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(54) INDEPENDENT REAR WHEEL SUSPENSION FOR MOTOR VEHICLES, ESPECIALLY PASSENGER VEHICLES

(71) We, BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT, a German Body Corporate of BMW-Haus, Petuelring 130, 8 München 40, German Federal Republic, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be partciularly described in and by the following statement:—

This invention relates to an independent rear wheel suspension for motor vehicles.

The published specification of German Patent Application No. 1,937,320 describes an independent suspension in which the arms carrying the road wheels are arranged to be shifted roughly in the crosswise direction of the vehicle in dependence upon the rise and fall of the wheels during travel. The suspension comprises an additional bar which is pivotally linked to the arm as well as to the vehicle frame at a point offset from the axis of the hinge of the arm. The additional bar causes the arm which carries the wheel to be shifted when the arm swings about its hinge. This results in the centre of contact of the wheel with the ground to move in a particular way in relation to the vehicle, to define a particular track curve, and the centre of roll to be located in a corresponding position. By "centre of roll' is meant the point where line passing through the centre of contact of the wheel at right angles to the tangent to the track curve at that centre intersects a vertical longitudinal median plane of the vehicle.

In the case of passenger motor vehicles in which the engine is at the front, the vehicle when empty tends to be very nose heavy and to exhibit oversteer, while the fully-laden vehicle is generally tail-heavy and therefore tends to understeer. By using a trailing arm for a rear wheel suspension of the above-described construction, a kinematic self-steering effect is obtained which tends to correct the empty vehicle for oversteer and the laden vehicle for understeer. Unfortunately, the same steering effects, i.e. slip angles, will also arise when the vehicle travels along a straight path and the wheels rise and fall. Since the roll centre directly affects the steering characteristic, this characteristic is generally to be preferred to the steering characteristic obtained by varying the slip angles.

Based on this thought, it is an aim of the present invention to provide an arrangement which permits the roll centre to be continuously moved into the correct position.

To achieve this aim, the invention is directed to an independent rear wheel suspension for motor vehicles, especially passenger motor vehicles, comprising two arms for carrying the road wheels, respective linkages pivotally connected to the arms and adapted to be coupled to the vehicle body, and adjusting means for varying the vertical positions of the pivotal connections between the arms and their respective linkages while the motor vehicle is in use in such a manner that those pivotal connections are moved in the same direction and by the same amount as one another and the orientations of the curves along which the centres of contact of the wheels with the ground can move in relation to the vehicle, by virtue of the suspension are varied accordingly so as to change the height of the vehicle's centre of roll (as hereinbefore defined) at the rear wheel axis or axes.

One advantage that can be obtained with a controlled roll centre, when control is by reference to the vehicle load, is a constancy in the riding properties of the vehicle whether the vehicle is empty or laden. If control is by reference to speed or effected by the driver himself, the result can be a vehicle with a desirable amount of oversteer when taking tight curves and when driving in city traffic, and stable straight line travel when moving at speed. At the same time, a controlled roll centre can improve road holding as well as riding comfort.

Two examples of wheel suspensions in

accordance with the invention are shown by way of example in the accompanying drawing, in which:—

Figure 1 is an independent suspension in which the roll centre is controllably movable and the camber is changed; and

Figure 2 is an independent suspension in which only the roll centre is variable.

The independent suspension shown in Figure 1 comprises road wheels 1 each of which is mounted in a wishbone arm 2 attached to a cross beam 3. The adjusting means for simultaneously adjusting both wheels 1 consist of an adjuster 15 which is fixed to the vehicle and contains a push rod 14 with a forked end 13 embracing a lever arm 12 attached thereto by a hinge pin 16 and rigidly affixed to a shaft 10.

The ends of the shaft 10 are rotatably mounted in bearings 11 secured to the cross beam 3. A pair of coplanar shackles 6 is fast on the shaft 10 near each of the ends. One limb 4 of each of the wishbone arms 2 is pivotally connected by a hinge pin 5 to each pair of shackles 6. The outer limbs 7 of the two wishbone arms 2 are each pivotally connected by hinge pins 8 to shackles 9 fixed to the cross beam 3.

The two hinge pins 5 and 8 have a common axis *a* and the axes defined by the hinge pins associated with the two wheels intersect in the longitudinal centre axis of the vehicle. Axis *a* is the hinge axis of the wheel arm 2 and includes an angle α with the rear face of the cross beam 3.

The adjuster 15 in the illustrated embodiment is a hydraulic actuator actuated by a control valve not shown in the drawing. The valve cooperates with a control linkage likewise not shown which may be connected to one of the wheel arms 2, or to both if provided with compensating means. It would also be feasible to control the adjuster 15 mechanically, electronically, pneumatically or in some other way.

The geometry of the suspension in Figure 1 can be varied as follows:—A piston attached to the push rod 14 is displaceable in both directions indicated by the two-headed arrow *b* so that the roll centre can be lowered, for instance when the vehicle is heavily loaded, by deflecting the hinge axes 5 downwards according to the magnitude of the load supported by each of the wheels 1.

The adjuster also permits the roll centre of both wheels 1 to be varied according to the vehicle speed whilst the vehicle travels. For this purpose the adjuster 15 displaces the push rod 14 in the direction of arrow *b* or b^1 causing the lever arm 12 to be pulled towards or pushed away from the adjuster 15. The lever arm 12 turns the shaft 10 and thus lowers or raises the shackles 6. This alters the orientations of the curves along which the centres of contact of the wheel with the ground can move in relation to the vehicle, so that the roll centre is raised or lowered at the rear wheel axis or axes.

A high roll centre is best at slow speeds and when negotiating tight curves, while a low roll centre is to be preferred at high speed for achieving maximum road holding properties and riding comfort. It would also be possible to regulate the roll centre according to load and speed. The change in position of the roll centre by reference to speed could be effected either by the driver or by linking the adjuster 15 to the speedometer of the vehicle.

Figure 2 is another embodiment of an indepedent rear wheel suspension in which the wheels 1 are each suspended from a vehicle body 20 by the two limbs 4^1, 7^1 of an obliquely hinged wishbone arm 2^1. The two limbs 4^1 and 7^1 of each arm swing on a hinge, about an axis 25, in such a way that the arm is displaceable in the directions of the hinge axis as indicated by the two-headed arrow *c*, i.e. roughly crosswise of the longitudinal axis of the vehicle. The two limbs 7^1 are each pivotably connected at 21 to a link 22 which at its other end carries one half 23^{11} of a pivotal joint 23 which may be for instance a ball-and-socket joint. The other half 23^1 of this pivotal joint 23 is part of a connecting arm 24. Both connecting arms 24 are fast on a shaft 10^1. The members 12^1, 16^1, 13^1, 14^1 and 15^1 connected to roughly the middle of this shaft 10^1 correspond to parts in Figure 1 bearing the same reference numbers.

An axial displacement of the push rod 14 in the direction of the two-headed arrow *b* — due to operation of the adjuster 15 — causes the shaft 10^1 to be turned by lever arms 12^1 and the connecting arms 24 to be reflected upwards or downwards and consequently the position of the pivotal joints 23 and the links 22 to change. The result is a changed relationship between the axial displacement of the wishbone arms 2^1 in the direction of the two-headed arrow *c* as the wheels rise and fall. During this process the orientations of the curves along which the centres of contact of the wheels with the ground can move in relation to the vehicle are varied, so that the roll centre of the independent suspension according to the invention is conformably lowered and raised at the rear wheel axis or axes.

With reference to the desirability of a high or low position of the roll centre the observations made in connection with the independent suspension according to Figure 1 here also apply.

Naturally it is also possible within the scope of the present invention for the wish-

bone arms 2^1 in Figure 2 to be longitudinally trailing arms.

WHAT WE CLAIM IS:—

1. An independent rear wheel suspension for motor vehicles, especially passenger motor vehicles, comprising two arms for carrying the road wheels, respective linkages pivotally connected to the arms and adapted to be coupled to the vehicle body, and adjusting means for varying the vertical positions of the pivotal connections between the arms and their respective linkages while the motor vehicle is in such a manner that those pivotal connections are moved in the same direction and by the same amount as one another and the orientations of the curves along which the centres of contact of the wheels with the ground can move in relation to the vehicle, by virtue of the suspension, are varied accordingly so as to change the height of the vehicle's centre of roll (as hereinbefore defined) at the rear wheel axis or axes.

2. An independent suspension according to claim 1, wherein the adjusting means comprises an actuator having a push rod, and a shaft which is rotatably mounted on a member fixed to the vehicle body when the suspension is in use, there being a lever arm rigidly fixed to the shaft and pivotably coupled to the push rod so that movement thereof causes rotation of the shaft, the said linkages being fixed to the shaft so that operation of the said actuator varies the vertical positions of the pivotal connections between the arms and the linkages.

3. An independent suspension according to claim 2, wherein the lever arm is pivotably coupled to the push rod by means of a hinge pin of the arm or rod held in a fork-like structure at an end of the other of those two components.

4. An independent suspension according to claim 3, wherein the fork-like structure is fixed to an end of the push rod.

5. An independent suspension according to any one of claims 2—4, wherein the shaft is rotatably mounted on the said member by means of respective bearings at or near opposite ends of the shaft.

6. An independent suspension according to any one of claims 2 to 5, wherein the said linkages comprise respective intermediate members which are fixed to the said shaft at or near opposite ends of the shaft.

7. An independent suspension according to any preceding claim, wherein the two wheel arms are both of wishbone form.

8. An independent suspension according to claim 7 when appendant to claim 6, wherein each intermediate member is pivoted to one limb of the associated wheel arm of the suspension.

9. An independent suspension according to claim 8, wherein the said lever arm is fixed to the central portion of the said shaft, and each intermediate member is a shackle to which is pivoted a limb of the associated wheel arm, the other limb of the wheel arm being pivoted to a part which is fixed in relation to the vehicle body when the suspension is in use.

10. An independent suspension according to claim 9, wherein the wheel arms are pivotable, by virtue of the pivotable connection of their limbs, about respective axes which include an angle of like magnitude with a transverse horizontal line when viewed from above when the suspension is installed for use in a motor vehicle.

11. An independent suspension according to claim 8, wherein each intermediate member comprises a connecting arm one end of which is fixed to the said shaft and the other end of which carries one half of a joint of which the other half is fast on the end of a link member which, at its other end, is connected to one limb of the assocated wheel arm, both limbs of which arm are hinged to a mounting shaft in such a manner that they can be shifted axially along the mounting shaft by operation of the said actuator, the mounting shaft being held transversely in relation to the intended direction of travel of the vehicle and obliquely to the horizontal when the suspension is in use.

12. An independent suspension according to any preceding claim, wherein the said adjusting means is hydraulically operated.

13. An independent suspension according to any one of claims 1 to 11, wherein the said adjusting means is mechanically operated.

14. An independent suspension according to any one of claims 1 to 11, wherein the said adjusting means is electronically operated.

15. An independent suspension according to any one of claims 1 to 11, wherein the said adjusting means is pneumatically operated.

16. An independent suspension according to any preceding claim, being installed for use in a motor vehicle, wherein the said adjusting means is connected to be operated in dependence upon the speed with which the vehicle is travelling.

17. An independent suspension according to claim 16, wherein the said adjusting means is connected to be operated in dependece upon the speedometer reading of the vehicle.

18. An independent suspension according to any preceding claim, being installed for use in a motor vehicle, wherein the said adjusting means is connected to be operated in dependence upon the load carried by the vehicle.

19. An independent rear wheel suspension for motor vehicles substantially as described herein with reference to Figure 1 or Figure 2 of the accompanying drawing.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

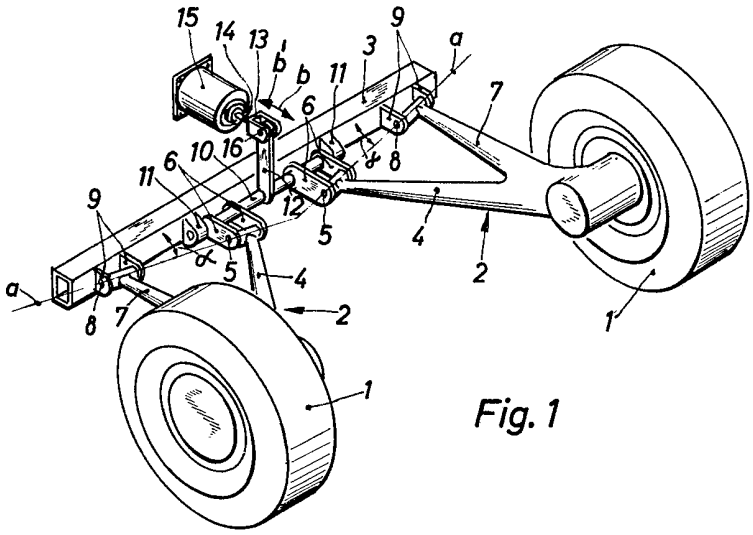

Fig. 1

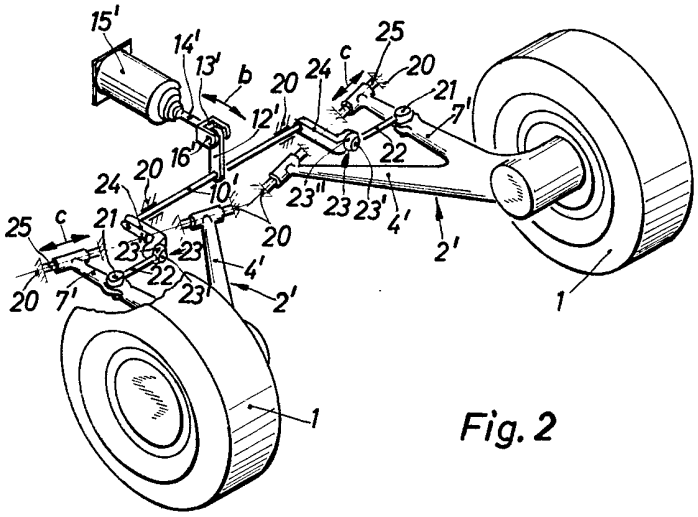

Fig. 2