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(72) BENASSI, GIAN CARLO, IT
(71) NEW HOLLAND ITALIA S.P.A., IT

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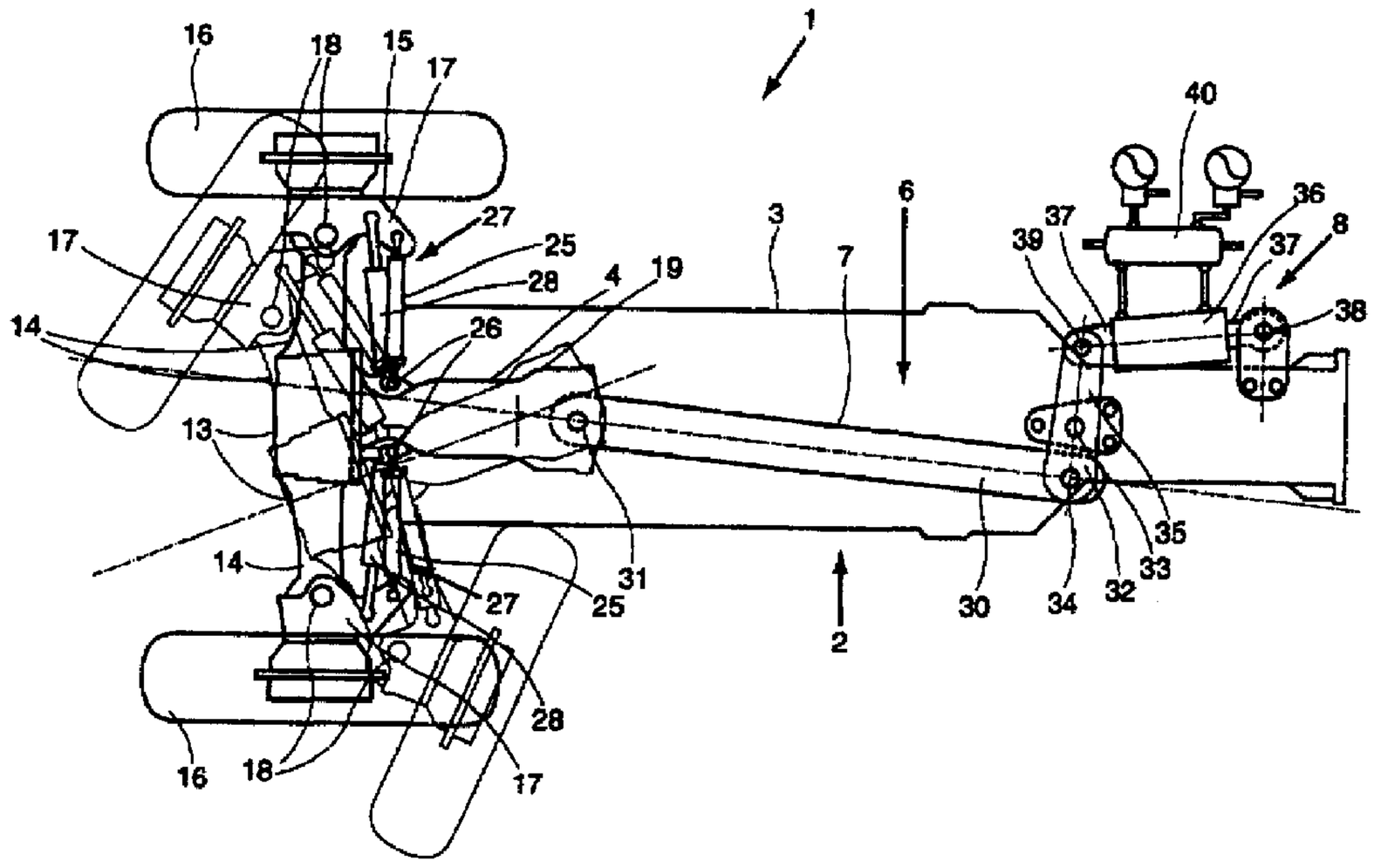
(54) **SUSPENSION DE L'ESSIEU AVANT**
(54) **FRONT AXLE SUSPENSION**



(57) L'invention concerne un ensemble direction (1) pour un véhicule utilitaire (2) comportant un cadre porteur (3). L'ensemble direction (1) comporte un essieu avant orientable (4) pourvu d'un élément d'essieu transversal (13) défini longitudinalement par des parties d'extrémité (15) pivotant autour de leur axe sensiblement vertical (18) respectif, chaque partie d'extrémité (15) portant une roue orientable (16) pour la rotation. L'essieu avant (4) comporte également un corps tubulaire (19) relié de manière rigide à l'axe (13) afin de le relier au cadre (3) en rotation libre par interposition d'un joint sphérique (5). Un organe de raccordement (6), fourni pour relier l'essieu avant (4) de manière stable au cadre, permet de transmettre les charges portant sur les roues (16) au cadre (3), cet organe de raccordement (6) étant pourvu d'un appareil amortisseur (8) afin d'isoler élastiquement l'essieu avant (4) du cadre (3).

(57) A steering assembly (1) for a utility vehicle (2) having a supporting frame (3); the assembly (1) having a steerable front axle (4) having a transverse axle member (13) defined longitudinally by end portions (15) pivotable about respective substantially vertical axes (18); each end portion (15) supporting for rotation a steerable wheel (16); the front axle (4) also having a tubular body (19) connected rigidly to the axle (13) to connect it to the frame (3) in freely rotating manner via the interposition of a spherical joint (5); a connecting unit (6) being provided to connect the front axle (4) in a stable manner to the frame and enable the loads on the wheels (16) to be transmitted to the frame (3); and the connecting unit (6) having a shock-absorbing device (8) for elastically disconnecting the front axle (4) from the frame (3).

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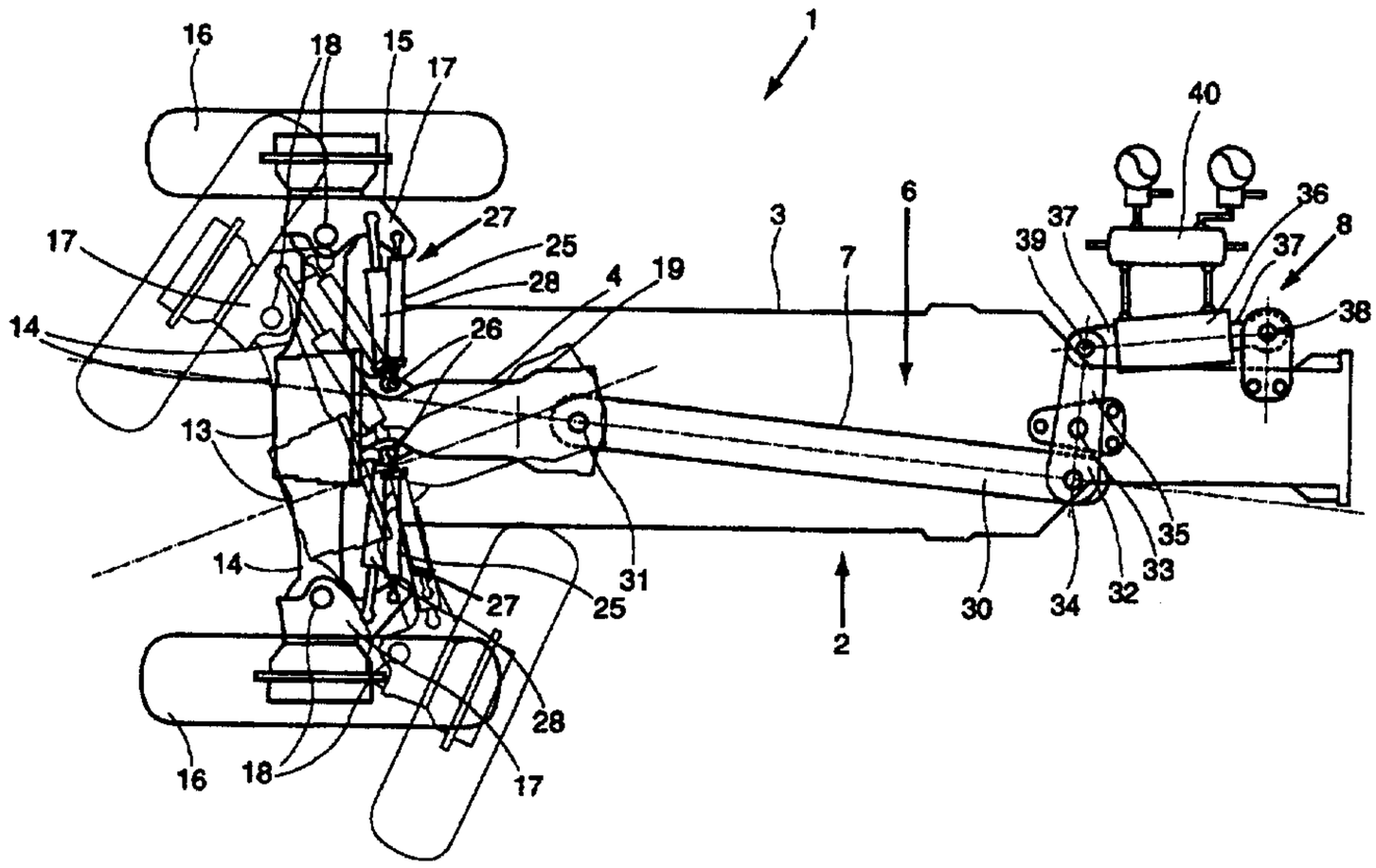
(71) Applicant *(for all designated States except MC US)*: NEW HOLLAND ITALIA S.P.A. [IT/IT]; Viale delle Nazioni, 55, I–41100 Modena (IT).

(71) Applicant *(for MC only)*: NEW HOLLAND UK LIMITED [GB/GB]; Cranes Farm Road, Basildon, Essex SS14 3AD (GB).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: BENASSI, Gian, Carlo [IT/IT]; Via Ascani, 73, I–41100 Modena (IT).

(74) Agent: MESSULAM, Alec, Moses; A. Messulam & Co., 24 Broadway, Leigh–on–Sea, Essex SS9 1BN (GB).

(54) Title: FRONT AXLE SUSPENSION



(57) Abstract

A steering assembly (1) for a utility vehicle (2) having a supporting frame (3); the assembly (1) having a steerable front axle (4) having a transverse axle member (13) defined longitudinally by end portions (15) pivotable about respective substantially vertical axes (18); each end portion (15) supporting for rotation a steerable wheel (16); the front axle (4) also having a tubular body (19) connected rigidly to the axle (13) to connect it to the frame (3) in freely rotating manner via the interposition of a spherical joint (5); a connecting unit (6) being provided to connect the front axle (4) in a stable manner to the frame and enable the loads on the wheels (16) to be transmitted to the frame (3); and the connecting unit (6) having a shock–absorbing device (8) for elastically disconnecting the front axle (4) from the frame (3).

FRONT AXLE SUSPENSION

Field of the invention

The present invention relates to a front axle suspension mechanism and steering assembly for an automotive vehicle suitable for use over uneven ground.

The present invention advantageously may be used on a utility vehicle such as a farm tractor, to which the following description refers purely by way of example.

Background of the invention

In the following description right hand and left hand references are determined by standing at the rear of the tractor facing in a direction of forward travel. Also, in the following description, it is to be understood that terms such as "forward", "rearward", "upward", etc., are words of convenience and are not to be construed as limiting terms.

In farming practice, it is generally known to employ wheel-mounted tractors for towing mechanical or chemical land processing machinery. The frame, which on most tractor models comprises the engine block, normally supports at the front a steering assembly having a front axle with steerable wheels mounted thereon. EP-A-0.691.258, which is incorporated herein by reference, discloses a steering assembly having a front axle of a T-shaped configuration which is rotatably connected to the frame. The front axle is laterally defined by pivoting end portions, carrying the steerable wheels, and has a rearwardly extending tubular body which is connected to the frame by means of a spherical joint. Each steerable wheel is connected to the tubular body by means of a linear actuator by which it is rotated relative to the front axle. The steering assembly further comprises a support link connecting the tubular body to the frame at a point close to the rear wheel end of the tractor. The support link is connected to the tubular body by a

substantially vertical cylindrical hinge, and to the frame by a spherical joint, allowing the front axle on the one hand to pivot laterally around the vertical hinge and on the other hand to oscillate vertically about a horizontal axis. With the foregoing configuration, the support link is mainly subjected to traction. The steering assembly finally comprises a pair of tie rods, each of which is connected at one end to the frame at a location alongside a front portion of the tubular body and at the other end to the respective steerable wheels.

It is observed that the distance between the spherical joint, connecting the front axle to the frame, and the axis of the rear wheels is less than the distance between the front and rear wheels. As such and due to the presence of the tie rods, the front axle is rotated with respect to the spherical joint at each opposed actuation of the linear actuators. As a consequence, the amount of motion of the steerable wheels with respect to the frame is a combination of the rotation of each steerable wheel with respect to the corresponding end of the front axle, and of the front axle with respect to the frame, providing for excellent manoeuvring of the vehicle in confined spaces.

It will be appreciated from the foregoing that a steering assembly as described above provides for a high degree of manoeuvrability of the tractor under various conditions, and for maintaining ground contact of as well the steerable wheels as the rear wheels even when travelling over rough, uneven ground. However, as the resistive forces on the front axle opposed by the terrain to the forward movement of the tractor are transmitted directly to the frame by the support link, which conversely also transmits the loads experienced by the frame to the axle, the effectiveness of the above steering assembly is reduced when driving over rough ground or at elevated speeds, in which case handling the tractor may be particularly strenuous and may result in the driver becoming distracted due to fatigue.

Object of the invention

It is therefore an object of the present invention to provide a steering assembly for an automotive vehicle, designed to overcome the aforementioned drawbacks.

Summary of the invention

According to the present invention, a steering assembly for a utility vehicle is provided having a supporting frame; said assembly comprising :

- a steering axle rotatable with respect to said frame and comprising :
  - an axle member defined transversely by end portions pivotable about respective substantially vertical axes; each said end portion supporting for rotation a steerable wheel; and
  - a member rigidly connected to said axle member and rotatably connecting the steering axle to said frame through a first spherical joint; and
- connecting means provided in-between said steering axle and said frame for limiting the movement of said steering axle relative to said frame in a given direction,

the steering assembly being characterised in that said connecting means comprises shock-absorbing means for elastically disconnecting said steering axle from said frame.

Brief description of the drawings

A steering assembly in accordance with the present invention will now be described in greater detail, by way of example, with reference to the accompanying drawings, in which :

Figure 1 shows a schematic plan view of a first embodiment of a steering assembly in accordance with the present invention;

Figure 2 is a side view of Figure 1;

Figure 3 shows a schematic plan view of a second embodiment of the Figure 1 assembly;

Figure 4 shows a schematic plan view of a third embodiment of the Figure 1 assembly;

Figure 5 is a side view of Figure 4;

Figure 6 shows a schematic plan view of a fourth embodiment of the Figure 1 assembly;

Figure 7 is a frontal section of an alternative mounting member applicable to the third embodiment shown in Figure 4; and

Figure 8 is a side view of Figure 7.

Detailed description of the preferred embodiments

Reference 1 in Figure 1 indicates as a whole a steering assembly for a utility vehicle, such as a tractor 2, which, for the sake of simplicity, is shown only partly in the accompanying drawings.

With reference to Figures 1 and 2, tractor 2 comprises a longitudinal supporting frame or chassis 3, and assembly 1 comprises a T-shaped front axle 4 connected to the underside of frame 3 (Figure 2) by means of a spherical joint 5. Assembly 1 further comprises a connecting unit 6 located between front axle 4 and frame 3 to support front axle 4, which would otherwise rotate clockwise, as seen in Figure 2, under the weight of frame 3. Connecting unit 6 provides for transmitting the loads on front axle 4 to frame 3, and comprises an articulated quadrilateral structure 7, and a shock-absorbing device 8. More specifically, shock-absorbing device 8 co-operates with the structure 7 to disconnect front axle 4 mechanically from frame 3 as such providing for smoother load transmission between front axle 4 and frame 3.

With reference to Figures 1 and 2, front axle 4 comprises a transverse axle portion 13 with two lateral arms 14, each of which is hollow and defined by a respective end portion 15 connected to a steerable wheel 16 via the

interposition of a rocking body 17 hinged about an axis 18 substantially perpendicular to the corresponding arm 14. Front axle 4 further comprises a member 19 in the form of a tubular body or trumpet portion, rigidly connected to the axle portion 13 and extending rearwardly therefrom. At the top rear end of the body 15, a head 20 of a joint 5 is provided which engages inside a cylindrical seat 21 connected rigidly to frame 3. It should be noted that axle 4 houses an axle shaft 22 (Figure 2), which is driven by a transmission shaft 23 via a differential 24 housed in the tubular body 19. The shaft 22 selectively may drive the front wheels when 4-wheel drive is desired.

Assembly 1 also comprises a pair of tie rods 25, each of which connects one of the end portions 15 of the front axle 4 to the frame 3 through a boss 26, which is attached to the frame 3 intermediate the wheels 16 and facing the front end of tubular body 19. More specifically, the two tie rods 25 together define a constraint 27 causing the tubular body 19 and hence the front axle 4 to rotate in the same direction as the wheels 16 are pivoted, as is explained in greater detail in EP-A-0.691.258. It will be appreciated that the combined rotation of the wheels 16 about the pivot axis 18 of the respective end portions 15 and of the tubular body 19 around joint 5 greatly reduces the steering radius of tractor 2.

In addition, assembly 1 comprises a pair of double-acting hydraulic linear actuators 28, each connected to the tubular body 19 and to a respective end portion 15, and which are operated in a conventional manner in opposite phase to rotate the wheels 16 with respect to the axle 4. Simultaneously, the constraint 27 causes front axle 4 to rotate about seat 21 of joint 5, to enable tractor 2 to be manoeuvred in confined spaces.

The articulated structure 7 comprises a connecting rod defined by an elongated body 30 connected to the tubular body 19 by a spherical joint 31 provided underneath joint 5. The structure 7 further comprises a vertical lever arm

defined by the portion of the tubular body 19 between the joints 5 and 31 and a horizontal lever arm 32 hinged to frame 3 by a hinge 33 having a vertical axis. At the distal end of joint 31, elongated body 30 is connected to lever 32 by a spherical joint 34, whereby the articulated quadrilateral structure 7 becomes a spatial type structure. It will be appreciated that the fixed base of the quadrilateral structure 7 coincides with frame 3 of tractor 2. It also should be noted that, in the present case, lever 32 functions as a so-called first-category lever.

Lever 32, in the form of a straight bell-crank, has an extension 35 extending on the opposite side of hinge 33 relative to spherical joint 34. The shock-absorbing device 8 comprises a known elongated shock absorber 36 having annular portions 37 for connection to the frame 3 on the one hand and to the extension 35 on the other hand. More specifically, the shock absorber 36 is connected to the frame 3 on the opposite side of hinge 33 relative to joint 31 by a hinge 38 and to lever 32 by a hinge 39, both hinges having a hinge axis parallel to that of hinge 33.

With reference to Figure 1, the shock absorber 36 is of the hydro-pneumatic type, and comprises a stiffness regulating member 40 having known hydro-pneumatic accumulators. The member 40 is operable to adapt the response of the shock absorber 36 to the characteristics of the ground over which tractor 2 is driven.

Referring specifically to Figures 1 and 2, it should be noted that elongated body 30 is normally located partially to the side of and underneath the transmission shaft 23 and therefore in no way interferes therewith.

The operation of steering assembly 1 is clearly understandable from the foregoing description without having to go into any further detail. It will be appreciated that, in response to ground-induced loads on the tractor 2, the front axle 4 will oscillate about joint 5 in a dampened manner by means of the shock absorber 36, thus providing for smooth operation of the tractor 2 over rough ground or when

driving at elevated speeds. Clearly, changes may be made to the assembly 1 as described and illustrated herein without, however, departing from the scope of the present invention.

For example, as shown in Figure 3, to reduce the forces on shock absorber 36, the locations of joint 34 and hinge 33 are inverted, so that lever 32, which in Figure 1 is hinged centrally to frame 3, is now hinged at a lateral end and operates as a so-called second-category lever.

With reference to Figures 4 and 5, lever 32 is modified and is delimited at its transverse ends by a pair of substantially identical, right-angled portions 45, thereby defining an H-like structure. The top ends of the portions 45 are pivotally connected to the frame 3 at 45'. Frame 3 further carries a pair of shock absorbers 36, only one of which is shown with its associated regulating member 40 for the sake of simplicity. Each shock absorber 36 is hinged to the frame 3 by a horizontal hinge 46, and is connected to one of the portions 45 at the lower end thereof by a hinge 47 parallel to hinge 46. In this arrangement, the lever 32 is held more freely from the frame 3 and is maintained in a floating manner by the two shock absorbers 36. Elongated body 30 is attached to the lever 32 through a spherical joint 48. As shown in Figure 4, elongated body 30 has a slot 49 through which the longitudinally extending transmission shaft 23 is guided.

Of course, if desired, the pair of hydro-pneumatic shock absorbers 36 may be substituted by a pair of springs of equivalent stiffness.

It is seen in Figure 5 that the support structure 32, 45 is upwardly offset from a horizontal plane through the lowest part of joint 31. This means that the provision of the shock absorbing mechanism does not impair the ground clearance.

Having regard of Figure 6, assembly 1 is greatly simplified by modifying elongated body 30, which, in this case, is composed of two parts connected to each other through the interposition of a pair of shock absorbers 50

functionally identical to the shock absorbers 36 of the previous Figures but obviously smaller in size. Elongated body 30 is connected to frame 3 directly by a spherical joint 34, and has an elongated slot 51 for guiding the transmission shaft 23 therethrough.

Again, if desired, the pair of hydro-pneumatic shock absorbers 50 may of course be replaced by a pair of springs having together an equivalent stiffness, or by a single spring.

In Figures 7 and 8 an alternative mounting structure 60 for the H-shaped structure 32, 45 of Figure 5 is shown. The structure 60 is shaped as an inverted U having a cylindrical extension 62 which is freely rotatably attached to the frame 3 by means of a spherical joint 64. At either outward side of the inverted U, a shock absorber 36, shown in phantom in Figure 8, is pivotably attached to the structure 60 through spherical joints 66. The shock absorbers 36 in turn are pivotably attached to the frame 3 by means of spherical joints 68, only one of which is shown in Figure 8. The elongated body 30 is provided at its rearward end with a cylindrical hub 70 which fits over a pin 72 maintained in-between the two legs of the inverted U structure 60. The elongated body 30 again has a slot for allowing the transmission shaft 23 to pass through in whatever position of the body 30 without interference. It will be understood that the provision of all the spherical joints allows the structure 60 with associated shock absorbers 36 to be moved in various directions, so as to be able to respond to the movement imposed by the elongated member 30.

To restrict the shock absorbing movement of the elongated body 30, and hence of the front axle 4, in-between predetermined limits, the structure 60 is provided with front and rear abutment extensions 74 which abut the frame 3 when in an extreme position, as shown in dashed lines in Figure 8. As such, the abutments 74 already restrict further movement of the elongated body 30 before the shock absorbers 36 reach their extreme operating positions, thereby

preventing the shock absorbers to be subjected to elevated forces at their end-of-stroke positions.

It will be appreciated that the positioning of the pin 72 in-between the joint 64 and the attachment points 66 of the shock absorbers 36 thereby creating a larger lever arm for the shock absorbers, is advantageous for reducing the forces transmitted to the shock absorbers 36.

CLAIMS

1. A steering assembly (1) for a utility vehicle (2) having a supporting frame (3); said assembly (1) comprising:

- a steering axle (4) rotatable with respect to said frame (3) and comprising :

- an axle member (13) defined transversely by end portions (15) pivotable about respective substantially vertical axes (18); each said end portion (15) supporting for rotation a steerable wheel (16); and

- a member (19) rigidly connected to said axle member (13) and rotatably connecting the steering axle (4) to said frame (3) through a first spherical joint (5); and

- connecting means (6) provided in-between said steering axle (4) and said frame (3) for limiting the movement of said steering axle (4) relative to said frame (3) in a given direction; and

characterised in that said connecting means (6) comprises shock-absorbing means (8) for elastically disconnecting said steering axle (4) from said frame (3).

2. An assembly according to claim 1, characterised in that it comprises :

- control means (28) provided in-between said end portions (15) and said member (19) for rotating said end portions (15) with respect to said steering axle (4); and

- a pair of rods (25), each of which is located between a said end portion (15) and said frame (3) to cause said steering axle (4) to rotate with respect to said first spherical joint (5).

3. An assembly according to claim 1 or 2, characterised in that said connecting means (6) comprises a first lever (30) connected to said front axle (4), close to said first spherical joint (5); and a second lever (32)

connected to said first lever (30) at a distal end thereof by a second spherical joint (34).

4. An assembly according to claim 3, characterised in that said second lever (32) is connected to said frame (3) on the opposite side of said first spherical joint (5) relative to said steerable wheels (16) by means of a first hinge (33) ; said member (19) and said first and second levers (30, 32) together defining an articulated, quadrilateral structure (7) connected to said frame (3) by said first spherical joint (5) and said first hinge (33).

5. An assembly according to claim 4, characterised in that said shock-absorbing means (8) comprises an elastic member (36) connected to said second lever (32) by means of a second hinge (39) to at least partially absorb the load transmitted to said second lever (32) by said first lever (30).

6. An assembly according to claim 5, characterised in that said first hinge (33) is provided intermediate said second spherical joint (34) and said second hinge (39); said second hinge (39) having a substantially vertical hinge axis.

7. An assembly according to claim 5, characterised in that said second spherical joint (34) is located in-between said first and second hinges (33, 39); said second hinge (39) having a substantially vertical hinge axis.

8. An assembly according to claim 5 characterised in that said elastic member (36) is of adjustable stiffness.

9. An assembly according to claim 5, characterised in that said elastic member (36) comprises a hydro-pneumatic shock absorber (36) of adjustable stiffness.

10. An assembly according to claim 3, characterised in that said second lever (32) is provided with end portions (45) standing perpendicular relative thereto, each of which is connected to said frame (3) on the one hand directly by means of a hinge (-) and on the other hand indirectly through said shock-absorbing means (8).

11. An assembly according to claim 2, characterised in that said connecting means (6) comprises an elongated body (30) connected to said frame (3) by a second spherical joint (34) provided on the opposite side of said first spherical joint (5) relative to said steerable wheels (16); said elongated body (30) being hingeably connected to said member (19) close to said first spherical joint (5) and consisting of at least two parts connected elastically to each other by said shock-absorbing means to elastically disconnect said steering axle (4) from said frame (3).

12. An assembly according to any of the foregoing claims, characterised in that said first lever (30) is connected to said steering axle (4) by means of a third spherical joint (31).

13. An assembly according to claim 1 characterised in that said connecting means (6) comprises :

- a mounting structure (60) hingeably connected to the frame (3) through a single pivot (64); and

- a lever (30) connected at one end to said front axle (4), close to said first spherical joint (5), and at the other end to said mounting structure (60); said shock-absorbing means (8, 36) being provided in-between said mounting structure (60) and said frame (3).

14. An assembly according to claim 13 characterised in that said mounting structure (60) is shaped as an inverted U, having an upward extension (62) for connection to the

frame (3) through said single pivot (64), formed by a spherical joint.

15. An assembly according to claim 14 characterised in that said shock-absorbing means (8, 36) are attached to said mounting structure (60) by means of spherical joints (66); said lever (30) being connected to said mounting structure (60) at a location in-between said single pivot (64) and said spherical joints (66).

16. An assembly according to claim 13 and any claim dependent therefrom, characterised in that said mounting structure (60) comprises abutment members (74) for engaging the frame (3) in extreme positions of said mounting structure (60), thereby limiting the stroke of said shock-absorbing means (8, 36).

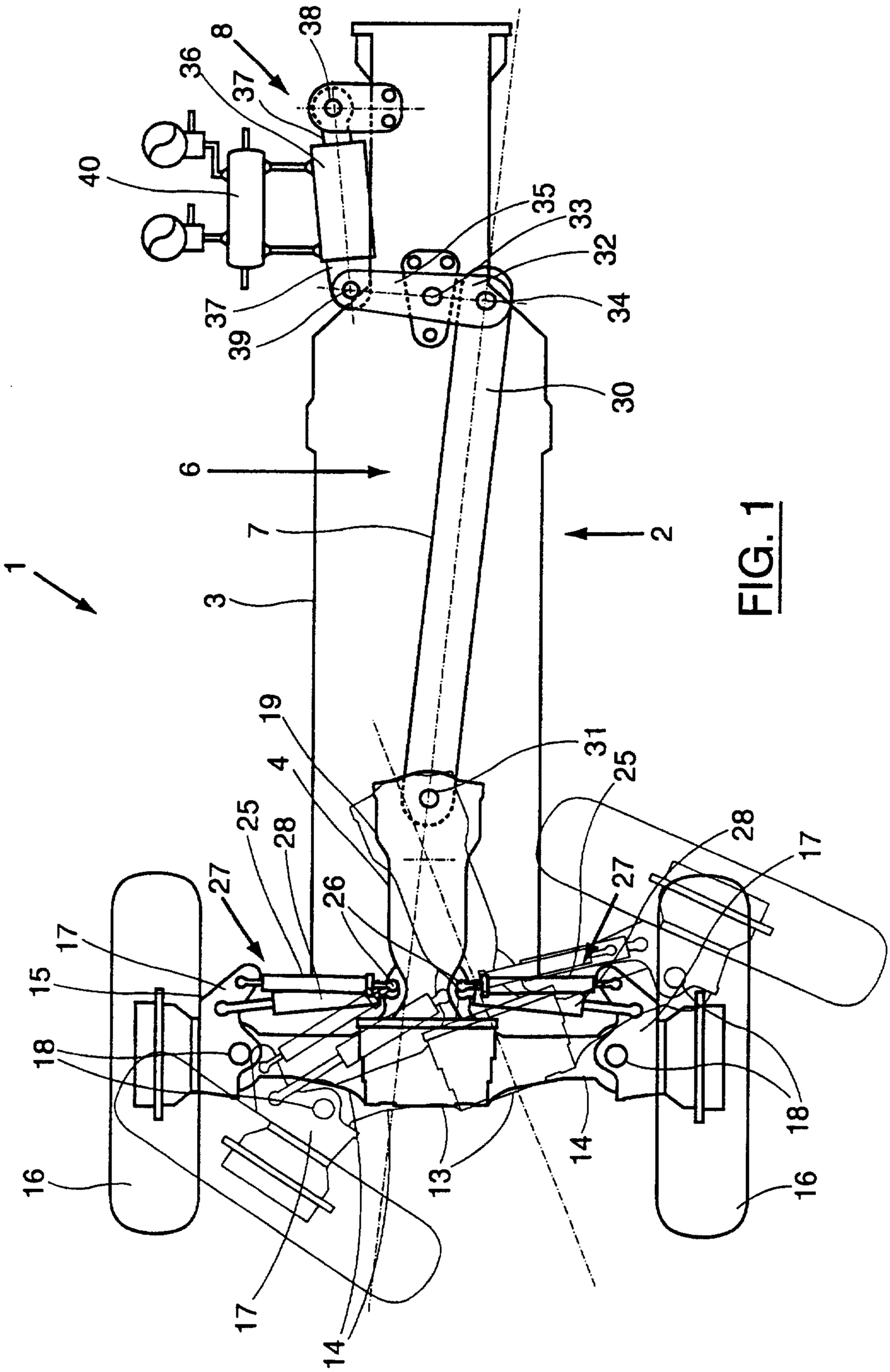

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FIG. 1

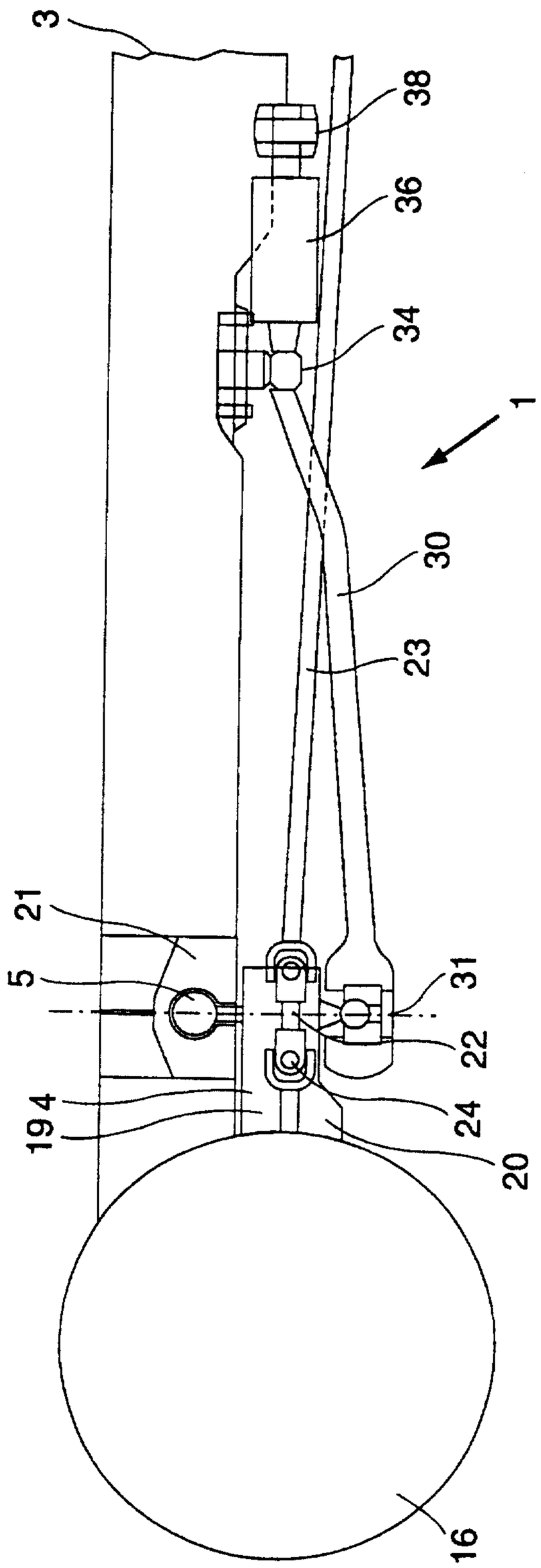

FIG. 2

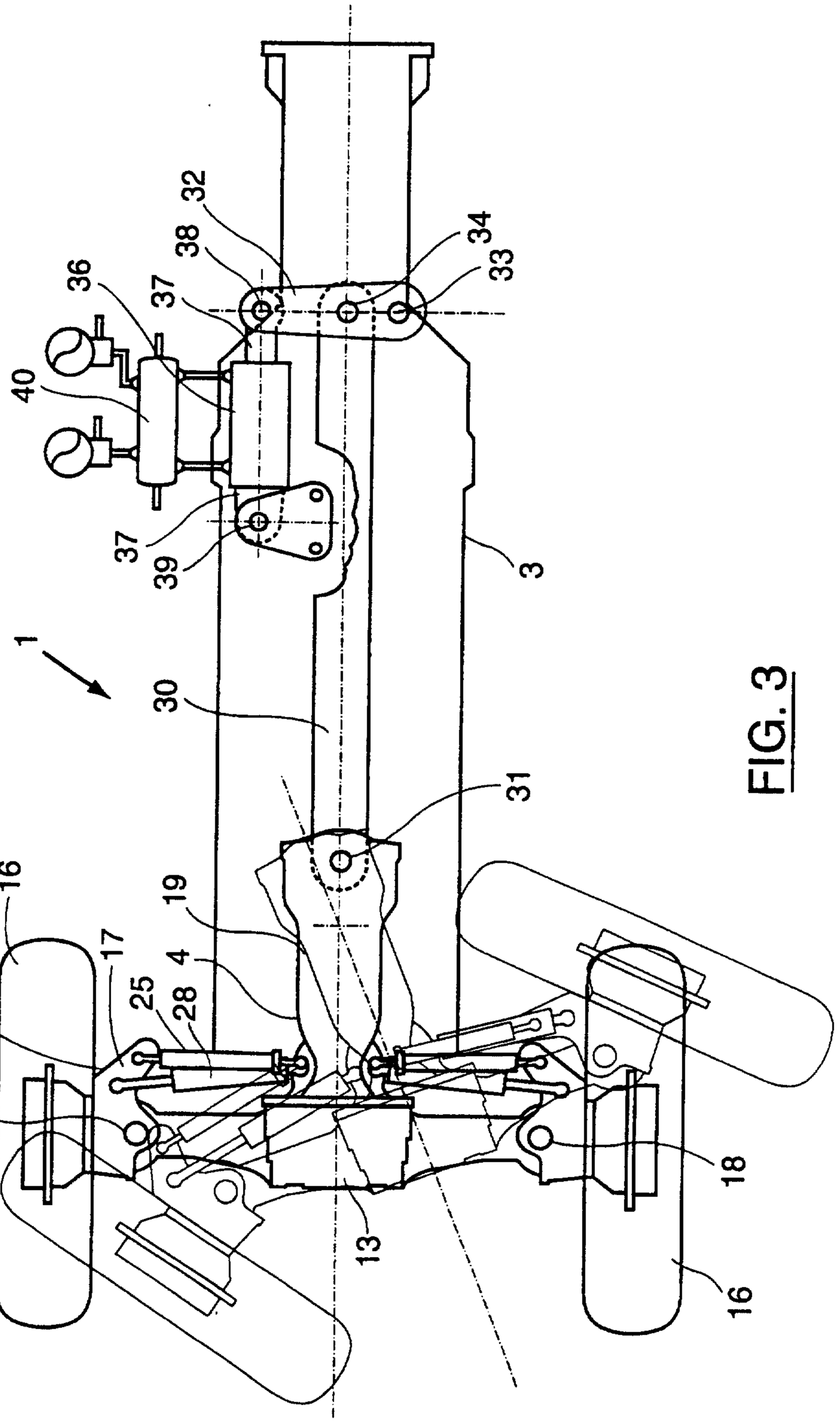

FIG. 3

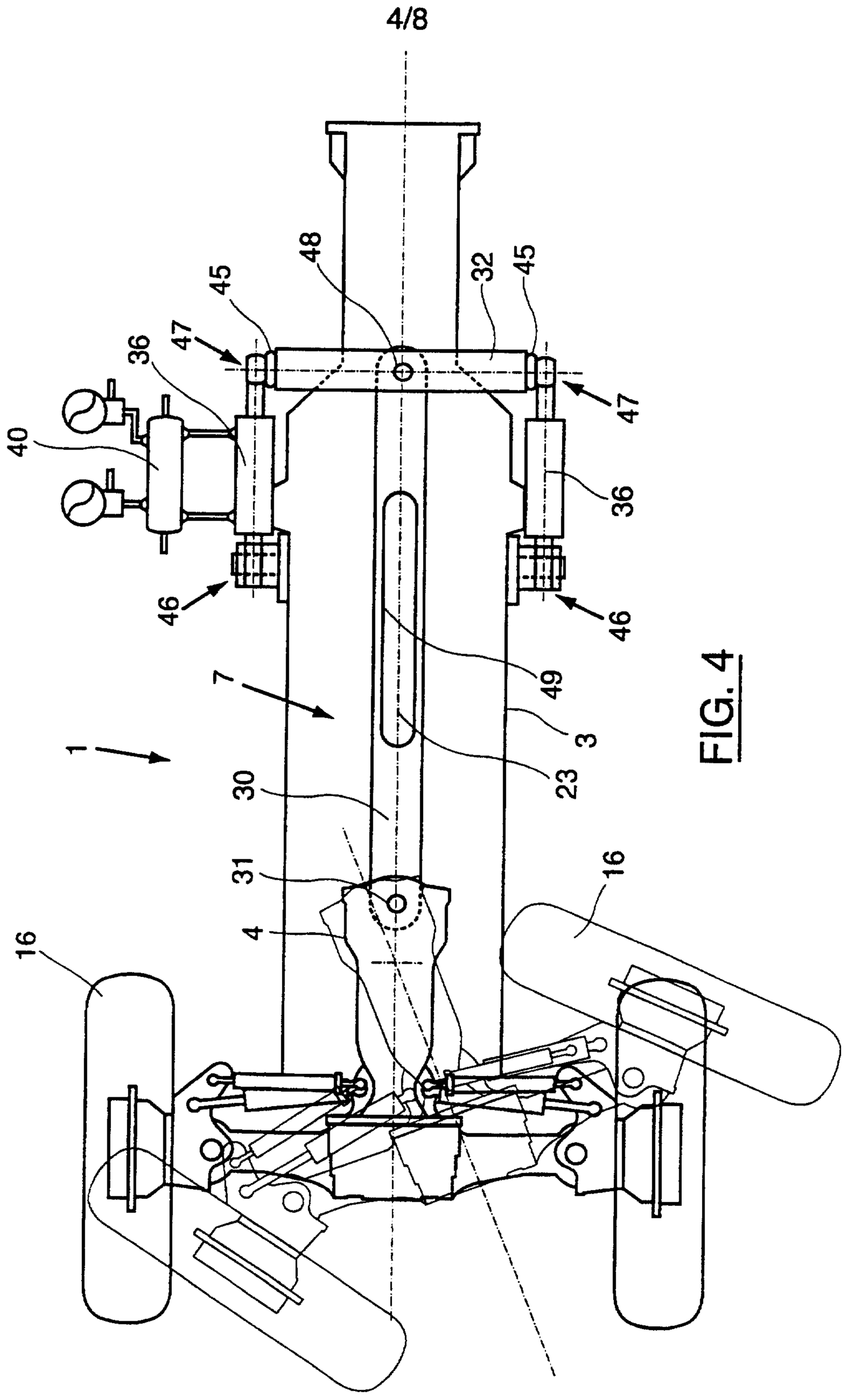

FIG. 4

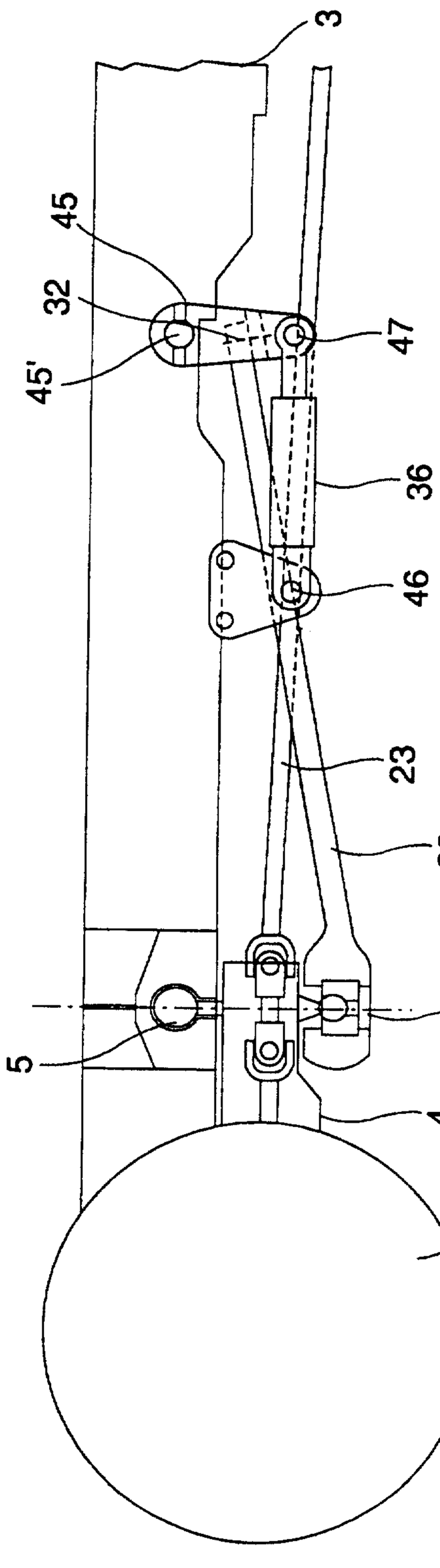

FIG. 5

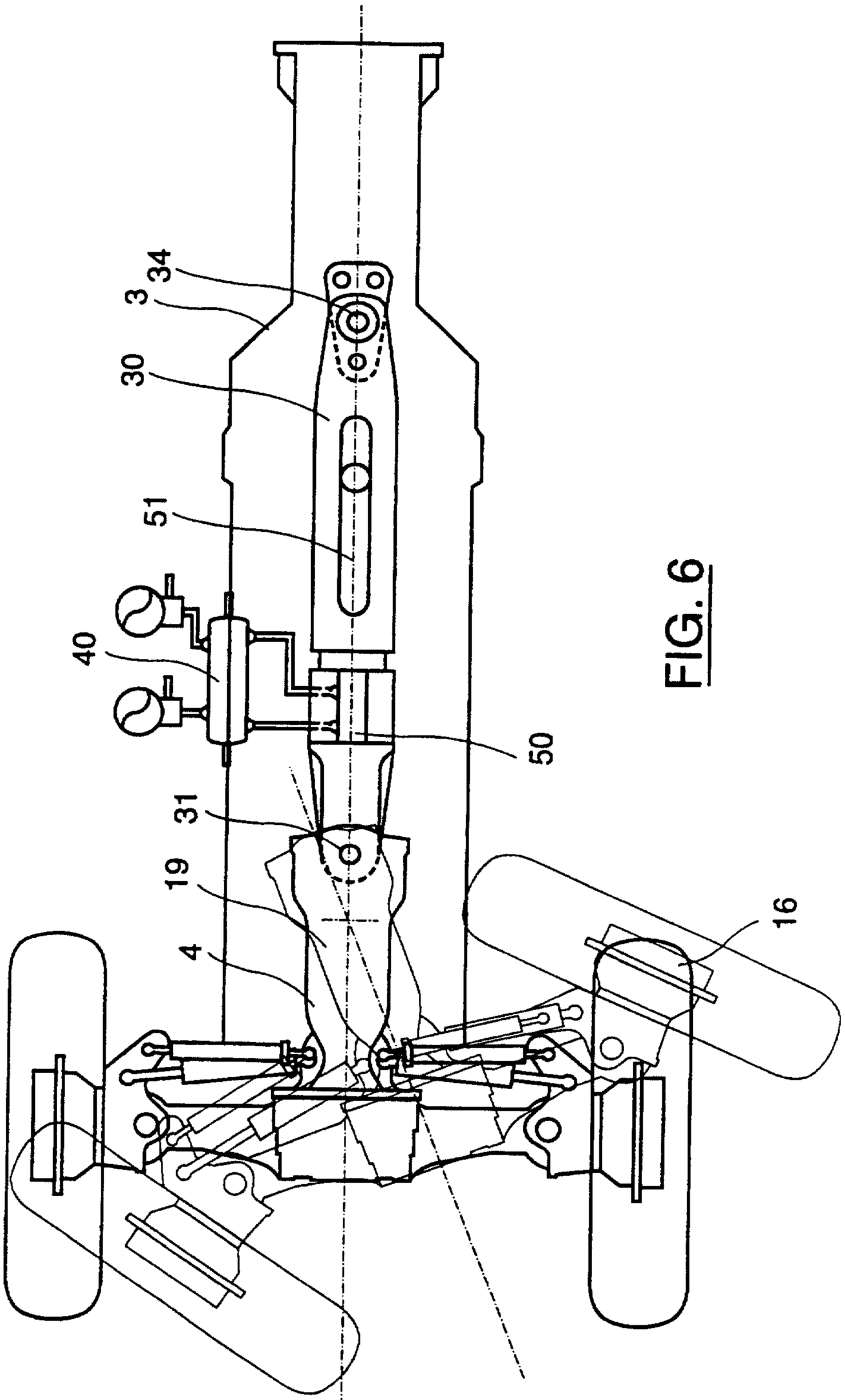

FIG. 6

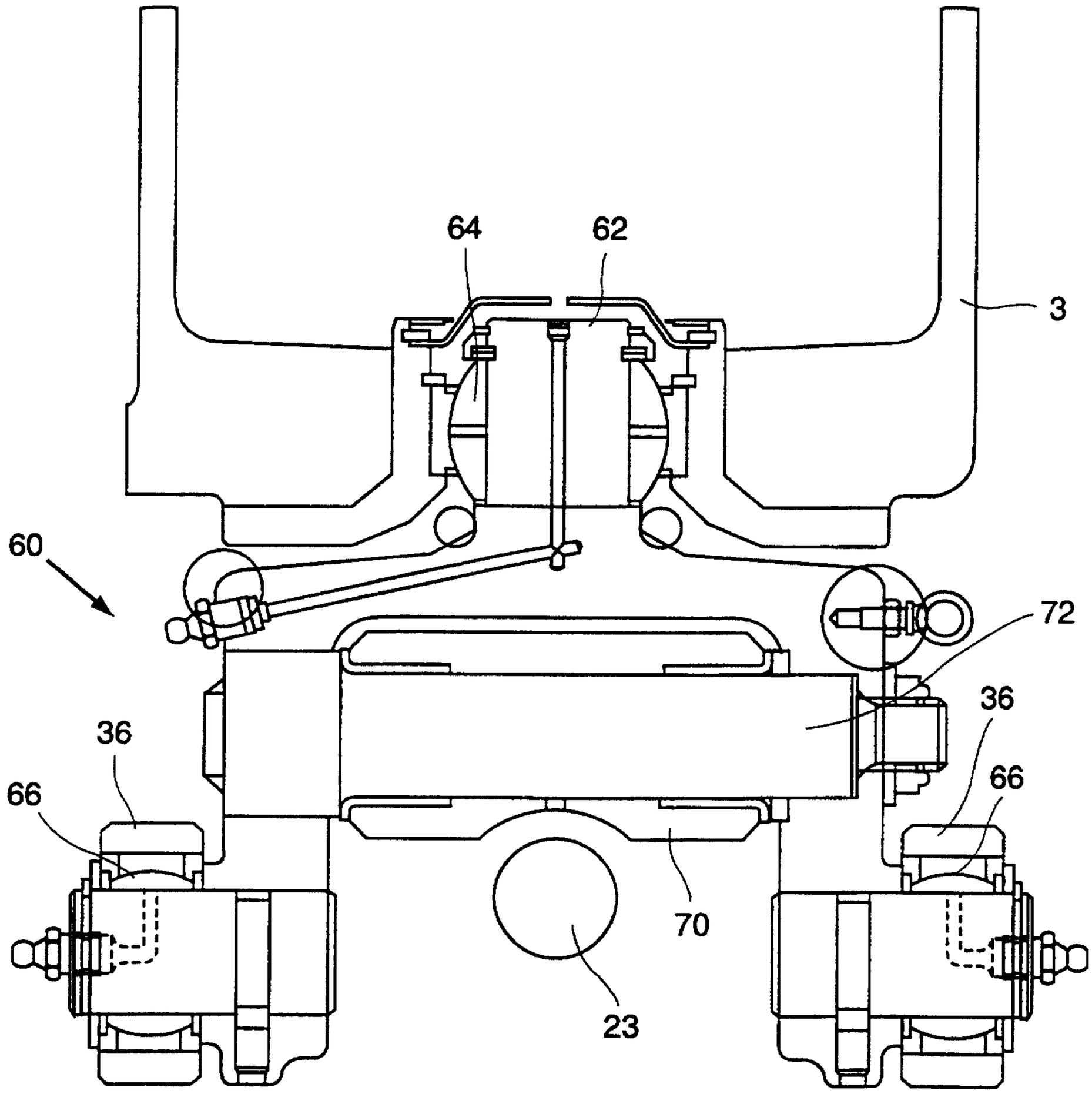

FIG. 7

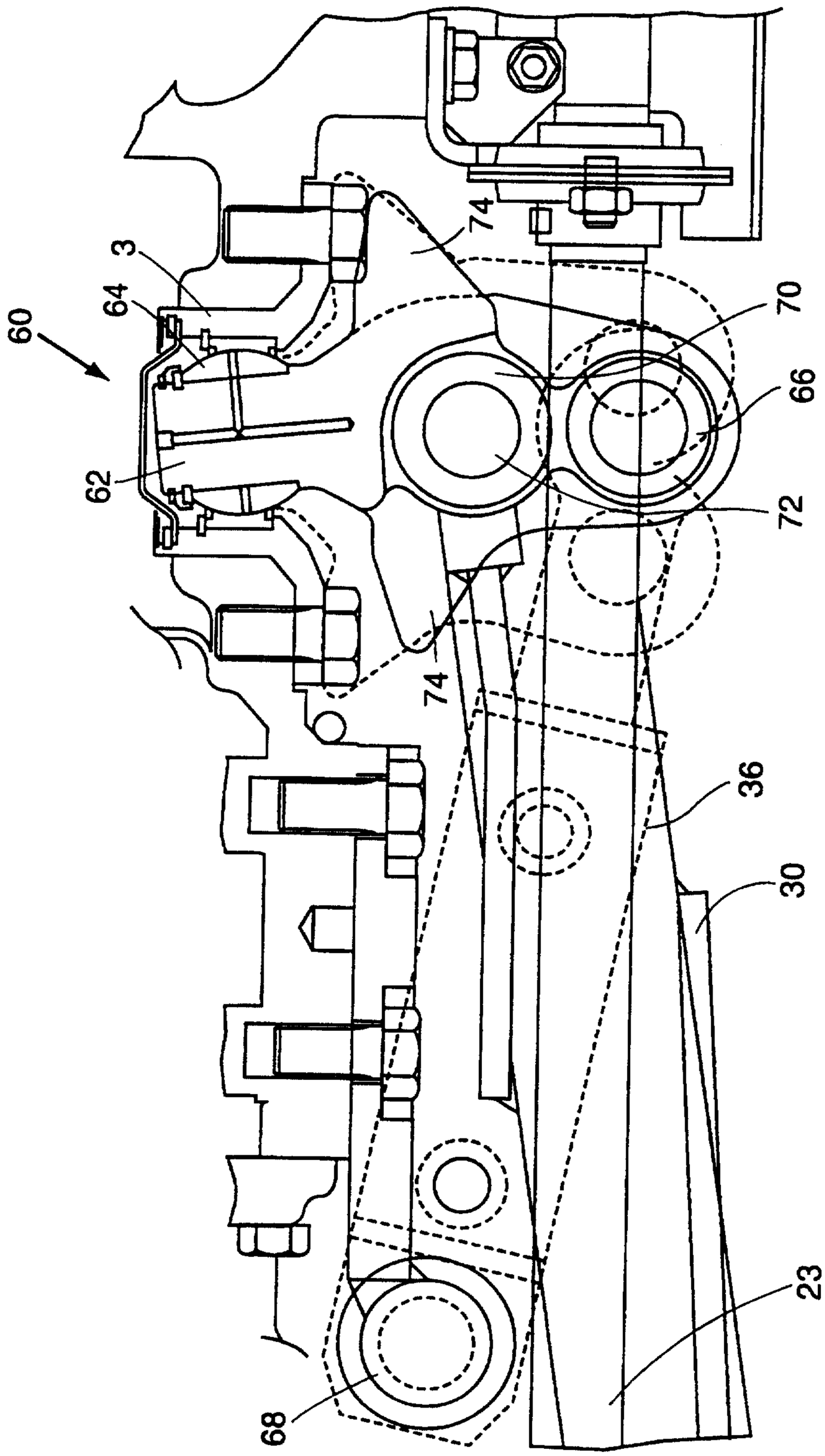

FIG. 8