(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
2 August 2001 (02.08.2001)

PCT

(10) International Publication Number
WO 01/54932 A1

(51) International Patent Classification[7]: B60G 21/05

(21) International Application Number: PCT/GB01/00144

(22) International Filing Date: 15 January 2001 (15.01.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0001520.6 25 January 2000 (25.01.2000) GB
0013464.3 5 June 2000 (05.06.2000) GB

(71) Applicant and
(72) Inventor: WALKER, Peter, John [GB/GB]; 44 St Michaels Drive, Roxwell, Essex CM1 4NU (GB).

(74) Agent: KEITH W NASH & CO; 90-92 Regent Street, Cambridge CB2 1DP (GB).

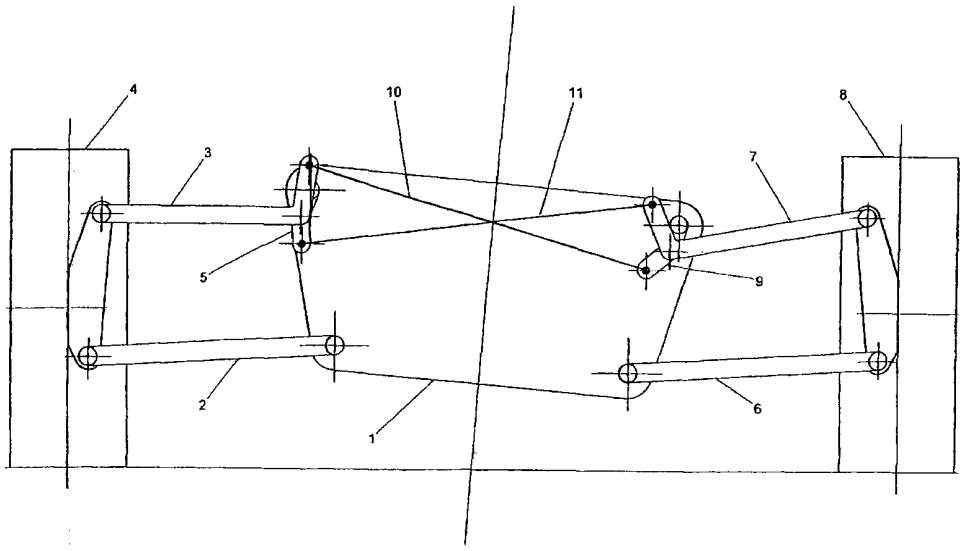
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *with amended claims*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: VEHICLE SUSPENSION SYSTEM



(57) Abstract: A motor vehicle chassis structure which includes an independent suspension system including left and right suspension components for left and right wheels (4, 8) respectively for gripping and travelling along a road surface, each of which suspension components is arranged to allow a constrained up and down movement of the respective wheel relative to the vehicle chassis structure, characterised in that the upper suspension components on one side of the vehicle are cross-linked with the upper suspension components on the other side of the vehicle by a connecting rod (10, 11) and an offset pivot shaft assembly (9, 5), so as to constrain the plane of each wheel towards an orientation which is normal to the road surface while allowing the chassis structure to move vertically and to roll relative to said wheels during cornering, acceleration, deceleration and combinations thereof.

WO 01/54932 A1

VEHICLE SUSPENSION SYSTEM

The present invention relates to suspension systems for vehicles.

Generally a motor vehicle incorporating independent suspension (i.e. not a solid axle) either at the front or the rear of the vehicle will have a chassis structure which includes a suspension system including left and right suspension components for left and right wheels respectively, each of which is arranged to allow a constrained up and down movement of the respective wheel relative to the chassis structure. A commonly encountered example is the well-known double wishbone suspension system.

The term chassis structure is used herewith to refer both to the chassis of a vehicle having a discrete chassis, to the corresponding load bearing part of a monocoque body (that is a vehicle body where the chassis and body are combined in one unit), and to any combination of the above, for example to the chassis component of a monocoque body with sub-frames.

With such independent suspension systems the suspension components will normally possess a geometry which enables each respective suspended wheel to compensate for roll of the chassis structure during cornering and still remain relatively perpendicular to the road surface so maintaining an optimum tyre-to-road contact patch and thereby maximum grip. In order to achieve this result the camber angle of each wheel has to change with respect to the chassis structure as the suspension is compressed or extended during cornering. (This contrasts with the requirement for a motorcycle where the tyre profile is round and the contact patch is unaffected by the angle of lean).

suspension is compressed or extended as a consequence of longitudinal weight transfer. For example, when the vehicle is subject to high acceleration there is longitudinal weight transfer directed to the rear of the vehicle thereby compressing the rear suspension and causing the rear wheels to adopt a negative camber, that is to say the rear wheels become inclined inwards. At the same time the front suspension extends causing the front wheels to adopt a positive camber. This then significantly reduces the level of contact of the tyres with the road. The converse arises when decelerating due to braking in which weight transfer goes forward and the rear suspension extends while the front suspension is compressed. In this case also the problem of compromised tyre-to-road contact arises.

The present invention is concerned with solving this problem without compromising the measures required for cornering, and in particular with ensuring maximum grip during cornering and during acceleration or deceleration and with intermediate situations involving both.

Several theoretical solutions to this problem have been devised but their commercial appeal has been tempered by a variety of attendant concerns commonly focusing on excessive complexity, cost, friction, NVH (noise/vibration/harshness), space & packaging demands and inherent roll centre, suspension travel and other design limitations.

The present invention provides a simple and commercially viable solution while affording low friction, intrinsic compactness, greater design freedom and an ability to achieve its objectives while allowing the use of rubber mounted lower suspension arms.

Accordingly the invention provides a motor vehicle chassis structure which includes an independent suspension system including left and right upper and lower suspension components for left and right wheels respectively for gripping and travelling along a road surface, each of which suspension components is arranged to allow a constrained up and down movement of the respective wheel relative to the chassis structure, characterised in that the upper suspension components on one side of the vehicle are cross-linked independently of the lower suspension components with the upper suspension components

on the other side of the vehicle, so as to constrain the rotational plane of each wheel towards an orientation which is normal to the road surface while allowing the chassis structure to move vertically and to roll relative to said wheels during cornering, acceleration, deceleration and combinations thereof.

Generally with conventional tyres, this means that each wheel will be constrained in a position where it is substantially perpendicular, ie perpendicular, or within a few degrees of being perpendicular, to the road surface.

The invention applies to left and right suspension components for left and right wheels respectively either in the form of a front suspension system of a vehicle or in the form of a rear suspension system of a vehicle or in both.

While the invention can be carried out by the use of direct mechanical links across the vehicle between left and right wheel upper suspension components respectively, it is also possible to provide embodiments of the invention where a cross-linking action is achieved by hydraulic or pneumatic or other links. For example movement of the upper suspension arm, suspension upright or other interposed arm or link can be used to operate a hydraulic actuating cylinder. Hydraulic pipes or hoses can then transfer movement to an operating cylinder on the opposite side of the vehicle which would affect a correction of camber, either through moving the top pivot arm axis (as shown in the specific example), or through the use of an extending/telescopic top arm, or through a specially constructed suspension upright.

The invention utilises the forces produced during cornering to reduce vehicle roll and allows for the magnitude of this effect to be modified in a variety of ways, by altering leverage ratios within the system, by changing the lateral distance between the wheel centrelines and the sprung arm outer pivots, and/or by mounting suspension spring units, acutely inclined to the vertical, to the chassis at their upper ends and to the top arms or upper sections of the suspension uprights at their lower ends. This latter method will

generally be detrimental to ride quality and would not normally be acceptable in a vehicle designed for road use. However, this is not usually an important consideration in the design of a vehicle for track use, where performance and cornering ability is of greater importance than comfort.

An embodiment of the invention will now be described by way of example with reference to the accompanying diagrammatic drawings in which:-

Figure 1 is an end elevation of the left and right suspension components of a dual arm (double wishbone) rear suspension system of a rear wheel driven vehicle shown in the normal ride position;

Figure 2 is the same suspension system shown with the vehicle cornering;

Figure 3 is the same suspension system shown with the suspension fully compressed;

Figure 4 is the same suspension system shown with the suspension fully extended, and

Figure 5 illustrates how a spring suspension unit can be fitted between a top arm and the chassis.

Referring to Figure 1, a diagrammatic representation of the rear view of a dual arm rear suspension system of a rear wheel driven vehicle is shown.

A chassis structure 1 is connected by a left hand bottom arm 2, and also by a left hand top arm 3, (via an offset pivot shaft assembly 5) to a wheel and tyre assembly 4.

The right hand suspension assembly is a mirror image of the left hand suspension assembly and involves a right hand bottom arm 6, a right hand top arm 7, a right hand offset pivot

shaft assembly 9, and a right hand wheel and tyre assembly 8, all similarly attached to the chassis structure 1.

In accordance with the present invention the left and right upper suspension components are cross connected by connecting rod 10, linking left hand top arm 3, to right hand offset pivot shaft assembly 9, and connecting rod 11, linking right hand top arm 7, to left hand offset pivot shaft assembly 5.

The cross-connection so described constrains the plane of each wheel (ie the overall disposition of the wheel perpendicular to its axis of rotation) towards an orientation which is substantially normal to the road surface, and thereby ensures maximum tyre-to-road contact both during cornering and during acceleration and deceleration. At the same time the linkages enable the chassis structure to move vertically and to roll relative to these wheels.

The following is an example of how this is achieved.

When cornering, say to the left (see Figure 2), the chassis structure 1, rolls towards the outside of the bend and the right hand suspension assembly moves up relative to the chassis structure and the left hand suspension assembly moves down relative to the chassis structure. As is normal with this type of suspension system, even without the cross-connection afforded by this invention, when the right hand top arm 7, pivots upwards, its geometry in relation to the right hand bottom arm 6, produces an increase in negative camber of the right hand wheel and tyre assembly 8, relative to the chassis structure (ie the wheel tilts inwards with respect to the chassis structure) to compensate for chassis/body roll and enable the wheel to remain substantially normal to the road surface.

With this invention, part of this required camber compensation is achieved by the action of connecting rod 10, and its offset pivot shaft assembly 9, which translates the simultaneous downward movement of the left hand top arm 3, into an inward lateral movement of the

right hand top arm 7. Thus a vertical movement of the wheel on one side of the vehicle provides a compensating change in the lateral inclination of the wheel on the other side.

Similarly, and in reverse fashion, the action of connecting rod 11, and offset pivot shaft assembly 5, contribute to the increase in positive camber of the left hand wheel and tyre assembly 4, with respect to the chassis structure (ie this wheel also remains substantially normal to the road surface), again to compensate for body/chassis roll.

An additional function of the connecting rods 10 and 11, and offset pivot shaft assemblies 9 and 5, is to use the forces generated during cornering to reduce chassis/body roll.

When accelerating in a straight line (see Figure 3), the effects of longitudinal weight transfer compress the suspension on both sides. In a normal dual arm suspension system of this kind this would lead to the adoption of negative camber on both wheels, (ie both wheels tilting inwards) compromising the tyre-to-road contact and therefore grip. With this invention, the upward movement of the two upper arms 3 and 7, acts via the connecting rods 10 and 11, and offset pivot shaft assemblies 9 and 5, to move the top arms laterally outwards, away from the centreline of the vehicle, thus ensuring the wheels remain substantially perpendicular to the road surface and the tyre-to-road contact patches remain at an optimum for tractive grip. Again it will be seen that a vertical movement of the wheel and tyre assembly relative to the chassis structure on one side of the vehicle provides a compensating change in the lateral inclination of the wheel on the other side.

Similarly, when decelerating in a straight line (see Figure 4), the effects of longitudinal weight transfer extend the suspension on both sides, which in a normal dual arm suspension system of this kind would lead to the adoption of unwanted positive camber. In this instance also, the action of the two connecting rods 10 and 11, and offset pivot shaft assemblies 9 and 5, act to move the two top arms 7 and 3, in compensation for this effect, this time by moving the two top arms laterally inwards. Thus again the wheels are held substantially perpendicular to the road surface and the tyre-to-road contact remains at the optimum for maximum braking grip.

In the embodiment of the invention shown in Figure 1, suspension spring units (not shown) will normally act between the chassis structure 1 and each of the bottom arms 2 and 6, so avoiding interaction between suspension spring loadings and the cross-linked upper suspension components. With suspension spring units so mounted, the inherent abililty of this embodiment to affect the degree of vehicle roll when cornering, can be modified by altering the leverage ratios within the system and/or the lateral distance between the wheel centrelines 12 (12') and the sprung arm outer pivots 13 (13').

Figure 5 shows a modification of the last mentioned arrangement. Here the system's ability to affect vehicle roll can be modified by pivotally mounting suspension spring units 14, (14') at opposite ends 18, 19 (18', 19') between upper support brackets 15, (15') attached to the chassis, and either lower support brackets 16, (16') attached to the top arms 3 (7), or the upper part of suspension uprights 17, (17'). The ability of the arrangement to affect the degree of roll can then be modified by altering the angle of inclination to the vertical of the suspension spring units 14, (14').

Claims

VEHICLE SUSPENSION SYSTEM

1. A motor vehicle chassis structure which includes an independent suspension system including left and right upper and lower suspension components for left and right wheels respectively for gripping and travelling along a road surface, each of which suspension components is arranged to allow a constrained up and down movement of the respective wheel relative to the vehicle chassis structure, characterised in that the upper suspension components on one side of the vehicle are cross-linked independently of the lower suspension components with the upper suspension components on the other side of the vehicle, so as to constrain the rotational plane of each wheel towards an orientation which is normal to the road surface while allowing the chassis structure to move vertically and to roll relative to said wheels during cornering, acceleration, deceleration and combinations thereof.

2. A motor vehicle chassis structure according to claim 1 in which an upper region of each wheel is constrained laterally so that each respective wheel is constrained in a position where it is substantially perpendicular to the road surface.

3. A motor vehicle chassis structure according to claim 1 or claim 2 in which the upper suspension components on each side are cross-linked to the corresponding components on the other side in such a way that a vertical movement of the wheel relative to the chassis structure on one side is arranged to feed a compensating change in the lateral inclination of the wheel relative to the chassis structure on the other side.

4. A motor vehicle chassis structure according to any one of claims 1 to 3, in which the cross-links are each provided by a mechanical linkage.

5. A motor vehicle chassis structure according to any of claims 1 to 3 in which the cross-links are each provided by a hydraulic means.

6. A motor vehicle chassis structure according to any of claims 1 to 5 in which, in order to provide camber compensation, the cross-links between the upper suspension components are arranged so that a downward vertical movement of the upper suspension component on one side is translated into a lateral inward movement of the upper suspension on the other side, and vice versa.

7. A motor vehicle chassis structure according to claim 4 or claim 6 when appendant to claim 4 in which the cross-links are each provided by a diagonal mechanical connection between an upper region of the suspension components on one side and a respective upper region of the suspension components on the other side via a connecting rod and offset pivot shaft assembly.

8. A motor vehicle chassis structure according to any of claims 1 to 7 wherein a spring unit is mounted so as to extend between the chassis and either the upper end of each suspension upright on which a wheel is mounted, or the related top arm of the wheel suspension, and each point of attachment provides for pivoting between the end of the spring unit and the chassis at one end, and the suspension upright or top arm, at the other end.

9. A motor vehicle chassis structure according to claim 8 wherein the spring unit extends between its two points of attachment at an acute angle to the vertical.

10. A motor vehicle chassis structure according to either of claims 8 or 9 wherein the inherent ability of the arrangement to affect the degree of vehicle roll when cornering is controllable by altering the leverage ratios within the system and/or the lateral distance between the wheel centrelines and the sprung arm outer pivots.

11. A motor vehicle chassis structure according to either of claims 8 or 9 wherein the ability of the arrangement to affect the degree of roll is controllable by altering the angle of inclination to the vertical of the suspension spring units.

12. A method of adjusting the degree of roll when cornering of a vehicle incorporating a chassis structure as claimed in either of claims 8 or 9 comprising the step of altering the leverage ratios within the system and/or the lateral distance between the wheel centrelines and the sprung arm outer pivots.

13. A method of adjusting the degree of roll when cornering of a vehicle incorporating a chassis structure as claimed in either of claims 8 or 9 comprising the step of altering the angle of inclination to the vertical of the suspension spring units.

14. A motor vehicle chassis structure substantially as hereinbefore described with reference to the accompanying drawings.

AMENDED CLAIMS

[received by the International Bureau on 11 May 2001 (11.05.01);
original claims 1-14 replaced by new claims 1-12 (3 pages)]

1. A motor vehicle chassis structure which includes an independent suspension system including left and right upper and lower suspension components for left and right wheels respectively for gripping and travelling along a road surface, each of which suspension components is arranged to allow a constrained up and down movement of the respective wheel relative to the vehicle chassis structure, characterised in that the upper suspension components on one side of the vehicle are cross-linked independently of the lower suspension components with the upper suspension components on the other side of the vehicle, so as to constrain the rotational plane of each wheel towards an orientation which is normal to the road surface while allowing the chassis structure to move vertically and to roll relative to said wheels during cornering, acceleration, deceleration and combinations thereof, an upper region of each wheel is constrained laterally so that each respective wheel is constrained in a position where it is substantially perpendicular to the road surface.

2. A motor vehicle chassis structure according to claim 1 in which the upper suspension components on each side are cross-linked to the corresponding components on the other side in such a way that a vertical movement of the wheel relative to the chassis structure on one side is arranged to feed a compensating change in the lateral inclination of the wheel relative to the chassis structure on the other side.

3. A motor vehicle chassis structure according to claim 1 or claim 2, in which the cross-links are each provided by a mechanical linkage.

4. A motor vehicle chassis structure according to claim 1 or claim 2 in which the cross-links are each provided by a hydraulic means.

5. A motor vehicle chassis structure according to any of claims 1 to 4 in which, in order to provide camber compensation, the cross-links between the upper suspension components are arranged so that a downward vertical movement of the upper suspension component on one side is translated into a lateral inward movement of the upper suspension on the other side, and vice versa.

6. A motor vehicle chassis structure according to claim 3 or claim 5 when appendant to claim 3 in which the cross-links are each provided by a diagonal mechanical connection between an upper region of the suspension components on one side and a respective upper region of the suspension components on the other side via a connecting rod and offset pivot shaft assembly.

7. A motor vehicle chassis structure according to any of claims 1 to 6 wherein a spring unit is mounted so as to extend between the chassis and either the upper end of each suspension upright on which a wheel is mounted, or the related top arm of the wheel suspension, and each point of attachment provides for pivoting between the end of the spring unit and the chassis at one end, and the suspension upright or top arm, at the other end.

8. A motor vehicle chassis structure according to claim 7 wherein the spring unit extends between its two points of attachment at an acute angle to the vertical.

9. A motor vehicle chassis structure according to either of claims 7 or 8 wherein the inherent ability of the arrangement to affect the degree of vehicle roll when cornering is controllable by altering the leverage ratios within the system and/or the lateral distance between the wheel centrelines and the sprung arm outer pivots.

10. A motor vehicle chassis structure according to either of claims 7 or 8 wherein the ability of the arrangement to affect the degree of roll is controllable by altering the angle of inclination to the vertical of the suspension spring units.

11. A method of adjusting the degree of roll when cornering of a vehicle incorporating a chassis structure as claimed in either of claims 7 or 8 comprising the step of altering the leverage ratios within the system and/or the lateral distance between the wheel centrelines and the sprung arm outer pivots.

12. A method of adjusting the degree of roll when cornering of a vehicle incorporating a chassis structure as claimed in either of claims 7 or 8 comprising the step of altering the angle of inclination to the vertical of the suspension spring units.

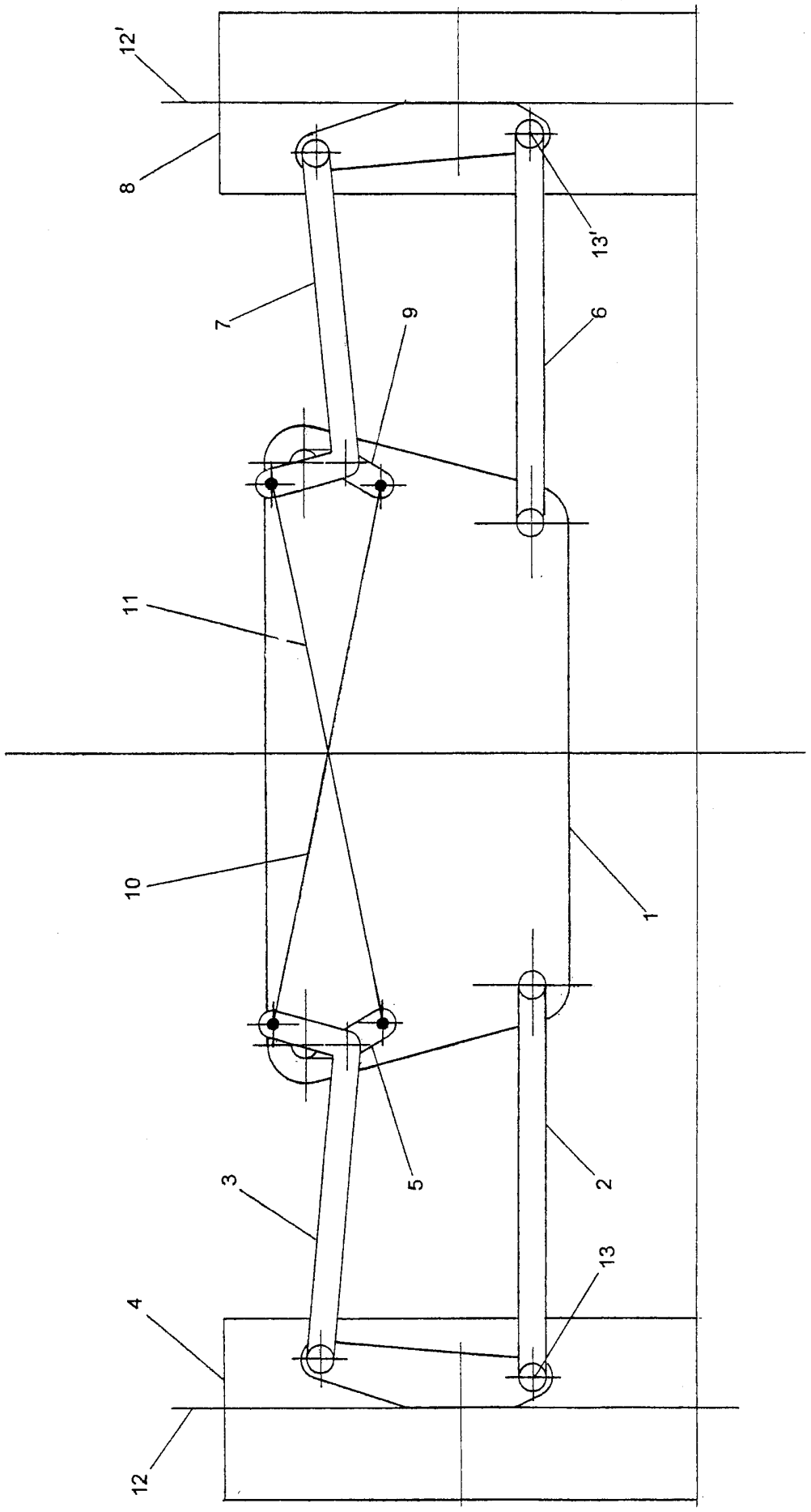


FIGURE 1

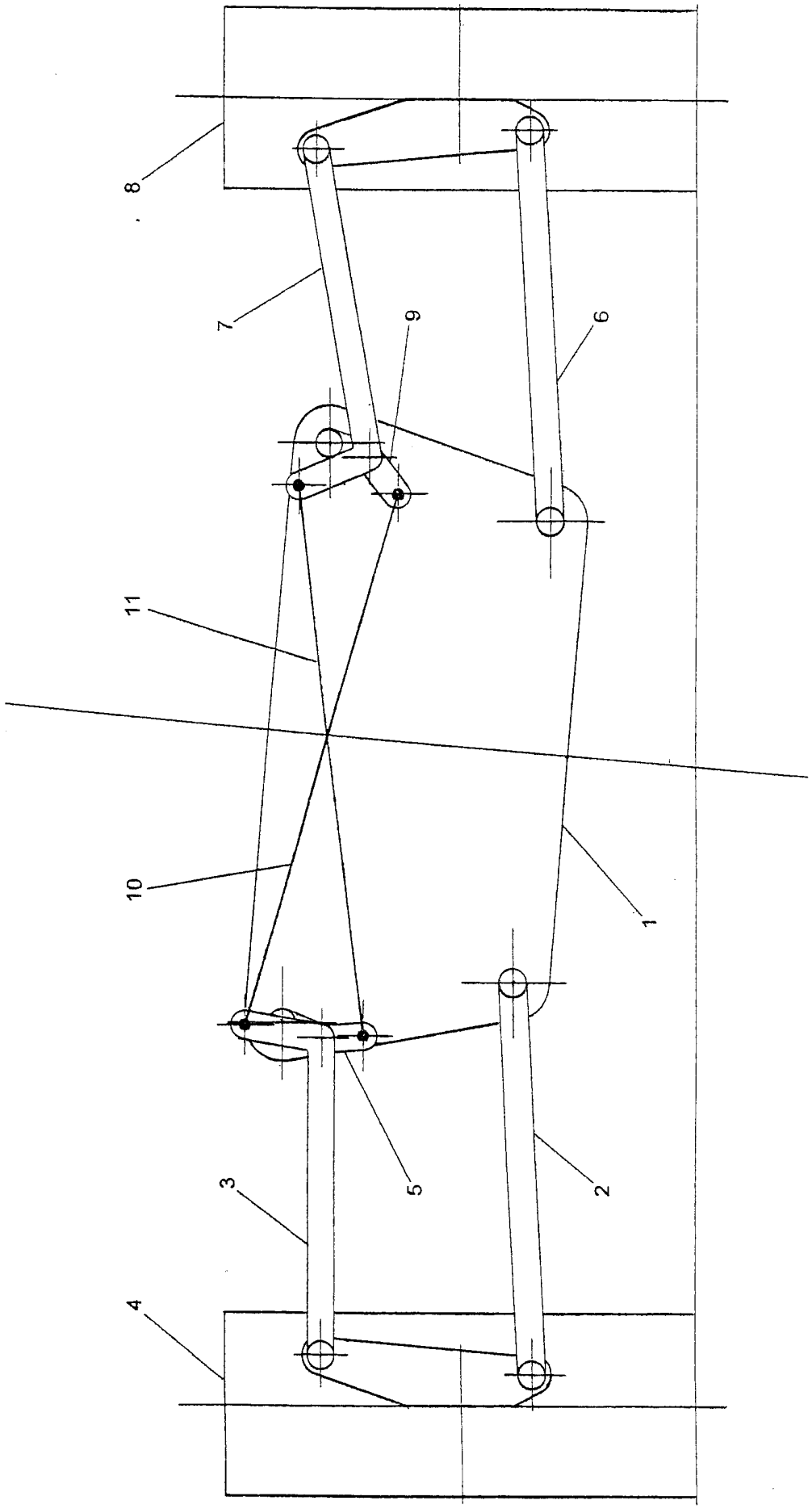


FIGURE 2

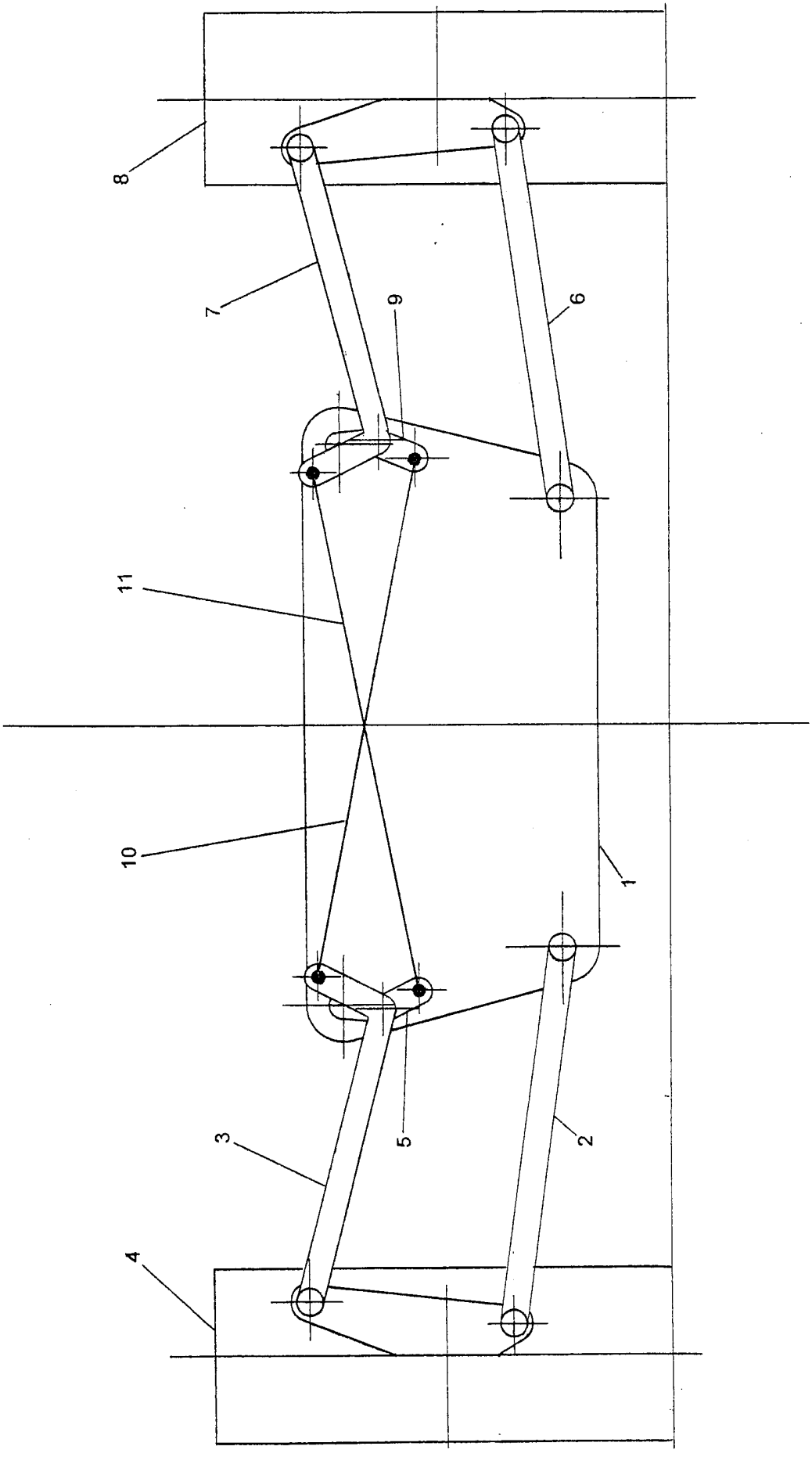


FIGURE 3

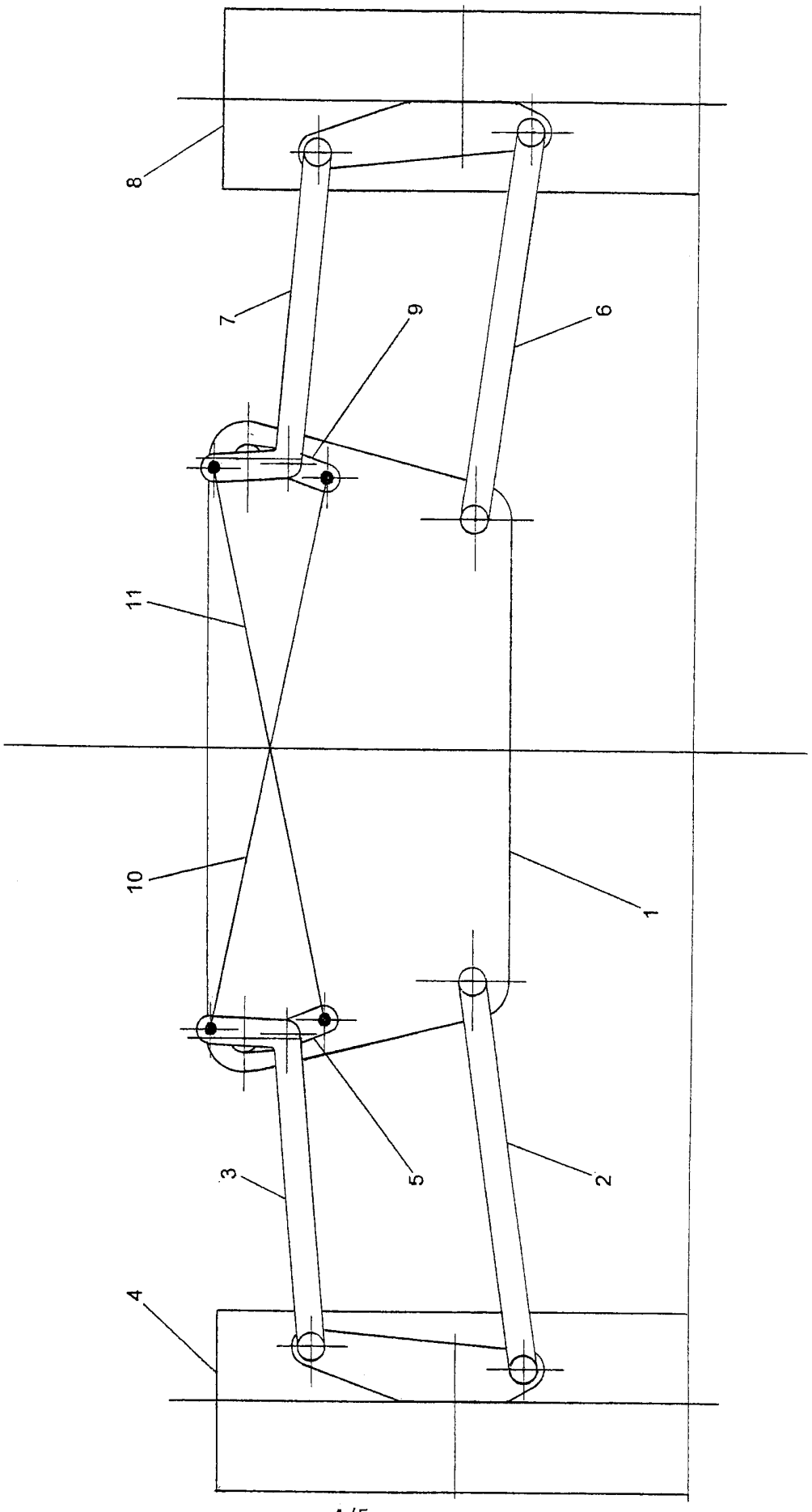


FIGURE 4

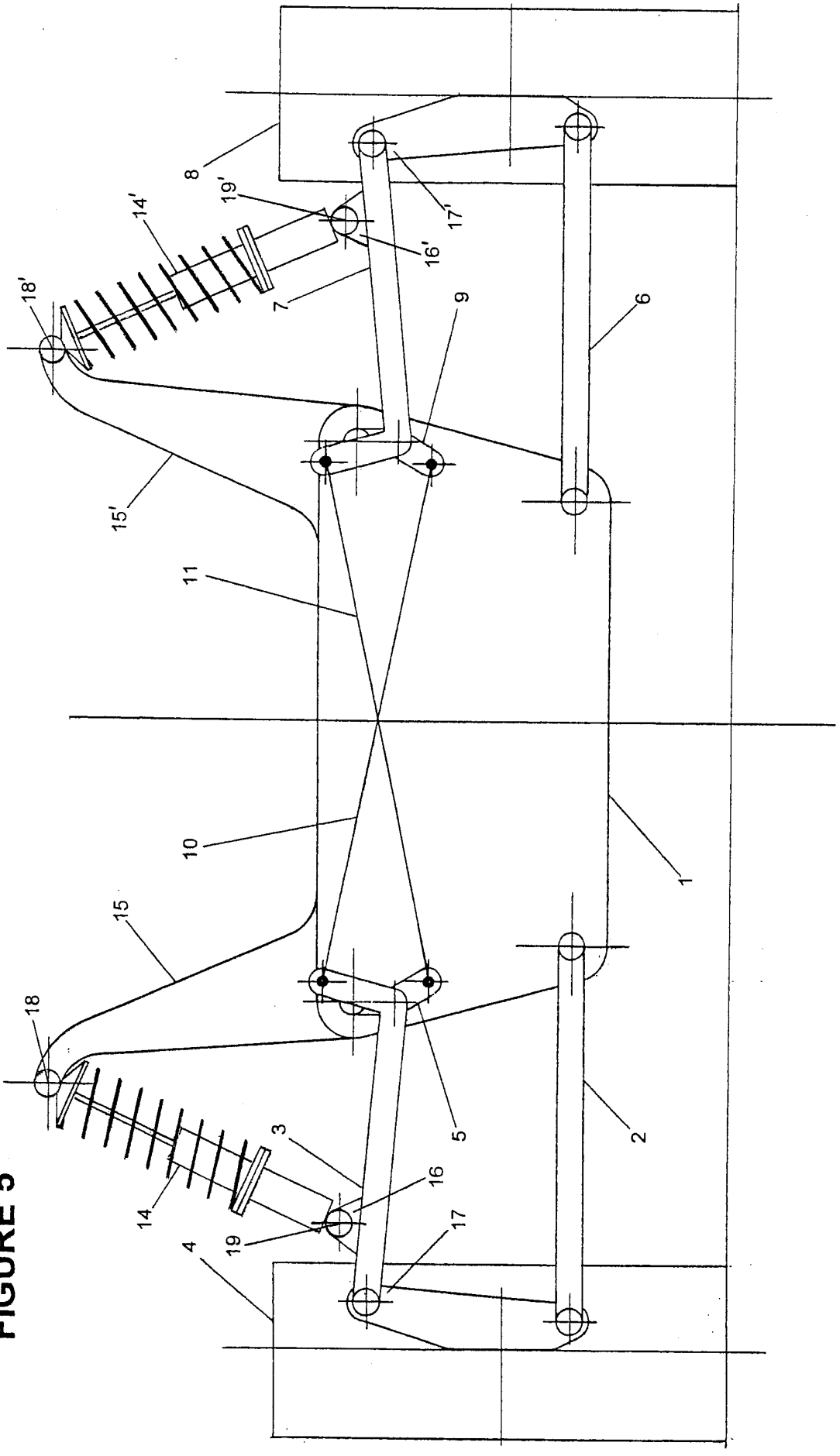


FIGURE 5

INTERNATIONAL SEARCH REPORT

Inte .onal Application No
PCT/GB 01/00144

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B60G21/05

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B60G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 040 840 A (ALPINE) 22 January 1971 (1971-01-22) figures 11-13	1-4,6,7
X	US 4 854 603 A (SCADUTO) 8 August 1989 (1989-08-08) abstract; figure 2	1-4,6
A	WO 98 10949 A (WEISS) 19 March 1998 (1998-03-19) figure 6	1-3,5
A	EP 0 319 391 A (RENAULT) 7 June 1989 (1989-06-07)	
A	FR 2 616 715 A (PEUGEOT ET AL.) 23 December 1988 (1988-12-23)	

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 March 2001	27/03/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Krieger, P

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Inte ..onal Application No
PCT/GB 01/00144

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 825 042 A (ILLINOIS TOOL WORKS) 25 February 1998 (1998-02-25) ---	
A	EP 0 827 851 A (DE GIACOMI) 11 March 1998 (1998-03-11) -----	

1

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte ional Application No
PCT/GB 01/00144

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR 2040840 A	22-01-1971	NONE	
US 4854603 A	08-08-1989	US 4927169 A	22-05-1990
WO 9810949 A	19-03-1998	DE 19637159 A	19-03-1998
		EP 0925199 A	30-06-1999
EP 319391 A	07-06-1989	FR 2624065 A	09-06-1989
		PT 89140 A	14-09-1989
FR 2616715 A	23-12-1988	NONE	
EP 825042 A	25-02-1998	US 5732969 A	31-03-1998
		CA 2208969 A	15-02-1998
		JP 10076830 A	24-03-1998
EP 827851 A	11-03-1998	IT BO960447 A	05-03-1998