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(54) Title of the Invention: **Air intake apparatus**
Abstract Title: **Air Intake Apparatus**

(57) An air intake apparatus for use in an induction system of a machine such as an engine, generator or compressor, the apparatus comprising: an air intake duct 10 comprising an inlet 22, through which air may be drawn into the machine; and means, such as an auxiliary tube 40 running externally to the duct 10, configured to communicate at least one internal region of the duct at a first pressure with at least one internal region of the duct at a second pressure, so as to reduce the difference between the first pressure and the second pressure. By using such an apparatus across the inlet 22 to an air duct and therefore reducing the difference in pressure across the entrance any large variations in air velocity can also be reduced to a level where the air velocity is less likely to draw in unwanted particles or debris.

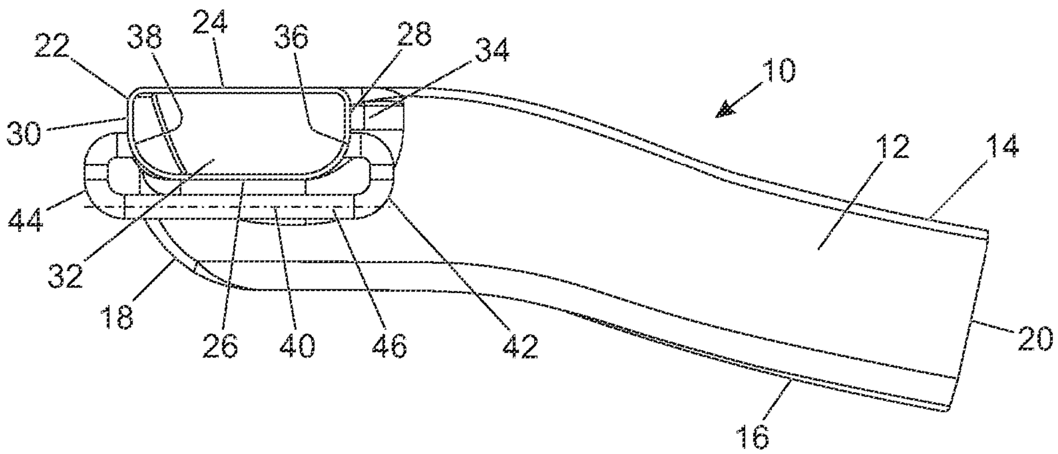

FIGURE 1

GB 2529241 A

23 10 15

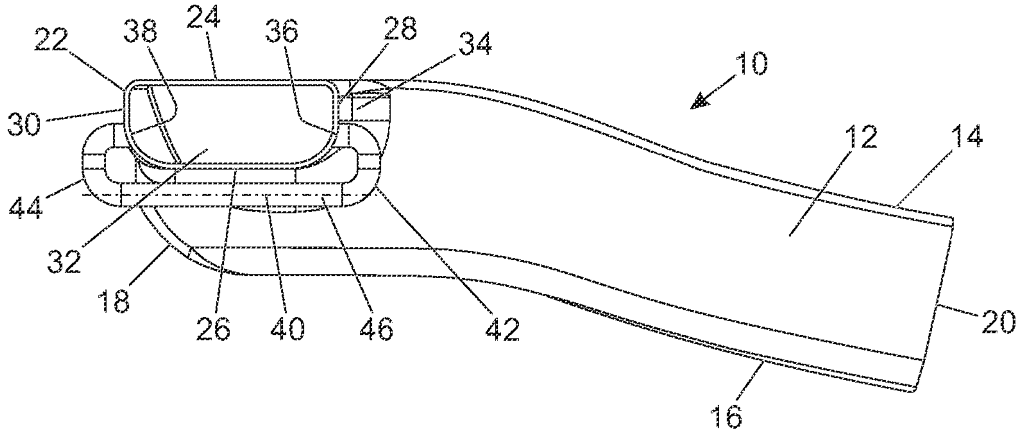

FIGURE 1

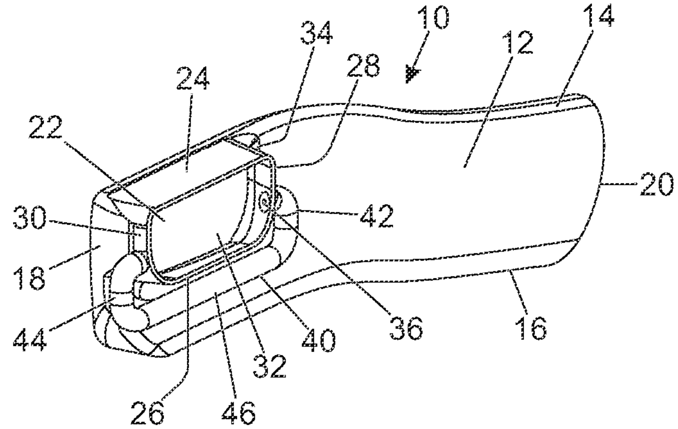

FIGURE 2

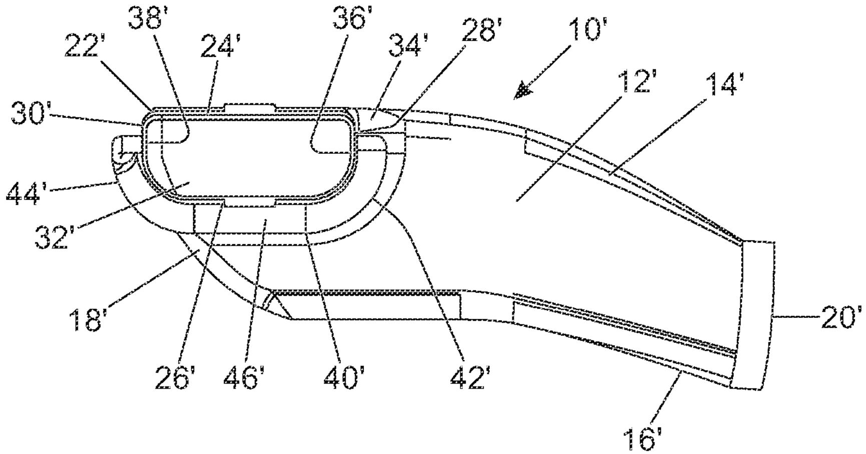

FIGURE 5

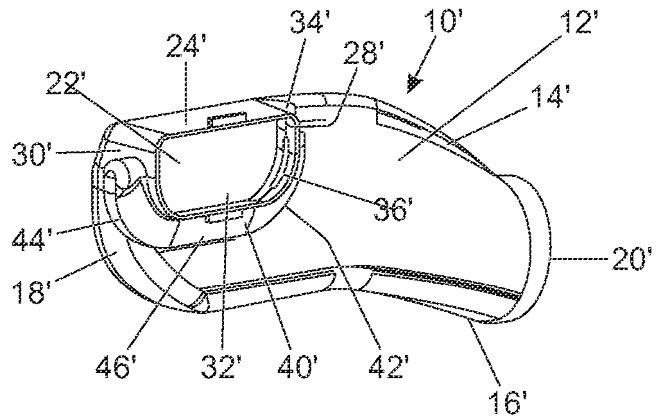

FIGURE 6

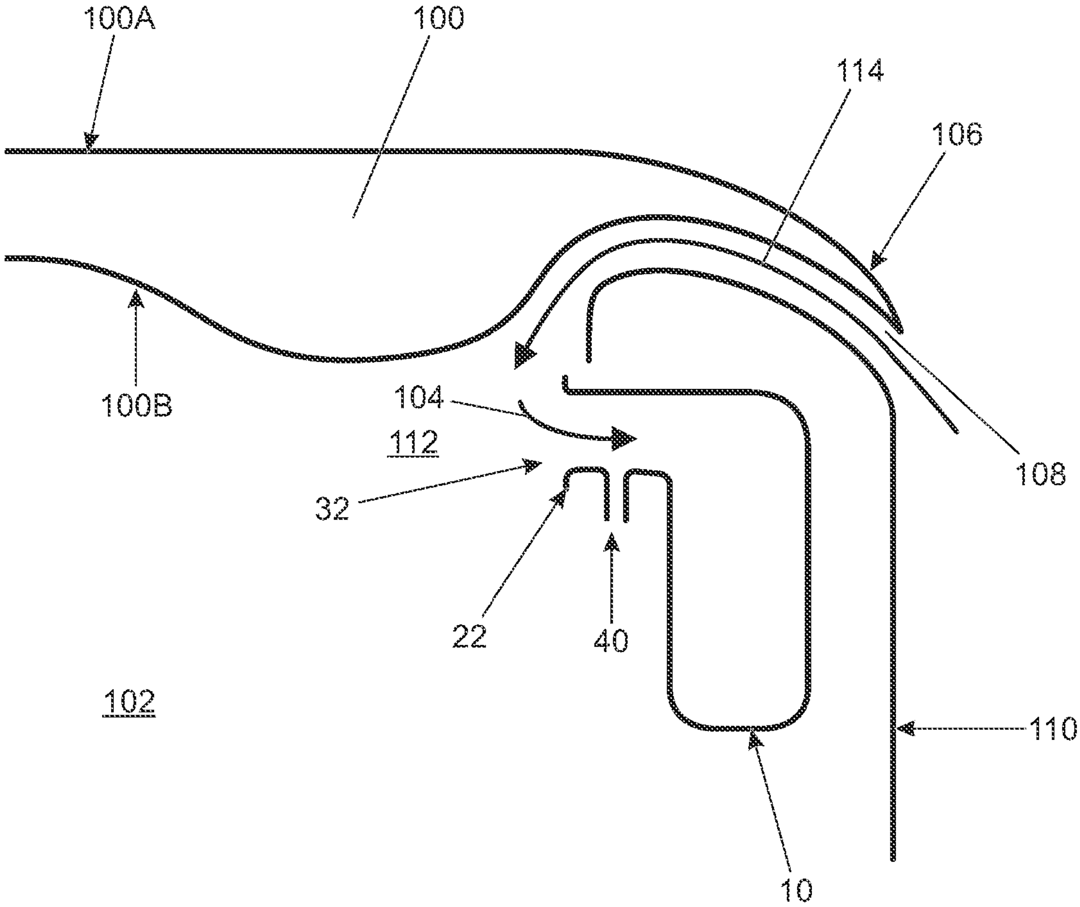

FIGURE 3

23 10 15

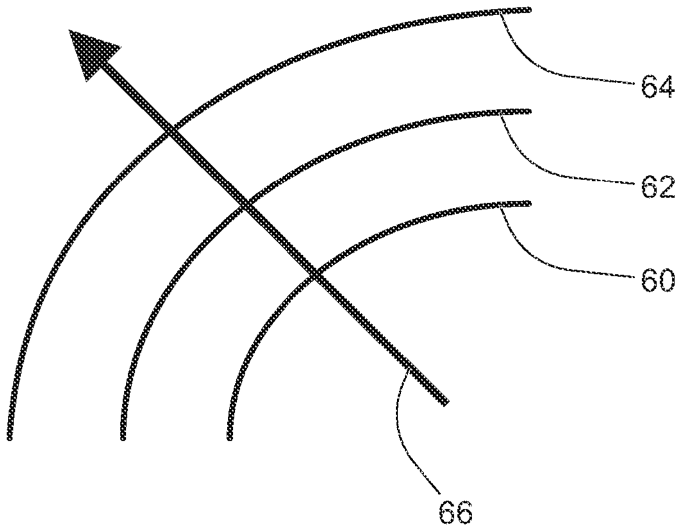

FIGURE 4

23 10 15

AIR INTAKE APPARATUS

TECHNICAL FIELD

The present invention relates to an air intake apparatus for use in an induction system for a machine such as an engine, generator or compressor and, in particular, to an apparatus that increases the amount of air that may be drawn into said machine, but which does not draw in particles or debris from the air. Aspects of the invention relate to an air intake apparatus, and to a vehicle.

BACKGROUND

Many types of machines, such as engines, generators and compressors, need to draw in air via an induction system in order to operate. For example, an internal combustion engine in a vehicle needs a constant supply of oxygen from the air to ensure efficient operation. It is known to provide a vehicle having an engine air intake duct arranged to draw air from an engine compartment of the vehicle into the engine. The temperature of the air drawn from the engine compartment tends to be higher than the temperature of the air outside the vehicle, that is, higher than atmospheric temperature. Since air is less dense at higher temperatures, and therefore contains less oxygen, it is preferable to draw cooler air from outside the vehicle into the engine to improve engine performance. It is known to provide a vehicle having an engine air intake duct located at either the front or side of the vehicle and arranged to draw air from outside the vehicle.

One problem with such an arrangement is that particles (or debris) in the air such as, for example, snow, spray, sand or dust, may be ingested through the engine air intake duct into the engine. It is known to provide an arrangement for separating these particles from the air before the air enters the engine. Such an arrangement, however, may be complex, bulky and/or expensive, and therefore it is preferable to prevent the particles being drawn into the duct in the first instance. To achieve this, the velocity of the air in the duct must be kept below a certain maximum value, for example 40 metres per second.

In addition, the location and design of an engine air intake duct arranged to draw air from outside the vehicle may be constrained by body panels and the styling of the vehicle. To overcome these constraints, the duct may comprise one or more corners around which the air must flow in order to enter the engine. Such corners alter the airflow through the duct such that there may be relatively large variations in air velocity and pressure in a given cross section of the duct. Given that the velocity of the air must be below the abovementioned certain maximum value at all points within the duct to prevent particles from being drawn in, a more even flow across the duct is desirable in order to maximise the amount of air that may be provided to the engine.

An aim of the present invention is to provide an improved air intake duct arranged to draw air from outside a machine such as a vehicle equipped with an internal combustion engine, which increases the amount of air that may be drawn into the machine and an engine, but which does not draw in particles or debris.

SUMMARY OF THE INVENTION

According to an aspect of the invention there is provided an air intake apparatus suitable for use in an induction system of a machine, the apparatus comprising an air intake duct comprising an inlet, through which air may be drawn into the machine. The apparatus also comprises means configured to communicate at least one internal region of the duct at a first pressure with at least one internal region of the duct at a second pressure, so as to reduce the difference between the first pressure and the second pressure. The means configured to communicate one region of the duct with another may include a device or other arrangement which is located external to the duct, or may alternatively comprise a device or other arrangement which is located inside the duct but which isolates air flow from the main body of the duct. There is provided an air intake apparatus suitable for use with a vehicle internal combustion engine, the apparatus comprising an air intake duct comprising an inlet, through which air may be drawn into the engine. The arrangement also comprises means configured to communicate at least one internal region of the duct at a first pressure with at least one internal region of the duct at a second pressure, so as to reduce the difference between the first pressure and the second pressure. The means configured to communicate may be external to the duct.

Alternatively the machine may be a generator, a compressor, or any other type of machine that needs to draw in air to ensure correct operation.

Reducing the differences in pressure between different regions within the air intake duct results in a more even distribution of air velocity in the duct. In particular, the velocity of intake air is reduced at a region of lower pressure. This lowering of velocity within the air intake duct is advantageous because particles or debris in the air such as snow, dust, sand or spray are not then drawn through the duct and into the machine. A more even distribution of velocity increases the amount of air that may be drawn through the duct into the machine.

The means external to the duct may comprise at least one auxiliary pipe, where each auxiliary pipe comprises at least two ends, and each end comprises at least one opening. In this embodiment, at least one of the openings is located to open into the internal region of the air intake duct at the first pressure, and at least one of the openings is located to open into the internal region of the air intake duct at the second pressure

The use of an auxiliary pipe to allow the fluid communication of air between at least two internal regions within the air intake duct is a simple, effective and inexpensive means of reducing the differences in pressure between these internal regions.

At least one opening may be located adjacent a front face of the inlet. Alternatively, or in addition, at least one opening is located close to a corner region of the engine air intake duct. Air that flows around the inside portion of a corner region may have a greater velocity and be of lower pressure than air that flows around the outside portion of a corner region. Hence the openings of an auxiliary pipe may advantageously be positioned to reduce the differences in pressure across such a corner region such that the velocity of the air flowing around the inside portion is reduced.

At least one opening may be located along the length of the air intake duct. At least one opening may be generally circular-shaped or generally oblong-shaped.

The at least one auxiliary pipe may be of generally circular cross-section. The at least one auxiliary pipe may comprise at least one manifold leading to a plurality of openings at at least one end of the pipe. Positioning a plurality of openings at one end of the pipe may advantageously provide a more even increase or reduction in pressure in a given region of the duct.

The at least one auxiliary pipe may sit flush to the air intake duct. An induction system for a machine such as an engine may be subject to design and space constraints and the at least one auxiliary pipe may advantageously be designed and positioned to comply with such constraints.

The cross-sectional area of the at least one auxiliary pipe may be substantially 1% of the cross-sectional area of the inlet. This is a non-limiting example of the relative proportions of the auxiliary pipe and the duct, and they may be of any size depending on the exact nature of the situation in which the disclosed apparatus is utilised.

According to another aspect of the invention, there is provided a vehicle comprising an apparatus as described above.

The vehicle may comprise a vehicle body, an engine compartment housing an engine, and a bonnet movably coupled to the body and arranged to provide a closure member for the engine compartment, the bonnet being movable between open and closed conditions to allow access to the engine compartment. In addition, the air intake apparatus may be located below the bonnet within the vehicle body, adjacent the engine compartment.

As mentioned above, the components of a vehicle may be subject to tight design restrictions to comply with aesthetic, spatial and performance requirements. For these reasons a vehicle induction system may be of sub-optimal shape and the disclosed invention may help to mitigate against the effects of these design restrictions.

In one embodiment the vehicle is provided with first and second air flow paths whereby air may be supplied to the air intake duct, the first flow path comprising a bonnet conduit for providing ram air to the inlet, and the second flow path being provided by a gap between a side edge of the bonnet and the body of the vehicle, whereby ambient air may be drawn through the gap to the inlet.

The inlet of the air intake duct may be arranged to face substantially laterally relative to a longitudinal vehicle axis or may be arranged to face in a substantially upwards direction relative to a vehicle floor.

Within the scope of this application it is expressly envisaged that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. For example, features disclosed in connection with one embodiment are applicable to all embodiments, except where such features are incompatible.

BRIEF DESCRIPTION OF DRAWINGS

The invention will now be described, by way of example only, with reference to the accompanying figures in which:

Figure 1 is a front view of an engine air intake duct according to one embodiment of the invention;

Figure 2 is a perspective view of the engine air intake duct in Figure 1;

Figure 3 is a vertical cross-sectional view of one side portion of a vehicle bonnet having the engine air intake duct shown in Figures 1 and 2;

Figure 4 is a schematic diagram showing streamlines of a laminar fluid flow round a curve and the direction of increasing pressure;

Figure 5 is a front view of an engine air intake duct according to an embodiment of the invention different from that shown in Figures 1 and 2; and

Figure 6 is a perspective view of the engine air intake duct in Figure 5.

DETAILED DESCRIPTION

Figures 1 and 2 show front and perspective views, respectively, of an induction system suitable for use in a machine according to one embodiment of the present invention. Specifically Figures 1 and 2 show an air intake duct 10 suitable for use in a vehicle internal combustion engine. The duct 10 comprises a front side 12 and a rear side (not pictured) joined by an upper edge 14 and a lower edge 16. The duct 10 also comprises an end portion 18 and an open-ended portion 20, the open-ended portion 20 leading to an internal combustion engine of a vehicle (not shown). The edges 14, 16 are non-planar in both the longitudinal direction (i.e. from the end portion 18 to the open-ended portion 20) and the transverse direction (i.e. from the front side 12 to the rear side). The width of the front side 12 and rear side is greater than the width of the edges 14, 16. The front side 12 and rear side are parallel to each other and the edges 14, 16 are parallel to each other.

The duct 10 further comprises a generally rectangular inlet 22 protruding from its front side 12 located adjacent the end portion 18. The inlet 22 comprises an upper portion 24 and a lower portion 26 joined by a first side portion 28 and a second side portion 30. The inlet 22 has a generally rectangular open face 32 at the inlet front. The first side portion 28 of the inlet 22 is joined to the front side 12 of the duct 10 by a generally curved surface 34. The lower portion 26 of the inlet 22 is joined substantially perpendicularly to the front side 12 of the duct 10. The second side portion 30 of the inlet 22 is joined to the end portion 18 of the duct 10 and the upper portion 24 of the inlet 22 is joined to the upper edge 14 of the duct 10.

The first and second side portions 28 and 30 of the inlet 22 each comprise a circular opening 36 and 38, respectively, located generally midway between the upper portion 24 and lower portion 26 of the inlet 22, and located generally midway between the front end (i.e. at the end at which front face 32 is located) and a rear end (i.e. at the end at which the curve 34 is located) of the inlet 22.

The openings 36, 38 are connected by a hollow pipe 40 of circular cross-section and of constant diameter. A typical cross-sectional area of the pipe 40 is approximately 1% of the cross-sectional area of the front face 32. The pipe 40 comprises two generally toroidal sections 42, 44 and a generally cylindrical section 46. The first toroidal section 42 is joined at its upper end to the outwardly-facing side of opening 36 and is joined at its lower end to a first end of the cylindrical section 46. The second toroidal section 44 is joined at its upper end to the outwardly-facing side of opening 38 and is joined at its lower end to a second end of the cylindrical section 46. The joins between the first and second toroidal sections 42, 44 of the pipe 40 and the openings 36, 38, respectively, are air tight. The cylindrical section 40 is below, and is generally parallel to, the lower portion 26 of the inlet 22. There is a gap between the lower portion 26 of the inlet 22 and the upper edge of the cylindrical section 46 of the pipe 40.

Figure 3 shows the location of the engine air intake duct 10 within a vehicle in one embodiment of the invention. In particular, Figure 3 shows a vertical cross section of one side portion of a vehicle bonnet 100 having an engine air intake duct 10. The bonnet 100 provides a closure member for an engine compartment 102 and is formed from an external panel 100A and an internal panel 100B. The external and internal panels 100A, 100B are joined together by welds although other joining technologies are also useful. When joined to the external panel 100A, the internal panel 100B is shaped in such a manner as to define an air conduit at the side of the bonnet 100. This air conduit is arranged to draw ram air from the front of the vehicle (that is, flowing into or out of the page in relation to the cross-section as shown in Figure 3) and then in the direction of arrow 104. Note that a similar arrangement on the other side of the bonnet 100 (not shown) may also be useful. More than two air conduits may also be useful.

In the embodiment shown the bonnet 100 is of the clamshell type, having a downwardly depending lip 106 provided around an outer peripheral edge of the bonnet 100. With the bonnet 100 in a closed condition a gap 108 is provided between a lower edge of the lip 106 and vehicle body 110. The vehicle body 110 is typically formed from a plurality of separate body panels, and the area shown in Figure 3 may be formed by the intersection of a bumper fascia panel, a headlamp assembly or light cluster and/or a fender panel, also known as a 'wing panel'. In the present embodiment the gap 108 is around 6mm in width although other arrangements are also useful. It is to be understood that other bonnet types are also useful.

Inboard of the lip 106 of the bonnet 100, but outboard of the engine compartment 102 is provided a convergence region 112. Air drawn through the bonnet air conduit is drawn into the convergence region 112 and subsequently through the front face 32 of the inlet 22 into the duct 10.

As shown in Figure 3 air may also be drawn into the convergence region 112, and thereby into the inlet 22, through the gap 108 between the bonnet 100 and vehicle body 110 (i.e. in the direction of arrow 114). That is, a leak path exists for air into the inlet 22 from around the duct 10 and not just from the bonnet air conduit. The convergence region 112 is therefore a region in which an air flow path through the bonnet air conduit converges with an air flow path through gap 108 between bonnet 100 and vehicle body 110.

The front face 32 of the inlet 22 is shown in Figure 3 facing in a substantially lateral direction relative to a longitudinal axis of the vehicle; however, the duct 10 may be arranged such that the front face 32 of the inlet 22 faces in a substantially upwards direction relative to a floor of the vehicle. Other directions may also be useful.

To understand the effect on the airflow caused by the inclusion of pipe 40, consider first the duct 10 shown in Figures 1 and 2, but in the absence of the openings 36, 38 and the pipe 40. Air from outside the vehicle is drawn into the inlet 22 via the front face 32 and directed through the duct 10 towards the open end 20 and onto the vehicle engine. In the vicinity of the corner defined by the join 34, the characteristics of the airflow are altered. In particular, and assuming laminar flow, since pressure increases as the radius of curvature of a streamline increases, then the pressure of the air flowing round the inside of the corner 34 is lower than the pressure of the air flowing round the outside of the corner 34. This is depicted schematically in Figure 4, wherein streamlines 60, 62, 64 show the laminar flow of a fluid (such as air) round a corner, and arrow 66 shows the direction of increasing pressure. The direction of flow along the streamlines 60, 62, 64 may be in either direction. Since a region of lower pressure leads to a region of higher velocity, the velocity of the air flowing along streamline 60 is greater than the velocity of the air flowing along streamline 64. Therefore, the velocity of the air flowing round the inside of the corner 34 is greater than the velocity of the air flowing round the outside of the corner 34.

The above-described scenario means that there is a relatively large variation of air velocity across any given cross section of the inlet 22, with a relatively high air velocity close to the inside of the corner 34. The velocity of the air at all points within the duct 10 must be below a certain maximum value in order to ensure that particles or debris are not drawn into the duct 10. Therefore, the large variation in velocity across the inlet 22 is undesirable because the amount of air that may be drawn into the vehicle engine via the duct 10 is reduced so as to meet the maximum velocity constraint.

Consider now the duct 10 with the openings 36, 38 and the pipe 40 included. The air in the internal region of the duct 10 in the vicinity of opening 36 is in fluid communication with the air in the internal region of the duct 10 in the vicinity of opening 38 (that is, air may flow freely through pipe 40 from one internal region to the other. Air from outside the vehicle enters the inlet 22 via the front face 32. The air flowing in the vicinity of opening 36 has a higher velocity than the air flowing in the vicinity of opening 38. In turn, the pressure of the air in the vicinity of opening 36 is lower than the pressure of the air in the vicinity of opening 38. Therefore, there is a pressure difference through the pipe 40. This causes a flow of air through the pipe 40 from opening 36 to opening 38. This reduces the pressure difference between the two ends of the pipe 40 such that the velocity of the air in the vicinity of opening 36 is decreased while the velocity of the air in the vicinity of opening 38 is increased. The variation in velocity across the inlet 22 is therefore smaller when the pipe 40 is included in the duct arrangement 10 compared to a similar duct arrangement in the absence of such an auxiliary pipe.

Figures 4 and 5 show front and perspective views, respectively, of an engine air intake duct 10’ according to another embodiment of the present invention. Similarly to the embodiment shown in Figures 1 and 2, the duct 10’ comprises a front side 12’, a rear side (not pictured), an upper edge 14’, a lower edge 16’, an end portion 18’ and an open-ended portion 20’. Also similar to the embodiment shown in Figures 1 and 2, the duct 10’ has a generally rectangular inlet 22’ protruding from the front side 12’ and comprising an upper portion 24’, a lower portion 26’, a first side portion 28’, a second side portion 30’, and a front face 32’.

As in the previous embodiment, the first and second side portions 28’ and 30’ comprise an opening 36’ and 38’, respectively; however, unlike in the previous embodiment, only the second opening 38’ is circular-shaped. The first opening 36’ is generally oblong-shaped with its vertical width greater than its transverse width.

Like in the previous embodiment, the openings 36', 38' are connected by a hollow pipe 40'. The pipe 40' comprises two generally curved sections 42', 44' and a generally uniform section 46'. Unlike in the previous embodiment, the upper edge of the uniform section 46' sits flush to the lower portion 26' of the inlet 22'.

The opening 36 in the embodiment shown in Figures 1 and 2 may lead to a relatively local reduction in air velocity in its vicinity. The opening 36' in the embodiment shown in Figures 5 and 6, however, is designed such that the high-pressure air flowing around the outside of corner 34' that is drawn in the direction of the pressure gradient through pipe 40' is used to provide a more even reduction in the velocity of the air flowing in the vicinity of side portion 28'.

Two possible embodiments of an auxiliary pipe attached to an engine air intake duct are described above; however, it is to be understood that such an auxiliary pipe may be shaped differently to these. It is to be understood also that the openings to which such an auxiliary pipe connects need not be positioned or shaped as shown in the examples above; rather, the auxiliary pipe may run from an opening located at any location of relatively low pressure to an opening located at any location of relatively high pressure (that is, the opening at the ends of the pipe are located such that there is a pressure difference through the pipe). The openings may be located at any location on the engine air intake duct (i.e. not necessarily on the inlet walls).

In another embodiment (not shown) one end of an auxiliary pipe attached to an engine air intake duct splits into a plurality of sections via a manifold, each section connecting to one of a plurality of duct openings. In a further embodiment, more than one end comprises a manifold. The inclusion of more than one auxiliary pipe may also be advantageous.

Depending on the location and the orientation of the air intake duct, and the device or machine to which the duct is connected and supplying air, use of a manifold in this way may facilitate tuning for a given volumetric airflow, and/or optimise the acoustic quality and performance in use.

In one embodiment, the ends of an auxiliary pipe are positioned close to the front face of an inlet rather than deeper into an engine air intake duct in order to reduce the effect of turbulence within the duct. Turbulent flow within the duct is undesirable because it increases the amount of work to be done by the system in order to draw air into the engine.

In a further embodiment, the ends of an auxiliary pipe are positioned close to a corner region of the engine air intake duct (that is, the openings in the duct to which the ends of the pipe are positioned are in the vicinity of internal regions of the duct where the airflow is changing direction).

Note that a simple opening in an area of low pressure (i.e. high velocity) within an engine air intake duct (i.e. in the absence of an auxiliary pipe) would not be suitable because of increased noise and vibration, and because the region surrounding the duct may be wet and so would draw water into the duct.

The embodiments of the air intake duct as described above may be configured to supply air to any suitable device or machine, and are not limited to the application of induction systems for engines. It is envisaged that, for example, the air intake duct according to an embodiment as described above, may be readily employed as part of an air supply to a compressor or other air handling device. Such a compressor, fitted with an air duct as described above, may also benefit from the aforementioned advantages provided by the reduction in pressure differences across an air intake duct as has been described above, along with the attendant reduction in ingestion of particulate matter, such as dust and sand, which may be otherwise entrained in the surrounding air.

Further aspects of the present invention are set out in the following numbered Clauses:

Clause 1: An air intake apparatus suitable for use in an induction system of a machine, the apparatus comprising: an air intake duct comprising an inlet, through which air may be drawn into the machine; and a device configured to communicate at least one internal region of the duct at a first pressure with at least one internal region of the duct at a second pressure, so as to reduce the difference between the first pressure and the second pressure.

Clause 2: The apparatus according to Clause 1, wherein the device configured to communicate is external to the duct.

Clause 3: The apparatus according to Clause 1, wherein the machine is a vehicle internal combustion engine.

Clause 4: The apparatus according to Clause 2, wherein the device external to the duct comprises at least one auxiliary pipe, each auxiliary pipe comprising at least two ends, each end comprising at least one opening, at least one of the openings being located to open into the internal region of the air intake duct at the first pressure, and at least one of the openings being located to open into the internal region of the air intake duct at the second pressure.

Clause 5: The apparatus according to Clause 4, wherein at least one opening is located adjacent a front face of the inlet.

Clause 6: The apparatus according to Clause 4, wherein at least one opening is located close to a corner region of the air intake duct.

Clause 7: The apparatus according to Clause 4, wherein at least one opening is located along the length of the air intake duct.

Clause 8: The apparatus according to Clause 4, wherein at least one opening is generally circular-shaped.

Clause 9: The apparatus according to Clause 4, wherein at least one opening is generally oblong-shaped.

Clause 10: The apparatus according to Clause 4, wherein the at least one auxiliary pipe is of generally circular cross-section.

Clause 11: The apparatus according to Clause 4, wherein the at least one auxiliary pipe comprises at least one manifold leading to a plurality of openings at at least one end of the pipe.

Clause 12: The apparatus according to Clause 4, wherein the at least one auxiliary pipe sits flush to the air intake duct.

Clause 13: The apparatus according to Clause 4, wherein the cross-sectional area of the at least one auxiliary pipe is substantially 1% of the cross-sectional area of the inlet.

Clause 14: A vehicle comprising at least one air intake apparatus according to Clause 3.

Clause 15: A vehicle according to Clause 14, further comprising: a vehicle body; an engine compartment housing an engine; and a bonnet movably coupled to the body and arranged to provide a closure member for the engine compartment, the bonnet being movable between open and closed conditions to allow access to the engine compartment, wherein the air intake apparatus is located below the bonnet within the vehicle body, adjacent the engine compartment.

Clause 16: A vehicle according to Clause 14, wherein the vehicle is provided with first and second air flow paths whereby air may be supplied to the air intake duct, the first flow path comprising a bonnet conduit for providing ram air to the inlet, and the second flow path being provided by a gap between a side edge of the bonnet and the body of the vehicle, whereby ambient air may be drawn through the gap to the inlet.

Clause 17: A vehicle according to Clause 14, wherein the inlet of the air intake duct is arranged to face substantially laterally relative to a longitudinal vehicle axis.

Clause 18: A vehicle according to Clause 14, wherein the inlet of the air intake duct is arranged to face in a substantially upwards direction relative to a vehicle floor.

CLAIMS

1. An air intake apparatus suitable for use in an induction system of a machine, the apparatus comprising:

   an air intake duct comprising an inlet, through which air may be drawn into the machine; and

   means configured to communicate at least one internal region of the duct at a first pressure with at least one internal region of the duct at a second pressure, so as to reduce the difference between the first pressure and the second pressure.

2. The apparatus according to claim 1, wherein the means configured to communicate is external to the duct.

3. The apparatus according to claim 1 or claim 2, wherein the machine is a vehicle internal combustion engine.

4. The apparatus according to claim 2 or claim 3, wherein the means external to the duct comprises at least one auxiliary pipe, each auxiliary pipe comprising at least two ends, each end comprising at least one opening, at least one of the openings being located to open into the internal region of the air intake duct at the first pressure, and at least one of the openings being located to open into the internal region of the air intake duct at the second pressure.

5. The apparatus according to claim 4, wherein at least one opening is located adjacent a front face of the inlet.

6. The apparatus according to claim 4 or claim 5, wherein at least one opening is located close to a corner region of the air intake duct.

7. The apparatus according to any of claims 4 to 6, wherein at least one opening is located along the length of the air intake duct.

8. The apparatus according to any of claims 4 to 7, wherein at least one opening is generally circular-shaped.

9. The apparatus according to any of claims 4 to 7, wherein at least one opening is generally oblong-shaped.

10. The apparatus according to any of claims 4 to 9, wherein the at least one auxiliary pipe is of generally circular cross-section.

11. The apparatus according to any of claims 4 to 9, wherein the at least one auxiliary pipe comprises at least one manifold leading to a plurality of openings at at least one end of the pipe.

12. The apparatus according to any of claims 4 to 11, wherein the at least one auxiliary pipe sits flush to the air intake duct.

13. The apparatus according to any of claims 4 to 12, wherein the cross-sectional area of the at least one auxiliary pipe is substantially 1% of the cross-sectional area of the inlet.

14. A vehicle comprising at least one air intake apparatus according to any of claims 3 to 13.

15. A vehicle according to claim 14, further comprising:

a vehicle body;

an engine compartment housing an engine; and

a bonnet movably coupled to the body and arranged to provide a closure member for the engine compartment, the bonnet being movable between open and closed conditions to allow access to the engine compartment,

wherein the air intake apparatus is located below the bonnet within the vehicle body, adjacent the engine compartment.

16. A vehicle according to claim 14 or claim 15, wherein the vehicle is provided with first and second air flow paths whereby air may be supplied to the air intake duct, the first flow path comprising a bonnet conduit for providing ram air to the inlet, and the second flow path being provided by a gap between a side edge of the

bonnet and the body of the vehicle, whereby ambient air may be drawn through the gap to the inlet.

17. A vehicle according to any of claims 14 to 16, wherein the inlet of the air intake duct is arranged to face substantially laterally relative to a longitudinal vehicle axis.

18. A vehicle according to any of claims 14 to 16, wherein the inlet of the air intake duct is arranged to face in a substantially upwards direction relative to a vehicle floor.

19. An air intake apparatus substantially as hereinbefore described with reference to the accompanying drawings.

20. A vehicle substantially as hereinbefore described with reference to the accompanying drawings.

Intellectual Property Office

Application No:	GB1414486.9	**Examiner:**	Mr Gareth Bond
Claims searched:	1 to 20	**Date of search:**	23 January 2015

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-4, 6-8, 10,14, 15,17,18	US4231329 A1 (Ishida) See figure 1, column 1 lines 51 to 54, and column 3 line 51 to column 4 line 15.
X	1-4, 7,8,10, 12,14, 15,17,18	JP S5862352 A (Aichi Machine) See figures 2 and 3 and the English language abstract.
X	1,3,14, 15,17,18	US2005/172924 A1 (Simon) See figures 3, 4, 6, 16 to 22 and 30, and paragraph 62.
X	1,3,14, 15,17,18	US2002/017262 A1 (Rutschmann et al) See figures 1 and 2, and paragraphs 6, 7 and 17 to 21.
X	1,3,14, 15,17,18	US2009/064959 A1 (Niakan et al) See figure 7 and paragraphs 13 and 31, particularly the apertures 36a (incorrectly marked as 30a in figure 7) in the turning vanes 36.
X	1,3,14, 15,17,18	JP S5862315 A (Toyo Kogyo) See figure 1 and the English language abstract. Particularly passage 11.
X	1,3,14, 15,17,18	US2745394 A1 (Holley Carburetor) See figures 1 and 2 and column 2 lines 1 to 22. Particularly suction tube 21.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Intellectual Property Office

Worldwide search of patent documents classified in the following areas of the IPC

F02M

The following online and other databases have been used in the preparation of this search report

WPI, Epodoc

International Classification:

Subclass	**Subgroup**	**Valid From**
F02M	0035/10	01/01/2006