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(58) Field of Search:
INT CL **B60P, B62D**
Other: **EPODOC, WPI**

(54) Title of the Invention: **Device for improving aerodynamics of vehicles**
Abstract Title: **Aerodynamic device in front of a wheel of a towed vehicle**

(57) A device 500 to manipulate a flow around a towed vehicle. The device comprises a deflector portion 600 and an attachment portion 700. The attachment portion is configured to connect the device to the towed vehicle. The deflector portion is configured to manipulate flow upstream of a wheel 282 of the towed vehicle such that the drag on a front face of the wheel is reduced. There are two embodiments included, figure 4 shows a wedge shaped deflector portion and figure 5 shows a flat plate 650 deflector portion. The wedge lowers a stagnation portion 272 and reduces the amount of flow that enters the channel (figure 4, 281) between the wheel and the wheel arch 288. The flat plate of figure 5 produces a low energy wake 652 which deflects the high energy flow lower, and reduces the amount of flow which enters the channel between the wheel arch and the wheel.

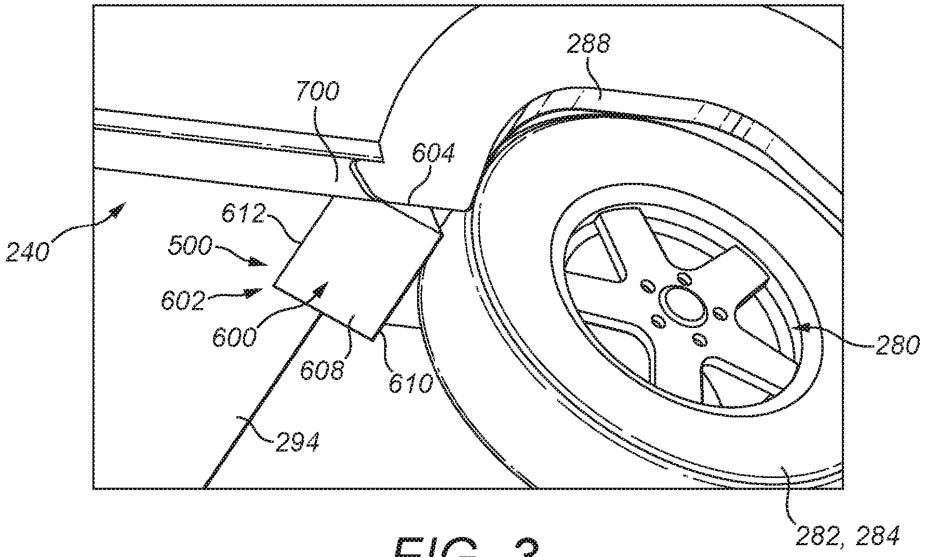

FIG. 3

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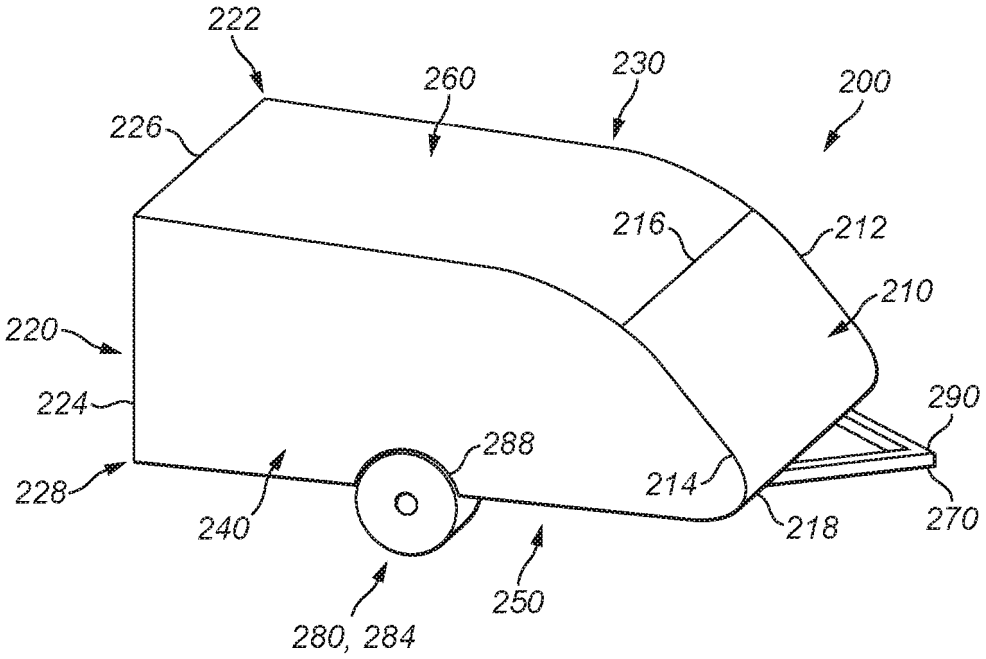
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date but within the period prescribed by Rule 22(1) of the Patents Rules 2007.


222
260
230
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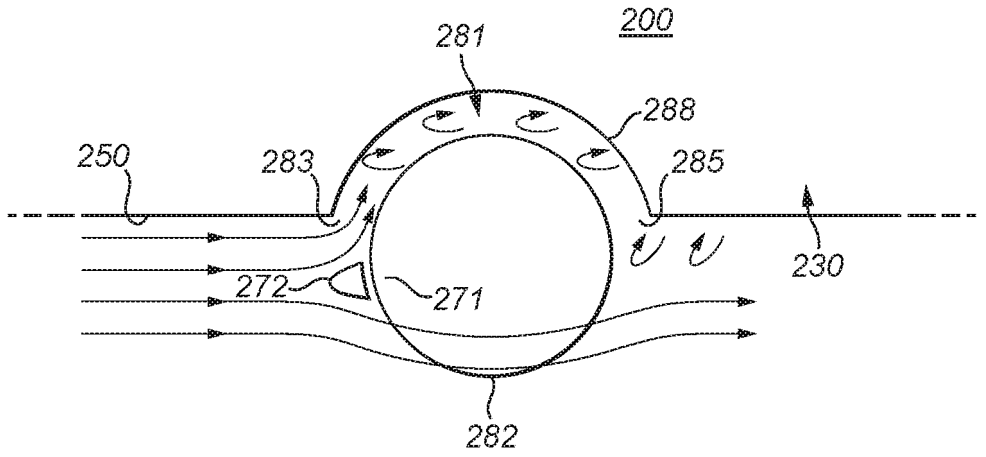
280, 284

FIG. 1


200
281
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285
230
272
271
282

FIG. 2

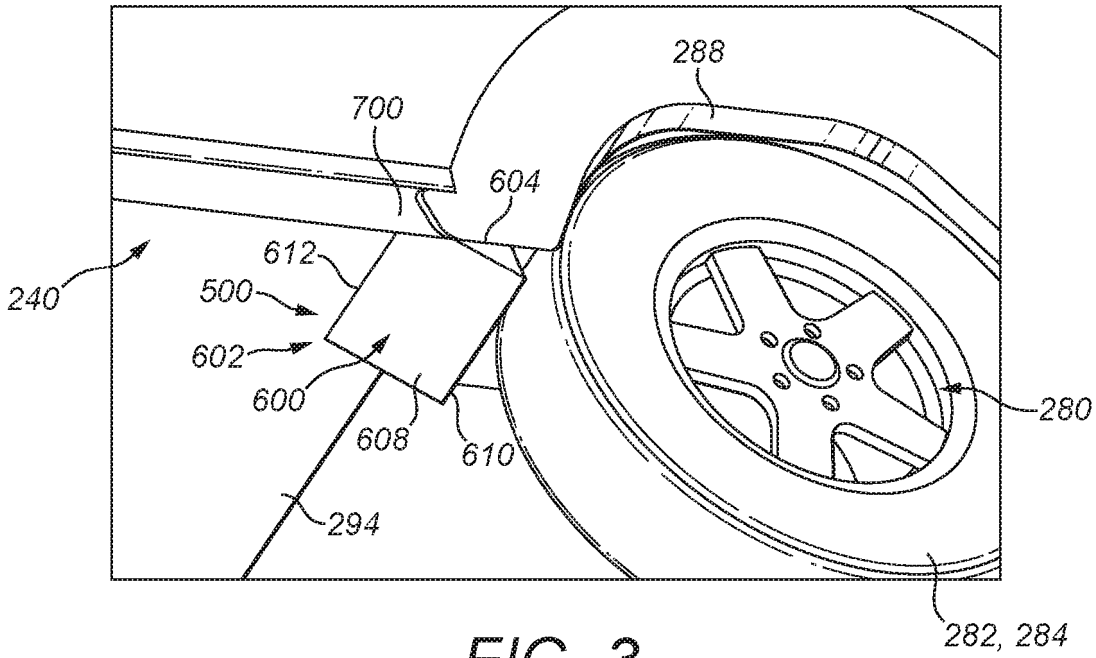

FIG. 3

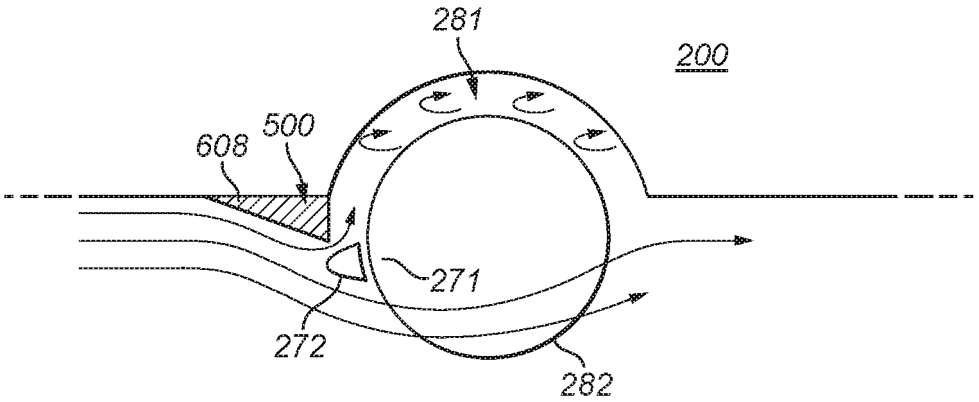

FIG. 4

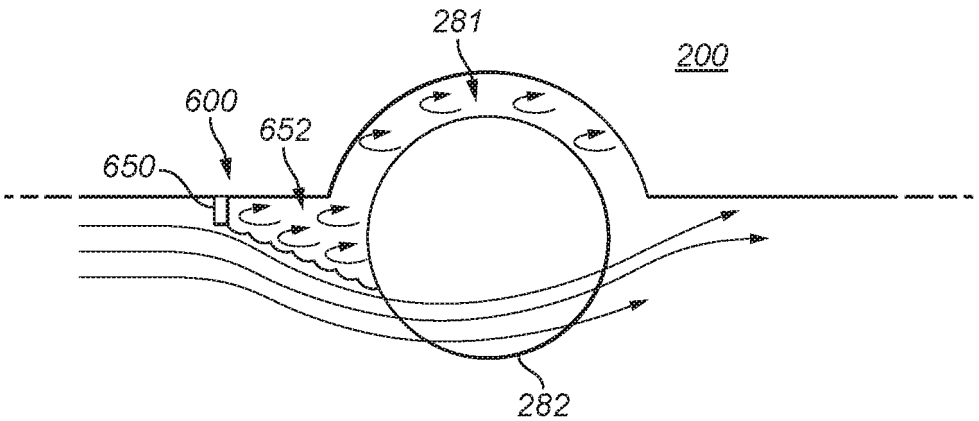

FIG. 5

DEVICE FOR IMPROVING AERODYNAMICS OF VEHICLES

FIELD OF INVENTION

The invention relates to apparatus for improving the aerodynamics of a towed vehicle such as a caravan or trailer.

BACKGROUND OF THE INVENTION

Caravans are not particularly efficient when towed. This is due to their high weight relative to the towing vehicle, rolling resistance from tyres, and their large size and shape. The latter contributes to a high aerodynamic drag, which comprises, skin friction drag and principally the pressure drag. Consequently, the vehicle used to tow the caravan expends a large amount of fuel during towing.

Historically, aerodynamic studies of flow around caravans have been considered unnecessary since it is generally accepted that the wake from the towing vehicle encompasses the flow around the caravan. Therefore, it is considered more effective to attach components upstream of the rear of the towing vehicle, such as deflectors or diffusers to control the wake, rather than attempt to optimise the shape of the caravan.

An object of the present invention is to provide a device for a towed vehicle which overcomes one of the above or other problems. More specifically, an object of the present invention is to provide a towed vehicle which is more efficient to tow.

SUMMARY OF THE INVENTION

According to a first aspect of the invention there is provided a device to manipulate a flow around a towed vehicle, the device comprising:

a deflector portion and an attachment portion,

wherein the attachment portion is configured to connect the device to the towed vehicle,

and the deflector portion is configured to manipulate flow upstream of a wheel of the towed vehicle such that the drag on a front face of the wheel is reduced.

Preferably, the towed vehicle is a caravan or a trailer.

Optionally the deflector portion is configured to manipulate flow upstream of the wheel such that a position of a region of flow stagnation, which is positioned proximate a furthest upstream position on the wheel, is lowered in respect of the ground, such that less of the front face wheel is exposed to the high energy oncoming flow to thereby reduce the drag on a front face the wheel. Preferably, the deflector portion is configured to redirect a portion of flow that travels over it downwardly such that a position of the region of stagnation is lowered. Preferably the deflector portion is configured to lower the region of stagnation such that the

oncoming flow acts on the wheel to at least partially push the wheel upwards, rather than backwards.

By undertaking numerical modelling of the flow around a caravan the inventors have found that, contrary to conventional opinion, and at normal towing velocities, the wake of the flow from the tow vehicle is in general resolved before the flow reaches the caravan. Accordingly, and contrary to the current technical prejudice, it has been found that substantial aerodynamic improvements can be made by optimising the shape of the caravan.

More particularly, it is has been found that on a conventional caravan a substantial portion of flow travels underneath the caravan, and between the bottom face of the caravan and the ground. This flow subsequently travels into the rotating tyre of the front face of the wheel and causes a region of high drag. Accordingly, the first objective is solved since the device acts to lower the flow stagnation point such that less of the wheel is exposed to the high energy oncoming flow, which results in a lower drag of the towed vehicle proximate its wheels. The inventors have found that the device can reduce the drag at the wheel by about 1 – 2%.

Optionally, the deflector portion is configured to increase the volume of the region of flow stagnation which is proximate a front face of the wheel.

Preferably, the deflector portion is configured optionally to lower the region of flow stagnation by at least 20%, more preferably by at least 10%. Preferably, the deflector portion is configured to increase the volume of the region of flow stagnation by at least 20%, more preferably by at least 10%.

Preferably, lower is defined as being in relation to a vertical direction, which extends from the ground which the wheel abuts. Preferably, the deflector portion is configured to reduce the vertical distance between the ground and the region of stagnation.

Preferably, the flow stagnation region is proximate a front face of the wheel.

Preferably, the flow stagnation region is defined as a region where the local flow velocity is approximately zero in relation to the free stream flow velocity of the flow traveling around the towed vehicle. The local flow velocity being defined in relation to the free stream flow velocity, from the reference frame of a fixed point on the moving towed vehicle.

Preferably, the front face of the wheel is defined as a region of the wheel which rotates in use and which is positioned between the rotational axis of the wheel and the furthest upstream point of the wheel, and preferably between the ground and a lower surface of the towed vehicle. More preferably, it is defined as the region of the wheel which experiences the oncoming flow.

Optionally, the device is configured to reduce the amount of flow which enters a channel defined by a gap between a wheel arch and wheel of the vehicle.

Accordingly, an aspect of the first objective is solved by re-directing a portion of the flow, which would otherwise travel in to and around the channel, towards the ground and around the sides of the wheel. In this way it has been found that the drag of the caravan can be reduced.

Preferably, the amount of flow to be reduced enters the channel substantially at an inlet of the channel, which is preferably positioned upstream of the wheel, and preferably on a bottom face of the vehicle. Preferably, flow enters the inlet by traveling substantially upwardly and into the bottom face of the vehicle. Preferably, the amount of flow to be reduced exits the channel substantially at an outlet of the channel, which is preferably positioned downstream of the wheel, and preferably on a bottom face of the vehicle. Preferably, flow exits the outlet by traveling substantially downwardly and away from the bottom face of the vehicle. However, it will be appreciate that some flow also enters and exits the channel via the sides of the channel.

Preferably, the deflector portion is configured to redirect a portion of flow which is proximate the inlet of the channel such that it preferably is redirected downwardly, towards the ground, and away from the inlet of the channel, such that it does not enter the channel, and preferably travels over the sides of the wheel. Preferably, the quantity of flow deflected is a substantial portion. More preferably, the device is operable to reduce the mass flow rate of flow traveling in a portion of the channel, such as the inlet, preferably by at least 10%, for conventional vehicle velocities, such as 30 – 120 Km/H. More preferably, the device is operable to reduce the mass flow rate by at least 20%.

Preferably, the deflected flow is defined as the portion of flow that travels over the deflector portion and / or proximate the deflector portion preferably such that the flow path is perturbed away from the channel inlet. This may be the flow that travels within a locus of about 20 cm of the control surface of the deflector portion.

Preferably, deflector portion is configured to deflect flow downwards and into the ground preferably at a position in front of the wheel. Preferably, the deflector portion is configured such that the deflected flow travels substantially around one or both sides of the wheel.

Preferably, the attachment portion is configured attach the device proximate the wheel arch. Preferably, the attachment portion is configured attach the device upstream of the wheel arch, preferably such that the deflector portion is proximate and upstream of the inlet, and preferably such that the deflector portion is in line with the wheel.

Preferably, the attachment portion is configured to attach the device to a component that forms part of the underside of the vehicle, such as the chassis. Preferably, the attachment portion is configured to be formed integrally to the vehicle or to be removably attached to the vehicle, for instance, by fixing means, such as bolts.

Optionally, the deflector portion is substantially wedge shaped. Preferably the wedge has a length, from a rear face to a tip of the wedge, of between about 10cm - 50cm, more preferably it is about 35cm. Preferably, a rear face of the wedge has a height of between 10cm – 30cm, more preferably it is about 20cm. Preferably, the deflector portion is configured such that the rear face of the wedge extends downwardly from the underside of the vehicle.

Preferably, the wedge has a width greater than or equal to a width of the wheel. Preferably, the wedge is arranged to point upstream of the flow, such that the tip is upstream of the rear face.

Optionally, the deflector portion is configured to manipulate flow upstream of the wheel such that a region of low energy wake is generated which extends proximate at least part front face of the wheel. Low energy is defined in relation to the high energy free stream flow.

Accordingly, the first objective is solved since the device acts to generate a low energy wake which extends over the front face of the wheel. Accordingly, less of the wheel is exposed to the high energy oncoming flow, which results in a lower drag of the towed vehicle proximate its wheels. The inventors have found that the device can reduce the drag at the wheel by about 1 - 2%.

Optionally, the deflector portion is configured to generate a region of wake downstream of the deflector portion. Preferably, the wake extends from the deflector portion to substantially around the front face of the wheel.

Optionally, the deflector portion comprises a substantially flat plate which is configured to extend vertically downwards from the bottom surface of the towed vehicle. Preferable, the flat plate extends downwards by about 2cm – 10cm, and is preferably about 10cm – 50cm upstream of the furthest upstream point of the wheel.

Preferably, the device is made from one or more or the following, or a similar material; ABS, GRP, Nylon, ASA, EPDM, TPV, metal.

According to a second aspect of the present invention there is provided towed vehicle such as a caravan or a trailer or comprising a device according to the first aspect of the invention.

According to a third aspect of the invention there is provided a method of manipulating flow around a towed vehicle the method comprising:

Manipulating flow upstream of a wheel of the towed vehicle by means of a deflector portion of a device which is attached to the towed vehicle at an attachment portion, the flow being manipulated such the drag on a front face of the wheel of the wheel is reduced.

Optionally, the method includes a step of manipulating the flow such that a position of a region of flow stagnation, which exists proximate a furthest upstream position on the wheel, is lowered in respect of the ground, to thereby reduce the drag on a front face the wheel.

Optionally, the method includes a step of manipulating the flow upstream of the wheel such that a region of low energy wake is generated which extends proximate at least part front face of the wheel.

Optionally, the method includes a step of using the deflector portion to reduce the amount of flow that enters a channel defined by a gap between a wheel arch and a wheel of the vehicle.

All of the features described herein may be combined with any of the above aspects, in any combination.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings in which:

Figure 1 shows a perspective view of a prior art caravan;

Figure 2 shows a side cross-sectional view of fluid flow around a wheel of the caravan of figure 1;

Figure 3 shows a perspective view of a device to manipulate flow according to an exemplary embodiment of the invention;

Figure 4 shows a side cross-sectional view of fluid flow around a wheel of a caravan comprising the device of figure 3.

Figure 5 shows a side view of a device to manipulate flow according to a further exemplary embodiment of the invention.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

Figure 1 shows a perspective view of a caravan 200. Herein, the caravan 200 is defined as having a front face 210 and rear face 220, both of which are generally arranged to have a plane which is substantially perpendicular to the direction of motion of the caravan 200 (although in this embodiment the front face is shown curved to improve the aerodynamics of the caravan) and extend substantially upwardly from the ground (not shown), wherein the front face 210 is positioned upstream with respect to the rear face 220 in relation to the flow over the caravan 200 when being towed.

The caravan 200 further comprises a left side face 230 (not shown) and right side face 240, both of which extend substantially upwards from the ground, and both of which extend from the front face 210 to the rear face 220.

The caravan 200 further comprises a bottom face 250 (not shown) and top face 260, both of which are substantially aligned to the ground, and both of which extend from the front face 210 to the rear face 220. The bottom face 250 is closest to the ground, and the top face 260 is positioned furthest from the ground.

In more detail, on one side of the front face 210 there is a left front edge 212, and on the other side there is a right front edge 214, both of which extend from a bottom to a top of the caravan 200. On one side of the rear face 220 there is a left rear edge 222 (not shown), and on the other side there is a right rear edge 224, both of which extend from a bottom to a top of the caravan 200. The left side face 230 and right side face 240 are positioned symmetrically about a centrally aligned plane 270 (not shown) of the caravan 200. The left side face 230

extends from the left front edge 212, to the left rear edge 222, and the right side face 240 extends from the right front edge 214, to right rear edge 224.

On the top of the front face 210 there is a top front edge 216, and on the bottom there is a bottom front edge 218, both of which extend in a direction which is substantially aligned to the ground and between the two side faces 230, 240. On the top of the rear face 220 there is a top rear edge 226, and on the bottom there is a bottom rear edge 228 (not shown), both of which extend in a direction which is substantially aligned to the ground and between the two side faces 230, 240. Hence the top face 260 extends from the top front edge 216 to the top rear edge 226, and the bottom face 250 extends from the bottom front edge 218 to the bottom rear edge 228.

The caravan 200 further comprises wheels 280. The wheels 280 are positioned between the bottom surface 250 and the ground and are located approximately mid-way between the front face 210 and rear face 220. In more detail the wheels 280 comprise a first wheel 282 (not shown) poisoned proximate the left side face 230, and a second wheel 284 positioned proximate the right side face 240. The wheels 282, 284 are connected by means of an axle 286 (not shown) and are arranged symmetrically about the central plane 270. The axle 286 protrudes from the bottom of the caravan 200 such that the wheels 280 extend partially into a wheel arch 288 of the bottom surface 250.

The caravan 200 yet further comprises a drawbar 290 for receiving a tow bar (not shown) of a towing vehicle, which may comprise a car or other suitable vehicle. The drawbar 290 is arranged to extend in the direction of towing from proximate the bottom front edge 218.

The caravan 200 yet further comprises a chassis 294 (not shown). The chassis 294 extends proximate the bottom face 250, and forms the main structural component of the caravan 294, to provide a rigid support for the wheels 280, drawbar 290, body panels which comprise the top, front, rear and side faces, and the framework 296 (not shown) that supports these body panels.

Figure 2 shows the flow around a conventional wheel 282 of a caravan. In more detail, at the furthest upstream position 271 of the wheel there is located a flow stagnation region 272, which extends between the low energy boundary layer flow proximate the surface of the wheel to the higher energy oncoming flow. A portion of the high energy flow travels around the stagnation region and upwards into the wheel arch that defines the channel 281, as will be discussed in more detail below. A portion of the flow also travels around the stagnation region 272 and downwards towards the ground and around the sides of the wheel 282. Numerical modelling of the flow around caravans has shown that due to the relatively high velocity of the oncoming flow, the front face of the wheel experiences high drag.

Accordingly, the invention is principally concerned in reducing this quantity of drag. To a lesser extent the invention is also concerned with reducing the portion of flow which enters the channel 281, as will be discussed following.

Considering the channel 281 in more detail, the channel 281 comprises an inlet 283, which is positioned upstream of the wheel 282, and on the bottom face 250. As show in figure 2 the flow which travels underneath the caravan enters the inlet 283 by traveling upwardly with

respect to the ground (not shown). The channel 281 further comprises an outlet 285, which is positioned downstream of the wheel 282, and on the bottom face 250. As show in figure 2 the flow which travels around the channel exits the channel via the outlet 285 by traveling downwardly with respect to the ground (not shown). Accordingly, the channel 281 is curved in the form of a roughly half an annular ring. Although, the channel is shown to have a more or less constant cross section, it will be appreciated that the shape of the channel varies as the wheel 282 moves relative to the wheel arch 288 as part of the suspension system of the caravan. It will also be appreciated that some flow may enter and exit the channel 281 via the sides of the channel, which are arranged on a portion of the channel that extends between the inlet 283 and the outlet 285. However, this amount of flow may be minimised by having a wheel arch 288 with side portions (not shown) that extend from the wheel arch to cover part or all of the sides channel and may further cover part or all of the wheel 282. From figure 2 it can be seen that a the flow that travels around the stagnation region 272 and into the channel 281 is subject to viscous losses caused between the stationary wheel arch 288 and rotating wheel, which leads to highly turbulent flow and drag.

Figure 3 shows a first embodiment of a device 500 to manipulate flow around the caravan 200. The device 500 comprises a deflector portion 600 and attachment portion 700, which will be discussed in more detail below.

In this embodiment the attachment portion 700 comprises a fixing means (not shown) to connect the device 500 to an underside of the caravan chassis 294, at a position upstream of the wheel 282, and in line with the wheel. In this embodiment the fixing means comprises four apertures through a bracket (not shown) through which bolts are inserted and secured into the chassis 294. To remove the device 500 from the caravan the bolts are unscrewed and removed from the apertures. Accordingly, the device 500 is removably attached to the caravan 200. In alternative embodiments, the fixing means comprise an adhesive strip, or other suitable attachment means such as welding.

In an alternative embodiment the device 500 may be formed integrally with the chassis or any other part of the underside of the caravan such that it is not removably attached. In more detail, the device 500 may be moulded as part of the wheel arch 288 or the bottom surface 250 of the caravan.

It will be appreciated that the caravan 200 has two devices 500 fitted thereto, one in front of each wheel 282, 284. However, for simplicity only one of the devices 500 is shown in figure 3.

In this embodiment the deflector portion 600 is shaped in the form of a wedge 602, comprising a base surface 604 and outer surface 608, which at one end are separated by a rear face 610 and at the other end come together to form a tip 612. In this embodiment a base surface 604 is formed integrally with the bracket of the attachment portion 700, however in other embodiments it may be formed separately and connected by fixing means such as bolts or an adhesive strip.

In this embodiment the outer surface 608 and rear face 610 are substantially straight, however it will be appreciated that in other embodiments it may be curved.

The base surface 604 is arranged to lie substantially flat in relation to the bottom face 250 of the caravan 200. In this way the outer surface 608 of the wedge extends outwardly from the chassis 294, and is arranged such that the wedge 602 points upstream, with the rear face 610 adjacent to the wheel 280, and the tip 612 upstream of the rear face 610.

In this embodiment the wedge 602 is arranged vertically such that the base surface 604 is approximately in line with the axle 286 of the wheels when the caravan is normally laden. Although it will be appreciated that the position of the axle will vary as it forms part of the caravan suspension system.

The horizontal distance between the rear face 610 and tip 612 of the wedge is about 30 - 50% of the diameter of the wheel 280. The rear face 610 has a vertical length of about 10 – 30% of the horizontal distance between the rear face 610 and tip 612.

In this embodiment the wedge 602 has a width which is roughly the same as the width of the channel 281 and which is greater than the width of the wheel 280. In this embodiment the width of the wedge is about 20% greater than that of the wheel 280.

The wedge 602 is arranged such that the outer surface 608 forms a control surface to guide flow. The outer surface 608 has an angle of attack in the range of about 20 – 70^0, however in a preferred embodiment it is about 30^0.

The flow pattern over the device 500 is illustrated in figure 4. It can be seen that, as the oncoming flow travels over / proximate to the outer surface 608, the stagnation region 272 is lowered, such that it is closer to the ground. In this particular example it is lowered such that the vertical distance between the ground and the stagnation region 272 is reduced by about 20%, however it will be appreciated that this amount will vary depending on flow velocity and the angle of the wedge 602.

This has the advantage that the area of the front face of the wheel 282 which is exposed to the high energy oncoming flow is reduced. Particularly because the flow between the stagnation region 272 and the channel 281 has less energy than the oncoming flow. Accordingly, the deflector portion has the effect of increasing the volume of this region, such that a greater portion of it extends around the wheel.

An additional effect of the lowered stagnation region is that the horizontal component of force that the oncoming flow applies to the wheel is reduced. In more detail, since the stagnation region is lowered, a greater portion of the oncoming flow travels into a lower portion of the wheel such that it acts to push the wheel upwards as well as backwards.

A further effect of the deflector portion is that the flow that would otherwise travel into the inlet 283 of the channel 281 is redirected such that it flows downwardly in front of the wheel 282, and away from the inlet 283. The redirected flow subsequently travels over the sides of the wheel. It has been calculated that the mass flow rate of flow traveling into the inlet is reduced by around 1 - 2%, for conventional caravan velocities, such as 30 – 90 Km/H.

Figure 5 shows an alternative embodiment of the invention, wherein the deflector portion 600 comprises a flat plate 650. In the example shown the flat plate 650 is orientated in a

substantially vertical plane and extends downwards by about 5cm from the bottom face 250 of the caravan 200 and is approximately the width of the wheel of the caravan. The material and thickness of the deflector portion are selected such that deflector portion maintains substantially the same shape in response to the oncoming flow, for instance, it is 3mm thick and made from metal. The flat plate is positioned about 30cm upstream of the furthest upstream point 271 of the wheel.

As shown in figure 5, the flat plate 650, at conventional towing velocities, is operable to generate a region of wake 652 in the oncoming flow which extends from the flat plate to around at least part of the front face of the wheel 282. Since the low energy wake extends around part of the front face of the wheel, the wheel is exposed to less of the higher energy oncoming flow, and thus has less drag.

In more detail, the wake extends from proximate the channel 281 to proximate the ground. In this way the majority of the front face of the wheel that would otherwise be subject to the high energy oncoming flow is covered by the wake. The wake 652 also extends around the entrance to the channel 281 such that less flow travels into the channel.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

CLAIMS

1. A device to manipulate a flow around a towed vehicle, the device comprising:

a deflector portion and an attachment portion,

wherein the attachment portion is configured to connect the device to the towed vehicle,

and the deflector portion is configured to manipulate flow upstream of a wheel of the towed vehicle such that the drag on a front face of the wheel is reduced.

2. The device as claimed in claim 1, wherein the towed vehicle is a caravan or a trailer.

3. The device as claimed in any preceding claim, wherein the deflector portion is configured to manipulate flow upstream of the wheel such that a position of a region of flow stagnation, which is positioned proximate a furthest upstream position on the wheel, is lowered in respect of the ground, such that less of a front face of the wheel is exposed to the high energy oncoming flow to thereby reduce the drag on the front face of the wheel.

4. The device as claimed in claim 3, wherein the deflector portion is configured to redirect a portion of flow that travels over the deflector portion downwardly such that a position of the region of stagnation is lowered.

5. The device as claimed in claim 4 , wherein the deflector portion is configured to lower the region of stagnation such that the oncoming flow acts on the wheel to at least partially push the wheel upwards, rather than backwards.

6. The device as claimed in claims 3 – 5, wherein the deflector portion is configured to increase the volume of the region of flow stagnation which is proximate a front face of the wheel by at least 20% or by at least 10%.

7. The device as claimed in claims 3 – 6, wherein the deflector portion is configured to lower the region of flow stagnation by at least 20%, or by at least 10%.

8. The device as claimed in any preceding claim, wherein the device is configured to reduce the amount of flow which enters a channel defined by a gap between a wheel arch and wheel of the vehicle.

9. The device as claimed in claim 8, wherein the flow reduced is the flow that enters the channel substantially at an inlet of the channel, which is positioned upstream of the wheel, and on a bottom face of the vehicle, and the flow enters the inlet by travelling substantially upwardly and into the bottom face of the vehicle, thereafter the flow exits the channel substantially at an outlet of the channel, which is positioned downstream of the wheel, and is on a bottom face of the vehicle, the flow exits the outlet by travelling substantially downwardly and away from the bottom face of the vehicle.

10. The device as claimed in claim 9, wherein the deflector portion is configured to redirect a portion of flow which is proximate the inlet of the channel such that it is redirected downwardly, towards the ground, and away from the inlet of the channel, such that it does not enter the channel, and travels over the sides of the wheel.

11. The device as claimed in claims 8 – 10, wherein the device is operable to reduce the mass flow rate of flow travelling in a portion of the channel, such as the inlet, by at least 10%, or at least 20%, for conventional vehicle velocities, such as 30 – 120 Km/H.

12. The device as claimed in any preceding claim, wherein the attachment portion is configured to attach the device upstream of the wheel such that the deflector portion is in line with the wheel.

13. The device as claimed in claim 12, wherein the attachment portion is configured to attach the device to part of the underside of the vehicle.

14. The device as claimed in any preceding claim, wherein the attachment portion is configured to be formed integrally to the vehicle or to be removably attached to the vehicle by fixing means.

15. The device as claimed in any preceding claim, wherein the deflector portion is substantially wedge shaped.

16. The device as claimed in claim 15, wherein the wedge has a length, from a rear face to a tip of the wedge, of between about 10cm – 50cm or about 35cm.

17. The device as claimed in claim 16, wherein a rear face of the wedge has a height of between 10cm – 30cm, or about 20cm.

18. The device as claimed in claims 15 – 17, wherein the deflector portion is configured such that the rear face of the wedge extends downwardly from the underside of the vehicle.

19. The device as claimed in claims 15 – 18, wherein the wedge has a width greater than or equal to a width of the wheel.

20. The device as claimed in claims 15 – 19, wherein the wedge is arranged to point upstream of the flow, such that the tip is upstream of the rear face.

21. The device as claimed in claims 1 – 2, wherein the deflector portion is configured to manipulate flow upstream of the wheel such that a region of low energy wake is generated which extends proximate at least part front face of the wheel.

22. The device as claimed in claim 21, wherein the deflector portion is configured to generate a region of wake downstream of the deflector portion.

23. The device as claimed in claim 22, wherein the wake extends from the deflector portion to substantially around the front face of the wheel.

24. The device as claimed in claims 21 – 23, wherein the deflector portion comprises a substantially flat plate which is configured to extend vertically downwards from the bottom surface of the towed vehicle.

25. The device as claimed in claim 24, wherein the flat plate is configured to extend downwards by about 2cm – 10cm and is configured to be positionable about 10cm – 50cm upstream of the furthest upstream point of the wheel.

26. A caravan or a trailer comprising a device according to any of claims 1 – 25.

27. A method of manipulating flow around a towed vehicle, the method comprising:

manipulating flow upstream of a wheel of the towed vehicle by means of a deflector portion of a device which is attached to the towed vehicle at an attachment portion, the flow being manipulated such, the drag on a front face of the wheel is reduced.

28. The method as claimed in claim 27, wherein the method includes a step of manipulating the flow such that a position of a region of flow stagnation, which exists proximate a furthest upstream position on the wheel, is lowered in respect of the ground, to thereby reduce the drag on a front face of the wheel.

29. The method as claimed in claim 27, wherein the method includes a step of manipulating the flow upstream of the wheel such that a region of low energy wake is generated which extends proximate at least part front face of the wheel.

Intellectual Property Office

Application No:	GB1302215.7	**Examiner:**	Mr Stephen Watts
Claims searched:	All	**Date of search:**	27 August 2014

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	1-20 and 26-28	DE29619772 U (ZAPPOLD) See specifically figures 1 and 3, and WPI Abstract accession no. 1998-180583.
X	1-20 and 26-28	US2006/252361 A1 (HENDERSON) See figures 6 and 7 especially.
X	1-20 and 26-28	CA1156293 A (AUBREY et al) Specifically see figures 1 and 3.
X	1, 2, 8, 9, 11-15, 18-20 26 and 27	US2013/076066 A1 (WONG) See especially figures 2-6.
X	1-20 and 26-28	FR2912080 A1 (RENAULT SAS) See figures and WPI abstract accession no. 2008-J32279.
X	1, 2, 21-27 and 29	US2605119 A1 (MAXWELL) See figure 8.
X	1, 2, 21-27 and 29	DE1903789 A1 (DAIMLER BENZ AG) See figures, especially figure 2, and WPI abstract accession no. 1978-B7206A.
X	1, 2, 21-27 and 29	EP2039595 A1 (BAYERISCHE MOTOREN WERKE AG) See figures 1-3, and WPI abstract accession no. 2009-G22192.

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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Field of Search:

Intellectual Property Office

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[X] :

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

B60P; B62D

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

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
B62D	0035/00	01/01/2006
B62D	0035/02	01/01/2006
B62D	0037/02	01/01/2006