from the exhaust system and away from the vehicle. Otherwise hot metal surfaces of Exhaust system start losing heat and by natural convection, these hot gases rise and fill the engine bay or compartment making the situation more severe.

As explained in above paragraphs, engine cooling with a radiator and cooling fan arrangement is conventional. Where the engine is positioned in a forward location of the vehicle, a natural draft of ambient air during vehicle running is sufficient to dissipate hot air away from the vehicle, if necessary employing an air guiding channel can be provided. Placing radiator in front of vehicle and engine rearward of vehicle gives advantage of natural draft of ambient air, but this would have increased the weight due to long coolant hose routings and higher coolant volume. Also, in such scenario the pumping losses would also be on higher side.

Taking above into consideration the radiator is placed on rear side and in engine bay in the close vicinity of engine. In this scenario advantage of natural draft of ambient air is not much available for heat dissipation and has to rely on fan to suck air across the radiator to cool it .Placing the radiator in transverse direction of vehicle in case the engine is also placed in transverse direction (i.e. the crank shaft is along the length of vehicle) , the cooling fan can be mounted on the crank shaft and would not require a separate mounting arrangement. However, compact lay out does not allow

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placing the engine in transverse direction. The situation in which engine placed in longitudinal direction and radiator placed along transverse direction of vehicle would require an electric or hydraulically operated cooling fan . Such provision allows controlled duty cycles of the cooling fan can be controlled depending on engine temperature. The fan can be kept running for a short duration even if the engine comes to a halt. Howevere, these provisions call separate mounting arrangement of fan, for example this would require a bulky alternator/ battery combination which needs space and also increase weight & cost of vehicle. In transverse direction, radiator can be placed in front of engine bay to take advantage of underbody air flow, but as explained above packing constraints in compact layout vehicle rules out this option. Placing radiator rearward of engine and at rear end of engine bay is alternative but the fan would suck hot air in engine bay which will reduce the radiator effectiveness.

Taking above things into consideration that engine needs to be placed in the longitudinal direction, the radiator may be placed longitudinally (i.e. along the length of vehicle) at rear side of vehicle. By such radiator placement allows to use engine driven fan (for example radiator fan mounted over crankshaft of the engine). Also the fan draws fresh ambient air across the radiator for cooling increasing its effectiveness.

In these types of layout and arrangement three heat sources (Engine, Radiator and Exhaust) are placed in the close vicinity. Various components like fuel tank, battery, air filter, electrical components, cables, etc are closely placed near to these heat sources. The material of this components have a temperature limit beyond which either its performance degrades or it becomes safety/warranty issue.(For example, higher battery temperature will reduce the battery life which will be a warranty issue/ High fuel temperature in fuel tank would be a safety issue/high ECU temperature would affect its life).

Since these heat sources are below the rear seat/luggage area, passenger thermal comfort is also important. Excessive heat transfer from engine compartment to these areas can create unsafe condition.

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One of the solution to limit the weight of vehicle is heat shielding/padding of vehicle floor, however this is not good and reliable solution. Another solution would be to provide heat resisting foam in the engine compartment to avoid transfer of heat from the engine and exhaust system to the passenger/driver compartment. However, use of heat resisting foam is typically additional to requirements for a radiator and cooling fan. In addition, heat resisting foam needs to be applied over a large surface area of the engine compartment, leading to increase in vehicle weight and additional complex assembly activity during manufacturing.

One of the known method to dissipate heat away from the exhaust system is disclosed in

US20080083217 which discloses an electronically controlled slide which covers/uncovers the exhaust system depending on exhaust system temperature. This is a complex and costly method and reliability for a longer period may be an issue.

Methods and Devices for preventing transfer of engine heat to passenger/driver compartment; and devices for preventing transfer of heat from exhaust system to passenger/driver compartment are separate and generally independent of each other. For this reason, prior art devices cannot readily be applied to heat management for compact layout vehicles with a significant space constraint. Thus there exists a challenge for heat management in compact layout vehicles where the independent devices cannot be adopted.

Objects:

It is an object of the invention to provide a heat or thermal management system for the engine compartment of a compact layout vehicle.

Yet another objective of the invention is to provide a heat or thermal management system which is simple, less bulky and cost effective

Statement of Invention

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With the above objects in view, the present invention provides a heat or thermal management system for a vehicle comprising an engine compartment accommodating an engine and an engine exhaust system, the engine and exhaust systems both generating heat within said engine compartment during engine operation; and

a cooling system comprising a radiator and cooling fan also located within said engine compartment, said cooling fan directing air flow through said engine compartment ;

wherein heat or thermal management system comprises a device located in the engine compartment ;said device confining air flow within its boundary and directing air flow away from the engine compartment and thus prevents dissipation of air and its absorbed heat throughout the engine compartment.

Conveniently, the heat or thermal management system comprises of a first part, in the form of duct, directing heated air flow away from engine and, most advantageously, a second part, in the form of enclosure, directing air flow received from first part away from vehicle and also directing heated air of exhaust system away from vehicle. The first and second parts may be interconnected by a connecting portion. If interconnected, as is most desirable to simplify engine design in the context of a compact layout vehicle, the second part in the form of enclosure comprises at least one outlet for directing air away from said engine compartment.

The heat or thermal management system may be designed to act as a heat shield preventing, or at least reducing, heat transfer from engine and exhaust system into the engine compartment and other portions of the vehicle. To this end, the enclosure may be fabricated with heat insulating materials or insulating thickness to reduce such heat transfer. Such heat shielding should remain effective when the engine and vehicle have stopped running.

The first part, in the form of duct is preferably arranged between the radiator and the engine. Efficient operation is also most assured if the first part, in the form of duct

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surrounds a substantial portion of the cooling fan to form a shroud, which is conveniently of helical shape to gain maximum air flow. The first part, in the form of duct is shaped desirably in such a way that it prevents air flow escaping out in the engine compartment from air in to air out path. However the escape of hot air form the bottom portion of cooling system adjacent to the fan can be arrested by having the shroud located at the bottom with suitable mounting arrangement which does not allow air leakage from bottom side of the fan.

The first part conveniently is positioned in such a way that air exits above the exhaust system, preferably above the silencer assembly, with an inlet for air from the first part at one end and one or more air vents to let out air from the second part at another end through one of its outlets or opening. Wall surfaces of the second part, in the form of enclosure, are oriented with suitable draft angle to facilitate flow of heated air towards the air vent(s). The second part may have only small clearance from the exhaust system components, notably the silencer assembly to assist in air flow along the enclosure towards the air vent(s).

The second part is positioned above the exhaust system comprising another outlet oe opening located away from the first outlet or opening. The said second opening of said second part connected to air flow guides/vents. Thus the hot air generated by exhaust system is guided through the second opening and air flow guides/vents away from the vehicle through and not allowing hot air to move towards wall of engine compartment.

Preferably the second opening of the second part is provided at its upper surface and its inner wall surface makes a suitable draft angle with the corresponding outer wall of the exhaust system to facilitate the flow of hot air towards the opening.

The arrangement of first and second parts of the heat management system prevents dissipation of air and associated heat throughout the engine compartment and particularly the walls of the engine compartment. It may be appreciated that heat may still be transferred from the heat or thermal management system through conduction and radiation. The first and, more particularly, the second part of the heat or thermal management system may therefore be configured as a heat shield

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using effective materials or other design criteria for this purpose. It is particularly desirable for the second part of heat or thermal management system to be configured as a heat shield which would desirably cover substantially the entire length and width of the exhaust system.

The heat or thermal management system helps to restrict heat transfer throughout the engine compartment and beyond whether or not the engine is running, at least because of the heat shielding benefits of the second part even when the engine is not running. Further advantage is gained for compact layout vehicles if the cooling fan is mounted on the engine crankshaft. This avoids an electric fan requirement of having separate motor and mounting arrangements. The fan may be connected/disonnectable to crank shaft through an electromagnetic clutch mechanism.

The heat management system is particularly well suited to compact layout vehicles having three or four wheels. Such vehicles may conveniently be provided with rear mounted engine having radiator and cooling fan in side by side configuration rather than front to back configuration as with conventional vehicles. One such compact lay out is disclosed in Applicant's co-pending application no. 19/CHE/2012.

Brief Description of the Drawings

Figure 1 shows a compact layout vehicle having a heat management system in accordance with one embodiment of the present invention.

Figure 2 is a schematic plan view of the compact layout vehicle shown in Figure 1.

Figure 3 is detailed schematic view showing a vehicle engine compartment and heat management system in accordance with the first embodiment of the present invention.

Figures 3a, 3b, 3c, 3d and 3e are various schematic views of fan and shroud in accordance with the first embodiment of the present invention. Figures 4a and 4b are

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respectively schematic side and plan views of the cooling system of the heat management system of the first embodiment of the invention.

Figures 5a and 5b are comparative schematic views showing movement of heated air around the engine compartment and around the engine when no heat management system is employed.

Figure 6 shows heated air movement from the exhaust system in the engine compartment when no heat management system is employed.

Figure 7a shows air movement when the bottom portion of the cooling system of the heat management system is not shrouded at the lower portion.

Figure 7b shows air movement when the bottom portion of the cooling system of the heat management system is shrouded at the lower portion.

Figure 8 shows the exhaust path for hot air in the vicinity of the exhaust system according to the first embodiment of the invention.

Figure 9 is a cross-sectional schematic view of the exhaust system and second part of the cooling system of the heat management system according to the first embodiment of the invention.

Figure 10 is a schematic view of the rear door of vehicle according to the first embodiment of the invention.

Figure 10a and 10b are schematic views of the air flow guides of the heat management system according to the first embodiment of the invention.

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Detailed Description of Preferred Embodiments of the Invention

Referring now to Figures 1, 2 and 3, there is shown a four wheel vehicle 1 having a rear mounted engine 2 positioned in engine compartment 20. The vehicle exhaust system 3 has its component piping connected to engine 2. The exhaust system 3 is located at the rear side of the engine and also within engine compartment 20. The engine 2 and exhaust system 3 are located below the passenger/driver compartment 6 and luggage compartment 7 of the vehicle 1 which is therefore of compact layout as described in the Applicant's co-pending Indian Patent Application No. 19/CHE/2012.

The engine cooling system comprises a radiator 4 and a cooling fan 5 which is mounted on the crankshaft 2a of the engine 2 and connectable to/disconnectable from crankshaft 2a through an electromagnetic clutch (not shown). So, the cooling fan 5 operates only when the engine 2 is in running condition. The radiator 4 and cooling fan 5 are positioned along the width of vehicle 1 in side by side configuration with the cooling fan 5 being located between the engine 2 and radiator 4. The engine 1 is therefore side mounted.

When the engine 2 is running, hot air from radiator 4 is circulated by cooling fan 5 to move towards engine 2 and dissipate throughout the engine compartment 20, when no heat management system is employed, with the consequence of increasing temperature within engine compartment 20. This leads to many adverse effects such as decrease in durability/safety of various electronics components and increases the temperature of fuel which is located in the vicinity of the engine 2. This has a very severe safety ramifications.

Further, heat in engine compartment 20 is transferred to passenger/driver compartment 6 and luggage compartment 7 which are located above engine compartment 20. Heat transfer to the passenger/driver compartment 6 leads to occupant discomfort. Heat zones in the luggage compartment 7 can also cause damage to goods and so on.

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Figures 5a and 5b show, with arrows, the direction of movement of the hot air with the consequences as described above when no heat management system is employed.

In addition, even when the vehicle 1 stops after running for some time, particularly for long duration, the exhaust system 3 remains hot for a substantial period time. As there is no ambient air flow, the hot air surrounding the exhaust system becomes trapped in the engine compartment 20 and heat is again transferred to passenger/driver compartment 6 and luggage compartment 7. The Applicant has found that, even where an exhaust system heat shield is provided, it has a limited effect, this is mainly due to absence of proper guiding path to take away the radiated heat away from the engine compartment. The hot air in that case raises and gets leaked through the heat shield interface. The path is chosen in such a way that natural buoyancy shall make the hot air accumulate at a particular location which then can be taken out by suitable guiding path.

Any significant vehicle running duration produces combined effects of spreading of hot air coming through the radiator 4 and exhaust system 3 in the engine compartment 20. This creates a hot zone within engine compartment 20 with heat being transferred to passenger/driver compartment 6 and luggage compartment 7. This hot zone in engine compartment 20 can cause uncomfortable and unsafe conditions for passengers and affect the durability and functioning of other engine and vehicle components located in the vicinity of the engine 2 and exhaust system 3, even in the rear of vehicle 1 under severe circumstances.

The Applicant seeks to manage heat dissipation during running conditions as well as heat dissipation when the vehicle has stopped.

To that end, the Applicant has invented a heat management system 10 which will now be described with reference to Figures 3 to 10. Heat management system 10 involves the cooling system of the engine 2 being provided with a duct 30 through which air flow is directed through only a restricted portion of the engine compartment 20. Duct 30 restricts dissipation of air heated by the engine 2 and exhaust system 3 throughout the engine compartment 20 thus reducing the adverse heat transfer to

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vehicle compartments 6 and 7 as described above. Duct 30 is also arranged to exit heated air from the engine compartment 20.

The entire cooling system, as shown in Figures 4, 5, 6a and 6b, comprises a first part 11 and a second part 12 connected through a connecting part 13 at one end of the second part 12.

The first part 11of the cooling system directs heated air flow from cooling fan 5 away from the engine 2 and the respective passenger and luggage compartments 6 and 7. As illustrated in Figures 7a and 7b, the first part 11 has hollow channel or duct structure and is of a helical shape. The first part 11 substantially surrounds the periphery of cooling fan 5 Refer figures 3a to 3e and 4a) Its first end is mounted on the engine with bottom part extended below the fan mounting axis 2a and other end is connected to connecting part 13.

Thus this first part 11 of the cooling system restricts the heated air flow coming from the radiator 4 from moving towards the engine 2 as well as towards the passenger/driver and luggage compartments 6 and 7. While the engine 2 and cooling fan 5 are in running condition, the hot air is directed through the first part 11 of cooling system towards the connecting part 13. From there hot air is exited from the engine compartment 20, preventing dissipation of the hot air elsewhere in the engine compartment 20.

The arrest any leakage from the bottom portion the first part 11 has an extended lower portion (shroud bottom) 15 fixed on a suitable bracket at a bottom side of the cooling fan 5 (refer figure 3b) This lower portion 15 restricts hot air flow towards the engine 2 and heated zone 25 from the lower side of cooling fan 5 and directs the hot air towards the remainder of the first part 11 as illustrated in Figure 7b. Lower portion 15 may be formed integral with the first part 11 or may be separately connected to it. This depends on the space and mounting options available in the vehicle layout.

The second part 12 of the cooling system is positioned above the exhaust system 3 and is provided with two openings 12a and 12b. These openings 12a and 12b are

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preferably provided substantially at the two ends of the second part. The end with first opening 12a is connected with the first part 11 of cooling system through connecting part 13. The end with second opening 12b is connected to exhaust air outlet duct 14 to exit hot air directed through the engine compartment 20 by the first part 11 of plenum 30. Second opening 12b of second part 12 is connected to air flow guides 21a, 21b to exhaust hot air in the vicinity of exhaust system 3 away from the vehicle 1 through air vent 21c. This prevents hot air flow from moving towards the walls 23) of engine compartment 20 which could cause conductive heating of vehicle compartments 6 and 7.

Second opening 12b of second part 12 is provided on an upper surface of that second part 12. The inner wall surface 12c of the second part 12 is oriented to make a suitable draft angle with the corresponding outer wall surface 3a of the exhaust system 3 to facilitate flow of hot air towards the second opening 12b as shown in Figure 9. The draft angle is selected in such a way to have a natural path of hot air moving up & towards the opening to exit it out of the vehicle.

The second part 12 also operates as a heat shield for the exhaust system 3 addressing the particular adverse heat transfer effects from the exhaust system 3 as described above. The first part 11 could also be configured as a heat shield if needed.

When the vehicle 1 is in a halt condition after a long running duration, there is no ambient air flow in any part of engine compartment 20. This leads to entrapment of hot air and a "hot soak" condition in which air heated by the exhaust system 3, and more particularly the hot surfaces 3a of the silence of the exhaust system 3, causes heat transfer to the engine compartment 20. This phenomenon is schematically shown in Figure 6. In the absence of any escape route for hot air, engine compartment 20 temperature will continue to increase with adverse effects as above described: decrease in durability/safety of various electronics and fuel system parts fitted in the engine and increase in temperature of surfaces coming into contact with passengers seated in the rear of the vehicle.

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To address this problem, the second part 12 is provided with an opening 16 on an upper surface, and in the vicinity of the silencer. The opening is oriented towards the rear of the vehicle 1 and is connected to air flow guides or baffles 21a, 21b suitably mounted on vehicle 1. Refer figure 10. 10a and 10b.[Air flow guides 21a, 21b extend to the rear access window/vent(s) 18 of the vehicle 1 so that the hot air is exited through opening 14 to the air flow guides 21a, 21b and away from the vehicle through rear access window/vent(s) 18 of the rear door 22 as schematically shown in Figure 8. The air flow guides 21a, 21b could be integrated as a single unit. The integration shall mainly depend on the assembly ease. The flow guides are mounted on vehicle which is stationary but the second part 12 which guides the hot air into these flow guides is mounted on the engine which is movement with respective to the vehicle. The flow guides are designed in such a way that even during the movement the flow guide is wrapped around the second part 12. To take care of this the flow guide with corrugations are used..

The heat management system of the present invention is capable of managing heat generated in the engine compartment 20 due to radiator heated air and exhaust system heated air. In particular, the system prevents spread of hot air within the engine compartment 20 and the adverse consequences that can arise from that. At the same time, the heat management system provides for exhaust of heated air away from the vehicle.

Modifications and variations to the heat management system of the present invention may be apparent to the skilled reader of this disclosure. Such modifications and variations are deemed within the scope of the present invention.

Dated on this the 21st day of November, 2013.

For **BAJAJ AUTO LIMITED,**
By its attorney

(BRINDA MOHAN)

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