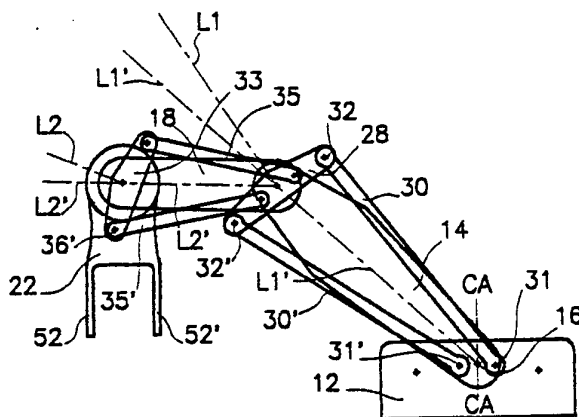




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>(51) International Patent Classification <sup>5</sup> :</b><br><br><b>E02F 3/36, 9/28</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>A1</b> | <b>(11) International Publication Number:</b> <b>WO 94/08099</b><br><br><b>(43) International Publication Date:</b> 14 April 1994 (14.04.94)                                                                                                                                                                                                                                                                                             |
| <b>(21) International Application Number:</b> PCT/NZ93/00089<br><b>(22) International Filing Date:</b> 1 October 1993 (01.10.93)<br><b>(30) Priority data:</b><br>244610                      2 October 1992 (02.10.92)                      NZ<br><b>(71) Applicant (for all designated States except US):</b> TELEPOINT<br>NEW ZEALAND LIMITED [NZ/NZ]; 85 Alexandra<br>Street, Hamilton (NZ).<br><b>(72) Inventor; and</b><br><b>(75) Inventor/Applicant (for US only) :</b> PARKER, Clifford, Allan<br>[AU/NZ]; 29A Aranui Road, Mt Wellington, Auckland<br>(NZ).<br><b>(74) Agents:</b> BENNETT, Michael, R. et al.; 6th Floor, Huddart<br>Parker Building, Post Office Square, PO Box 949, Wel-<br>lington 6015 (NZ). |           | <b>(81) Designated States:</b> AT, AU, BB, BG, BR, BY, CA, CH,<br>CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, KZ, LK,<br>LU, LV, MG, MN, MW, NL, NO, NZ, PL, PT, RO,<br>RU, SD, SE, SK, UA, US, UZ, VN, European patent<br>(AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU,<br>MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI,<br>CM, GA, GN, ML, MR, NE, SN, TD, TG).<br><br><b>Published</b><br><i>With international search report.</i> |

**(54) Title:** LINKAGE ARRANGEMENT**(57) Abstract**

The linkage arrangement supports an implement such that the implement is movable relative to a support member which is also movable relative to a structure, movement of the implement and support member being limited by mechanical and/or mechanically operated limits, the linkage mechanism enabling an increase in the ability to move and orientate the implement within a limit envelope. In a preferred form, a linkage arm (14) is pivotably mounted to a prime mover (12). At a distal end of the said first linkage arm (14) an orientation member (28) is pivotably attached, the orientation member being pivotably attached to a first limit actuating arm (30). The rotation of the first linkage arm (14) causes rotation of said orientation member (28). Said orientation member provides a base for the attachment of a further arm or implement. The further arm or implement is prevented contacting the prime mover by the limits provided by the orientation member (28).

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

|    |                          |    |                                          |    |                          |
|----|--------------------------|----|------------------------------------------|----|--------------------------|
| AT | Austria                  | FR | France                                   | MR | Mauritania               |
| AU | Australia                | GA | Gabon                                    | MW | Malawi                   |
| BB | Barbados                 | GB | United Kingdom                           | NE | Niger                    |
| BE | Belgium                  | GN | Guinea                                   | NL | Netherlands              |
| BF | Burkina Faso             | GR | Greece                                   | NO | Norway                   |
| BG | Bulgaria                 | HU | Hungary                                  | NZ | New Zealand              |
| BJ | Benin                    | IE | Ireland                                  | PL | Poland                   |
| BR | Brazil                   | IT | Italy                                    | PT | Portugal                 |
| BY | Belarus                  | JP | Japan                                    | RO | Romania                  |
| CA | Canada                   | KP | Democratic People's Republic<br>of Korea | RU | Russian Federation       |
| CF | Central African Republic | KR | Republic of Korea                        | SD | Sudan                    |
| CG | Congo                    | KZ | Kazakhstan                               | SE | Sweden                   |
| CH | Switzerland              | LI | Liechtenstein                            | SI | Slovenia                 |
| CI | Côte d'Ivoire            | LK | Sri Lanka                                | SK | Slovak Republic          |
| CM | Cameroon                 | LU | Luxembourg                               | SN | Senegal                  |
| CN | China                    | LV | Latvia                                   | TD | Chad                     |
| CS | Czechoslovakia           | MC | Monaco                                   | TG | Togo                     |
| CZ | Czech Republic           | MG | Madagascar                               | UA | Ukraine                  |
| DE | Germany                  | ML | Mali                                     | US | United States of America |
| DK | Denmark                  | MN | Mongolia                                 | UZ | Uzbekistan               |
| ES | Spain                    |    |                                          | VN | Viet Nam                 |
| FI | Finland                  |    |                                          |    |                          |

## "LINKAGE ARRANGEMENT"

### TECHNICAL FIELD

The present invention relates to a linkage arrangement suitable for mounting an implement to a structure. In particular the invention relates to a linkage arrangement for mounting implements such as backhoes, verge mowers, shovels and the like to prime movers and will principally be described hereinafter with reference to this application. It should be appreciated, however, that the invention is not limited to this type of use.

### BACKGROUND ART

Various arrangements for mounting implements such as backhoes to prime movers are known in the art. For example the arrangements shown in US patent No. 4,403,429 Haringer, US Patent No. 3,313,431 Kelly, US Patent No. 4,049,139 Stedman, and US Patent No. 3,027,026 Couquet and Australian Patent No. 243,547 Couquet. Such arrangements have been employed in order to improve the flexibility and scope of operation of the implement and have met with varying degrees of success. US patent No. 4,403,429 Haringer, discloses an articulated arm for supporting a bucket, mounted on a rotatable turret of an excavator and designed for digging parallel to either side of a prime mover. Limits to rotatable movement of arms of the articulated arm comprise mechanical stops fixed to the arms. Hence limits to movement and orientation of the bucket is not variable with movement of the arms so that mobility of operation of the linkage is limited.

US Patent No. 3,313,431 Kelly discloses a similar double arm linkage arrangement for a backhoe wherein the articulated arm is mounted on a side shift attachment on a prime mover with pivotal movement of the arms about the pivots provided by rack and pinion actuators. The provision of a side shift attachment enables a lateral change in limits at the linkage mounting to the prime mover, however limits to movement and orientation of the backhoe relative to the linkage are fixed, so that there is a similar limitation to mobility of operation.

US Patent No. 4,049,139 Stedman discloses a linkage arrangement for a backhoe comprising two linkage arms pivotally connected together, the linkage arrangement being pivotally connected to the prime mover. Pivotal movement between the two arms is provided by a hydraulic swing motor mounted therebetween. The hydraulic swing motor gives a high degree of mobility such that the linkages can be folded to enable an implement to be stowed close to the prime mover for transport. However, due to this

high degree of mobility, skilled operator control of swing motor rotation is required depending on the orientation of the linkage relative to the prime mover, to ensure that the implement does not strike the prime mover under normal operating conditions. Operability of the linkage arrangement is thus compromised.

5 US Patent No. 3,027,026 Couquet and Australian Patent No. 243,547 Couquet, disclose a linkage for an excavator such as a trencher having a single arm pivotally mounted on a support frame, and pivotally supporting a digger attachment on a distal end thereof. Pivotal movement of the arm relative to the support frame, and of the digger attachment relative to the arm is by means of manually operated gear actuators whereby  
10 the linkage can be set up for a particular operation. An additional actuator is also provided for pivotal movement of the arm relative to the support once the linkage has been set up. Operating flexibility and range is however limited due to the limited range possible with the actuators and the requirement for manual operation to provide a new setting.

15 Due to the various limitations of the above mentioned prior art devices, such as limited operating range, a dependence on skilled operator control, and a requirement for manual adjustment, they are not suitable as mountings for implements such as a backhoes, verge mowers, shovels and the like wherein a high degree of mobility is required including the ability to work to either side of the prime mover. To obtain such  
20 a high degree of mobility the rotational limits of the arms must be increased. However with increased rotational limits the resultant possibility of the tool striking the prime mover when working to either side thereof due to operator error would generally not be acceptable. Hence with the above prior art devices, there is a limit to the acceptable increase in rotational limits. This limitation on rotational limits to avoid striking the  
25 prime mover poses an unnecessary restriction on the rotational movement of the tool when positioned for alternate work applications away from the prime mover where there is no danger of striking the prime mover, reducing mobility of operation of the device for work operations and for stowing for transportation.

The present invention is thus addressed to methods and apparatus for supporting  
30 an implement such that the implement is movable relative to a support member which is also movable relative to a structure, movement of the implement and support member being limited by mechanical and/or mechanically operated limits, such methods and apparatus enabling an increase in the ability to move and orientate the implement within

-3-

a limit envelope, or at least provide the public with a useful choice.

For example in the case of a backhoe, such methods and apparatus may provide a linkage arrangement for the support and positioning of an implement, which enables an increase in the possible scope of operation of the implement mounted thereon compared to conventional support linkages, while still ensuring that the implement does not to contact the prime mover when supported close to the prime mover, and which enables the implement to be supported within weight distribution, and dimension requirements for road transportation.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.

#### DISCLOSURE OF INVENTION

According to one aspect of the present invention there is provided a linkage arrangement for mounting an implement to a structure said linkage arrangement comprising:

15 a linkage arm having a first end and a second end distal from the first end and adapted to be pivotally mounted at its first end to the structure at a first pivot point and arranged to pivot relative to the structure about the first pivot point;

a mounting head rotatably mounted to the second end of the linkage arm and arranged to rotate relative to the linkage arm and adapted to have said implement  
20 mounted directly or indirectly thereon;

first actuating means for pivoting the linkage arm relative to the structure;

second actuating means for rotating the mounting head relative to the linkage arm,

limit means defining limits to the extent of rotational motion of the mounting head to either side of a central datum line about which the mounting head pivots relative to  
25 the linkage arm; and

limit adjusting means for adjusting the limit means such that the limits to the extent of rotational motion of the mounting head are varied with pivotal movement of the linkage arm relative to the structure.

Preferably said limit means comprises a limit support means on which are mounted  
30 mechanical limit means, said limit support means being mounted on said linkage arm so as to be movable relative thereto, and said limit adjusting means comprises mechanical means for adjusting a location of said limit support means relative to said linkage arm with pivotal movement of said linkage arm relative to said structure.

-4-

Preferably said limit support means comprises an orientation member, and said mechanical limit means comprises two limit stops attached thereto, said orientation member being pivotally mounted on said linkage arm, and said limit adjusting means comprises mechanical means for changing an orientation of said central datum line  
5 relative to said linkage arm with pivotal movement of said linkage arm relative to said structure.

Preferably said second actuating means for rotating said mounting head relative to said linkage arm comprises a rotary actuator having a shaft and vane rotatably mounted in a housing so as to be rotatable in said housing between limits provided on said housing  
10 and on opposite sides of said vane, and said orientation member comprises the casing or shaft of said rotary actuator.

Preferably said second actuating means for rotating said mounting head relative to said linkage arm comprises a linear actuator having a rod member moving relative to a casing between limits provided on said rod member and said casing, and said orientation  
15 member comprises one of said rod member and said casing of said linear actuator.

Preferably said limit support means comprises at least one cam member having a peripheral face for providing a mechanical limit to rotation of said mounting head, said cam member being mounted on said linkage arm so as to be rotatable relative thereto, thereby moving the position of said mechanical limit.

20 Preferably said second actuating means for rotating said mounting head relative to said linkage arm comprises a rotary actuator having a shaft and vane rotatably mounted in a housing, said housing being mounted on said linkage arm, and said cam member being mounted inside said housing so as to be rotatable relative thereto, with said peripheral face arranged so as to provide limits to rotary motion of said vane.

25 Preferably said limit adjusting means comprises linkage means connected between said limit support means and said structure.

Preferably said linkage means comprises gearing and a drive shaft whereby rotational movement proportional to pivotal movement of said linkage arm about said first pivot is transmitted to said limit support means.

30 Preferably said linkage means comprises a limit actuating arm whereby linear movement proportional to pivotal movement of said linkage arm about said first pivot is transmitted to said limit support means.

Preferably said linkage means comprises a limit actuating arm whereby linear

-5-

movement proportional to pivotal movement of said linkage arm about said first pivot is transmitted to said orientation member, wherein said limit actuating arm is pivotally mounted at one end to said structure adjacent the pivot point of said first end of said linkage arm and is pivotally mounted at another end to said orientation member;

5 wherein location of the mounting of said limit actuating arm to the structure for predetermined extremes of pivotal rotation of said orientation member relative to said linkage arm for predetermined extremes of pivotal rotation of said linkage arm relative to said structure is determined by;

(a) determining a first reference point which corresponds with the point of  
10 mounting of the limit actuating arm to the orientation member when the linkage arm has been rotated to an extreme in one direction about the pivot point and the orientation member has been rotated to an extreme in one direction relative to said linkage arm;

(b) determining a second reference point which corresponds with the point of  
15 mounting of the limit actuating arm to the orientation member when the linkage arm has been rotated to an extreme in another direction about the pivot point and the orientation member has been rotated to an extreme in another direction relative to the linkage arm;

(c) determining a third reference point which corresponds with the point of  
mounting of the limit actuating arm to the orientation member when the linkage arm has been rotated to a position intermediate its positions in (a) and (b); and

20 (d) determining an arc of a circle which passes through the first, second and third reference points, and locating the centre of the circle, which centre gives said location of mounting of the limit actuating arm to the structure.

Preferably said linkage means further comprises an auxiliary arm pivotally mounted at one end to said structure at a predetermined point adjacent the pivot point of said first  
25 end and on an opposite side to the pivotal mounting of said limit actuating arm, and is pivotally mounted at another end to said orientation member such that said rotatable mounting of said mounting head is disposed substantially centrally and symmetrically between the pivotal mountings of said auxiliary arm and said limit actuating arm when said linkage arm has been rotated to a position intermediate its positions in (a) and (b).

30 Preferably said linkage arm comprises a plurality of members connected together such that the relative location between said first and second ends is variable.

Preferably said linkage arm comprises a single member with said first and second ends fixedly located relative to each other.

According to another aspect of the present invention there is provided a linkage arrangement substantially as described above, said linkage arrangement comprising:

a second linkage arm having a first end and a second end distal from the first end with the first end fixedly mounted on the mounting head of said linkage arm,

5 a second mounting head rotatably mounted to the second end of the second linkage arm, and arranged to rotate relative to the second linkage arm, and adapted to have the implement mounted directly or indirectly thereon;

third actuating means for pivoting the second linkage arm relative to the linkage arm;

10 fourth actuating means for rotating the second mounting head relative to the second linkage arm;

second limit means defining limits to the extent of rotational motion of the second mounting head to either side of a central datum line about which the second mounting head pivots relative to the second arm; and

15 second limit adjusting means for adjusting the second limit means such that said limits to the extent of rotational motion of the second mounting head are varied with pivotal movement of the second linkage arm relative to the linkage arm.

Preferably said second limit means comprises a second limit support means on which are mounted mechanical limits, said second limit support means being mounted on  
20 said second linkage arm so as to be movable relative thereto, thereby moving said mechanical limits, and said second limit adjusting means comprises second mechanical means for moving said second limit support means relative to said second linkage arm with pivotal movement of said second linkage arm relative to said linkage arm.

Preferably said second limit support means comprises a second orientation member,  
25 and said second limits comprise two limit stops attached thereto, said second orientation member being pivotally mounted on said second linkage arm such that an orientation of said limit stops relative to said second linkage arm is variable with pivotal movement of said second orientation member.

Preferably said second actuating means for rotating said second mounting head  
30 relative to said fourth linkage arm comprises a rotary actuator having a shaft and vane rotatably mounted in a housing so as to be rotatable in said casing between limits provided on said casing and on opposite sides of said vane, and said second orientation member comprises the casing or shaft of said rotary actuator.

-7-

Preferably said limit actuating arm serves additionally as a support member of said linkage arrangement, said limit actuating arm and said linkage arm being arranged in the form of a pantograph, formed by the structure, the orientation member and the arms themselves.

5        Preferably said structure is a prime mover and said implement is a backhoe.

According to another aspect of the present invention there is provided a method of increasing the ability to move and orientate an implement movably supported relative to a structure by a linkage arrangement, and limited from movement relative to the  
10 linkage arrangement and the structure by limit means, the method comprising the step of varying limits imposed by the limit means with movement of the implement relative to the structure.

In yet another aspect the present invention consists in a method of changing a limit to rotation of an arm of a linkage provided by limit means, said method comprising the  
15 steps of:

mounting said limit means so as to be movable relative to said arm; and

linking a movement of said arm to said limit means so that said limit to rotation is changed with movement of said arm.

In yet another aspect the present invention consists in a prime mover vehicle having  
20 an implement supported operatively therefrom by a linkage arrangement as hereinbefore described.

In yet another aspect the present invention consists in a linkage arrangement for mounting an implement to a structure comprising:

a first linkage arm having a first end and a second end distal from said first end,  
25 pivotally mounted at its first end to the said structure at a first pivot point, and arranged to rotate relative to the structure about the said first pivot point;

a first orientation member rotatably mounted to the said second end of the said first linkage arm and arranged to rotate thereon;

a first linkage means pivotally mounted from said structure adjacent the first pivot  
30 point and extending to and pivotally mounted to the said first orientation member other than at rotation axis of said mounting of said first linkage arm and first orientation member;

a second linkage arm having a first end and a second end remote from said first

end, pivotally mounted at said first end to said first orientation means at a second pivot point, said second pivot point being displaced from said first pivot point so as to be capable of providing a moment about said second pivot point and arranged to pivot relative to said first orientation member about said second pivot point;

- 5       a second orientation member rotatably mounted to the said second end of the said second linkage arm and arranged to rotate relative to second orientation member;

          a second linkage means pivotally from said first or orientation means mounted adjacent the second pivot point and extending to and pivotally mounted to the said second orientation member other than at rotation axis of said mounting of said first  
10 linkage arm and said second orientation member;

          mounting head rotatably mounted to the second end of the said second linkage arm and/or the orientation member, and arranged to rotate relative to the second orientation member, and being adapted to have a said implement mounted thereon; the axes of rotation and/or pivoting of each said pivot or rotational mounting or point being  
15 substantially parallel.

          Preferably said first linkage means consists of at least two members.

          Preferably said second linkage means consists of at least two members.

          Preferably means is provided to rotate first linkage arm about said structure.

          Preferably said means for rotating consists in a hydraulic ram.

- 20       Preferably said structure consists of a prime mover.

          Preferably said implement consists of a hoe.

          In yet another aspect the present invention consists in a linkage arrangement for mounting an implement to a structure comprising:

- a first linkage arm having a first end and a second end distal from said first end,  
25 and mounted at said first end to said structure at a pivot point and arranged to pivot relative to said structure about said pivot point;

          an orientation member rotatably mounted to the said second end of the linkage mechanism and arranged to rotate thereon;

- a second linkage arm pivotally mounted from said structure adjacent said first pivot  
30 point and extending to and pivotally mounted to the orientation member other than at rotation axis of said mounting of said first linkage arm and said orientation member;

          a mounting head rotatably mounted to the distal end of either the first linkage arm or second linkage arm and/or the orientation member, and arranged to rotate relative to

the said orientation member, said mounting head adapted to have said implement mounted thereon; the axes of rotation and/or pivoting of each said pivot or rotational mounting or point being substantially parallel.

Preferably said first linkage arm and said second linkage arm in a cross over  
5 arrangement.

Preferably there is provided means to rotate said orientation member about said structure.

Preferably said means to rotate consists in a hydraulic ram.

Preferably said structure comprises a prime mover.

10 Preferably said implement comprises a mower.

Alternatively said implement comprises a backhoe shovel.

With the above described linkage arrangements and method for increasing the ability to move and orientate an implement, since the limits to rotational movement of the mounting head supporting the implement may be adjusted with pivotal movement of  
15 the linkage arm relative to the structure, then rotational limits set so as to ensure that the implement may not strike the structure when working close thereto may be altered when working away from the structure where there is no danger of striking the prime mover. Unnecessary restriction to pivotal movement of the linkage arrangement is thus avoided enabling an increase in the ability to move and orientate the implement within a limit  
20 envelope, and giving an increase in mobility of operation of the device.

Preferably the structure is a prime mover such as the prime mover of a backhoe or verge mower, but may also be a stationary body. The linkage arm may be a single integral arm or may comprise a plurality of members connected together such that the relationship between said first and second ends is variable. For example the linkage arm  
25 may comprise two arms pivotally connected together and provided with a suitable actuator to pivot the arms relative to each other.

The mounting head may comprise any means whereby a tool or implement may be mounted directly or indirectly on the linkage arm. In the case of indirect mounting this may involve additional linkage arms fixedly connected to or formed integral with the  
30 mounting head. The additional linkage arms may also be provided with mounting heads for directly or indirectly mounting the implement.

Preferably the linkage arrangement may comprise one or more such linkage arms with one or more such mounting heads. In the case of two or more arms, a first one of

the two or more arms may have a first mounting head provided at a second end thereof and may be pivotally mounted to the prime mover at its first end, a second of the two or more arms may have a second mounting head provided at a second end thereof and may be pivotally mounted at its first end to the second end of the first arm by means of the  
5 first mounting head, and so forth.

The actuating means may comprise any suitable means whereby the linkage arm may be pivoted about its pivotal mounting on the structure, and the mounting head may be rotated relative to the linkage arm. For example, this may comprise electrically or hydraulically powered actuators. In the case of hydraulic actuators a hydraulic ram may  
10 be connected between the prime mover and the linkage arm, and another ram or swing motor may be connected between the mounting head and the linkage arm.

The limit means may comprise any suitable means whereby the rotational motion of the mounting head relative to the linkage arm may be limited. For example this may comprise devices such as switches/valves for controlling electric/hydraulic power for  
15 operation of the mounting head actuator.

In this case the limit adjusting means may comprise a control system whereby the operation of the switches/valves may be varied in some predetermined ratio with respect to pivotal movement of the linkage arm. For example sensors may be used for determining the location of the linkage arm, and the switches/valves operated on the basis  
20 of signals from the sensors.

Alternatively the limit means may comprise a limit support means on which are mounted mechanical limits, the limit support means being mounted on the linkage arm so as to be movable relative thereto, thereby moving the mechanical limits. In this case the limit adjusting means may comprise mechanical means for moving the limit support  
25 means relative to the linkage arm with pivotal movement of the linkage arm relative to the structure.

The limit support means may be in the form of an orientation member with two limit stops attached thereto, the orientation member being pivotally mounted on the linkage arm such that an orientation of the limits stops relative to the linkage arm is  
30 variable with pivotal movement of the orientation member.

The orientation member may comprise any suitable member that is able to be rotatably mounted. In the case where the mounting head is rotated by a rotary actuator the orientation member may comprise the housing or shaft of the rotary actuator, with

-11-

the limits being those for limiting rotation of the shaft relative to the housing. In the case of a vane type rotary actuator with the vane mounted on the shaft, the limits may comprise two limit stops on the housing which abut with opposite sides of the vane.

In the case where the mounting head is rotated by a linear actuator having a rod member moving relative to a casing between limit stops provided on the rod member and the casing, the orientation member may comprise a support plate pivotally mounted to the linkage arm with the rod member or casing of the actuator is connected between the support plate and the linkage arm, the orientation member including the rod member or casing with its limit stops.

10 Instead of an orientation member, the limit support means may comprise a mechanical stop which may be supported so as to be movable relative to the linkage arm. For example this may be in the form of a cam member having a peripheral face for providing a mechanical limit to rotation of the mounting head. The cam member may comprise a pivot shaft for rotatable mounting on the linkage arm such that the position  
15 of the mechanical limit whereby rotation of the mounting head is limited, is moved when the cam is rotated.

In the case where the mounting head is rotated by a rotary actuator comprising a vane moving in a housing, the cam member may be mounted inside the housing so as to be rotatable relative thereto, with the peripheral face of the cam member arranged so as  
20 to provide limits to rotary motion of the vane.

When the limit means comprises a limit support means, the limit adjusting means may comprise linkage means connected either directly or indirectly between the limit support means and the structure. Any suitable linkage means may be possible providing it enables adjustment of the position of the limit support means and hence the limits,  
25 relative to the linkage arm. For example this may comprise any one of or a combination of an electric/hydraulic actuator, gearing, or link arms. In the case of gearing this may comprise gears and a drive shaft extending to the limit support means, whereby rotational movement proportional to pivotal movement of the arm about the first pivot may be transmitted to the limit support means to cause movement thereof.

30 Alternatively or in addition the linkage means may comprise a limit actuating arm whereby linear movement proportional to pivotal movement of the linkage arm about the first pivot may be transmitted to the limit support means to cause movement thereof.

In the case of limit support means such as a cam member rotatably mounted by

means of a pivot pin, the linkage means may be connected to the cam member so as to cause rotation thereof. For example the cam member may be provided with a crank arm connected to the pivot pin and the linkage means connected to the crank arm. The linkage means in this case may comprise a limit actuating arm. This may be pivotally  
5 mounted at one end to the structure adjacent the pivot point of the first end of the linkage arm, and pivotally mounted at another end to the crank arm, so that linear movement proportional to the pivotal movement of the linkage arm about the first pivot may be transmitted to the cam by way of the linkage arm. A second cam member having a second crank arm may also be provided to give a second movable limit stop for limiting  
10 the rotational motion of the mounting head in another direction, instead of having a fixed limit stop for this purpose. In this case a second limit actuating arm may be pivotally mounted at one end to the structure adjacent the pivot point and on an opposite side to the pivotal mounting of the other limit actuating arm, and pivotally mounted at another end to the second crank arm, so that linear movement proportional to the pivotal  
15 movement of the linkage arm about the first pivot may also be transmitted to the second cam by way of the second linkage arm.

In the case of limit support means in the form of an orientation member with the linkage means comprising a limit actuating arm, this arm may be pivotally mounted at one end to the structure adjacent the pivot point of the first end of the linkage arm, and  
20 pivotally mounted at another end to the orientation member, so that linear movement proportional to the pivotal movement of the linkage arm about the first pivot may be transmitted to the orientation member by way of the linkage arm. In this case the location of the mounting of the limit actuating arm to the structure for predetermined extremes of pivotal rotation of the orientation member relative to the linkage arm for  
25 predetermined extremes of pivotal rotation of the linkage arm relative to the structure may be determined by:

(a) determining a first reference point which corresponds with the point of mounting of the limit actuating arm to the orientation member when the linkage arm has been rotated to an extreme in one direction about the pivot point and the orientation  
30 member has been rotated to an extreme in one direction relative to the linkage arm;

(b) determining a second reference point which corresponds with the point of mounting of the limit actuating arm to the orientation member when the linkage arm has been rotated to an extreme in another direction about the pivot point and the orientation

-13-

member has been rotated to an extreme in another direction relative to the linkage arm;

(c) determining a third reference point which corresponds with the point of mounting of the limit actuating arm to the orientation member when the linkage arm has been rotated to a position intermediate its positions in (a) and (b); and

- 5 (d) determining an arc of a circle which passes through the first, second and third reference points, and locating the centre of the circle, which centre gives the location of mounting of the limit actuating arm to the structure.

It may be desirable for the linkage means to further comprise an auxiliary arm in conjunction with the limit actuating arm to ensure that maximum moment may be applied  
10 to the orientation member at all positions of the linkage arm. In this case, the auxiliary arm may be pivotally mounted at one end to the structure at a predetermined point adjacent the pivot point of the first end and on an opposite side to the pivotal mounting of the limit actuating arm, and may be pivotally mounted at another end to the orientation member such that the rotatable mounting of the mounting head is disposed  
15 substantially centrally and symmetrically between the pivotal mountings of the auxiliary arm and the limit actuating arm when the linkage arm has been rotated to a position intermediate its extreme limit positions. Determination of the predetermined point for the pivotal mounting of the auxiliary arm on the structure may be determined such that movement of the auxiliary arm and the limit adjusting arm, with movement of the linkage  
20 arm is symmetrical about a central axis datum coincident with a central axis between the two extremes of movement of the linkage arm.

Due to the integral form of the orientation member as compared to the independent limit support means as with the cam arrangement or some other arrangement, when the linkage means comprises two arms pivotally mounted on the  
25 orientation member, there may be positions of the linkage arm on either side of the central axis where binding may occur at any of the connection points. This binding may be due to a slight difference in trajectory of the pivot point for pivotal connection to the linkage arm and located on the orientation member which is supported by the auxiliary and limit actuating arms, and the pivot point located on the linkage arm for pivotal  
30 connection to the orientation member. Preferably, the points where the auxiliary and limit actuating arms are connected to the orientation member would be chosen so that this binding was zero at the extreme limits of movement of the linkage arm, and when the position of the linkage arm corresponded with the central axis datum. This binding may

be minimized at other positional locations of the linkage arm by suitable positioning of the auxiliary and limit actuating arm pivot points on the orientation member and on the structure, relative to the linkage arm pivot point on the orientation member and on the structure respectively.

- 5        Alternatively, the linkage means may comprise one or two hydraulic rams in place of the arm or arms respectively.

It may also be possible to have a linkage arrangement with a limit actuating arm which serves additionally as a support member of the linkage arrangement in conjunction with the linkage arm. In this case the limit actuating arm may be pivotally mounted to  
10 the structure and to the limit support member such that it supports the limit support member while pivoting. The limit actuating arm and the linkage arm may be arranged in the form of a pantograph, formed by the structure, the limit support member and the arms themselves. Alternatively the arms may be connected to the limit support member so as to cross over intermediate the structure and the limit support member.

- 15        In the case where the mounting head is rotated by the shaft/housing of a rotary actuator with the orientation member comprising the housing/shaft and rotation of the shaft relative to the housing limited by mechanical stops, the limit actuating arm or arms may be connected to the housing/shaft so that rotation of the housing/shaft relative to the linkage arm will move the mechanical stops relative to the linkage arm resulting in a  
20 change in the range of pivotal movement of the mounting head relative to the linkage arm.

In the case that the linkage arrangement comprises two linkage arms, the limit adjusting arms may be either a single arm member per each linkage arm or a pair of arm members per each linkage arm. For example, when the linkage arrangement comprises  
25 two arms with the first arm pivotally mounted at its first end to the structure, the limit actuating arm for the second arm may be pivotally mounted to the limit support member at the second end of the first arm, and may extend to a second limit support member rotatably mounted to the second end of the second arm. In this arrangement, the mounting head may be rotatably mounted to the second end of the second arm and/or  
30 to the second limit support member.

Preferably the implement is a backhoe or a verge mower.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described, by way of example only, with reference to the

accompanying drawings in which:

Figure 1 shows a plan view of a first embodiment of a linkage arrangement according to the invention;

Figure 2 shows various positions of the linkage arrangement of Figure 1;

5 Figure 3 details a preferred mounting head suitable for use with various embodiments of the present invention;

Figure 4 shows a schematic plan view of a linkage arrangement accordingly to the present invention, and the possible scope of operation of an implement when mounted on the linkage arrangement;

10 Figure 5 shows a plan view of a second preferred embodiment of a linkage arrangement according to the present invention;

Figure 6 shows a plan view of a third preferred embodiment of a linkage arrangement according to the present invention;

15 Figure 7 shows a plan view of a fourth preferred embodiment of a linkage arrangement according to the present invention;

Figure 8 shows the linkage arrangement of Figure 5 mounted to a prime mover, with a backhoe mounted on the mounting head;

Figure 9 shows schematically, a method by which a point of mounting of a limit actuating arm to a structure can be determined; and

20 Figure 10 shows a linkage arrangement according to a fifth preferred embodiment of the present invention.

#### BEST MODE FOR CARRYING OUT THE INVENTION

Referring to Figure 1, a linkage arrangement 10 for mounting on a structure such as a prime mover 12 is shown in the neutral (non-rotated) position. The linkage arrangement 10 includes a first linkage arm 14 pivotally mounted to the prime mover 12 at a first pivot point 16. A second linkage arm 18 is pivotally mounted to the first linkage arm 14 by way of a first rotary actuator 19. The second linkage arm 18 is fixedly attached to the housing of the actuator 19, and the shaft of the actuator is rotatably mounted on the first linkage arm 14 at a second pivot point 20. A mounting head in the form of a rotating head 22 is rotatably mounted to the second linkage arm 18 by way of a second rotary actuator 23. The rotating head 22 is fixedly attached to the housing of the actuator 23, and the shaft of the actuator 23 is rotatably mounted on the second linkage arm 18 at a third pivot point 24.

A pair of hydraulic rams 26,26' are pivotally mounted to and extend from the prime mover 12 and act on the first linkage arm 14 to cause it to pivot about the first pivot point 16. (This pivotal movement is depicted, for example, in Figures 2G and 2H).

A first limit support member in the form of a first orientation base 28 is fixedly  
5 attached to the shaft of the first rotary actuator 19 so as to be rotatably mounted to the first linkage arm 14 at the second pivot point 20. The first orientation base 28 is connected to the prime mover by a first limit actuating arm 30, and a first auxiliary arm 30' which extend from respective pivot points 31, 31' adjacent the first pivot point 16 and to either side thereof, to pivot points 32, 32' on the first orientation base 28, located so  
10 that the second pivot point 20 is disposed substantially centrally and symmetrically therebetween.

A second limit support member in the form of a second orientation base 33 is fixedly attached to the shaft of the second rotary actuator 23 so as to be rotatably mounted to the second linkage arm 18 at the third pivot point 24. The second orientation  
15 base 33 is connected to the first orientation base by a second limit actuating arm 35, and a second auxiliary arm 35' which extend from respective points of pivot 37, 37' on the first orientation base 28 adjacent the second pivot point 20 and to either side thereof, to respective pivot points 36, 36' located so that the third pivot point 24 is disposed substantially centrally and symmetrically therebetween.

20 The first orientation base 28 is provided with rotational delimiters in the form of vanes 40, 40' of the rotary actuator 19 rotating within a ring portion 42 of the actuator 19 housing which is fixedly attached to the second linkage arm 18. These rotational delimiters 40, 40' define limits to the extent of rotational motion of the second linkage arm 18 to either side of a central datum line L1 (coinciding with a central axis CA in the  
25 symmetrical configuration of Figure 1) about which the second arm 18 pivots relative to the first arm 14.

The second orientation base is provided with rotational delimiters on either side of a vane 44 of the rotary actuator 23 rotating within a ring sector 46 of the actuator 23 housing which is fixedly attached to the rotating head 22. These rotational delimiters  
30 provided by vane 44 define limits to the extent of rotational motion of the rotating arm 22 to either side of a central datum line L2 (coinciding with a central axis CA in the symmetrical configuration of Figure 1) about which the rotating head 22 pivots relative to the second arm 18.

-17-

The ring portion 42 of the hydraulic actuator 19 is provided with vanes 48, 48' which extend inwardly from the ring portion 42 towards the second pivot point 20. The ring sector 46 of the hydraulic actuator 23 is provided with slew cams 50, 50' (to be described later with reference to Fig. 3) which extend inwardly from the walls of the ring sector 46 and are pivotally mounted to the housing of the actuator 23. Normally the slew cams 50, 50' are rotated to butt against the casing 51 (wall of ring sector 46), to provide for maximum rotation of the rotating head 22.

The rotating head 22 is provided with projecting arms 52, 52' for receiving an implement such as a back-hoe, verge mower or the like. In this regard, the boom of the backhoe would be mounted between the arms 52, 52' (as shown in Figure 8).

Referring to Figure 2 various positions of the linkage arrangement are depicted. In Figures 1 and 2B, a central axis extending through the prime mover, first pivot point 16, (and the second and third pivot points 20, 24 when the linkage arrangement is in the neutral position), is shown and depicted as CA. It should be noted that the various positions of the linkage arrangement on one side of the central axis CA, can be mirrored (reproduced identically) on the other side of the axis, as shown for example by Figure 2F which is a mirror of the position shown in Figure 2D. As a result, a number of advantages are provided (as will later be described) stemming from the linkage arrangement of the present invention.

Figures 2A to 2E show views in which the rotating head 22 has been rotated to a position in which slew cam 50' engages rotational delimiter 44 to stop rotational travel of the rotating head 22. The rotational travel can be effected by operating the hydraulic actuator 23 to turn the actuator 23 housing relative to the vane 44 in either clockwise or anti-clockwise directions.

Referring to Figure 2C, the second arm 18 is shown pivoting about the second pivot point 20. This pivotal movement can be effected by operation of the hydraulic actuator 19 to cause the second arm 18 to pivot until vanes 48, 48' engage rotational delimiters 40', 40 respectively, arresting the movement of the second arm 18.

It will also be noted in Figure 2C that pivoting of the second arm 18 about the second pivot point 20 causes pivotal motion of second limit actuating arm 35 and second auxiliary arm 35' about their respective points of pivot 37, 37'. As these arms 35, 35' are also pivotally mounted to respective pivot points 36, 36' on the second orientation base

-18-

33, the pivotal motion of the second arm 18 about the second pivot point 20 causes a change in orientation of the central datum line L2 between the limits of the second orientation base 33, with respect to the second linkage arm's longitudinal axis (denoted in Figure 2C by L2'). Thus, the relative rotation of the rotating head 22 with respect to  
5 the second arm 18 is changed; (ie rotating head 22 has a lesser rotational sweep from axis L2' in the anti-clockwise direction than in the clockwise direction).

Referring to Figure 2E (and Figures 2A, 2D, and 2F) a view is shown in which the first linkage arm 14 has been pivoted about the first pivot point 16. In Figure 2E this is achieved by extending the piston rod of hydraulic ram 26 and retracting the piston rod  
10 of hydraulic ram 26' (see Figure 1). The extent of pivotal motion of the first linkage arm 14 about the first pivot point 16 is limited by the extent of travel of the piston rods within their respective hydraulic rams 26, 26'.

As the first linkage arm 14 is pivoted about the first pivot point 16, the first limit actuating arm 30 and first auxiliary arm 30' are caused to pivot about their respective  
15 pivot points 31, 31'. Since the ends of these arms are pivotally connected at pivot points 32, 32' on the first orientation base 28, pivoting of the first linkage arm 14 about the first pivot point 16 causes a change in orientation of the central datum line L1 between the limits of the first orientation base 32, with respect to the longitudinal axis of the first arm 14 (denoted in Figure 2E by L1'). Referring to Figures 2E and 2F it can be seen that the  
20 new orientation of the first orientation base 28 indicated by central datum line L1 causes a change in the extent of sweep of the second arm 18 with respect to the first arm 14 on either side of axis L1'. Thus the extent of sweep is greater in the clockwise direction (Figure 2F) than in the anti-clockwise direction (Figure 2E). The orientation of the second orientation base 36 indicated by central datum line L2 is also changed because the  
25 second limit actuating arm 35 and second auxiliary arm 35' are pivotally mounted to the first orientation base 28 and therefore will change position with a change in position of the first orientation base 28.

By varying the extent of pivotal motion of the first linkage arm 14 about the first pivot point 16 and the second linkage arm 18 about the second pivot point 20, the third  
30 pivot point 24 can be located in a variety of positions away from the prime mover 12. Furthermore, by selecting different locations for pivotal attachment of the limit actuating arm 30 to the prime mover 12 and to the orientation base 28, and by changing the location of the delimiters on the orientation bases 28 and 33, the linkage arrangement can

be designed to suit a variety of applications.

When an implement such as a backhoe is mounted to the rotating head 22, a variety of different sized areas (bounded by envelopes which denote the limit to which a backhoe may reach from the third pivot point 24) can be reached by a backhoe shovel, and these are shown schematically in Figure 4 and Figure 8. Figure 4 also illustrates the potential to utilize automatic orientation of the orientation base as the linkage mechanism is turned about its respective pivots. In Figure 4, arrowed lines indicate movement due to a rotary actuator, or a mechanism providing a similar function. Figure 4a shows a cross over linkage arrangement whereby the second arm 18 is turned relative to the first linkage arm 14 as the first linkage arm 14 is turned about the first pivot point 16. In this case, the orientation base 28 on which the rotating head 22 is mounted by means of the second arm 18 is turned relative to the first linkage arm 14 by a limit actuating arm 30 and auxiliary arm 30' which cross over intermediate the prime mover 12 and the orientation base 28 to attach to pivot points on opposite sides of the first pivot point 16. In Figure 4, the first linkage arm 14 is rotated about the first pivot point 16 to one extreme. In this position the rotating head 22 may be rotated so that at either extreme, an implement attached to the rotating head 22 does not contact the prime mover 12.

Figure 4b shows a similar linkage mechanism to that of Figure 4a with the attachment points of the limit actuating arm 30 and the auxiliary arm 30' on the prime mover 12 positioned closer to the first pivot point 16. The rotating head 22 in this configuration has a greater range of rotation about its pivot point, and hence, to prevent an implement attached to the rotating head 22 from contacting the prime mover 12, the limit of rotation of the first linkage arm 14 is reduced.

Figure 4c show an arrangement with the pivot points for the limit actuating arm 30 and the auxiliary arm 30' positioned relative to the first pivot point 16 so that they do not cross over. In this configuration, as well as the rotating head 22 being able to rotate about second linkage arm 18 and hence relative to the orientation base 28, the second linkage arm 18 is also able to rotate about the orientation base 28. The limits of rotation of the first linkage arm 14 and the second linkage arm 18, and the rotating head 22 are set so that when the first linkage arm 14 is at one extreme (to the left in Figure 4), an implement mounted to the rotating head 22 cannot contact the prime mover 12 throughout its range of movement. It will be apparent that if the limit actuating arm 30 (auxiliary arm 30' may or may not be fitted) was not provided, then with swinging of the

-20-

first linkage arm 14 to the other extreme position (to the right in Figure 4a), an implement mounted on the rotating head 22 could contact the side of the prime mover 12. Due to the presence of the limit actuating arm 30 (and auxiliary arm 30') connected between the prime mover 12 and the orientation base 28, the orientation base 28 turns anti-clockwise as the first linkage arm 14 turns clockwise about the first pivot point 16 so that the central axis of movement of the second linkage arm 18 (central datum line) is turned relative to the axis of the first linkage arm 14 and positioned so that in the right side extreme position, an implement mounted on the rotating head 22 will not contact the prime mover 12.

Figure 4d shows a configuration with a second orientation base 33. With this arrangement, the rotational range of the rotating head 22 may be increased whilst still ensuring that an implement mounted to the rotating head 22 will not contact the side of the prime mover 12 throughout the whole range of travel of the linkage arrangement.

As can be seen in more detail in Figure 2D, the linkage arrangement is mounted to a prime mover 12 with for example, large rear wheels (denoted as W). The delimiters are arranged so that full anti-clockwise travel of the rotating head 22 first linkage arm 14 and second linkage arm 18 about their respective pivot points 16, 20 and 24 results in the projecting arms 52, 52' being parallel to one side of the prime mover 12. In this limiting linkage position an implement mounted on the rotating head 22 of the linkage arrangement can operate to either side of and adjacent the prime mover 12 without contacting the prime mover 12 (as can be seen by the mirrored arrangement in Figures 2D and 2F). Thus, if a backhoe of defined width was mounted on the linkage arrangement it could dig along side of and parallel to the prime mover 12 without the possibility of the prime mover 12 being contacted by the backhoe. (See for example the operating range indicated in Figure 8).

Referring to Figure 3, the operation of the rotating head 22 with respect to the second orientation base 36 will now be explained in greater detail. The slew cams 50, 50' are pivotally mounted to the rotating head 22 at pivot points 60, 60' respectively. Each cam 50, 50' is provided with a number of notches 62, 62' respectively which are shaped to engage a knobs 64, 64' formed on either side of the rotation delimiter 44 (shown in dotted outline in one position) which is fixedly connected to the second orientation base 36 (not shown in Figure 3).

In Figure 3, slew cam 50' is shown in its normal operating position, ie. butted up

against the casing 51 with slew cam 50 pivoted away from the casing 51, thereby reducing the extent of rotational sweep of the rotating head 22. This configuration may be used for example, when a different implement is mounted on the rotating head.

One of the notches 62,62' is selected to engage the knob 64,64' (as shown in Figure 5 3) and thus rotational sweep of the rotating head 22 about the second orientation base 36 can be varied to suit the type of implement mounted on the linkage arrangement. When, for example, a backhoe is mounted on the mounting head 22 with the linkage arrangement as shown in Figures 1 and 2, the slew cam configuration could be modified to include a number of operating configurations (not shown). These might include a safe, 10 "in-use" configuration wherein the backhoe is restrained from contacting the prime mover, by limiting rotating head 22 rotational sweep, and a transporting configuration (ie. where the rotational sweep is increased by appropriate positioning of the slew cams) which allows the backhoe to be positioned close or on the prime mover for transporting between sites. In this regard reference is made to the embodiment of Figure 7 (to be 15 subsequently described) and the various positions of the rotating head 22 shown therein. The various configurations could be modified according to the implement types mounted on the linkage arrangement.

Figure 5 shows a second embodiment of the linkage mechanism according to the present invention in which the first limit actuating arms 30 is replaced by a single 20 hydraulic ram 68 pivotally mounted on the prime mover 12 adjacent the first pivot point 16. The piston rod of the hydraulic ram 68 is pivotally connected to the first orientation base 28 at a side pivot point 70.

In the embodiment of Figure 5, the rotary actuator 32 of the embodiment of Figure 1 is replaced by a pair of respective hydraulic rams 72, 72'. Each ram 72, 72' is pivotally 25 mounted between an attachment member 65 formed integral with the second linkage arm 18 and the first orientation base 28 at respective pivot points 73, 73' and 74, 74'. The rams 72,72' thus provide a similar function to that of the rotary actuator 32, to cause the second linkage arm 18 to pivot about the second pivot point 20.

It should be noted that if the attachment member 65 was free to pivot on the 30 second arm 18 as a second orientation base (not shown in Figure 5), the arrangement of Figure 5 would allow for a greater variation in the position of the second orientation base with respect to the second arm due to the use of the hydraulic ram 68 instead of a fixed length limit actuating arm. Similarly, the position of the first orientation base 28 in Figure

-22-

5 can be varied independently of the first linkage arm 14 (ie. the position of the orientation base 28 can be changed by either pivoting the first linkage arm 14 or by operation of the ram 68).

Referring to Figure 6 a third embodiment of the linkage arrangement according to the present invention is depicted, in which the arrangement of the first linkage arm 14 is similar to that shown in Figure 5. However, the first orientation base 28 is made integral with the second arm 18 to form an L-shaped member 74, and variation in orientation of the central datum line L1 relative to the central axis L1' of the first linkage arm 14 is varied by turning the L-shaped member 74 about the second pivot point 20. In the arrangement shown in Figure 6, extension of the hydraulic ram 68 causes the L-shaped member 74 to rotate about the second pivot point 20 in a clockwise direction. Retraction of the ram 68 causes the L-shaped member 74 to rotate about the second pivot point 20 in an anti-clockwise direction.

The hydraulic ram 68 also functions as a limit actuating arm. Thus, when the first arm 14 is pivoted about the first pivot point 16 and, for example, the length of hydraulic ram 68 is fixed (as shown in Figure 6A), a change in position of the L-shaped member 74 with respect to the first arm 14 occurs (ie. the L-shaped member 74 pivots about the second pivot point 20). By varying the length of the hydraulic ram 68 (as shown in Figures 6B,6C) before and or during motion of the first arm 14 about pivot point 16, a variety of positions of the rotating head 22 can be achieved during and/or at the termination of motion of the first arm 14.

Once again the rotating head 22 can be mounted at the third pivot point 24 and its rotational sweep can be controlled such that any implement mounted to the rotating head 22 can be positioned to operated laterally of and adjacent to the prime mover 12 without contacting the prime mover 12. Note in this embodiment a cross over linkage is used in mounting the hydraulic ram 68 to the prime mover 12. This enables a greater rotation of the L-shaped member 74 with respect to rotation of the first linkage arm 14. That is to say when the first linkage arm 14 is pivoted relative to the prime mover 12 with the hydraulic ram 68 locked, the ratio of consequent rotation of the L-shaped member relative to the first linkage arm 14 is greater than the ratio of rotation of the first linkage arm 14 relative to the prime mover 12.

Referring to Figure 7 a fourth embodiment of the linkage arrangement according to the present invention is shown. In this embodiment, an orientation base 80 is pivotally

mounted to the prime mover by crossover (interwoven) linkage arms 82 and 82'. The linkage arms 82, 82' are pivotally mounted to the prime mover 12 at pivot points 83 and 83' respectively, and to respective opposite ends of the orientation base 80 at pivot points 84, 84'. With this arrangement one of the linkage arms (82' in the following) can be considered as a limit actuating arm which is also adapted to function as a support arm for the linkage arrangement. Hydraulic rams 85 and 85' are pivotally mounted to the prime mover 12 and extend to and are pivotally mounted to respective opposite ends of the orientation base 80 at the pivot points 84, 84'. The rotating head 22 is rotatably mounted to the orientation base 80 in a similar manner to the aforementioned embodiments and is pivotal about a central datum line L1.

By extending the hydraulic ram 85 and retracting hydraulic ram 85', the crossover linkage arms 82 and 82' are caused to pivot about their respective pivot points in an anti-clockwise direction, and the location of the orientation base 80 with respect to the prime mover 12 and consequent orientation of the central datum line L1 of the rotating head 22 relative to the linkage arm 82 can be varied as shown in Figures 7A to 7E.

Figures 7A to 7D also show how a change of ratio in the rotation of the orientation base 80 with respect to the total slew of the linkage arms 82, 82' about the prime mover can be achieved. This is achieved by changing the position of mounting of the crossover linkage arms 82, 82' and hydraulic rams 85, 85' to the orientation base 80 at various mounting points 86 (Figure 7E). This alteration of orientation ratio also changes the rotation of the orientation base 80 and therefore mounting head 22 with respect to the prime mover.

With an arrangement of appropriate delimiters, the rotating head 22 can be positioned such that the projecting arms 52, 52' of the rotating head 22 remain parallel to the side of the prime mover 12. The embodiment of Figure 7, however, shows a position of the rotating head 22 wherein the arms 52, 52' are directed towards the prime mover 12 (Figure 7A). This positioning might be employed during transportation of the prime mover 12, and could be obtained by employing the slew cam configuration as described earlier; (ie the positioning could correspond with a configuration in which the slew cams abutted against the casing 51). Also, when certain implements are operating on the linkage arrangement with this particular positioning, it may not necessarily be dangerous to the prime mover 12. However, the position would usually not be selected when, for example, a backhoe or shovel was operating from the linkage arrangement.

Referring to Figure 8 the linkage arrangement of Figure 5 is shown with a backhoe mounted thereon. The boom 90 of the backhoe is rotatably mounted on the rotating head 22 to slew in the vertical plane. Figure 8A depicts a rear view of the prime mover 12, wherein a backhoe is shown digging adjacent to and laterally of the prime mover 12 and dumping at some distance from the prime mover 12. Figure 8B shows the extent of digging achievable with the linkage arrangement of the present invention when a backhoe is mounted thereon. This is depicted as area 92 bounded by envelope 92A.

With reference to Figure 9 a method for locating pivotal connection points for the limit actuating arm on the prime mover 12 to obtain a required pivotal relationship between a linkage arm and an orientation member according to the present invention will now be described. In this description location of the first limit actuating arm pivot point on the prime mover is described. However the method may also be applied to location of a pivot point on an orientation base, such as the pivot point for the second limit actuating arm on the first orientation base in the embodiment of Figure 1.

In this method, with reference to the components of Figure 1, the first linkage arm 14 is pivotally mounted to the prime mover 12 at the first pivot point 16. The first orientation base 28 is pivotally mounted at the other end of the first linkage arm 14 at the second pivot point 20. The limit actuating arm 30 (a plurality of actuating arms are shown in Figure 9A, each of which would correspond to various orientation base extreme positions) is pivotally mounted to the prime mover 12 and extends to the orientation base 28 to be mounted at reference point 100.

The ratio of rotation of the orientation base about the first linkage arm 14, to rotation of the first linkage arm 14 relative to the prime mover 12 is predetermined, and varying ratios are depicted schematically as a, b, c, d, etc in Figure 9A. For each predetermined ratio a different point of mounting of the limit actuating arm 30 to the prime mover 12 is required. The corresponding points of mounting are shown more clearly in Figure 9B.

Referring to Figure 9C, a methods for determining the point of mounting of the limit actuating arm 30 to the prime mover will now be explained. It should be appreciated that this method is a preferred method and other similar methods may also be employed.

Step A - Linkage arm 14 is pivoted in a clockwise direction about pivot point 16 to position A as shown. A preselected extent of rotation of the orientation member 28

-25-

about the second pivot point 20 is determined and shown as reference point 100 taking position x. Position x is recorded.

Step B - Linkage arm 14 is rotated, until it extends perpendicularly from the back of the prime mover 12, to position B corresponding with the central axis CA. When moving to this position, the limit actuating arm 30 rotates about second pivot point 20 until it assumes the positions shown. The position of reference point 100 is recorded (and is shown as y).

Step C - Linkage arm 14 is pivoted about the first pivot point 16 in an anti-clockwise direction until it reaches position C. In the case depicted, the extent of pivotal motion of linkage arm 14 in the anti-clockwise direction from position B to position C corresponds with the extent of pivotal motion in the clockwise direction from position B to position A. When moving to position C, the orientation member 28 rotates about the second pivot point 20 until it assumes the position as shown (a mirror image of the orientation at A). The position of reference point 100 is recorded (and is shown as z).

Step D - Once the positions x, y and z have been established, an arc of a circle is drawn to pass through these three positions. The centre of the circle is determined and its point of correspondence with the prime mover 12 is located. This point becomes the location for mounting of the limit actuating arm 30 to the prime mover 12 and is depicted in Figure 9C as L.

It should also be noted from Figures 9A and 9C that the orientation base 28 is not mounted to the linkage arm 14 at the point at which a straight line extending between its ends crosses (or intersects) linkage arm 14. Instead, the mounting to the linkage arm 14 is off-set to the second pivot point 20. Thus, in the case where a limit actuating arm and an auxiliary arm are mounted to respective ends of the orientation base, the off-set mounting of the orientation base 28 minimizes binding at the pivotal connections of the limit actuating arm and the auxiliary arm to the orientation base 28 during pivotal motion of the linkage arm 14 about the first pivot point 16.

Referring to Figure 10 a fifth embodiment of the linkage arrangement according to the present invention is shown. In this embodiment components having a similar function to those of the previous embodiments are indicated by the same numerals. Instead of the orientation member 28 of the previous embodiments, with their integrally mounted limits stops, the limit support means in this embodiment comprises a pair of cams 93, 93' of a

-26-

similar design and function to the slew cams 50, 50' illustrated in Figure 3. In this embodiment however, the cams 93, 93' are rotatably mounted by means of pivot shafts 95, 95' inside a housing 94 of a rotary actuator 96 which is fixedly attached to the first linkage arm 14, and the second linkage arm 18 is fixedly attached to the shaft 97 of the rotary actuator 96. Peripheral faces of the cams 93, 93' are arranged so as to provide limits to the rotary motion of a vane 98 formed integral with the shaft 97. The cams 93, 93' are provided with crank arms 99, 99' connected to the pivot pins 95, 95', and limit actuating arms 102, 102' are pivotally connected at their respective first ends to the crank arms 99, 99', and at their respective second ends to the structure at pivot points 104, 104' adjacent to and on either side of the first pivot point 16 of the linkage arm 14. With this arrangement linear movement proportional to the pivotal movement of the linkage arm 14 about the first pivot 16 is transmitted to the cams 93, 93' by way of the limit actuating arms 102, 102'. As a result the cams 93, 93' are rotated relative to the housing 94 so that the extent of rotational motion of the second linkage arm 18 to either side of a central datum line L1 about which the second linkage arm 18 pivots is varied, depending on the profile of the cams 93, 93', the location of the various pivot points and the lengths of the limit actuating arms 102, 102' and the crank arms 99, 99'. Since in this embodiment two cams 93, 93' are used instead of one, these variables may be set so that the orientation of the central datum line L1 with respect to the orientation of the central axis L1' remains constant, and only the extent of rotational motion of the second linkage arm 18 is varied. However it is generally envisaged that in most applications the orientation of the central datum line L1 would also vary with respect to the orientation of the central axis L1'.

As with the previous embodiments, an additional rotating head 22 may be provided at the end of the second linkage arm 18, and fitted with either cam or orientation base limit mounting means which are linked back to the prime mover 12. In this case with the arrangement of Figure 10, the cams 93, 93' fixed to the shafts 95, 95' may be eliminated so that the limits to rotation of the actuator 96 are not varied with pivotal movement of the first linkage arm 14, the limits to rotational motion of the mounting head 22 being varied only by cams or an orientation base provided at its mounting to the second linkage arm 18.

With the linkage arrangement of the present invention a number of advantages become apparent, when for example, the linkage arrangement is mounted to a prime mover.

-27-

For example, when a backhoe is mounted on the linkage arrangement it is possible to excavate almost entirely around a prime mover, without the need for moving and repositioning the prime mover. At the same time, the prime mover and a human operator of the backhoe are not endangered.

- 5       Alternatively, if an elongate trench was to be dug, it is possible to dig the trench with the mounting head rotated to one side of the linkage mechanism and thence to rotate the mounting head through 180 degrees and to continue digging the trench from the other side of the linkage mechanism. This ability is available with a variation of for example 45 degrees in orientation, with 22.5 degrees of freedom to each side, for cleaning  
10 off hanging shoulders or for correction after the prime mover had been pulled from its stationary position (unless the work requires the linkage to be positioned against the limits on one side).

The elliptical arc envelope available to the third pivot due to the change in radius affected by independent operation of the two arms, combined with a possible large degree  
15 (of the order of 225 degrees) of rotation of the head, produces a manipulative ability which can accommodate a multitude of alignments and traverses required for such operation as trench digging and the like, which heretofore have not been available for conventional side mounted hoes. Thus the arrangement makes it possible to extend the length and shape of trenches, holes, excavation pits, etc.

- 20       Furthermore, when a verge mower is mounted to the rotating head, the linkage mechanism of the present invention could be appropriately controlled so that the mower could readily operate to the side and above of both sides of the prime mover, and for example, in the case of hedge trimming, the mechanism movement could be controlled where hedge cuttings of various shapes were desired.

- 25       Verge mowers could be mounted to the front and rear of a prime mover, to be operated one on either side of the prime mover when traveling. An operator could be positioned so that the rear-mounted verge mower could be operating forward of the operator in the direction of the prime-mover travel, thereby enabling two sides or passes of, for example, a roadway to be mowed simultaneously. Thus, the operator would have  
30 a simultaneous view of the direction of travel, the approaching terrain and implements mounted on the prime mover, and this would facilitate controlled arrangement of implements. The arrangement of the present invention provides the added advantage of operator protection from both sides. Thus, if one or both of the verge mowers was to

-28-

catch or become entangled during prime-mover travel, the linkage arrangement of the present invention can facilitate an implement breakaway system. In such a system, when an implement, such as a verge mower, becomes entangled, the arrangement breaks away from its forward position about the pivot point and swings back parallel to the side of the  
5 prime mover to prevent damage to the implement arm, cabin or prime mover generally.

A prime mover could also be fitted with linkage mechanisms according to the present invention at both the front and rear, accommodating for example a backhoe at the rear and a shovel at the front of the prime mover.

Whilst the invention has been described with reference to a number preferred  
10 embodiments, it will be appreciated that the invention can be embodied in many other forms.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof as defined in the appended claims.

CLAIMS

1. A linkage arrangement for mounting an implement to a structure said linkage arrangement comprising:
  - a linkage arm having a first end and a second end distal from said first end and
  - 5 adapted to be pivotally mounted at its first end to the structure at a first pivot point and arranged to pivot relative to said structure about said first pivot point;
  - a mounting head rotatably mounted to the second end of said linkage arm and arranged to rotate relative to said linkage arm and adapted to have said implement mounted directly or indirectly thereon;
  - 10 first actuating means for pivoting said linkage arm relative to said structure;
  - second actuating means for rotating said mounting head relative to said linkage arm;
  - limit means defining limits to the extent of rotational motion of said mounting head to either side of a central datum line about which said mounting head pivots relative to said linkage arm; and
  - 15 limit adjusting means for adjusting said limit means such that said limits to the extent of rotational motion of said mounting head are varied with pivotal movement of said linkage arm relative to said structure.
2. A linkage arrangement for mounting an implement to a structure as claimed in claim 1, wherein said limit means comprises a limit support means on which are mounted
- 20 mechanical limit means, said limit support means being mounted on said linkage arm so as to be movable relative thereto, and said limit adjusting means comprises mechanical means for adjusting a location of said limit support means relative to said linkage arm with pivotal movement of said linkage arm relative to said structure.
3. A linkage arrangement for mounting an implement to a structure as claimed in
- 25 claim 2, wherein said limit support means comprises an orientation member, and said mechanical limit means comprises two limit stops attached thereto, said orientation member being pivotally mounted on said linkage arm, and said limit adjusting means comprises mechanical means for changing an orientation of said central datum line relative to said linkage arm with pivotal movement of said linkage arm relative to said
- 30 structure.
4. A linkage arrangement for mounting an implement to a structure as claimed in claim 3, wherein said second actuating means for rotating said mounting head relative to said linkage arm comprises a rotary actuator having a shaft and vane rotatably mounted

-30-

in a housing so as to be rotatable in said housing between limits provided on said housing and on opposite sides of said vane, and said orientation member comprises the casing or shaft of said rotary actuator.

5. A linkage arrangement for mounting an implement to a structure as claimed in  
5 claim 3, wherein said second actuating means for rotating said mounting head relative to said linkage arm comprises a linear actuator having a rod member moving relative to a casing between limits provided on said rod member and said casing, and said orientation member comprises one of said rod member and said casing of said linear actuator.

6. A linkage arrangement for mounting an implement to a structure as claimed in  
10 claim 2, wherein said limit support means comprises at least one cam member having a peripheral face for providing a mechanical limit to rotation of said mounting head, said cam member being mounted on said linkage arm so as to be rotatable relative thereto, thereby moving the position of said mechanical limit.

7. A linkage arrangement for mounting an implement to a structure as claimed in  
15 claim 6, wherein said second actuating means for rotating said mounting head relative to said linkage arm comprises a rotary actuator having a shaft and vane rotatably mounted in a housing, said housing being mounted on said linkage arm, and said cam member being mounted inside said housing so as to be rotatable relative thereto, with said peripheral face arranged so as to provide limits to rotary motion of said vane.

20 8. A linkage arrangement for mounting an implement to a structure as claimed in any one of claims 2 to 7, wherein said limit adjusting means comprises;

linkage means connected between said limit support means and said structure.

9. A linkage arrangement for mounting an implement to a structure as claimed in  
25 claim 8, wherein said linkage means comprises gearing and a drive shaft whereby rotational movement proportional to pivotal movement of said linkage arm about said first pivot is transmitted to said limit support means.

10. A linkage arrangement for mounting an implement to a structure as claimed in 8,  
wherein said linkage means comprises a limit actuating arm whereby linear movement proportional to pivotal movement of said linkage arm about said first pivot is transmitted  
30 to said limit support means.

11. A linkage arrangement for mounting an implement to a structure as claimed in any one of claims 8 to 10, wherein said linkage means comprises a limit actuating arm whereby linear movement proportional to pivotal movement of said linkage arm about

-31-

said first pivot is transmitted to said orientation member, wherein said limit actuating arm is pivotally mounted at one end to said structure adjacent the pivot point of said first end of said linkage arm and is pivotally mounted at another end to said orientation member;

wherein location of the mounting of said limit actuating arm to the structure for  
5 predetermined extremes of pivotal rotation of said orientation member relative to said linkage arm for predetermined extremes of pivotal rotation of said linkage arm relative to said structure is determined by;

(a) determining a first reference point which corresponds with the point of mounting of the limit actuating arm to the orientation member when the linkage arm has  
10 been rotated to an extreme in one direction about the pivot point and the orientation member has been rotated to an extreme in one direction relative to said linkage arm;

(b) determining a second reference point which corresponds with the point of mounting of the limit actuating arm to the orientation member when the linkage arm has been rotated to an extreme in another direction about the pivot point and the orientation  
15 member has been rotated to an extreme in another direction relative to the linkage arm;

(c) determining a third reference point which corresponds with the point of mounting of the limit actuating arm to the orientation member when the linkage arm has been rotated to a position intermediate its positions in (a) and (b); and

(d) determining an arc of a circle which passes through the first, second and third  
20 reference points, and locating the centre of the circle, which centre gives said location of mounting of the limit actuating arm to the structure.

12. A linkage arrangement for mounting an implement to a structure as claimed in claim 11, wherein said linkage means further comprises an auxiliary arm pivotally mounted at one end to said structure at a predetermined point adjacent the pivot point  
25 of said first end and on an opposite side to the pivotal mounting of said limit actuating arm, and is pivotally mounted at another end to said orientation member such that said rotatable mounting of said mounting head is disposed substantially centrally and symmetrically between the pivotal mountings of said auxiliary arm and said limit actuating arm when said linkage arm has been rotated to a position intermediate its positions in (a)  
30 and (b).

13. A linkage arrangement for mounting an implement to a structure as claimed in any one of claims 1 to 12, wherein said linkage arm comprises a plurality of members connected together such that the relative location between said first and second ends is

variable.

14. A linkage arrangement for mounting an implement to a structure as claimed in any one of claims 1 to 12, wherein said linkage arm comprises a single member with said first and second ends fixedly located relative to each other.

5 15. A linkage arrangement for mounting an implement to a structure as claimed in any one of claims 1 to 14, said linkage arrangement comprising;

a second linkage arm having a first end and a second end distal from said first end with said first end fixedly mounted on said mounting head of said linkage arm,

a second mounting head rotatably mounted to the second end of said second  
10 linkage arm, and arranged to rotate relative to the second linkage arm, and adapted to have said implement mounted directly or indirectly thereon;

third actuating means for pivoting said second linkage arm relative to said linkage arm;

fourth actuating means for rotating said second mounting head relative to said  
15 second linkage arm;

second limit means defining limits to the extent of rotational motion of said second mounting head to either side of a central datum line about which said second mounting head pivots relative to said second arm; and

second limit adjusting means for adjusting said second limit means such that said  
20 limits to the extent of rotational motion of said second mounting head are varied with pivotal movement of said second linkage arm relative to said linkage arm.

16. A linkage arrangement for mounting an implement to a structure as claimed in claim 15, wherein said second limit means comprises a second limit support means on which are mounted mechanical limits, said second limit support means being mounted on  
25 said second linkage arm so as to be movable relative thereto, thereby moving said mechanical limits, and said second limit adjusting means comprises second mechanical means for moving said second limit support means relative to said second linkage arm with pivotal movement of said second linkage arm relative to said linkage arm.

17. A linkage arrangement for mounting an implement to a structure as claimed in  
30 claim 16, wherein said second limit support means comprises a second orientation member, and said second limits comprise two limit stops attached thereto, said second orientation member being pivotally mounted on said second linkage arm such that an orientation of said limits stops relative to said second linkage arm is variable with pivotal

movement of said second orientation member.

18. A linkage arrangement for mounting an implement to a structure as claimed in claim 17, wherein said fourth actuating means for rotating said second mounting head relative to said second linkage arm comprises a rotary actuator having a shaft and vane  
5 rotatably mounted in a housing so as to be rotatable in said casing between limits provided on said casing and on opposite sides of said vane, and said second orientation member comprises the casing or shaft of said rotary actuator.

19. A linkage arrangement for mounting an implement to a structure as claimed in claim 11, wherein said limit actuating arm serves additionally as a support member of said  
10 linkage arrangement, said limit actuating arm and said linkage arm being arranged in the form of a pantograph, formed by the structure, the orientation member and the arms themselves.

20. A linkage arrangement for mounting an implement to a structure as claimed in any on of claims 1 to 19 wherein said structure is a prime mover and said  
15 implement is a backhoe.

21. A method of increasing the ability to move and orientate an implement movably supported relative to a structure by a linkage arrangement, and limited from movement relative to said linkage arrangement and said structure by limit means, said method comprising the step of varying limits imposed by said limit means with movement of said  
20 implement relative to said structure.

22. A method of changing a limit to rotation of an arm of a linkage provided by limit means, said method comprising the steps of;  
mounting said limit means so as to be movable relative to said arm, and  
linking a movement of said arm to said limit means so that said limit to rotation is  
25 changed with movement of said arm.

23. A linkage arrangement substantially as herein described with reference to Figures 1 to 10 of the accompanying drawings.

24. A method of changing limits to rotation of an arm of a linkage, substantially as herein described with reference to Figures 1 to 10 of the accompanying drawings.

30 25. A prime mover vehicle having an implement supported operatively therefrom by a linkage arrangement of any one of claims 1 to 20.

26. A linkage arrangement for mounting an implement to a structure comprising:  
a first linkage arm having a first end and a second end distal from said first end,

pivotally mounted at its first end to the said structure at a first pivot point, and arranged to rotate relative to the structure about the said first pivot point;

a first orientation member rotatably mounted to the said second end of the said first linkage arm and arranged to rotate thereon;

5 a first linkage means pivotally mounted from said structure adjacent the first pivot point and extending to and pivotally mounted to the said first orientation member other than at rotation axis of said mounting of said first linkage arm and first orientation member;

a second linkage arm having a first end and a second end remote from said first  
10 end, pivotally mounted at said first end to said first orientation means at a second pivot point, said second pivot point being displaced from said first pivot point so as to be capable of providing a moment about said second pivot point and arranged to pivot relative to said first orientation member about said second pivot point;

a second orientation member rotatably mounted to the said second end of the said  
15 second linkage arm and arranged to rotate relative to second orientation member;

a second linkage means pivotally from said first or orientation means mounted adjacent the second pivot point and extending to and pivotally mounted to the said second orientation member other than at rotation axis of said mounting of said first linkage arm and said second orientation member;

20 mounting head rotatably mounted to the second end of the said second linkage arm and/or the orientation member, and arranged to rotate relative to the second orientation member, and being adapted to have a said implement mounted thereon; the axes of rotation and/or pivoting of each said pivot or rotational mounting or point being substantially parallel.

25 27. A linkage arrangement as claimed in Claim 26 wherein said first linkage means consists of at least two members.

28. A linkage arrangement as claimed in Claim 26 or Claim 27 wherein said second linkage means consists of at least two members.

29. A linkage arrangement as claimed in any one of Claims 26 to 28 wherein means is  
30 provided to rotate first linkage arm about said structure.

30. A linkage arrangement as claimed in Claim 29 wherein said means for rotating consists in a hydraulic ram.

31. A linkage arrangement as claimed in any one of Claims 26 to 31 wherein said

-35-

structure consists of a prime mover.

32. A linkage arrangement as claimed in any one of Claims 26 to 32 wherein said implement consists of a hoe.

33. A linkage arrangement for mounting an implement to a structure comprising:

5 a first linkage arm having a first end and a second end distal from said first end, and mounted at said first end to said structure at a pivot point and arranged to pivot relative to said structure about said pivot point;

an orientation member rotatably mounted to the said second end of the linkage mechanism and arranged to rotate thereon;

10 a second linkage arm pivotally mounted from said structure adjacent said first pivot point and extending to and pivotally mounted to the orientation member other than at rotation axis of said mounting of said first linkage arm and said orientation member;

a mounting head rotatably mounted to the distal end of either the first linkage arm or second linkage arm and/or the orientation member, and arranged to rotate relative to 15 the said orientation member, said mounting head adapted to have said implement mounted thereon; the axes of rotation and/or pivoting of each said pivot or rotational mounting or point being substantially parallel.

34. A linkage arrangement as claimed in Claim 33 wherein said first linkage arm and said second linkage arm in a cross over arrangement.

20 35. A linkage arrangement as claimed in either one of Claims 33 or 34 wherein there is provided means to rotate said orientation member about said structure.

36. A linkage arrangement as claimed in any one of Claims 33,34 or 35 wherein said means to rotate consists in a hydraulic ram.

37. A linkage arrangement as claimed in any one of Claims 33,34, 35 or 36 wherein said 25 structure comprises a prime mover.

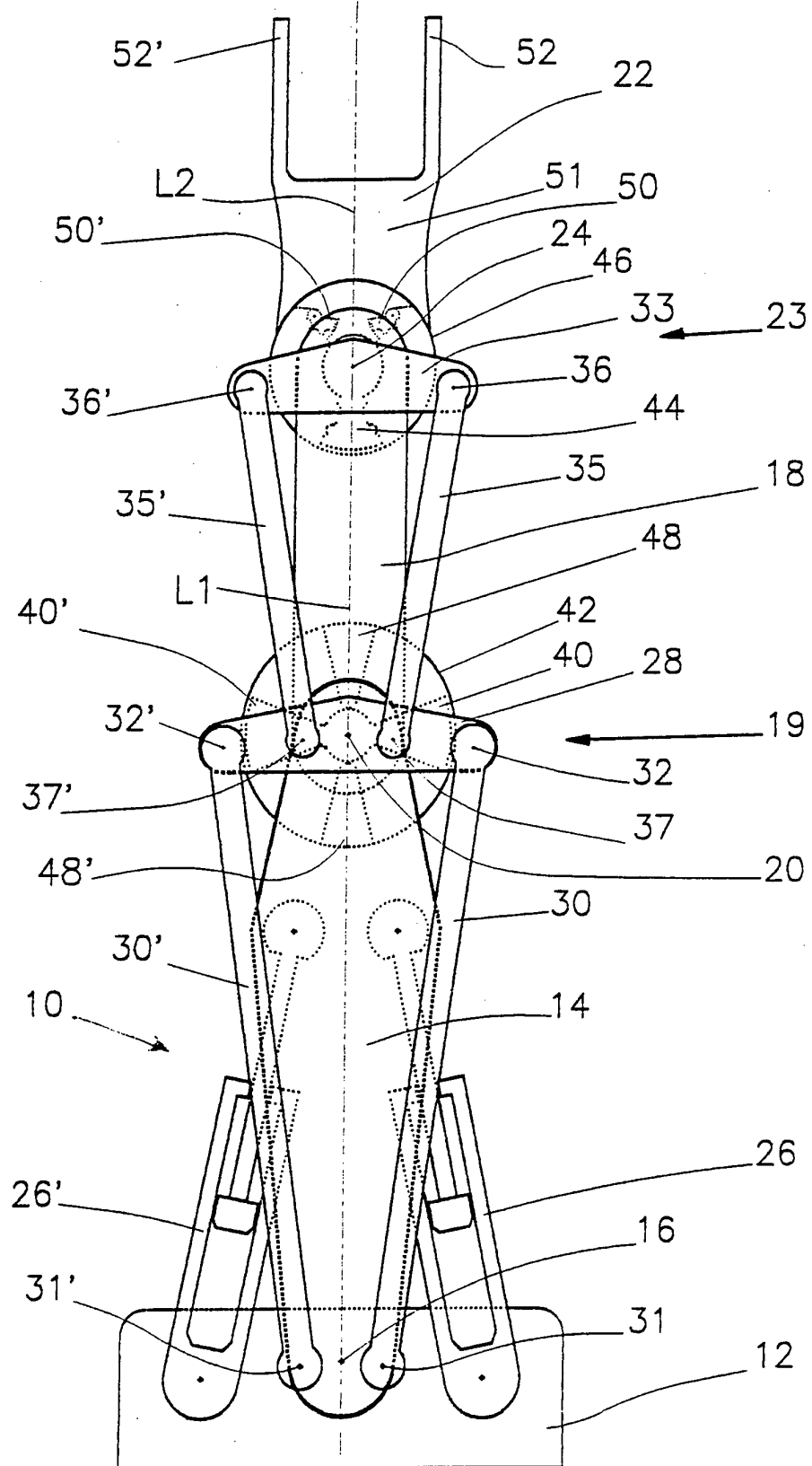
38. A linkage arrangement as claimed in any one of Claims 33, 34, 35, 36, 37 or 38 wherein said implement comprises a mower.

39. A linkage arrangement as claimed in any one of Claims 33, 34, 35, 36, 37 or 38 wherein said implement comprises a backhoe shovel.

1/10

CA

FIGURE 1



2/10

FIGURE 2

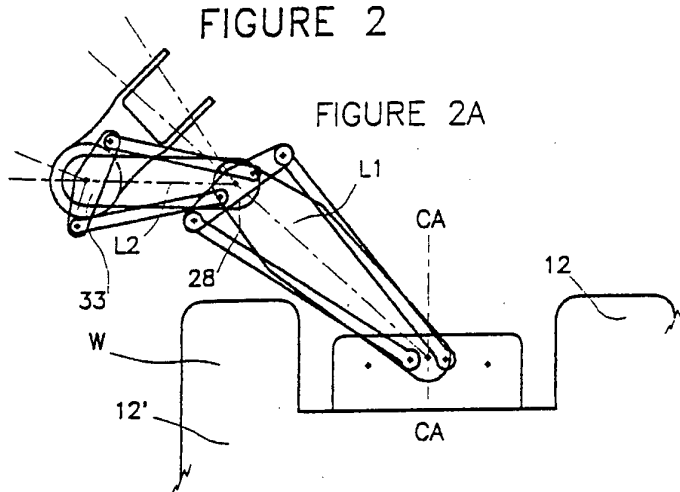


FIGURE 2B

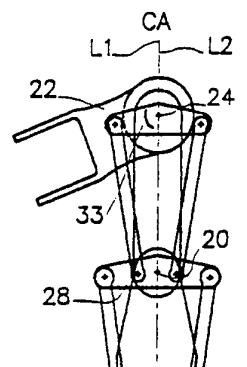


FIGURE 2C

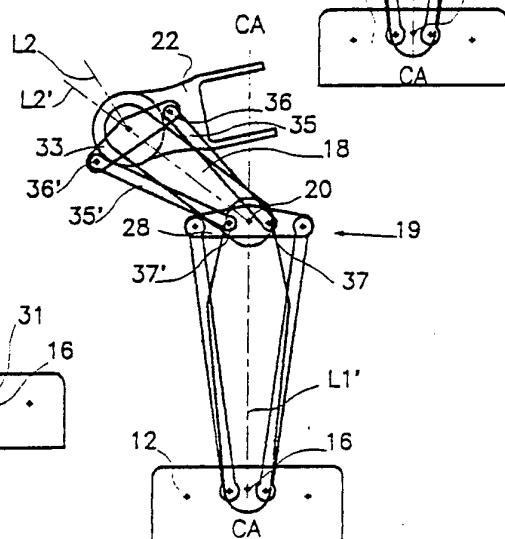


FIGURE 2D

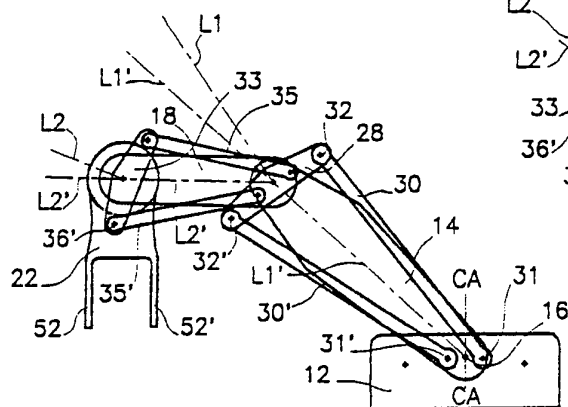


FIGURE 2E

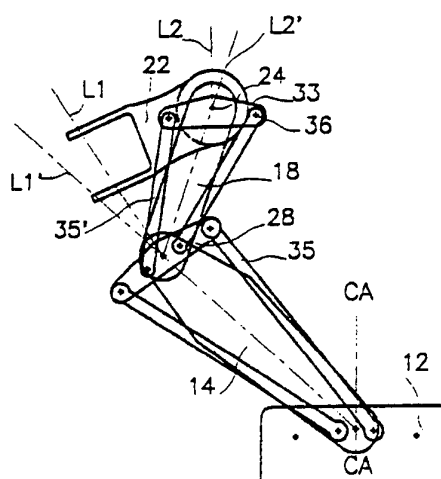


FIGURE 2F

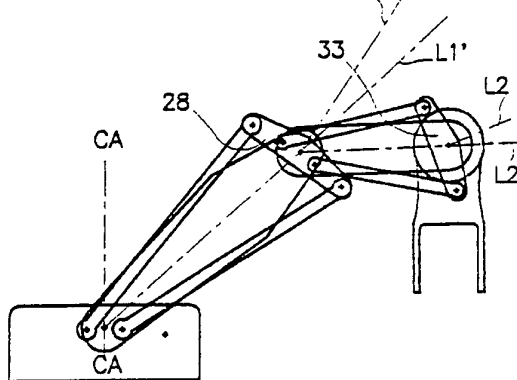


FIGURE 3.

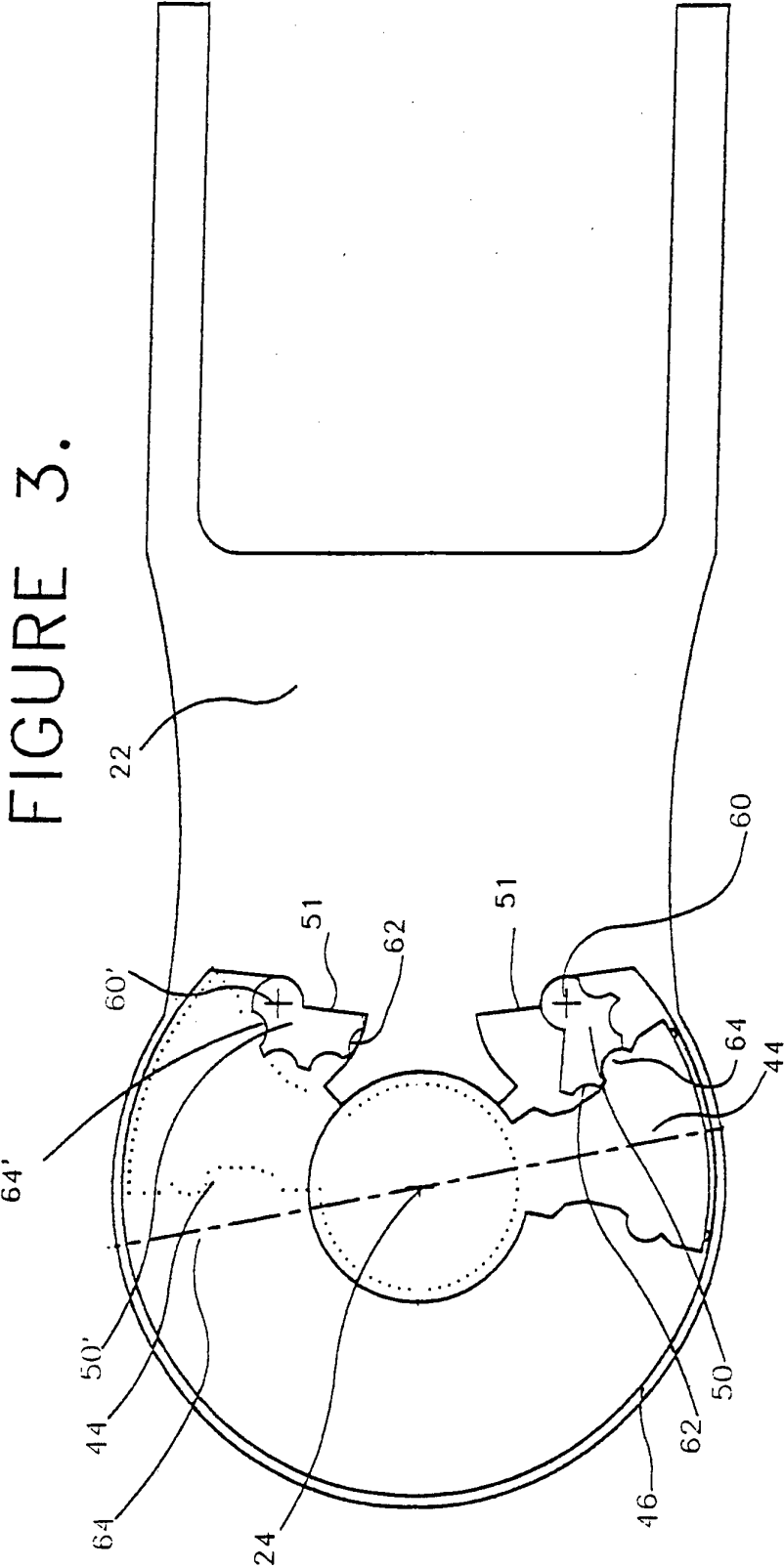


FIGURE 4

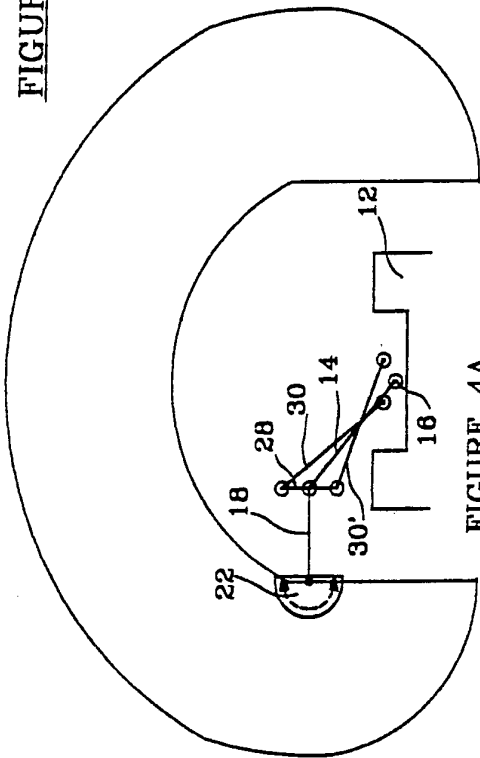


FIGURE 4A

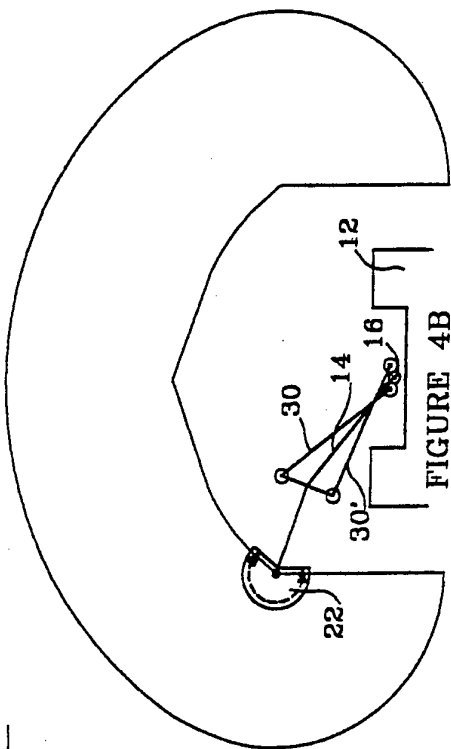


FIGURE 4B

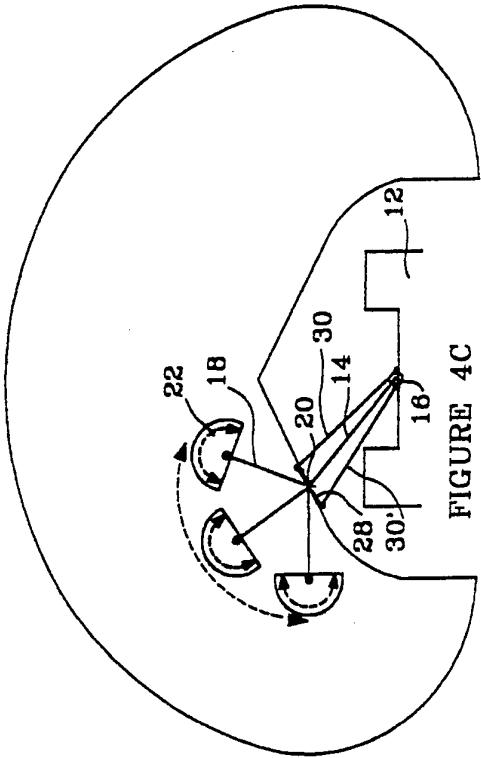


FIGURE 4C

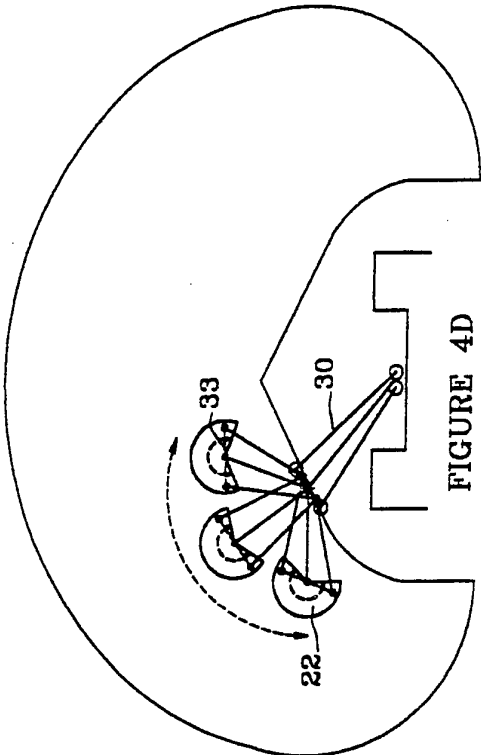
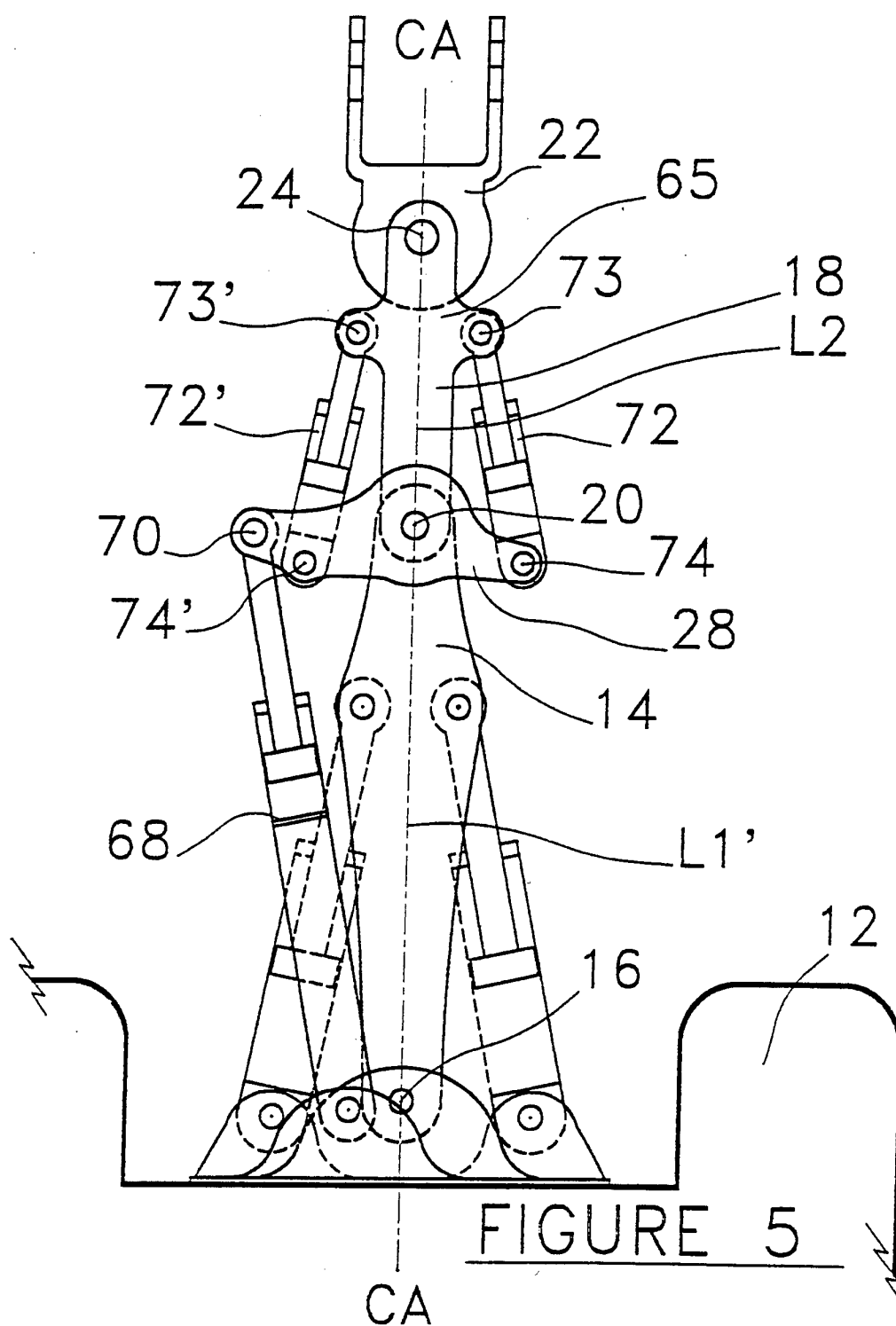
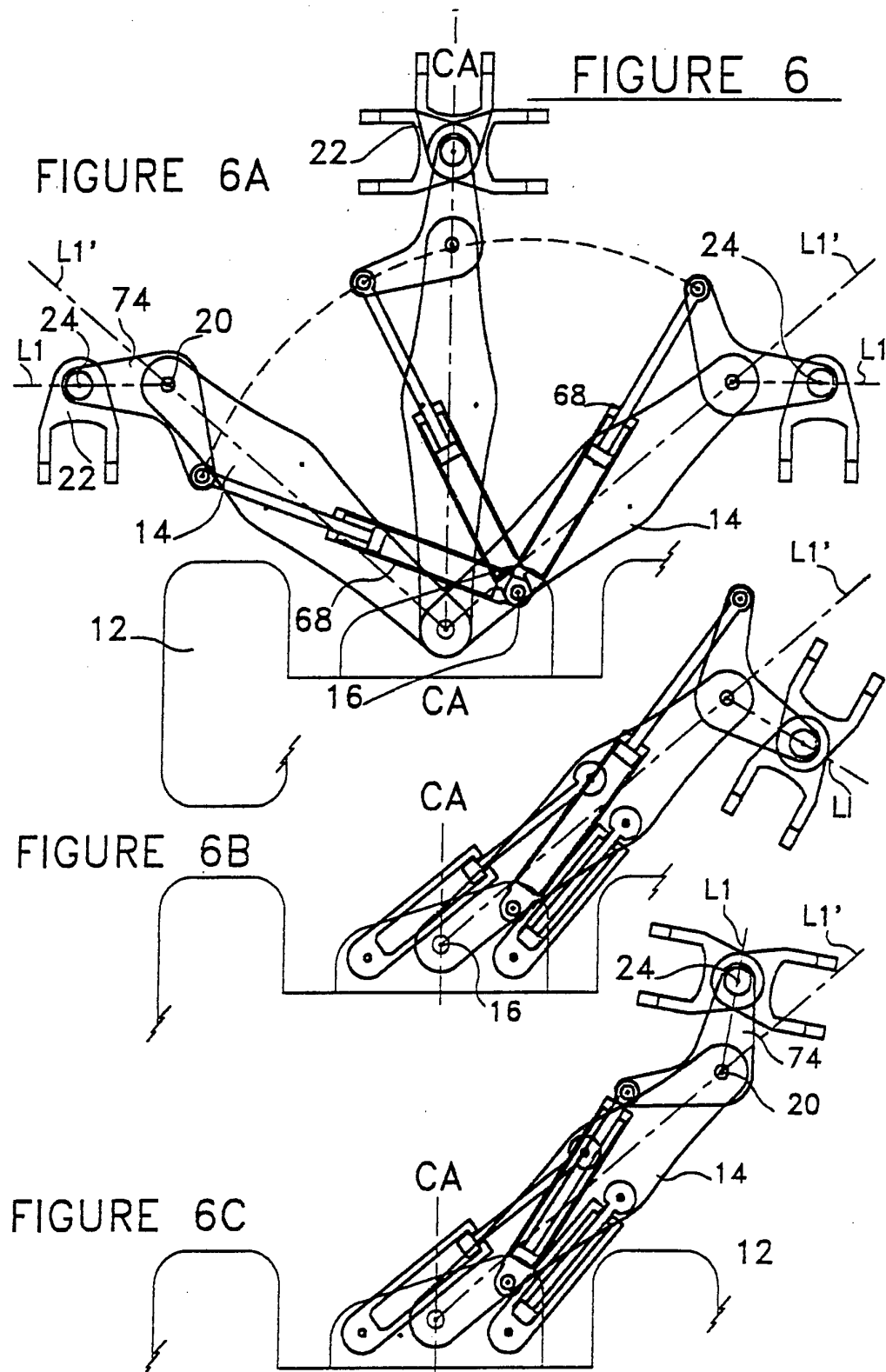


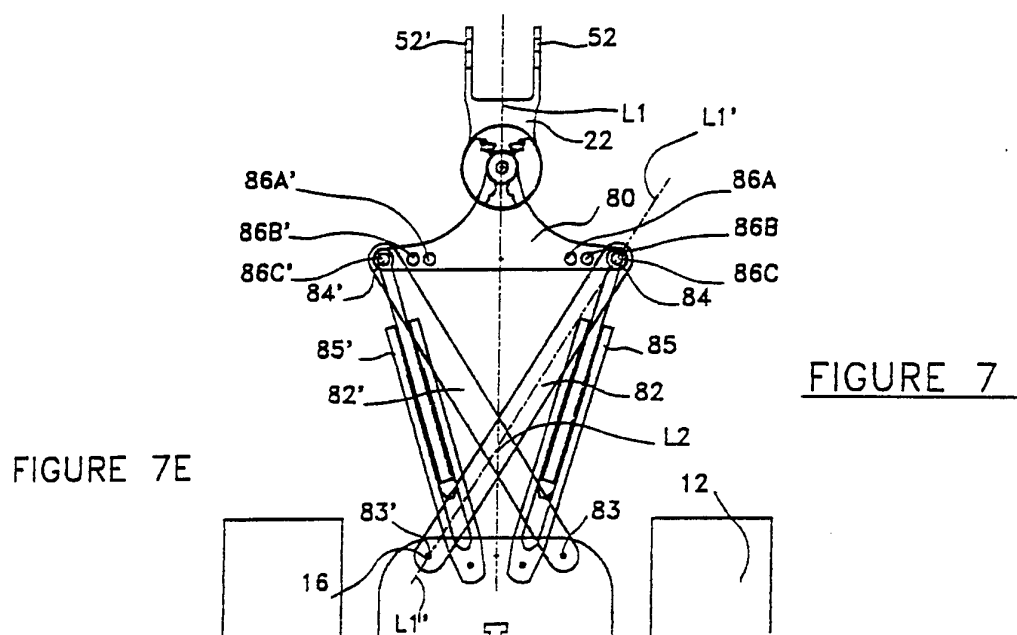
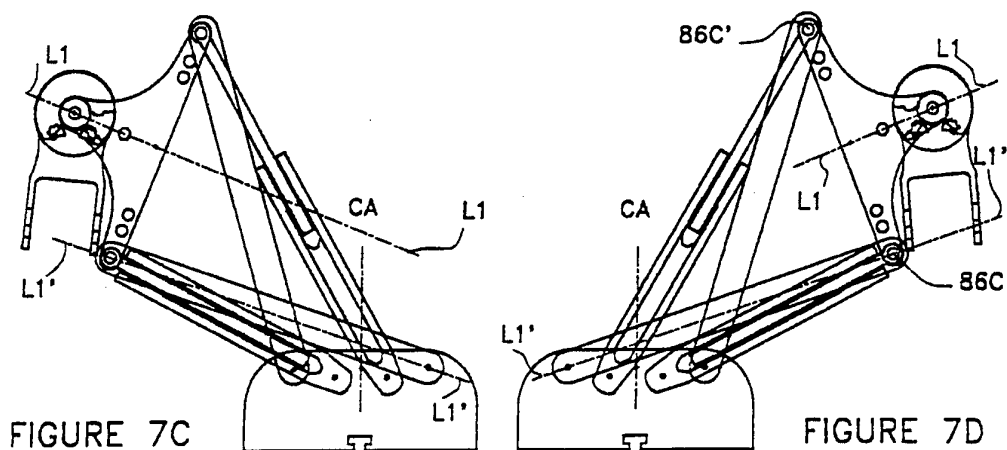
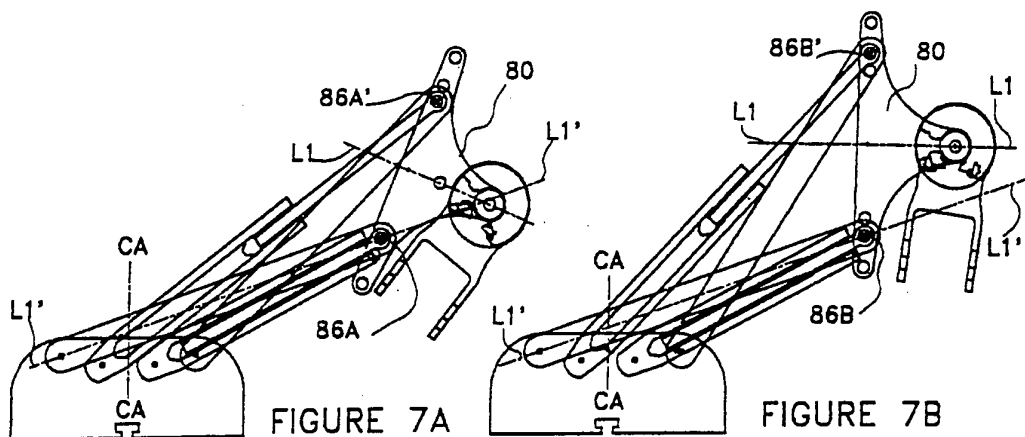
FIGURE 4D

5/10



6/10





8/10

FIGURE 8B

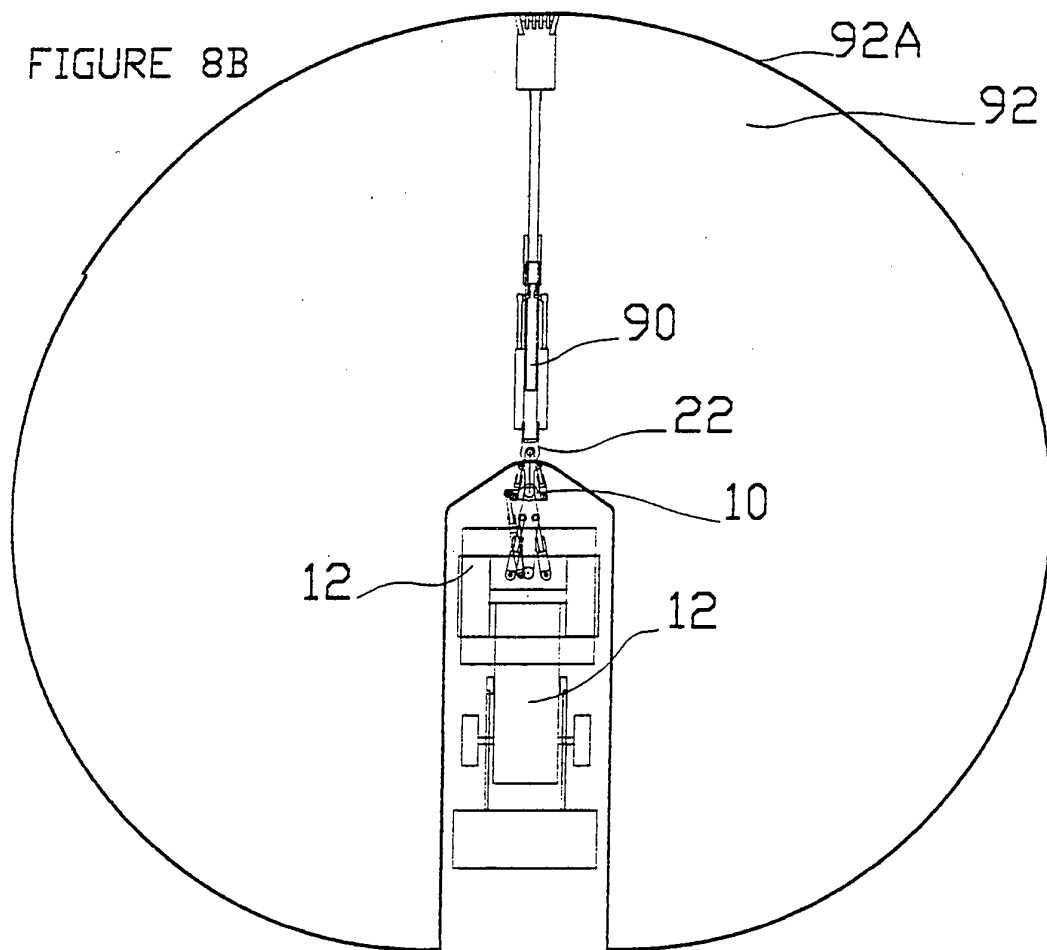


FIGURE 8A

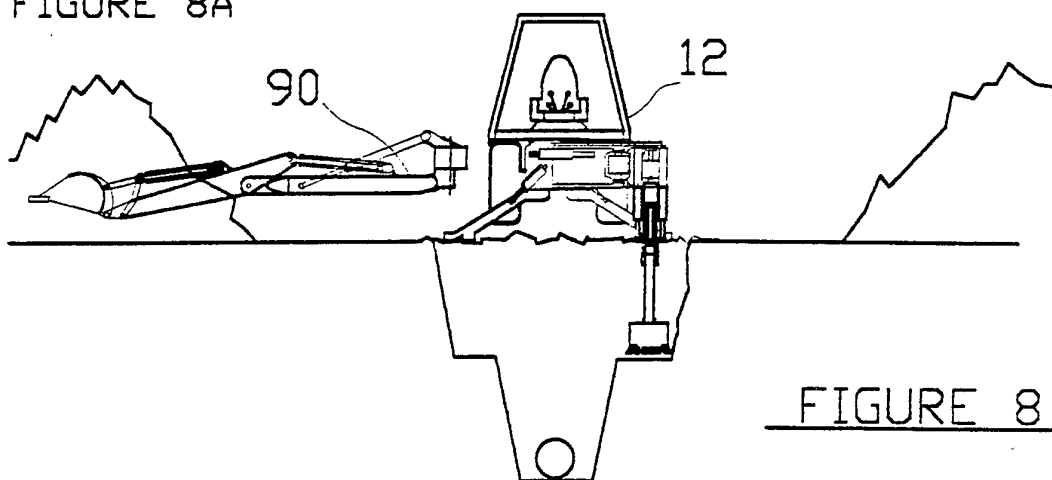
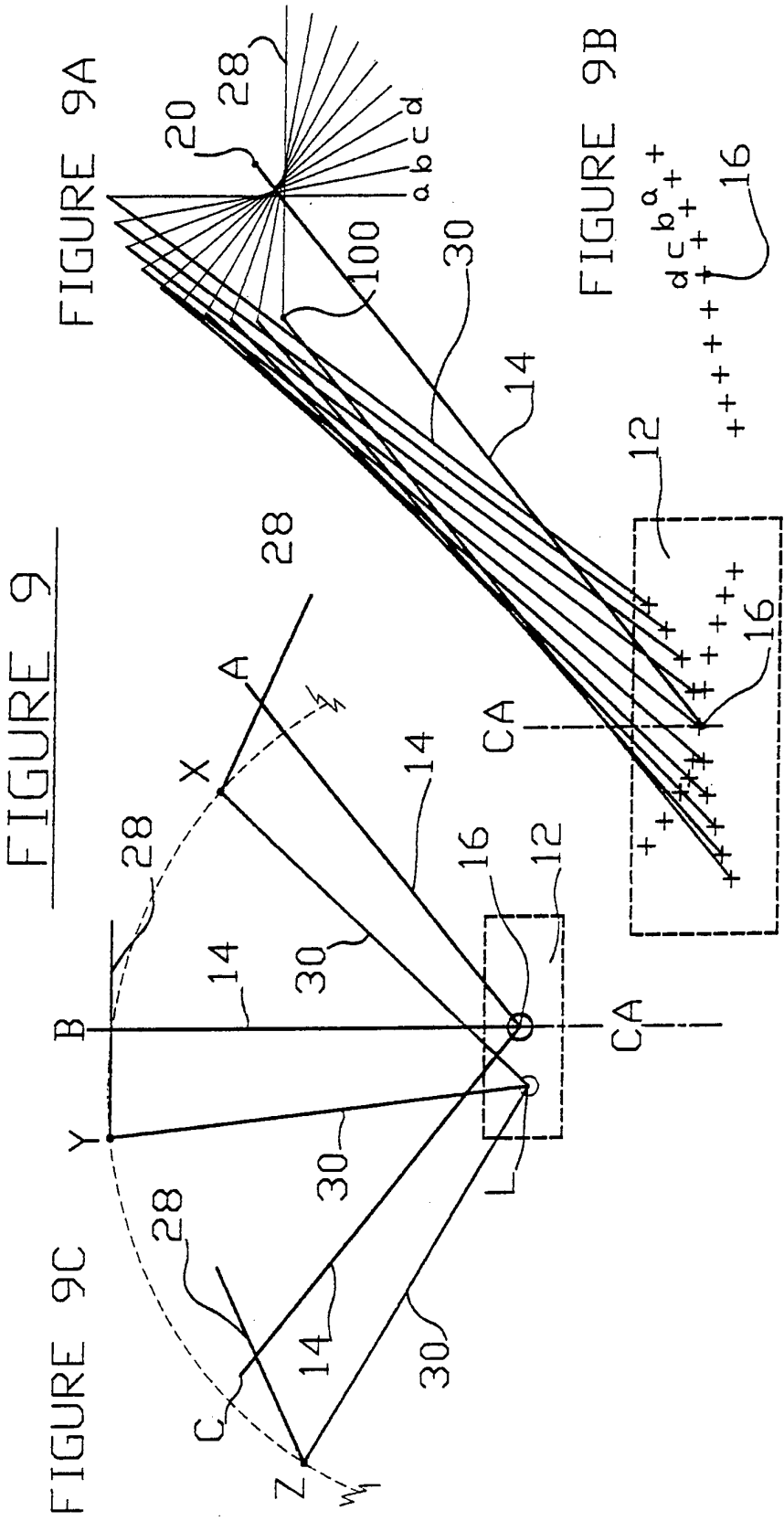
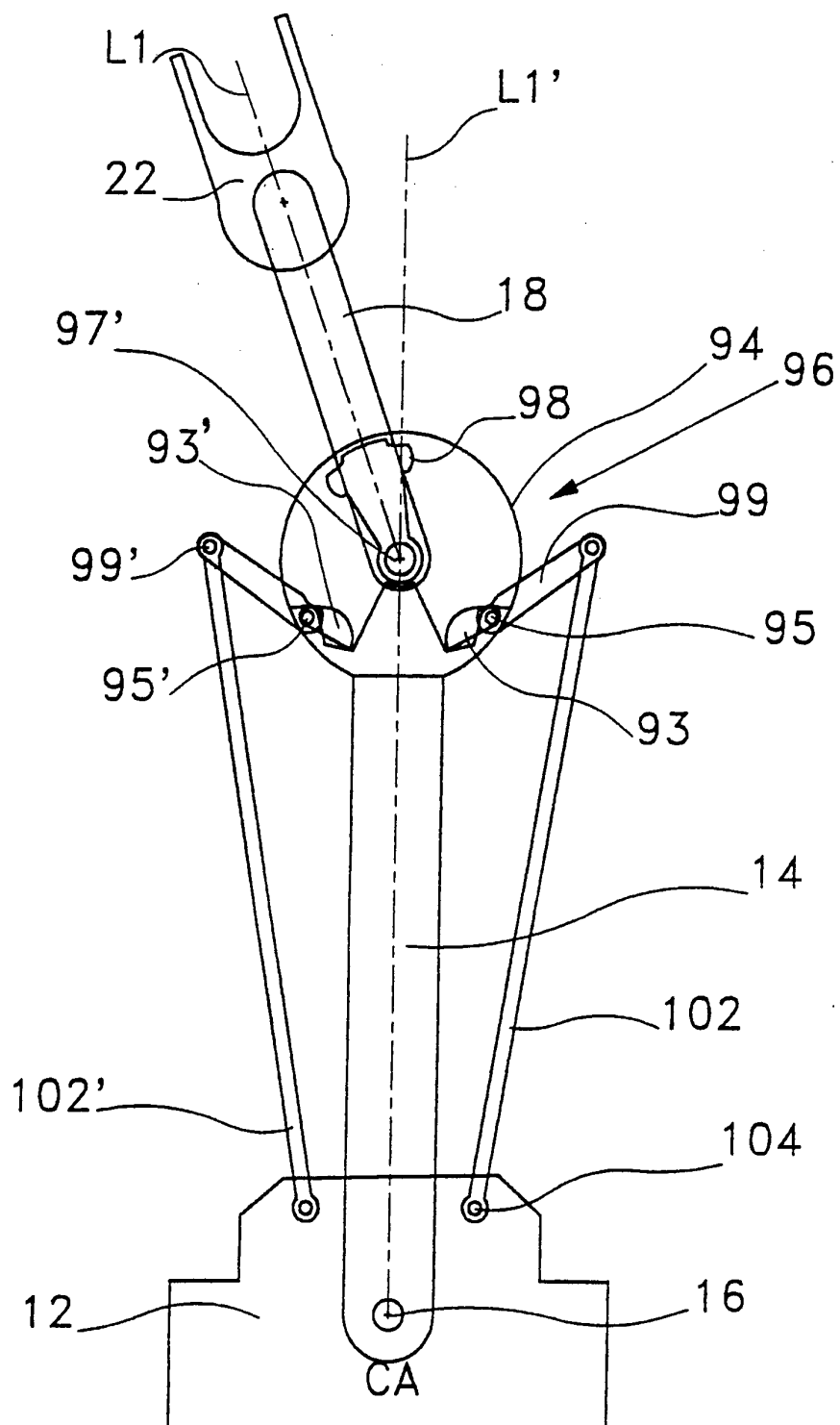


FIGURE 8



10/10

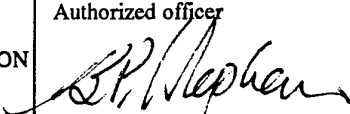
FIGURE 10.



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/NZ 93/00089

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <b>A. CLASSIFICATION OF SUBJECT MATTER</b><br>Int. Cl. <sup>5</sup> E02F 3/36, 9/28<br><br>According to International Patent Classification (IPC) or to both national classification and IPC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |
| <b>B. FIELDS SEARCHED</b><br><br>Minimum documentation searched (classification system followed by classification symbols)<br>IPC : E02F 3/36, 9/28<br><br>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched<br>AU : IPC as above<br><br>Electronic data base consulted during the international search (name of data base, and where practicable, search terms used)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |
| <b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |
| <b>Category*</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Citation of document, with indication, where appropriate, of the relevant passages</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Relevant to Claim No.</b>                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | AU,B, 14941/83 (562058) (ANDREW W. MILLWOOD) 1 December 1983 (01.12.83)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | US,A, 4958981 (MASATOSHI UCHIHASHI) 25 September 1990 (25.09.90)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |
| <div style="display: flex; justify-content: space-between;"> <div> <input type="checkbox"/> Further documents are listed in the continuation of Box C.         </div> <div> <input type="checkbox"/> See patent family annex.         </div> </div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |
| <table style="width: 100%; border: none;"> <tr> <td style="width: 33%; vertical-align: top;"> <p>* Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </td> <td style="width: 33%; vertical-align: top;"> <p>"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</p> <p>"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</p> <p>"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</p> <p>"&amp;" document member of the same patent family</p> </td> <td style="width: 33%;"></td> </tr> </table> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                       | <p>* Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> | <p>"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</p> <p>"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</p> <p>"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</p> <p>"&amp;" document member of the same patent family</p> |  |
| <p>* Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <p>"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</p> <p>"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</p> <p>"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</p> <p>"&amp;" document member of the same patent family</p> |                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |
| Date of the actual completion of the international search<br>26 November 1993 (26.11.93)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Date of mailing of the international search report<br>3 DEC 1993 (3.12.93)                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |
| Name and mailing address of the ISA/AU<br><br>AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION<br>PO BOX 200<br>WODEN ACT 2606<br>AUSTRALIA<br><br>Facsimile No. 06 2853929                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Authorized officer<br><br><b>BARRY STEPHENS</b><br><br>Telephone No. (06) 2832106 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |