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(54) INDEPENDENT WHEEL SUSPENSIONS

(71) We, DAIMLER-BENZ AKTIENGESELLSCHAFT, a Company incorporated under the laws of the Federal Republic of Germany, of Stuttgart-Untertürkheim, Federal Republic of Germany, 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 particularly described in and by the following statement:—

The invention relates to an independent wheel suspension for vehicles, particularly but not exclusively for motor vehicles, having a wheel carrier which is articulated between an upper and a lower guide link or control arm and has a fixed pivotal axis with respect to one of the guide links.

It is the underlying aim of the invention to develop such a wheel suspension further from the standpoint of minimum installation space and maximum variability and versatility in use, including more particularly its usefulness as a front axle.

According to the invention there is provided an independent wheel suspension for a vehicle having a wheel carrier pivotally connected to an upper wheel control arm and to a lower wheel control arm which is also pivotally connected to the vehicle, the steering axis of the wheel carrier passing through the pivotal connection between the wheel carrier and the wheel control arms, the upper wheel control arm comprising a connecting link and a guide strut pivotally connected to one another, the connecting link being pivotably connected at one end to the wheel carrier and at its other end being pivotably connected to the lower wheel control arm, a pivot axis for the wheel carrier passing through the points of articulation between the wheel carrier and the lower wheel control arm and between the lower wheel control arm and the connecting link, the movement of the wheel carrier about said pivot axis being controlled by the guide strut which extends between the connecting link and the vehicle.

The construction according to the invention makes wide support bases possible for the links for a comparatively small installation space. It further permits considerable independence of the camber variation throughout the spring travel, from the link lengths. Lastly, it provides good possibilities with regard to the choice of the steering rolling radius desired in each case, and also permits long negative steering rolling radii, and even with conventional wheel dish configurations it provides possibilities of accommodation both for floating saddle and for fixed saddle brakes.

In another aspect of the invention, it is particularly advantageous if the lower wheel control arm to which the connecting link is connected is oriented rearwardly with refernce to the longitudinal axis or direction of the vehicle, in the form of an inclined link with its povital axis extending obliquely from the outside rear to the inside front as seen in plan. Such a configuration more particularly gives the possbility of bracing the axle as far behind the wheel centre as possible and also the possibility of realsing a toe-in of ≥ 0 with longtudinal traction, namely by displacing the oblique link outwards under the influence of the braking force. This is particularly advantageous in front axles, in which the design of the steering kinematics is no longer obstructed by the length of possible extended positions in the steering linkage. On the contrary, optimisation of the transmission ratio in the steering linkage is possible in order that no increase in the steering wheel forces occurs at greater angles of lock.

The wheel suspension according to this invention makes possible, including more particularly for springs and torsion bar stabilisers, transmission ratios of the order of magnitude of 1, and without the necessity for direct bracing on the wheel carrier.

For front wheel suspensions, in spite of a very wide support base in which the outer point of articulation with the vehicle is located approximately in the wheel plane and the inner point of articulation to the vehicle lies approximately in the region of the longitudinal median plane of the vehicle, a large angle of steering lock can be realised if, the lower guide link or control arm being constructed as an inclined link and the orientation of its pivotal axis being oblique from the outside rear to the inside front at a comparatively shallow angle, the inclined link or control arm has a base part substantially associated with the pivotal axis, and an extension displaced at right angles with reference to the front inner point of articulation, at the outer end of which, preferably located in front of the wheel median plane, a spring and a stabiliser are supported and from which a branch carrying the lower point of articulation of the wheel carrier extends generally in the transverse direction of the vehicle.

With such a configuration the inclined control arm or link leaves adequate clearance even for large angles of lock, more particularly if the connecting link, starting from the upper point of articulation to the whel carrier, is articulated to the lower control arm substantially transversely oriented in the region of the spring support and a tension strut, extending effectively parallel to the forwardly projecting arm of the inclined link, to engage the connecting link close to the upper point of articulation of the wheel carrier is articulated to the vehicle above the lower wheel control arm.

Embodiments of the invention will now be described by way of example and with reference to the accompanying drawings, in which:—

Figure 1 shows an independent front wheel suspension according to the invention in a somewhat schematic plan view,

Figure 2 shows the front wheel suspension of Figure 1 in rear elevation,

Figure 3 shows the front wheel suspension of Figure 1 in side elevation,

Figure 4 shows, in schematic view, a modified form of a front wheel suspension in which the lower guide link or control arm, constructed as an inclined link, is articulated to the wheel carrier through the drag link or steering arm acting as an intermediate element,

Figure 5 shows a simplified side elevation of Figure 4,

Figure 6 shows a section along the line VI-VI in Figure 5,

Figure 7 shows a modification of the wheel suspension shown in the previous Figures, in which a brake disc is arranged within the wheel carrier and the wheel carrier is constructed with a part projecting radially inwards above the brake disc,

Figure 8 shows a view similar to Figure 7, with respect to the position of the brake disc with reference to the wheel carrier, and in which the connecting link articulated to the wheel carrier overhangs the brake disc,

Figure 9 shows an embodiment of the invention corresponding to Figures 7 and 8 with reference to the position of the wheel carrier and brake disc, in which the connecting link overhangs the brake disc and has a point of articulation for the tension strut which is offset with reference to the line connecting the points of articulation of the connecting link to the wheel carrier and inclined link, and

Figure 10 shows a section along the line X-X in Figure 9.

Figures 1 to 3 illustrate, partly schematically and in simplified form, an independent wheel suspension according to the invention for a front axle which comprises a lower guide link or wheel control arm 1 and an upper guide link or control arm 2. These support, at points of articulation E and F associated with them, the wheel carrier 3, to which the wheel 4 is attached rotatably in customary manner, as shown more particularly in Figure 2, whilst in the illustrated embodiment the wheel carrier and also the wheel stub axle associated therewith (but not further shown here), and the wheel hub 5 overlapping the latter, to which the brake disc 6 is attached integrally for rotation, are located within the wheel dish 7. This position of the wheel carrier 3 and of its point of articulation E and F together with the brake disc 6 and brake saddle 8 within the wheel dish 7 is possible because, in the wheel suspension according to the invention, only very slight relative movements occur between the wheel carrier 3 and the lower guide link 1 and the upper control arm 2 during spring action. The indicated position of the points of articulation E and F furthermore makes it possible in a simple manner, for a slight spread, or camber angle of approximately 7° in this embodiment, as Figure 2 shows, to realise negative steering rolling radii.

The lower guide link or wheel control arm 1 is constituted, in the embodiment of the invention illustrated in Figures 1 to 3, by an inclined link pivotally mounted on the vehicle at the points A and B and, the pivotal axis *a-b* of which, as seen in plan, is oriented obliquely forwardly and inwardly at an angle of substantially 27° with respect to the wheel axis. In rear elevation, the pivotal axis *a-b* is inclined upwardly and inwardly at an angle of substantially 3° to the horizontal. In side elevation the inclination of the pivotal axis *a-b* with refereuce to the horizontal is forwardly and upwardly at substantially 5°.

The inclined member forming the lower wheel control arm 1 consists of a base part 9 extending substantially parallel to the pivotal axis *a-b*, which in conformity with the position of the points of articulation, A and B extends virtually across half the width of the vehicle, because the point of articulation A is located close to the longitudinal median line 10 of the vehicle, whereas the point of articulation B falls virtually in the median plane 11 of the wheel 4.

Projecting forward from the base part 9, the control arm 1 has an arm 12 which, as a rough approximation extends perpendicularly to the pivot axis *a-b* and at the front end of which, close to the transverse median plane 13 of the wheel 4, a suspension spring 14, which in this embodiment is a coil spring, is braced against the lower guide link. In this embodiment the point of support of the spring 14 upon the arm 12 lies in front of the transverse median plane 13 and due to the distance of the point of support of the spring 14 on the control arm 1 from the pivotal axis *a-b* a spring transmission ratio of virtually 1 is obtained.

Extending outwards transversely from the arm 12, the lower wheel control arm 1 has an extension 15, so that a basic shape of approximately U-shaped configuration in plan is obtained for the lower control arm, which permits large angles of lock because the arm 12 extends from the base part 9 closer to the point of articulation A than to the point of articulation B.

The upper guide link or wheel control arm 2 in this embodiment consists of a connecting link 16 and a guide strut 17. The connecting link 16 is articulated at the point F to the wheel carrier 3, which is indicated only schematically in Figure 1, and it extends from the point of articulation F obliquely forwards and downwards, whilst it is also articulated at the point C to the lower control arm 1 in the region in front of the transverse median plane 13 of the wheel. In practice, the point C illustrated in Figures 1 to 3, as may be seen more particularly from Figure 1, is located in front of the saddle 18 provided on the lower control arm 1 and supporting the spring 14. With reference to the line joining the points of articulation F and C, the connecting link has, in plan, an inclination of the order of 35° with reference to the transverse plane of the vehicle, whilst it extends obliquely forwards and inwards from F to C. In rear elevation as shown in Figure 2, the connecting link is inclined to the horizontal at an angle of approximately 43°, whilst it extends obliquely upwardly and outwardly from the point of articulation C to the point of articulation F. In the side elevation shown in Figure 3, the connecting link 16 has an upwards and rearward inclination of approximately 35° with reference to the horizontal, from the point of articulation C to the point of articulation F. As a result of this position of the connecting link 16, the point of articulation C has a position beneath the wheel centre and in front of the transverse median plane 13, which dictates, in plan, for the plane determined by the points of articulation C-E-F of the connecting link 16 and the points of articulation of the wheel carrier 3, a pivotal axis *c-e* with respect to the lower guide link or wheel control arm 1 which extends in plan obliquely inwards and forwardly at an angle of approximately 22° with respect to the transverse median plane 13. In rear elevation the axis *c-e* is inclined at an angle of approximately 16° with reference to the horizontal and extends obliquely upwards and inwards. In side elevation of the axis *c-e* has an inclination of approximately 35° with respect to the horizontal and extends upwards and forwards from point E to point C.

The connecting link 16 is articulated to the tension strut 17, at the point of articulation R. The point of articulation of the tension strut to the vehicle is designated D and is located behind the connecting link with reference to the longitudinal direction of the vehicle (Figure 3). The tension strut 17 extends, in the plan shown in Figure 1, at an angle of approximately 36° to the transverse median plane, obliquely inwards and rearwardly. The orientation of the tension strut 17 in the design position is approximately horizontal, as shown in the side elevation of Figure 3 and the rear elevation of Figure 2.

In the embodiment, shown in Figures 1 and 3, an arm 21 of a stabiliser 20, which is U-shaped in plan, is articulated to the guide link or lower control arm 1 at the point S close to the point of articulation C of the connecting link 16 on the control arm 1. In the design position, the stabiliser 20, generally considered, then lies approximately at the same height as that of the point of articulation C. Due to the fact that the point of articulation S of the stabiliser on the guide link or lower wheel control arm 1 is positioned remotely from the pivotal axis *a-b*, a very good transmission ratio is obtained. In the region of its base 22, the stabiliser 20 is attached by links 23 to the vehicle, in this case to the side members 24, of which, as in the case of the wheel suspension and of the steering, only those parts associated with one side of the vehicle are shown. The connection of the links 23 to the side members 24 and to the base 22 of the stabiliser 20 is effected through resilient bearings in customary manner.

As clearly shown in Figure 3, a drag link or steering arm 25 which projects somewhat obliquely forwards and downwards from the wheel centre is provided on the wheel carrier 3. The steering arm 25 is connected at the point of articulation K to the track rod 26, which is articulated to the steering-gear arm 27 at the point of articulation L. The connection of the steering-gear arm 27 (the steering gear is not further shown) to the steering intermediate lever belonging to the other side of the vehicle, which is not shown further here and is correspondingly arranged and supported, is effected by means of a track rod 28. The steering-gear arm 27, and likewise a steering intermediate lever (not shown) extend counter to the direction of travel and are connected to the steering rod 28 at points T. This steering arrangement complements the wheel suspension, more particularly with regard to the provision of favourable steering transmission ratios even for large angles of lock.

As shown in Figure 3, the point of articulation K between drag link 25 and track rod 26 is located, in side elevation, somewhat in front of and beneath the point of articulation C of the connecting link 16 to the guide link or lower wheel control arm 1, so that, generally considered from a practical standpoint, it is located close to the wheel rim circumference approximately in the inner boundary plane of the wheel. The track rod 26 extends upwardly and rearwardly at an inclination of approximately 13° as can be seen in the side elevation of Figure 3, and in doing so it connects the points of articulation K-L. In plan, the track rod 26 in this embodiment has an angle of approximately 30° with reference to the transverse median plane and it extends from the inside (point L) obliquely forwards and outwards (point K). In rear elevation (Figure 2, the track rod 26 is inclined upwards and inwards at approximately 8°, the point of articulation K being positioned lower than the point of articulation L.

The spring 14, which is braced to the spring saddle 18 upon the lower control arm 1, surrounds the shock absorber 29 which is arranged centrally within the spring. The inclination of shock absorber and spring axis with respect to the vertical, for the present embodiment, is approximately 17° as shown in the side elevation of Figure 3 and approximately 7° as shown in the rear elevation according to Figure 2, the spring axis extending obliquely rearwardly as seen in side elevation and inwards as seen from the rear of the vehicle. In plan and as shown in Figure 1, the spring axis is at an angle of approximately 20° with respect to the transverse plane of the vehicle and it extends forwards and outwards.

Figure 3 shows that in side elevation the inclination of the spring axis is greater than the inclination of the steering axis, which is inclined at approximately 9° to the vertical. The point of articulation E of the lower control arm to the wheel carrier lies virtually in the vertical transverse median plane 13 of the wheel, whereas the point of articulation F of the wheel bracket is offset somewhat to the rear with respect to the upper control arm 2. Furthermore, both points of articulation E, F of the wheel carrier lie in the hollow of the wheel rim, while the point of articulation E lies proximate to or substantially in the median plane of the wheel 4.

The Figures which follow illustrate further embodiments of an independent wheel suspension according to the invention, and corresponding reference numerals, but designated by an index in each case, are used for identical parts.

The embodiment of the wheel suspension according to the invention illustrated in Figures 4 to 6, which is shown only highly schematically, differs from that according to Figures 1 to 3 in principle solely in the fact that here the lower point of articulation E_a of the wheel carrier 3*a* to the lower guide link or control arm 1*a* does not directly represent the connection between the wheel carrier and the control arm, but the point of articulation E_a is the connection of the control arm to the drag link or steering arm 25*a* which is in turn connected rigidly to the wheel carrier 3*a*. For this purpose, as shown more particularly in Figures 5 and 6, it is combined with a connecting element 30*a* in the form of an oval ring cut away on one longitudinal side, of which the two free arm ends 31*a* connect rigidly with corresponding arm ends 32*a* of the wheel carrier 3*a* which is bifurcate in its lower region.

By this means a comparatively simple, largely flat construction of the wheel carrier is possible, and the point of articulation E_a between the wheel carrier 3*a* and the lower control arm 1*a* can nevertheless be positioned so that the brake disc 6*a* lies between said point of articulation and the wheel carrier. The brake disc then projects, in the region of the point of articulation E_a and at the level of the lower wheel control arm 1*a*, into the centre of the ring 30*a* which embraces the brake disc 6*a*. Such a configuration permits a particularly large number of possible constructional variations and hence also adaptation to very different design desiderata and conditions.

With reference to Figure 4, and also to the further following Figures, it may be pointed out once more that the tension strut 17*a* (or 17*b* or 17*c* or 17*d*) extends, contrary to the schematic illustration shown here, substantially transversely to the plane which is defined by the respective points of articulation between connecting link, wheel carrier and lower wheel control arm.

Whereas in the previous embodiments the brake disc is positioned in convenitonal manner outside the wheel carrier in the hollow of the wheel, Figures 7 to 10 illustrate embodiments which display an inverted arrangement, in which the brake disc is offset inwards, with reference to the wheel carrier. In the embodiments according to Figures 7 and 8, the wheel carriers are designated *3b* and *3c* and the brake discs *6b* and *6c*. The reference numerals of the connecting links *16b* and *16c* and of the lower control arms *1b* and *1c* conform to this identification. The points of articulation of the wheel suspension visible in Figures 7 and 8 are analogously designated by the suffixes *b* and *c* respectively.

In the embodiment of Figure 7, the wheel carrier *3b* is cranked inwards at its top end across the brake disc *6b* and the point of articulation F_b between the wheel carrier *3b* and the connecting link *16b* is offset inwards with reference to the disc *6b*. This makes possible a wheel suspension with a wide base.

In the embodiment of Figure 8, in contradistinction to the embodiment shown in Figure 7, the point of articulation F_c is offset outwards with reference to the brake disc *6c*, whereby a construction with a narrower base and correspondingly small offset of the steering axis with reference to the wheel centre is obtained. Nevertheless, a negative steering rolling radius can be realised. Such an embodiment would be found convenient more particularly for front wheel drive suspensions.

In spite of the overlap across the brake disc both below and above, sufficiently large brake disc diameters can be realised in the case of the construction according to the invention, because the wheel carrier, and hence also the wheel when springing with reference to the connecting link and to the lower control arm, executes practically no movements, with the result that only very small plays are necessary between the wheel rim and the wheel guide elements mentioned.

A further embodiment of a wheel suspension according to the invention will now be explained with reference to Figures 9 and 10, in which similar reference numerals, but suffixed by the letter *d*, are used. The wheel suspension illustrated in these two Figures, which corresponds to that shown in Figures 7 and 8 with regard to the arrangement of the brake disc *6d*, has been further developed in the sense that the forces introduced into the vehicle through the tension strut *17d*, instead of which a thrust rod could of course also be used within the ambit of the invention, are kept as low as possible. For this purpose the point of articulation R_d is arranged at a greater distance with respect to the pivotal axis *c*-e about which the wheel carrier *3d* with the connecting link *16d* pivots than is the case in the embodiments previously described, in which the tension strut engages the connection link substantially at the line joining the points of articulation C and F.

This is achieved by associating a transverse member *33d* with the connecting link *16d* which, whilst being rigidly attached to the connecting link *16d*, is articulated at one end to the lower control arm *1d*, preferably on the axis *c-e*, and at the other end at an interval from the connecting link, to the tension strut *17d* at the point R_d. Since the point R_d is widely spaced from the axis *c-e* weaker bracing forces are obtained at the point D_d.

The connection of the transverse member *33d* to the guide link *1d* is illustrated by way of example in Figure 10 and can be ensured in a simple manner by providing a pin on the control arm *1d*, transversely to the axis *c-e*, by which the transverse member *33d* is tensioned with interposition of resilient buffers *34d*.

WHAT WE CLAIM IS:—

1. An independent wheel suspension for a vehicle, comprising a wheel carrier pivotally connected to an upper wheel control arm and to a lower wheel control arm which is also pivotally connected to the vehicle, the steering axis of the wheel carrier passing through the pivotal connection between the wheel carrier and the wheel control arms, the upper wheel control arm comprising a connecting link and a guide strut pivotally connected to one another, the connecting link being pivotably connected at one end to the wheel carrier and at its other end being pivotably connected to the lower wheel control arm, a pivot axis for the wheel carrier passing through the points of articulation between the wheel carrier and the lower control arm and between the lower wheel control arm and the connecting link, the movement of the wheel carrier about said pivot axis being controlled by the guide strut which extends between the connecting link and the vehicle.

2. An independent wheel suspension according to claim 1, wherein the wheel is steerable.

3. An independent wheel suspension according to claim 1 or claim 2 wherein the pivot axis of the lower wheel control arm is inclined rearwardly and outwardly with respect to the longitudinal axis of the vehicle.

4. An independent wheel suspension according to any one of the preceding claims wherein the lower wheel control arm is constructed as a three-point wheel control arm, two of said points forming the points of articulation of the lower wheel control arm to the vehicle and the third of said points forming the point of articulation of the wheel carrier to the lower wheel control arm.

5. An independent wheel suspension according to Claim 4, wherein the three-point control arm is constructed as an inclined link.

6. An independent wheel suspension according to Claim 4, wherein the rearward outer point of articulation of the lower wheel control arm to the vehicle lies substantially in the longitudinal median plane of the wheel.

7. An independent wheel suspension according to any one of Claims 4 to 6, wherein the forward inner point of articulation of the lower wheel control arm to the vehicle lies in the region of the longitudinal axis of the vehicle.

8. An independent wheel suspension according to any one of Claims 4 to 7, wherein the point of articulation of the connecting link to the lower wheel control arm lies outside a triangle defined by said three points of articulation of said control arm as seen in plan view.

9. An independent wheel suspension according to any one of Claims 4 to 8, wherein the spring is supported on the three-point control arm at a point which lies outside a triangle bounded by the points of articulation of said control arm to the vehicle and the wheel carrier, as viewed in plan.

10. An independent wheel suspension according to any one of the preceding claims, wherein the point of articulation of the connecting link to the lower wheel control arm lies in the front of a transverse plane containing the wheel axis with reference to the longitudinal direction of the vehicle.

11. An independent wheel suspension according to any one of the preceding claims, wherein the connecting link extends substantially in the transverse direction of the vehicle in plan.

12. An independent wheel suspension according to any one of the preceding claims, wherein the point of articulation of the connecting link to the wheel carrier lies behind the transverse plane of the vehicle containing the wheel centre, with reference to the longitudinal direction of the vehicle.

13. An independent wheel suspension according to any one of claims 1 to 12, wherein the guide strut is articulated to the connecting link at a point adjacent to the wheel carrier.

14. An independent wheel suspension according to any one of claims 1 to 13, wherein the strut is a tension strut and is rearwardly inclined with reference to the longitudinal direction of the vehicle.

15. An independent wheel suspension according to any one of claims 1 to 14, wherein the guide strut is oriented, in plan, substantially perpendicularly to the pivotal axis of the lower control arm.

16. An independent wheel suspension according to any one of Claims 9 to 15, wherein a spring is braced upon the lower wheel control arm adjacent the point of articulation of the connecting link to the lower wheel control arm.

17. An independent wheel suspension according to any one of Claims 9 to 16, wherein, as seen in plan view, a spring saddle is associated with the lower wheel control arm, which lies substantially between the point of articulation of the connecting link to the lower wheel control arm and the point of articulation of the strut to the vehicle.

18. An independent wheel suspension according to Claim 17, wherein the point of articulation of the wheel carrier to the lower wheel control arm is at substantially the same distance from the pivotal axis of said guide link as the spring saddle.

19. An independent wheel suspension according to Claim 17 or Claim 23, wherein one arm of a stabiliser is articulated to the lower wheel control arm in the region of the spring saddle.

20. An independent wheel suspension according to Claim 19, wherein the stabiliser is U-shaped in plan, and lies in front of the lower wheel control arm with respect to the longitudinal axis of the vehicle.

21. An independent wheel suspension according to any one of the preceding claims wherein the axis about which the wheel carrier is pivotable with respect to the lower wheel control arm and the axis about which the lower wheel control arm is pivotable are substantially parallel to each other, as seen in plan view.

22. An independent wheel suspension substantially as hereinbefore described, with reference to the accompanying drawings.

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1588760 COMPLETE SPECIFICATION

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Sheet 1

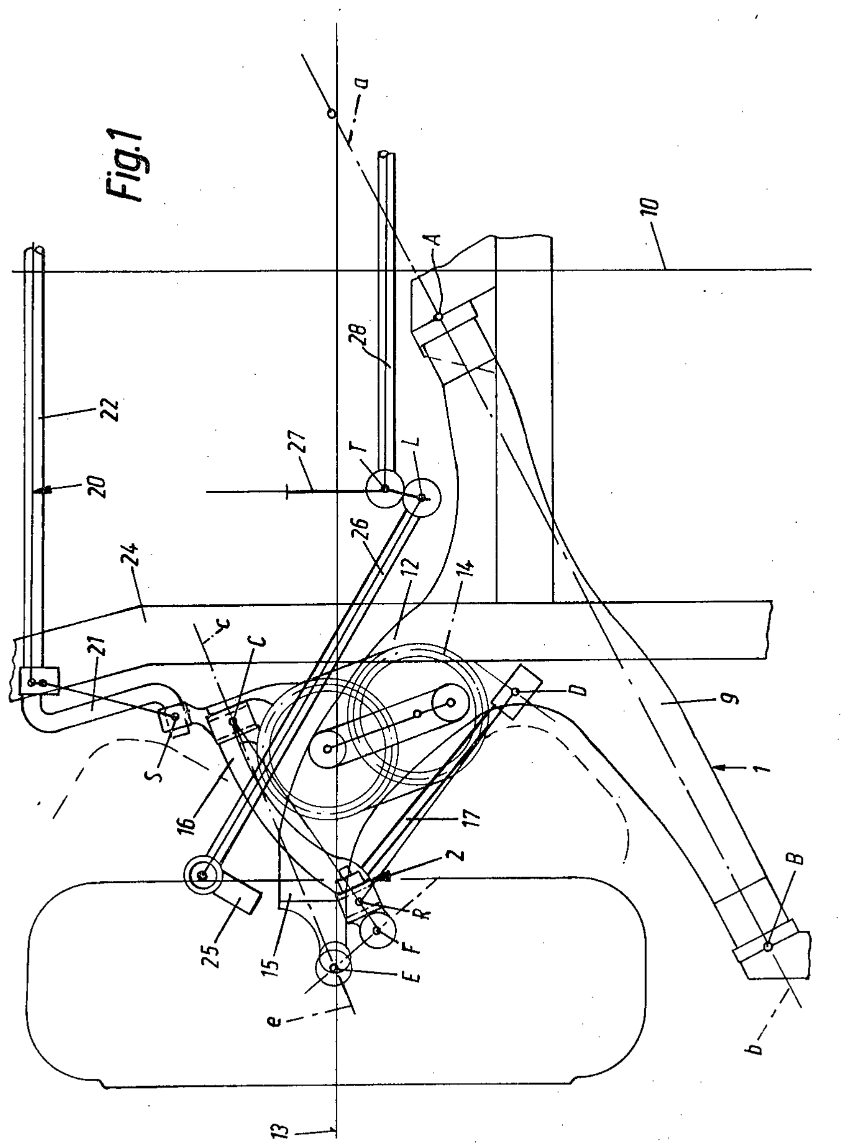

Fig.1

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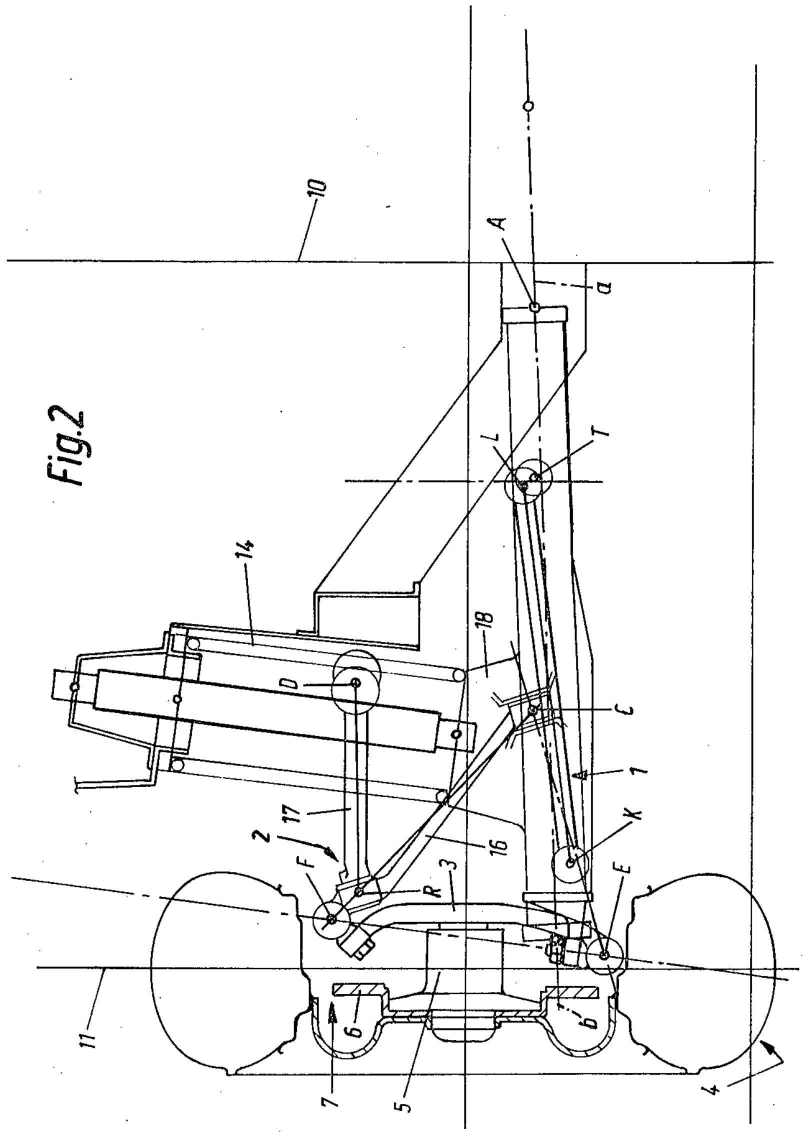

Fig.2

1588760 COMPLETE SPECIFICATION

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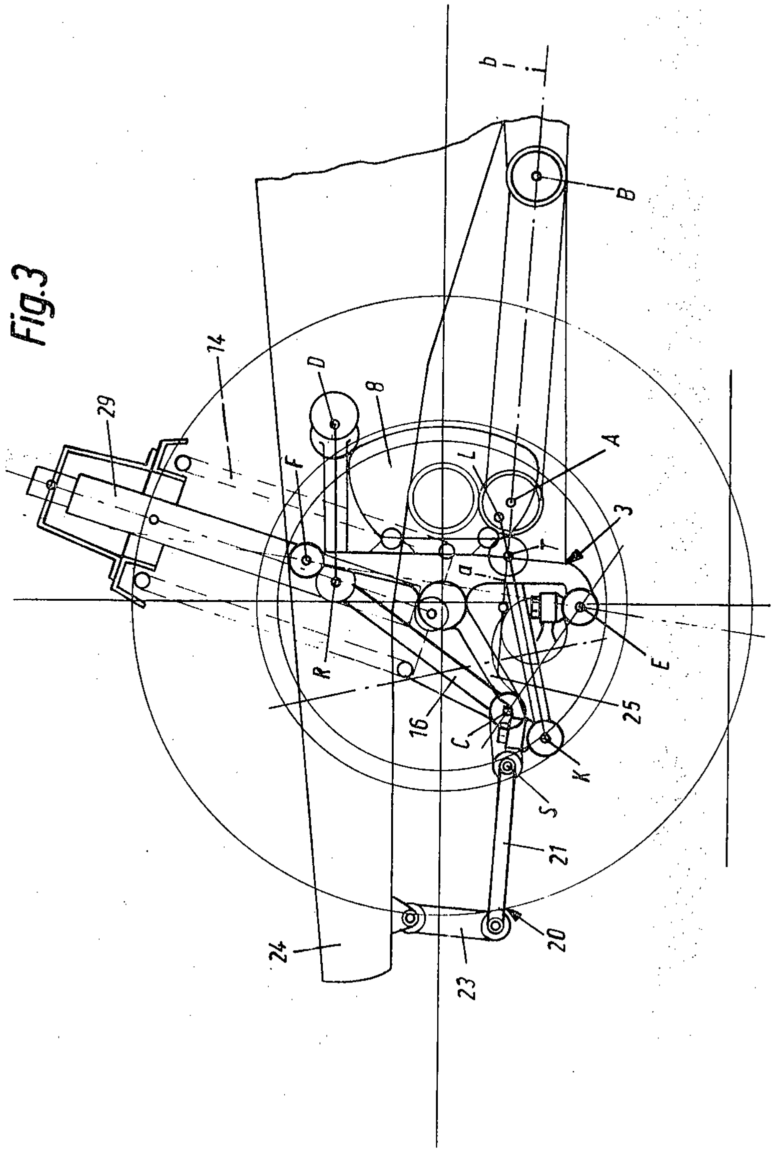


Fig.3

Fig.4

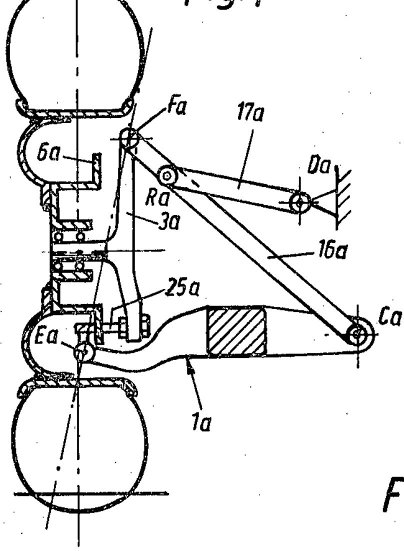


Fig.5

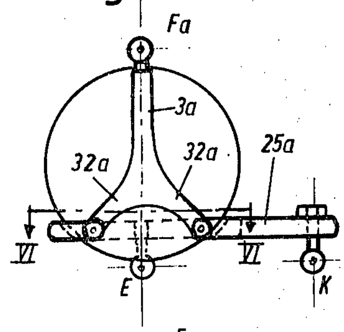


Fig.6

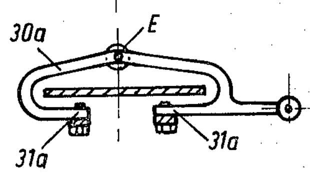


Fig.9

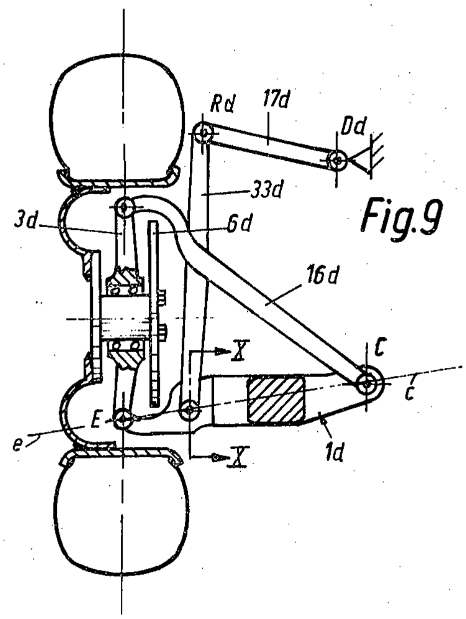
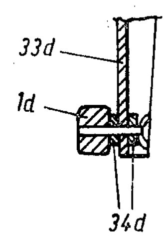


Fig.10



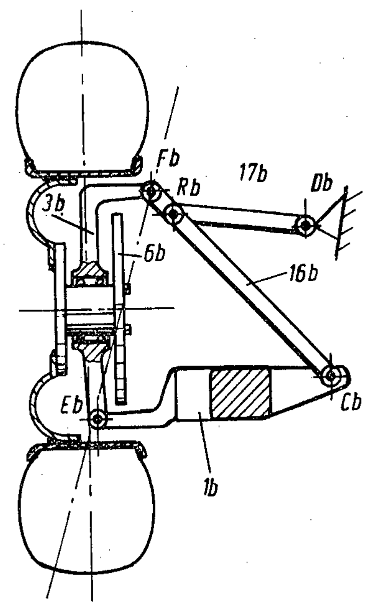


Fig.7

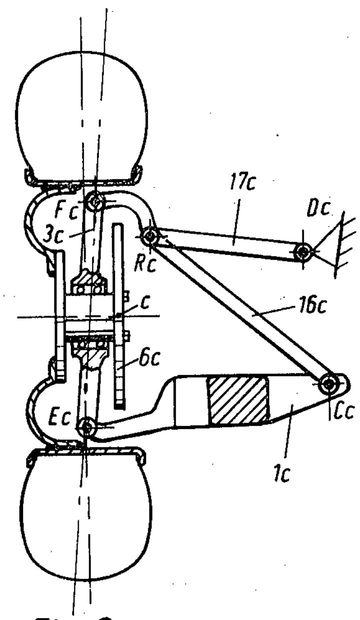


Fig.8