(12) UK Patent Application (19) GB (11) 2 356 610 (13) A

(43) Date of A Publication 30.05.2001

(21) Application No 9927838.4

(22) Date of Filing 26.11.1999

(51) INT CL[7]
B60B 39/00 // B60S 1/68

(52) UK CL (Edition S)
B7H HQX

(56) Documents Cited
GB 2290884 A US 5566420 A US 3893535 A

(58) Field of Search
UK CL (Edition R) B7D DXA DXX , B7H HQX HXG
INT CL[7] B60B 15/00 39/00 , B60S 1/68 , B62D 55/08
Online WPI, EPODOC, JAPIO

(71) Applicant(s)
Bayerische Motoren Werke AG
(Incorporated in the Federal Republic of Germany)
Petuelring 130, BMW Haus, D-800 München 40,
Federal Republic of Germany

(72) Inventor(s)
Martin Ranson
Paul Thomas Faithfull

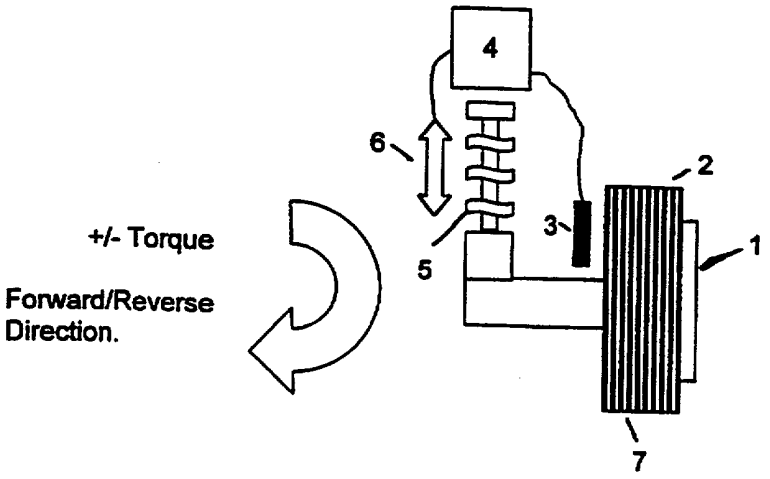
(74) Agent and/or Address for Service
Bromhead & Co
37 Great James Street, LONDON, WC1N 3HB,
United Kingdom

(54) Abstract Title

An arrangement for the unclogging of the wheel of an off-road motor vehicle

(57) A controller 4, 14 is configured to determine any changes in the speed of the wheel 1, 11 or inertia mass indicative of clogging to the tread 7, 17. Then, at an appropriate point in the extension of a suspension mechanism 5, or by activating the suspension lift mechanism 15 the speed of rotation for the wheel assembly 1, 11 is altered in order to increase the centrifugal force applied to the tread 7, 17, thus urging the clogging matter from the tread 7, 17. The controller 4, 14 will also slow and/or reverse the direction of rotation of the wheel 1, 11 or provide abrupt stopping to the wheel 1, 11 in order to further urge detachment of the clogging matter from the tread 7, 17.

Figure 1.



GB 2 356 610 A

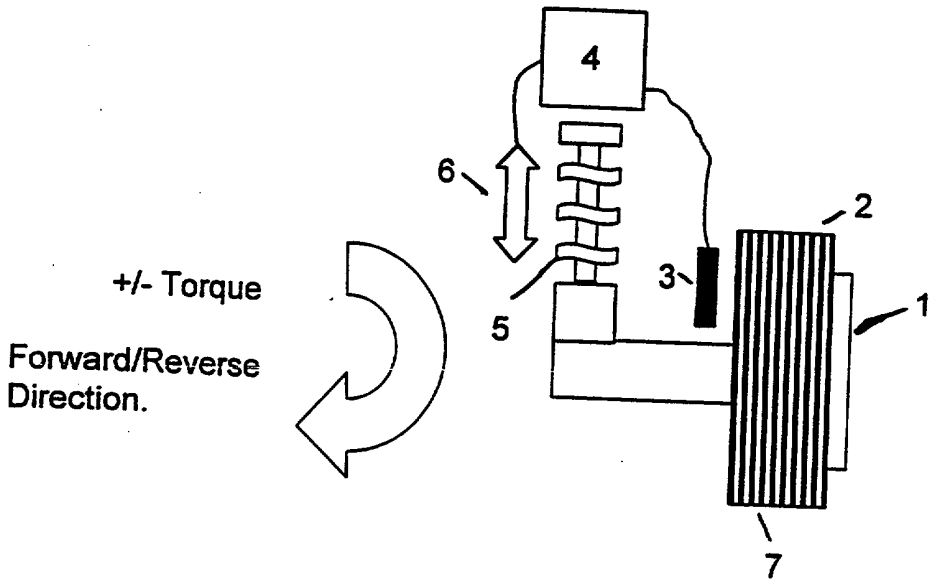
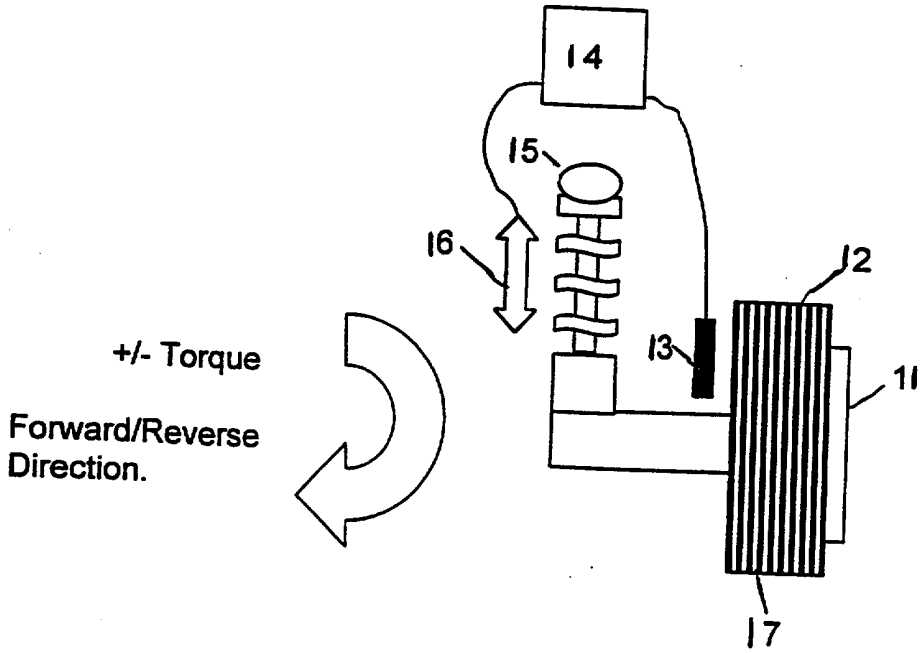

4
6
2
3
1
5
+/- Torque
Forward/Reverse
Direction.
7

Figure 2.


14
15
16
12
13
11
+/- Torque
Forward/Reverse
Direction.
17

A Traction Arrangement

The present invention relates to a traction arrangement and more particularly to a traction arrangement for a vehicle having individually driven treaded traction wheels where the vehicle is used off-road.

A common problem with treaded vehicles when used off-road is the inherent tendency for debris and other matter to clog the treads of a wheel such that the limit of adhesion between that wheel and a surface upon which the vehicle is being driven is exceeded with resultant slippage and lack of traction. Thus, it is known whilst traversing certain types of terrain for the tread of vehicle wheels to accumulate material to a point where that tread is substantially or completely full of clogging material i.e. mud and debris and the vehicles ability to maximise traction over such terrain becomes greatly reduced until the vehicle completely loses traction. Once such complete loss of traction has occurred it will be understood that typically the wheels of the vehicle will spin with a significant impact upon the environment of a vehicle as the terrain is churned-up by the action of the spinning wheels.

It will be understood that wheels that are clogged such that there is slippage can be induced into a cleaning process by acceleration of the wheels to increase the centrifugal forces particularly about the periphery of the wheels in order to throw the clogging debris or other matter from the tread of the wheel. Typically, through a known off-road driving technique the driver of a vehicle will blip or temporarily accelerate all the driven vehicle wheels in order to provide this induced detachment of clogging debris from the treads of a wheel. Clearly, this driving technique can result in significant churning of the surface upon which an off-road vehicle is driven and so is not an ideal practice.

It will be understood that some wheels are arranged whereby individual wheels of a vehicle can be controlled in terms of their torque and speed independently of one another or in a co-ordinated manner as determined by a controller within the vehicle. In such circumstances, the rotational of speed of individual wheels will be altered.

It is an object of the present invention to provide a traction arrangement in which clogging debris can be conveniently removed from a treaded wheel.

In accordance with the present invention there is provided a traction arrangement for a vehicle having an individually driven treaded traction wheel, the arrangement including a controller to control and monitor rotation and drive of the treaded traction wheel along with configuration of that traction wheel relative to a surface upon which the treaded traction wheel is driven whereby the controller determines either any change in the rate of wheel rotation or inertia mass of the traction wheel indicative of clogging of that traction wheel by clogging matter and the controller then monitors configuration of that wheel to determine when it is appropriate to significantly increase the speed of wheel rotation to enhance centrifugal force imposed upon the periphery of the wheel such that the clogging matter is urged to detach from the treaded traction wheel.

Typically, the controller will monitor the configuration of the wheel such that it is raised relative to the ground upon which that wheel is driven or will determine when the wheel is in a configuration where the load placed upon that respective wheel is reduced. Such monitoring of the configuration of the wheel will be through sensors appropriate for determining the suspended height of the wheel via the suspension arrangement of the vehicle or by proximity radar sensors located in the structure of the vehicle directed to determine the variation in

distance between that structure of the vehicle and the surface upon which the wheel is driven or alternatively, load sensors may be provided.

The controller may be arranged to reverse the direction of rotation of the traction wheel in order to urge detachment of the clogging matter from the treaded traction wheel.

The traction arrangement may also include specific wheel configuration mechanisms in order to specifically configure the wheel as desired for urging detachment of clogging matter from the treaded wheel by increasing the speed of wheel rotation.

Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings in which:-

Figure 1 is a schematic illustration of a first embodiment of a traction arrangement; and

Figure 2 is a schematic illustration of a second embodiment of a traction arrangement.

Figure 1 is a schematic illustration of a first embodiment of a traction arrangement in accordance with the present invention. Thus, it will be appreciated when a vehicle is driven across a surface, a treaded traction wheel 1 having a tyre 2 incorporating a tread rotates relative to the direction of vehicle travel. The wheel 1 speed is measured with a wheel speed sensor 3 such that the controller 4 monitors the speed of wheel rotation relative to the speed of other vehicles (not shown). Thus, the relative performance of the wheel 1 can be determined by the controller 4. The vehicle will also incorporate the suspension mechanism 5 which will move up and down relative to the surface upon which the

wheel is driven. This displacement of the suspension 5 and therefore the wheel 1 configuration is monitored by a sensor 6 which in turn responds to the controller 4 in order that that controller 4 appreciates the wheel 1 configuration.

As indicated previously, if the surface upon which the wheel 1 is driven is of a certain composition the tread surface of the tyre 2 upon the wheel 1 will become clogged as the individual treads 7 fill up with clogging matter. It will be understand that such clogging matter may include mud, gravel, vegetation or other debris.

It is known with regard to vehicle traction control that if a wheel is rotating at a speed that it is not keeping pace with others in the vehicle then it is slipping. Clearly, measures can be taken to arrest slippage of the wheel. However, as described previously, it can be beneficial for wheels to spin at a speed greater than normal in order to provide a centrifugal force to urge detachment of clogging matter from the wheel. In accordance with the present invention the controller 4 is arranged to manage wheel speed in order to facilitate such detachment of clogging matter at the most appropriate time.

In accordance with a first embodiment of the present invention depicted in Figure 1, the controller 4 utilises a simple strategy whereby wheel 1 speed is controlled in a predetermined manner such that every time the wheel 1 slips when in an off-road environment a particular wheel speed variation process is implemented. Typically, this wheel speed variation process will involve accelerating and decelerating the wheel 1 by applying and removing torque as required. In such circumstances, it will appreciated that the greater centrifugal force applied to the tread 7 will urge detachment of clogging matter from the tread 7 and this detachment will also be facilitated by relatively abrupt acceleration, deceleration, stopping and wheel 1 rotation in a reverse direction.

Clearly, in order to implement the present invention the vehicle must incorporate a powertrain i.e., traction transmission which is configured such that it is possible to individually control torque and traction at each wheel 1. In such circumstances, as described previously it will also be understood that individual control of each wheel 1 allows the direction of that wheels rotation to be changed in order to enhance the forces presented about the periphery of the wheel to enhance urging of clogging matter from the tread 7.

In order to improve both efficiency and to ensure minimum damage to the surface upon which the wheel 1 is driven it is beneficial to ensure that the controller 4 should specifically decide that a particular wheel 1 of the vehicle needs "clearing" of clogging material. Such selective and intermittent operation of the present vehicle traction arrangements will ensure localised and minimum damage to the environment through which the wheel 1 and therefore the vehicle is driven.

It will be understood wherever implemented the accelerated wheel speed as the wheel 1 is spinned for clogging material detachment or the wheel 1 is reversed will inherently churn and gouge any surface upon which that wheel 1 is currently located. However, it is preferable that such churning and gouging of the surface upon which the wheel 1 is driven is localised rather than spread over a significant area. Furthermore, the present invention ensures an intense tread 7 clearing procedure with localised damage rather than a diffuse procedure previously with its inherent widespread damage to the environment.

It will be understood that the sensor 6 associated with the suspension mechanism 5 will be used by the controller 4 to determine situations where the wheel 1 is either raised or at a lower forced contact with a surface upon which the wheel 1 is driven. In such circumstances, when these raised or low force contact configurations of the wheel are determined by the controller 4, that controller 4

will arrange acceleration, deceleration, reversal abrupt braking of the wheel 1 in order to urge detachment of clogging material. Thus, damage to the surface upon which the wheel 1 is driven will be reduced.

It will be understood that the suspension 5 will be particularly articulate with regard to off-road vehicles due to the very uneven surface upon which such a vehicle will travel. Thus, the potential for short time period wheel rotations in order to dislodge clogging matter from the tread 7 is greater for off road vehicles in comparison with normal road vehicles.

An alternative approach to determination of whether a wheel has too much compacted clogging matter attached to it is to determine the condition of the tyre tread in relation to their material content and the position of the wheel relative to the surface upon which the wheel is driven. It is known for a given mass of wheel spinning in free space and thus assuming a constant radius, the wheel will have a known value for its mass of inertia. Consequently, it is also known that for a given torque input to the wheel with that known mass of inertia, the wheel will tend to accelerate at a constant rate assuming losses within the system internally and externally are constant. In such circumstances, as the vehicle progresses across a terrain having a composition whereby the tread of the respective traction wheels may become embedded with clogging material, the suspension will move relative to the terrain. Thus, assuming that a traction wheel will lose contact or is on the point of losing contact as a result of such suspension articulation it will be possible to determine from the value of the mass of inertia for that wheel the level of clogging material attached to the wheel.

In such the above circumstances, the controller 4 includes a reference value for the mass of inertia for each wheel assembly 1. Thus, as the vehicle progresses across a terrain, the controller 4 monitors movement of the suspension 5 and the

speed of each respective wheel 1 in order to determine any loss of traction. When a wheel 1 begins to slip, the controller determines whether the suspension 5 is fully extended by monitoring the sensor 6. Clearly, when the suspension 5 is fully extended the wheel will typically be off or very close to detachment from the surface of the terrain over which the wheel 1 is being driven. With the suspension 5 in such a fully extended state it will be appreciated that a known torque can be presented to the wheel and the resultant acceleration of that wheel 1 determined. It is then possible to compare the value of mass of inertia for the wheel 1 with the known value of torque with that expected for a free wheel at that torque value which will generally be held within the controller 4 as a reference.

Clearly, if upon comparing the result for the value of the mass of inertia at the point of suspension 5 at full extension with the reference value it is found that there is a disparity, a consideration must be made as to whether that disparity is within a threshold typically consistent with measurement errors and/or any residual contact with the surface of the terrain. However, the value of the mass of inertia is found to exceed this threshold it can be accepted that the wheel 1 has gained mass as a result of the tread 7 becoming clogged with clogging material. In such circumstances, the controller 4 will implement a clearing strategy as described previously in order to dislodge and urge such clogging matter from attachment to the tread 7. Such strategies as described previously may include acceleration, deceleration, reverse rotation and/or abrupt stopping of the wheel 1.

The embodiments of the present invention described so far have depended upon natural articulation of the suspension mechanism 5 as a vehicle is driven over rough terrain. Thus, the arrangement is dependant upon the unevenness of that terrain in order to provide situations where the wheel 1 can undertake a cleaning strategy as described. However, it will be understood that as depicted in Figure 2, a second embodiment of the present invention may include a suspension

lift mechanism 15 in order to actively adjust the vertical displacement of the suspension and therefore of a wheel 11 secured to that suspension mechanism 15 to enable wheel tread cleaning.

Generally, the traction arrangement as depicted in Figure 2 operates in a similar manner to that described with regard to Figure 1 except that the suspension lift mechanism 15 can actively raise the wheel 11 relative to a surface upon which that wheel 11 is driven. Thus, as a vehicle drives across a surface, the wheel 11 and its tyre 12 rotate relative to the direction of vehicle travel. The wheel 11 speed is measured by a controller 13 using a wheel speed sensor 14.

As described previously, the controller 14 monitors the wheel 11 in terms of any changes in its speed of rotation or value of its mass of inertia both with regard to a reference expected for that wheel 11 and/or relative to other wheels of the vehicle. However, as the controller 14 has the facility to alter the vertical position of the wheel 11 relative to the surface upon which that wheel 11 is driven using the suspension lift mechanism 15 and a position sensor 16 it is possible to dislodge and urge detachment of clogging matter from the tyre 12 and more particularly its tread 17 in the following ways:-

a/ by raising the suspension mechanism 15 it is possible to induce a slip condition for the wheel 11 and so produce a situation as described above with regard to embodiment 1 where the wheel 11 can be made to rotate faster or slower or in a reverse direction or stopped abruptly in order to dislodge and urge detachment of clogging matter from the traction assembly comprising wheel 11, tyre 12 and its tread 17.

b/ it will be understood by selectively raising individual wheels 11 of a vehicle at periodic intervals during that vehicles time traversing off-road and

checking that wheel assemblies mass of inertia, and where necessary implementing wheel cleaning strategy as described previously, it is possible to implement preventive management of clogging to the tyre tread 17 and so improve traction control. Furthermore, by coupling such preventative management of tread clogging with a traction control system the particular preventative management strategy employed may be altered upon recognition of different types of terrain across which the wheel assembly will be driven. In such circumstances, the tendency of the tread 17 to accumulate clogging matter and debris can be monitored using the controller 14 in order to maintain a pre-determined or at least a minimum percentage of tread 17 available for grip and so maximise the traction of the vehicle over a particular type of terrain.

It will be understood that the particular cleaning strategy used by the traction arrangement in accordance with the present invention will be generally dependent upon the wheel assembly along with the vehicle in which that assembly is located.

CLAIMS

1. A traction arrangement for a vehicle having an individually driven treaded traction wheel, the arrangement including a controller to control and monitor rotation and drive of the treaded traction wheel along with configuration of that traction wheel relative to a surface upon which the treaded traction wheel is driven whereby the controller determines either any change in the rate of wheel rotation or inertia mass of the traction wheel indicative of clogging of the traction wheel by clogging matter and the controller then monitors configuration of that wheel to determine when it is appropriate to significantly increase the speed of wheel rotation to enhance centrifugal force imposed upon the periphery of the wheel such that the clogging matter is urged to detach from the treaded traction wheel.

2. An arrangement as claimed in claim 1 wherein the configuration of the wheel where it is appropriate to significantly increase the speed of wheel rotation to enhance centrifugal force is when a suspension mechanism upon which that wheel is secured is fully extended.

3. An arrangement as claimed in claim 2 wherein the suspension mechanism includes a sensor to determine when the suspension mechanism is fully extended and provide a signal to the controller to indicate such full extension of the suspension mechanism.

4. An arrangement as claimed in any preceding claim wherein the controller is coupled to a load sensor associated with the treaded wheel in order to determine when that treaded wheel has a reduced load indicative of a configuration of the wheel appropriate to significantly increase the speed of wheel rotation and centrifugal force.

5. An arrangement as claimed in any preceding claim wherein the controller in addition to increasing the speed of wheel rotation to enhance centrifugal force can also slow the speed of rotation and/or reverse the direction of treaded wheel rotation and/or provide abrupt stopping of the rotation of the treaded wheel in order to urge the detachment of clogging matter from the treaded traction wheel.

6. An arrangement as claimed in any preceding claim wherein the arrangement includes a suspension lift mechanism whereby the wheel can be specifically moved by the controller to a configuration appropriate to significantly increase the speed of wheel rotation to enhance centrifugal force.

7. An arrangement as claimed in claim 6 wherein the controller is arranged to determine the type of terrain of the surface upon which the treaded traction wheel is driven in order to adjust the configuration of that wheel by the suspension lift mechanism to be appropriate to significantly increase the speed of rotation to enhance centrifugal force as required at appropriate time period intervals in order to prevent the treaded wheel becoming clogged with clogging matter.

8. An arrangement as claimed in claim 6 or 7 wherein the controller is arranged to ensure a predetermined level of clogging matter upon the traction wheel is not exceeded in order to ensure traction coupling between that wheel and the surface upon which the wheel is driven is maintained at a desired level.

9. A traction arrangement substantially as hereinbefore described with reference to Figure 1.

10. A traction arrangement substantially as hereinbefore described with reference to Figure 2.

11. A motor vehicle including a traction arrangement as claimed in any preceding claim.

Application No: GB 9927838.4 **Examiner:** Kevin Hewitt
Claims searched: 1-11 **Date of search:** 10 March 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): B7H (HQX, HXG), B7D (DXA, DXX)

Int Cl (Ed.7): B60B (39/00, 15/00), B60S (1/68), B62D (55/08)

Other: Online WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2290884 A	(Fuji Jukogyo) Example of torque distribution system.	
A	US 5566420 A	(M.Specht) Device for cleaning the surface of a tyre.	
A	US 3893535 A	(Daimler-Benz AG) Anti slip controller.	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	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.