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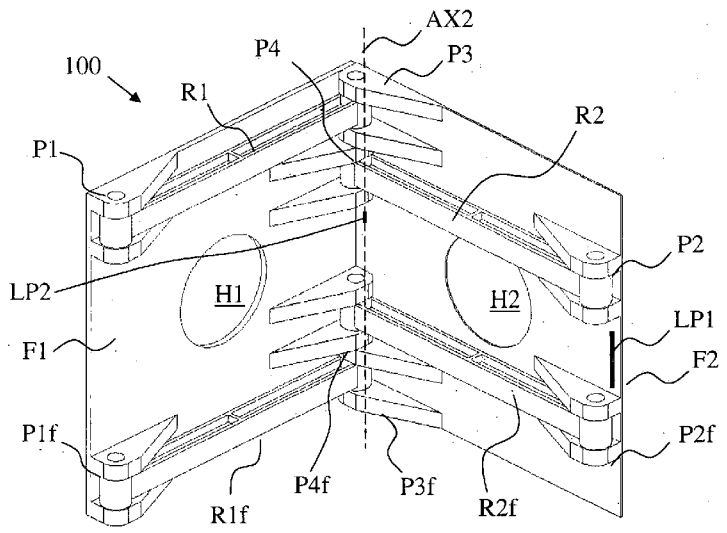

Fig. 2

(57) Abstract: There is provided a pivotal joint (100) comprising: • first and second frames (Fl, F2) that are pivotable with respect to one another about a first axis (AXI) and a second axis (AX2), the first and second axes being parallel to one another and at a constant non-zero distance apart from one another;. • a first rod (R I) connected to the first frame (Fl) by a first pivot attachment (PI) aligned with the first axis (AXI), and connected to the second frame (F2) by a third pivot (P3) attachment aligned with the second axis (AX2); and • a second rod (R2) connected to the first frame (Fl) by a fourth pivot attachment (P4) aligned with the second axis (AX2), and connected to the second frame (F2) by a second pivot attachment (P2) aligned with the first axis (AXI).

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PIVOTAL JOINT COMPRISING FIRST AND SECOND FRAMES

Technical Field of the Invention

This invention relates to a pivotal joint comprising first and second frames, in particular wherein the first and second frames are pivotable with respect to one another.

Background to the Invention

Known pivotal joints typically provide movement along one or more specified pivot axes, and can be used to connect two parts of a system together whilst allowing some relative movement between the parts.

One of the problems with known pivotal joints is that they often take up significant space between the parts to be connected, particularly as the number of axes of pivoting required between the parts is increased.

For example, US Patent No. 5,452,912 describes an articulated bus having a pulling vehicle, a pulled vehicle, and a pivotal joint therebetween to allow the pulling and pulled vehicles to pivot with respect to one another. A significant part of the length of the articulated bus is taken up by the pivotal joint section between the pulling and pulled vehicles, partly to allow the articulated bus to turn tightly without the ends of the pulling and pulled vehicles clashing with one another during turning.

It would be desirable to provide a pivotal joint that could be applied to connect two or more parts of a system together, without taking up too large a space between the parts.

It is therefore an aim of the invention to improve upon the known art.

Summary of the Invention

According to an embodiment of the invention, there is provided a pivotal joint comprising:

first and second frames that are pivotable with respect to one another about a first axis and a second axis, the first and second axes being parallel to one another and at a constant non-zero distance apart from one another;

a first rod connected to the first frame by a first pivot attachment aligned with the first axis, and connected to the second frame by a third pivot attachment aligned with the second axis; and

a second rod connected to the first frame by a fourth pivot attachment aligned with the second axis, and connected to the second frame by a second pivot attachment aligned with the first axis.

The provision of two spaced apart axes that are parallel to one another means that the pivotal joint can pivot about either the first axis or the second axis depending upon which direction the turn is being made in. Since there are two axes instead of only one, the first and second frames can pivot about one another over a wider angle before they come into contact with one another, and so the distance required between the first and second frames can be reduced.

The geometry of the first rod being connected to the first frame at the first axis and the second frame at the second axis, and the second rod being connected the first frame at the second axis and the second frame at the first axis, means that the two frames must pivot around only one of the first and second axes at a time. Attempting to pull the first and second frames apart from one another gives a scissor-like action between the rods that attempts to pull the first and second axes closer to one another, although since the distance between the first and second axis is fixed constant by the first to fourth pivot attachments connected to the frames, the frames cannot be pulled apart. Instead, the frames must pivot about one or the other of the first and second axes.

When the frames are pivoted about the first axis, the first pivot attachment and the second pivot attachment are axially aligned and so enable rotation about the first axis, and at least one of the third pivot attachment P3 and the fourth pivot attachment P4 move away from the second axis thereby preventing rotation about the second axis. When the frames are pivoted about the second axis, the third pivot attachment and the fourth pivot attachment are axially

aligned and so enable rotation about the second axis, and at least one of the first pivot attachment P1 and the second pivot attachment P2 move away from the first axis thereby preventing rotation about the first axis.

In order to improve the tensile strength of the joint and place less stress on the pivot attachments, the pivotal joint may further comprise a plurality of locking pins. The locking pins may be configured to lock the first and second pivot attachments in axial alignment with one another when the first and second frames are pivoted about the first axis, and to lock the third and fourth or pivot attachments in axial alignment with one another when the first and second frames are pivoted about the second axis. The locking pins may be inserted through apertures in the pivot attachments to hold the pivot attachments in axial alignment with one another. Respective apertures of the first and second pivot attachments may be axially aligned with the first axis, and respective apertures of the third and fourth pivot attachments may be axially aligned with the second axis.

Accordingly, a first locking pin may be inserted through the apertures of the first and second pivot attachments and a second locking pin may be withdrawn from the apertures of the third and fourth pivot attachments, to ensure pivoting movement about the first axis and to allow the third and fourth pivot attachments to swing away from one another. Furthermore, the first locking pin may be withdrawn from the apertures of the first and second pivot attachments, and the second locking pin may be inserted into the apertures of the third and fourth pivot attachments, to allow the first and second pivot attachments to swing away from one another and to ensure pivoting movement about the second axis.

The insertion and withdrawal of the first and second locking pins may be controlled by a wide variety of methods, for example by electrical and/or hydraulic and/or mechanical controls. Electronic sensors may be used to determine the first of the first and second pivot attachments and the third and fourth pivot attachments to move more than a certain distance apart from one another, and insert the relevant locking pin into the apertures of the other two pivot attachments. Alternatively, first and second cams may be used to move the first and second locking pins against first and second springs to set the position of the locking pins.

Both the first and second locking pins may also be inserted simultaneously to lock the pivotal joint so that no pivoting is possible about either one of the first and second axes.

Advantageously, the first and second axes may be at opposite sides of the first frame (and/or opposite sides of the second frame) to help maximise the angle over which the first and second frames can pivot about one another.

The first frame may comprise a first plate, the first and fourth pivot attachments being fixed to the first plate, and the second frame may comprise a second plate, the second and third pivot attachments being fixed to the second plate. The use of plates rather than open frameworks can help improve the rigidity of the frame and prevent un-wanted movement of the pivot attachments with respect to one another. Each one of the plates may comprise a hole passing therethrough, the holes being large enough for an adult person to pass through them. Accordingly, a person may move between two units that are connected together by the frames via the holes in the frames. The holes may be linked by a flexible tube through which the person can move from the first frame to the second frame.

The pivotal joint may comprise eleventh and twelfth frames that are pivotable with respect to one another about a eleventh axis and a twelfth axis, the eleventh and twelfth axes being parallel to one another and at a constant non-zero distance apart from one another, the joint comprising:

an eleventh rod connected to the eleventh frame by an eleventh pivot attachment aligned with the eleventh axis, and connected to the twelfth frame by a thirteenth pivot attachment aligned with the twelfth axis; and

a twelfth rod connected to the eleventh frame by a fourteenth pivot attachment aligned with the twelfth axis, and connected to the twelfth frame by a twelfth pivot attachment aligned with the eleventh axis.

Then, one of the first and second frames may be connected to one of the eleventh and twelfth frames, or one of the first and second frames may be the same frame as one of the eleventh and twelfth frames, so that the pivotal joint can provide pivoting about four axes, i.e. about the first, second, eleventh, and twelfth axes.

The eleventh frame may comprise an eleventh plate, the eleventh and fourteenth pivot attachments being fixed to the eleventh plate, and the twelfth frame may comprise a twelfth plate, the twelfth and thirteenth pivot attachments being fixed to the twelfth plate.

Furthermore, each one of the eleventh and twelfth plates may comprise a hole passing through the plate, the hole being large enough for an adult person to pass therethrough.

The pivotal joint may be arranged with the first and second axes perpendicular to the eleventh and twelfth axes to form a universal joint allowing relative movement in both up/down and left/right directions. In the case where one of the first and second frames is connected to one of the eleventh and twelfth frames, the relative rotation between the frames that are connected may be fixed. Or, in the case where one of the first and second frames is the same frame as one of the eleventh and twelfth frames, the same frame may have the pivot attachments fixed at one end of the same frame to set the first and second axes, and may have the pivot attachments fixed at an opposite end of the same frame to set the eleventh and twelve axes perpendicular to the first and second axes.

Alternatively, the first and second axes may define a first plane, the eleventh and twelfth axes may define a second plane, and one of the first and second frames may be connected to one of the eleventh and twelfth frames by a rotatable connection allowing the first and second axes to rotate within the first plane and the eleventh and twelfth axes to rotate within the second plane. Then, the pivotal joint may form a universal joint that also allows rotation.

The eleventh and twelfth frames may also have holes, with the tube passing through the holes of the first, second, eleventh, and twelfth frames. The tube is not necessarily circular in cross section, although a circular cross section may be advantageous to allow bending of the tube in any direction. When a rotatable connection is used to connect one of the first and second frames to one of the eleventh and twelfth frames, the rotatable connection may comprise a set of bearings surrounding the holes through the one of the first and second frames and the one of the eleventh and twelfth frames.

Advantageously, to further strengthen the pivotal joint, the pivotal joint may further comprise:

a further first rod connected to the first frame by a further first pivot attachment aligned with the first axis, and connected to the second frame by a further third pivot attachment aligned with the second axis; and

a further second rod connected to the first frame by a further fourth pivot attachment aligned with the second axis, and connected to the second frame by a further second pivot attachment aligned with the first axis.

Furthermore, the pivotal joint may further comprise:

a further eleventh rod connected to the eleventh frame by a further eleventh pivot attachment aligned with the eleventh axis, and connected to the twelfth frame by a further thirteenth pivot attachment aligned with the twelfth axis; and

a further twelfth rod connected to the eleventh frame by a further fourteenth pivot attachment aligned with the twelfth axis, and connected to the twelfth frame by a further twelfth pivot attachment aligned with the eleventh axis.

Further locking pins may be provided for the pivot attachments besides the first, second, third and fourth pivot attachments, in just the same manner as the first and second locking pins that are provided for the first, second, third and fourth pivot attachments.

The pivotal joint may for example be used to connect between two carriages, transporters, or other vehicular units. The pivotal joint could also be used to move an earth moving bucket attached to a vehicle. In one example, the pivotal joint could be used to tip the contents of the bucket either side of the vehicle or in another example, the joint could be rotated before tipping the contents of the bucket out. The pivotal joint could also be used as an aerodynamic control surface. For example one frame of the pivotal joint could be raised and lowered to act as a control surface to adjust the direction of a portion of air over the frame surface, the frame surface acting like an aileron or taileron and the other frame surface could be raised to act like an airbrake. Other such combinations of uses of the pivotal joint could be used for adjusting airflow, the shape of the surface of the frame does not need to be limited to a flat surface but could be curved or another shape. The pivotal joint could also be used between various parts in other smaller-scale applications, as will be apparent to those skilled in the art.

The terminology first, second, third, fourth, eleventh, twelve, thirteenth, and fourteenth is purely used to label the various parts of embodiments of the invention, and does not imply any particular ordering or the presence of any differently labelled parts such as fifth to tenth parts.

Brief Description of the Drawings

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

Fig. 1 shows a schematic perspective diagram of a pivotal joint according to a first embodiment of the invention when the pivotal joint is in a closed position;
Fig. 2 shows a schematic perspective diagram of the pivotal joint of Fig. 1 when the pivotal joint is pivoted about a second axis;
Fig. 3 shows a schematic perspective diagram of the pivotal joint of Fig. 1 when the pivotal joint is pivoted about a first axis;
Fig. 4 shows a schematic perspective diagram of a pivotal joint according to a second embodiment of the invention when the pivotal joint is in a closed position;
Fig. 5 shows a schematic perspective diagram of the pivotal joint of Fig. 4 when the pivotal joint is pivoted about a second axis and a twelfth axis;
Fig. 6 shows a schematic perspective diagram of the pivotal joint of Fig. 4 when the pivotal joint is pivoted about a second axis and; and an eleventh axis;
Fig. 7 shows a schematic perspective diagram of a pivotal joint according to a third embodiment of the invention when the pivotal joint is in an open position;

The drawings are purely illustrative and are not to scale. Same or similar reference signs denote same or similar features.

Detailed Description

A first embodiment of the invention will now be described with reference to Figs 1 – 3. The schematic diagram of Fig. 1 shows a pivotal joint 100 when in a closed position. The pivotal joint comprises a first frame F1 and a second frame F2 that face towards one another, the first frame F1 being a plate that has a hole H1 and the second frame F2 being a plate that has a hole H2.

The first frame F1 and the second frame F2 can pivot with respect to one another about an axis AX1 at one side of the pivotal joint, or about an axis AX2 at an opposite side of the pivotal joint. Visible in Fig. 1 are a first pivot attachment P1, a third pivot attachment P3, a

fourth pivot attachment P4, a further third pivot attachment P3f, and a further fourth pivot attachment P4f. The pivot attachments are formed as protrusions upon the plates of frame F1 and F2, and are attached to rods going between the pivot attachments of the frames.

In this embodiment, the first and second frames F1 and F2 are formed of metal plates, for example steel plates, and each pivot attachment comprises two protrusions supporting opposite ends of a pivot axle that extends through a respective rod. In this embodiment, the pivot axles are inserted through the pivot attachments and the respective rods to pivotally attach the rod to the pivot attachments. Alternatively, the pivot axle may be comprised within the pivot attachment or within the corresponding rod, for example if the pivot axle is formed integrally with the pivot attachment or formed integrally with the corresponding rod. In this embodiment, the pivot axes AX1 and AX2 are at opposite sides of the first frame F1 and at opposite side of the first frame F2, although one of the frames could extend further outwardly in a direction perpendicular to the axes if desired. For example, the axes AX1 and AX2 could be placed at opposite sides of the first frame, but the second frame could be wider so that the axis AX1 fell 1/3 of the way across the second frame and the axis AX2 fell 2/3 of the way across the second frame.

The schematic diagram of Fig. 2 shows the pivotal joint 100 of Fig. 1 when the pivotal joint has been pivoted through 120 degrees about the second axis AX2. The first frame F1 is at the left side of the figure and the second frame F2 is at the right side of the figure. A first rod R1 is connected to the first frame F1 by a first pivot attachment P1, and is connected to the second frame F2 by a third pivot attachment P3. A second rod R2 is connected to the first frame F1 by a fourth pivot attachment P4, and is connected to the second frame F2 by a second pivot attachment P2.

In order to provide further stabilisation to the pivotal joint, a further first rod R1f is connected to the first frame F1 by a further first pivot attachment P1f, and is connected to the second frame F2 by a further third pivot attachment P3f. A further second rod R2f is connected to the first frame F1 by a further fourth pivot attachment P4f, and is connected to the second frame F2 by a further second pivot attachment P2f.

In the position shown in Fig. 2, the first and further first rods R1 and R1f lie along the first frame F1, and the second and further second rods R2 and R2f lie along the second frame F2.

The first frame F1 is fitted with a second locking pin LP2 that has been slid along the second axis AX2 from a position between the fourth P4 and further fourth P4f pivot attachments to a position inside the fourth P4 and third pivot attachments P3 to help hold the fourth and third pivot attachments in alignment along the second axis. The second frame F2 is fitted with a first locking pin LP1 that has been withdrawn from the second P2 and first P1 pivot attachments along the first axis, to between the second P2 and further second P2f pivot attachments.

The schematic diagram of Fig. 3 shows the pivotal joint 100 of Fig. 1 when the pivotal joint has been pivoted through 120 degrees about the first axis AX1. The second frame F2 is at the left side of the figure and the first frame F1 is at the right side of the figure. In this position, the first and further first rods R1 and R1f now lie along the second frame F2, and the second and further second rods R2 and R2f now lie along the second frame F2.

The second locking pin LP2 has been withdrawn from the fourth P4 and third pivot attachments P3 along the second axis AX2 to a position between the fourth P4 and further fourth P4f pivot attachments, and the first locking pin LP1 has been inserted into the second P2 and first P1 pivot attachments along the first axis, to help hold the first and second pivot attachments in axial alignment.

The pivotal joint 100 may for example be used to form a connection between two vehicles to allow left/right turns, without the pivotal joint taking up too much space between the two vehicles. The holes H1 and H2 in the first and second plates respectively may enable a person to move between the two vehicles that are joined by the pivotal joint 100. A tube (not shown in Figs for clarity) may be provided between the two vehicles and through the holes H1 and H2, to assist movement of a person therethrough. The holes and tubes could have shapes other than circular shapes, for example rectangular shapes.

In the closed position shown in Fig. 1, the first pivot attachment P1 and the second pivot attachment P2 are aligned with the first axis AX1, and the third pivot attachment P3 and the fourth pivot attachment P4 are aligned with the second axis AX2. Accordingly, in use the rods R1 and R2 can pivot in opposite directions to one another about the pivot attachments P1 and P2 to allow the frames to pivot about the first axis (refer to Fig. 3), and the rods R1 and

R2 can also pivot in opposite directions to one another about the pivot attachments P3 and P4 to allow the frames to pivot about the second axis AX2 (refer to Fig. 2).

A second embodiment of the invention will now be described with reference to Figs. 4 – 6. The schematic diagram of Fig. 4 shows two units U1 and U2 that are connected together by a pivotal joint that comprises two of the pivotal joints of Figs. 1 – 3 when fixed at a rotation of 90 degrees with respect to one another. In particular, the pivotal joint comprises eleventh and twelfth frames F11 and F12 with corresponding pivotal attachments and rods that are similar to the pivotal attachments and rods of the first and second frames F1 and F2 described in relation to the first embodiment.

The first frame F1 is connected to the eleventh frame F11 at a 90 degree angle, and so enables pivoting about eleventh and twelfth axes AX11 and AX12 that are perpendicular to the first and second axes AX1 and AX2.

The schematic diagram of Fig. 5 shows the units U1 and U2 when they have been pivoted by 90 degrees about the second axis AX2 by the first and second frames F1 and F2, and 90 degrees about the twelfth axis AX12 by the eleventh and twelfth frames F11 and F12. An eleventh rod R11 is connected to the eleventh frame F11 by an eleventh pivot attachment P11, and is connected to the twelfth frame F12 by a thirteenth pivot attachment P13. A twelfth rod R12 is connected to the eleventh frame F11 by a fourteenth pivot attachment P14, and is connected to the twelfth frame F12 by a twelfth pivot attachment P12.

In order to provide further stabilisation to the pivotal joint, a further eleventh rod R11f is connected to the eleventh frame F11 by a further eleventh pivot attachment, and is connected to the twelfth frame F12 by a further thirteenth pivot attachment. A further twelfth rod R12f is connected to the eleventh frame F11 by a further fourteenth pivot attachment, and is connected to the twelfth frame F12 by a further twelfth pivot attachment P12f.

The schematic diagram of Fig. 6 shows the units U1 and U2 when they have been pivoted by 90 degrees about the second axis AX2 by the first and second frames F1 and F2, and 90 degrees about the eleventh axis AX11 by the eleventh and twelfth frames F11 and F12.

The second and twelfth frames F2 and F12 are formed as part of the units U1 and U2 respectively, and the first and eleventh frames abut one another. Alternatively, the first and eleventh frames may be formed as a single frame having the various pivot attachments formed on either side of it.

The eleventh and twelfth frames F11 and F12 are plates that each comprise a hole for allowing the passage of an adult person therethrough. In a similar manner to the first embodiment, the holes through the first, second, eleventh, and twelfth plates may be fitted with a flexible tube connecting between the first and second units U1 and U2 for supporting the adult person.

The second embodiment of the invention allows pivoting of the units U1 and U2 in left/right and up/down directions, improving the range of movement compared to the pivotal joint of the first embodiment.

The schematic diagram of Fig. 7 shows a pivotal joint according to a third embodiment of the invention. The third embodiment differs from the second embodiment in that the pivotal joint further comprises a rotatable connection RC between the first and eleventh frames F1 and F11, so that the units U1 and U2 can rotate with respect to one another, as well as pivot in left/right and up/down directions. In this embodiment, the rotatable connection RC comprises a set of bearings surrounding the holes through the first and eleventh frames.

The units U1 and U2 are shown in Fig. 4 - 7 with large pivot angles between them so that the various pivot attachments and rods can be easily seen, although in some applications such as for connecting vehicular units the pivot angles are obviously likely to be much smaller.

Various other embodiments of the invention falling within the scope of the appended claims will be apparent to those skilled in the art. For example, although the described embodiments are shown with particular types of frames and particular types of pivots, other types of frames and pivots could alternatively be used, for example frames formed of open frameworks rather than plates.

CLAIMS

1. A pivotal joint comprising:

first and second frames that are pivotable with respect to one another about a first axis and a second axis, the first and second axes being parallel to one another and at a constant non-zero distance apart from one another;

a first rod connected to the first frame by a first pivot attachment aligned with the first axis, and connected to the second frame by a third pivot attachment aligned with the second axis; and

a second rod connected to the first frame by a fourth pivot attachment aligned with the second axis, and connected to the second frame by a second pivot attachment aligned with the first axis.

2. The pivotal joint of claim 1, wherein the first and second axes are positioned at:

- opposite sides of the first frame;
- opposite sides of the second frame; or
- opposite sides of the first frame and at opposite sides of the second frame.

3. The pivotal joint of claim 1 or 2, further comprising a plurality of locking pins, the locking pins configured to lock the first and second pivot attachments in axial alignment with one another when the first and second frames are pivoted about the first axis, and to lock the third and fourth or pivot attachments in axial alignment with one another when the first and second frames are pivoted about the second axis.

4. The pivotal joint of any preceding claim, wherein the first frame comprises a first plate, the first and fourth pivot attachments being fixed to the first plate, and wherein the second frame comprises a second plate, the second and third pivot attachments being fixed to the second plate.

5. The pivotal joint of claim 4, wherein each one of the first and second plates comprises a hole passing through the plate, the hole being large enough for an adult person to pass therethrough.

6. The pivotal joint of any preceding claim, further comprising:

eleventh and twelfth frames that are pivotable with respect to one another about a eleventh axis and a twelfth axis, the eleventh and twelfth axes being parallel to one another and at a constant non-zero distance apart from one another, the joint comprising:

an eleventh rod connected to the eleventh frame by an eleventh pivot attachment aligned with the eleventh axis, and connected to the twelfth frame by a thirteenth pivot attachment aligned with the twelfth axis; and

a twelfth rod connected to the eleventh frame by a fourteenth pivot attachment aligned with the twelfth axis, and connected to the twelfth frame by a twelfth pivot attachment aligned with the eleventh axis.

7. The pivotal joint of claim 6, wherein the eleventh frame comprises an eleventh plate, the eleventh and fourteenth pivot attachments being fixed to the eleventh plate, and wherein the twelfth frame comprises a twelfth plate, the twelfth and thirteenth pivot attachments being fixed to the twelfth plate.

8. The pivotal joint of claim 7, wherein each one of the eleventh and twelfth plates comprises a hole passing through the plate, the hole being large enough for an adult person to pass therethrough.

9. The pivotal joint of claim 6, 7, or 8, wherein the first and second axes define a first plane, wherein the eleventh and twelfth axes define a second plane, and wherein one of the first and second frames is connected to one of the eleventh and twelfth frames by a rotatable connection allowing the first and second axes to rotate within the first plane and the eleventh and twelfth axes to rotate within the second plane.

10. The pivotal joint of claim 9 when appended to claim 8, wherein claim 6 is appended to claim 5, and wherein the rotatable connection comprises a set of bearings surrounding the holes through the one of the first and second frames and the one of the eleventh and twelfth frames.

11. The pivotal joint of claim 6, 7, or 8, wherein one of the first and second frames is connected to one of the eleventh and twelfth frames at a fixed rotation setting the first and second axes perpendicular to the eleventh and twelfth axes.

12. The pivotal joint of claim 6, 7 or 8, wherein one of the first and second frames is the same frame as one of the eleventh and twelfth frames, the first and second axes being perpendicular to the eleventh and twelfth axes.

13. The pivotal joint of any preceding claim, further comprising:

a further first rod connected to the first frame by a further first pivot attachment aligned with the first axis, and connected to the second frame by a further third pivot attachment aligned with the second axis; and

a further second rod connected to the first frame by a further fourth pivot attachment aligned with the second axis, and connected to the second frame by a further second pivot attachment aligned with the first axis.

14. The pivotal joint of any one of claims 6 – 12, or of claim 13 when claim 13 is appended to any one of claims 6 – 12, wherein the pivotal joint further comprises:

a further eleventh rod connected to the eleventh frame by a further eleventh pivot attachment aligned with the eleventh axis, and connected to the twelfth frame by a further thirteenth pivot attachment aligned with the twelfth axis; and

a further twelfth rod connected to the eleventh frame by a further fourteenth pivot attachment aligned with the twelfth axis, and connected to the twelfth frame by a further twelfth pivot attachment aligned with the eleventh axis.

15. The pivotal joint of any preceding claim, wherein the pivotal joint is a pivotal joint between two carriages, transporters, or other vehicular units.

16. An earth moving vehicle comprising an earth moving bucket having a pivotal joint according to any one of claims 1 to claim 14.

17. A pivotal joint substantially as described herein with reference to the accompanying drawings.

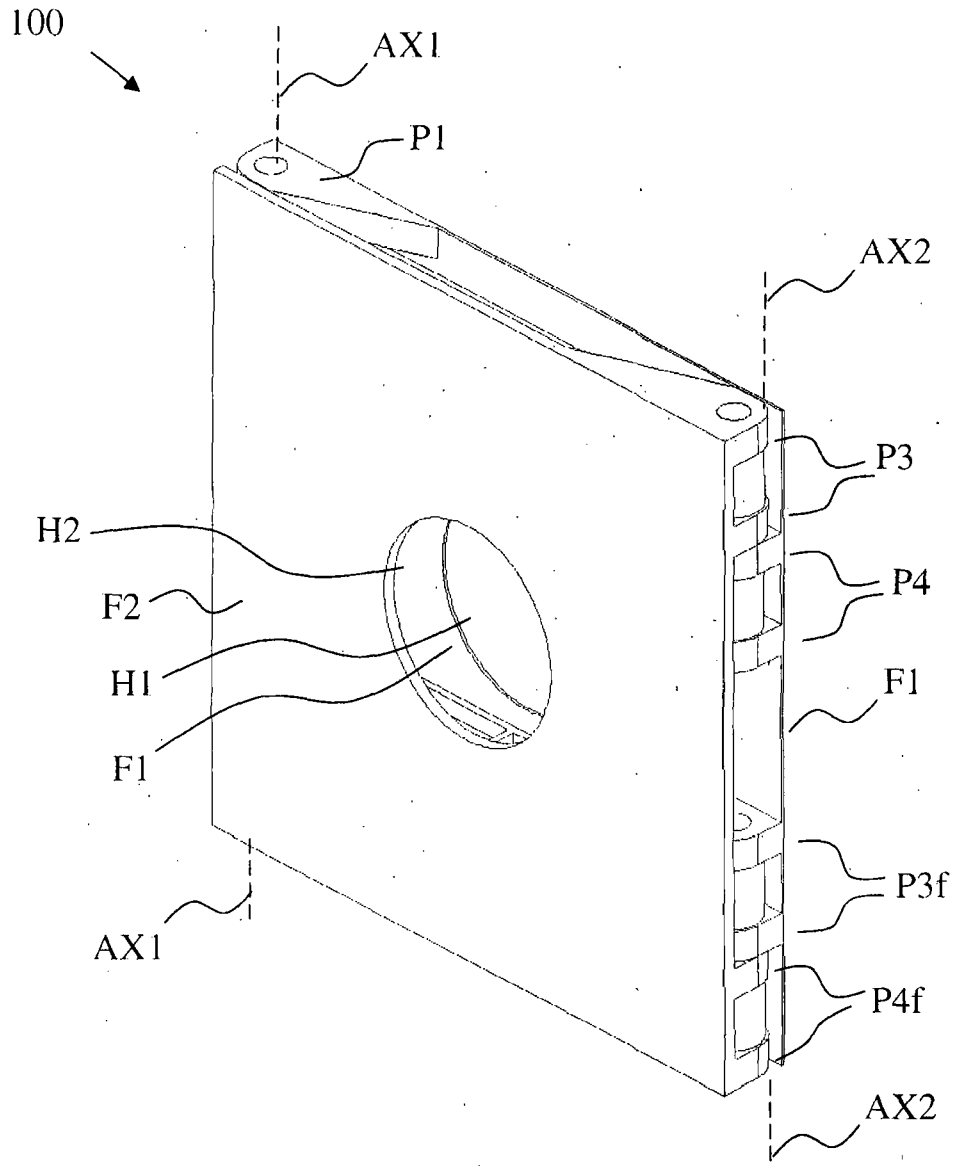
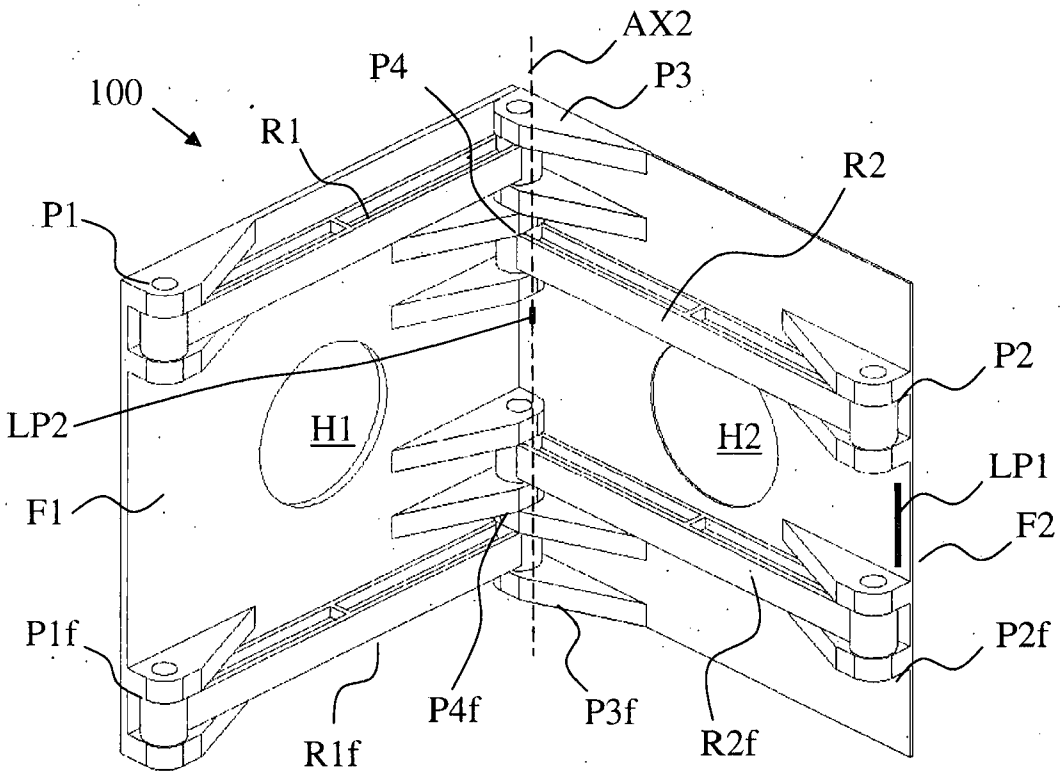


Fig. 1


AX2
P4
P3
100
R1
R2
P1
P2
LP2
H1
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R1f
P4f
P3f
R2f

Fig. 2

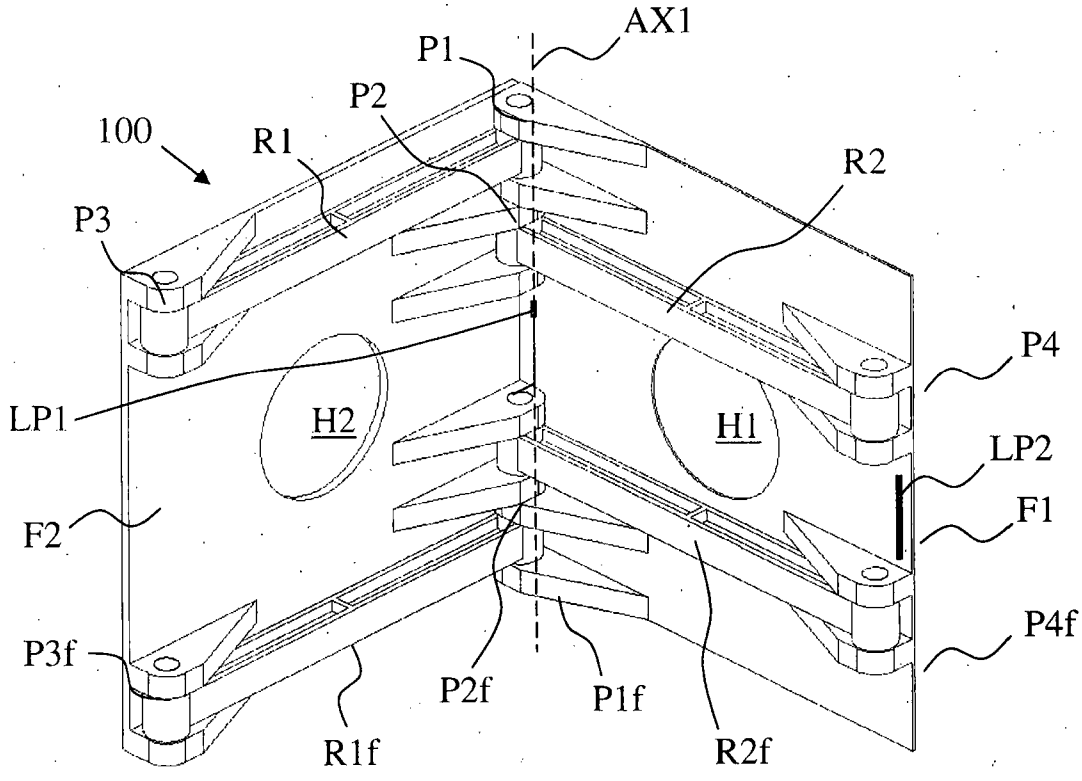
AX1
P1
P2
100
R1
R2
P3
P4
LP1
H2
H1
LP2
F2
F1
P3f
P4f
R1f
P2f
P1f
R2f

Fig. 3

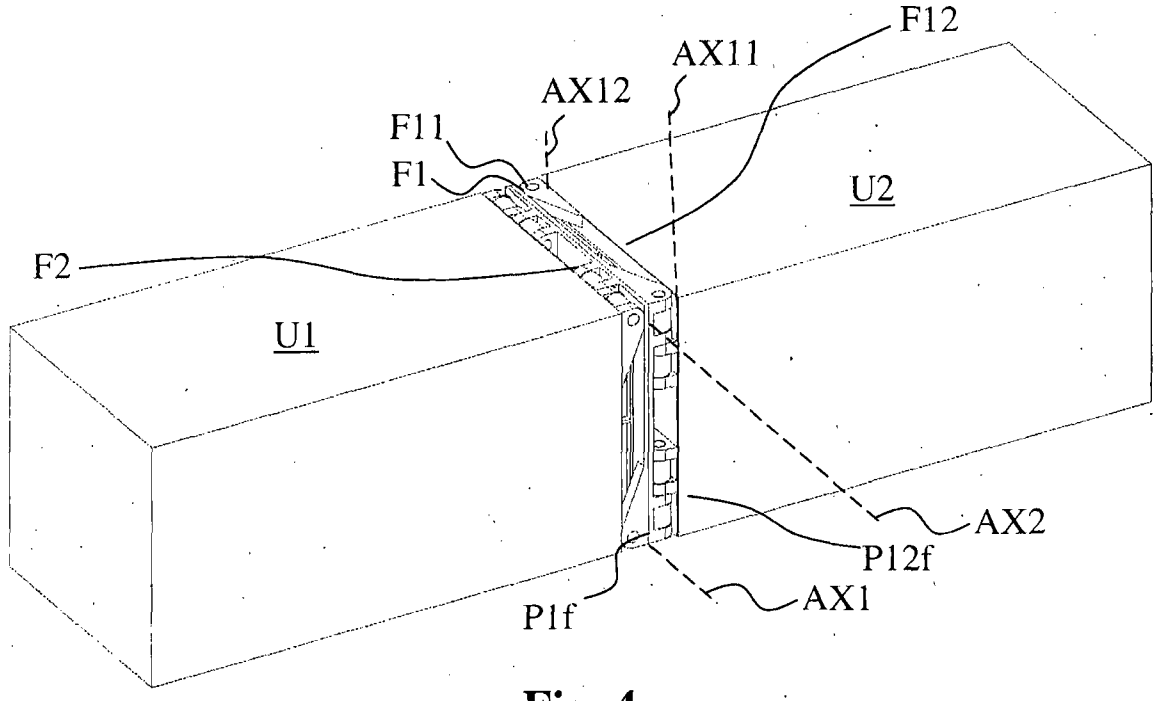
F12
AX11
AX12
F11
F1
U2
F2
U1
AX2
P12f
AX1
P1f

Fig. 4

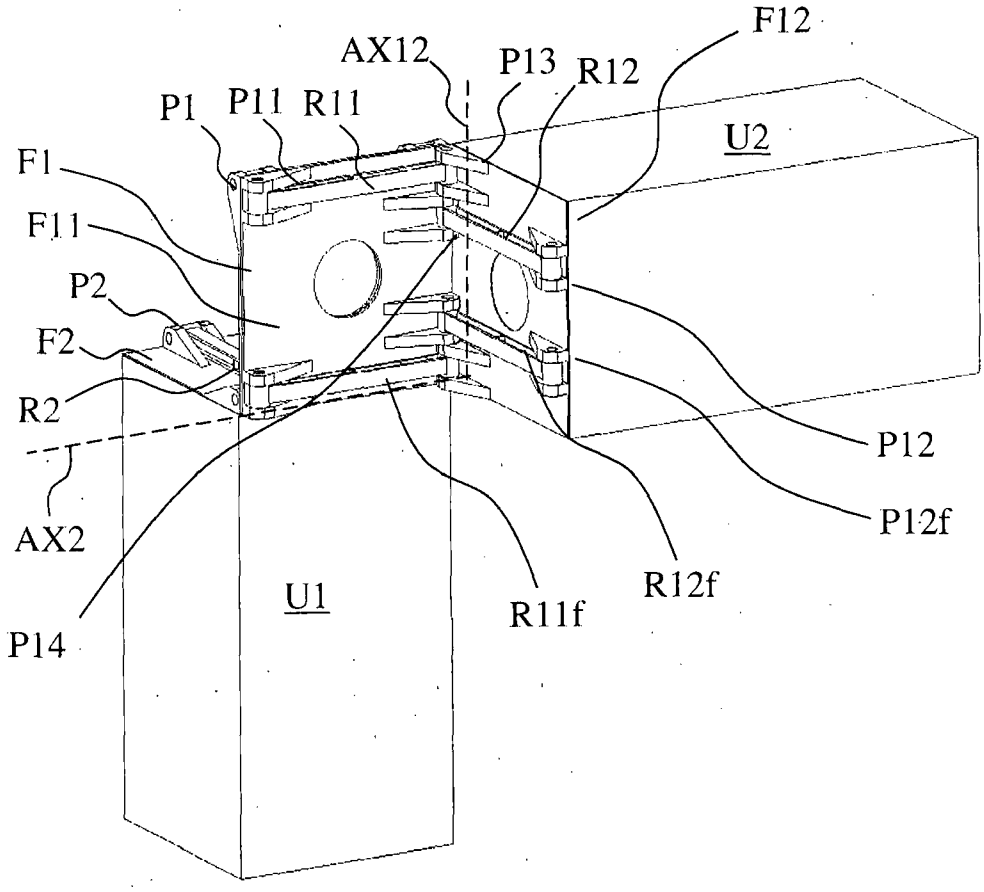
F12
AX12
P13
R12
P1
P11
R11
U2
F1
F11
P2
F2
R2
P12
AX2
P12f
U1
R12f
R11f
P14

Fig. 5

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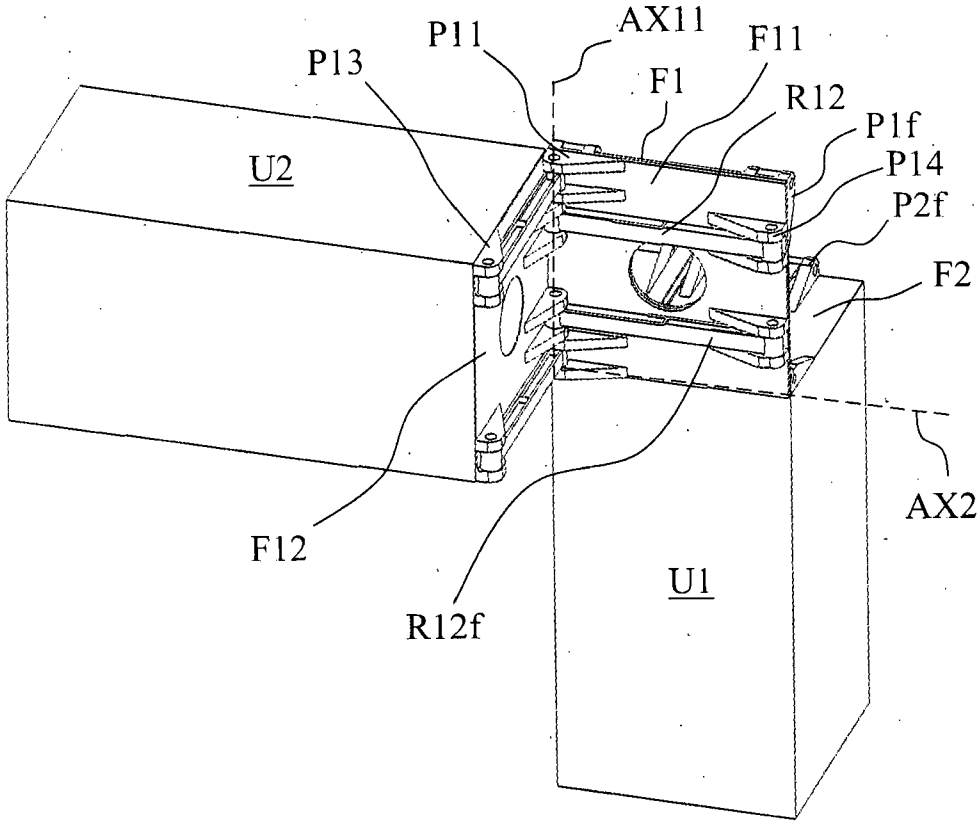
P11
AX11
F11
P13
F1
R12
P1f
U2
P14
P2f
F2
AX2
F12
U1
R12f

Fig. 6

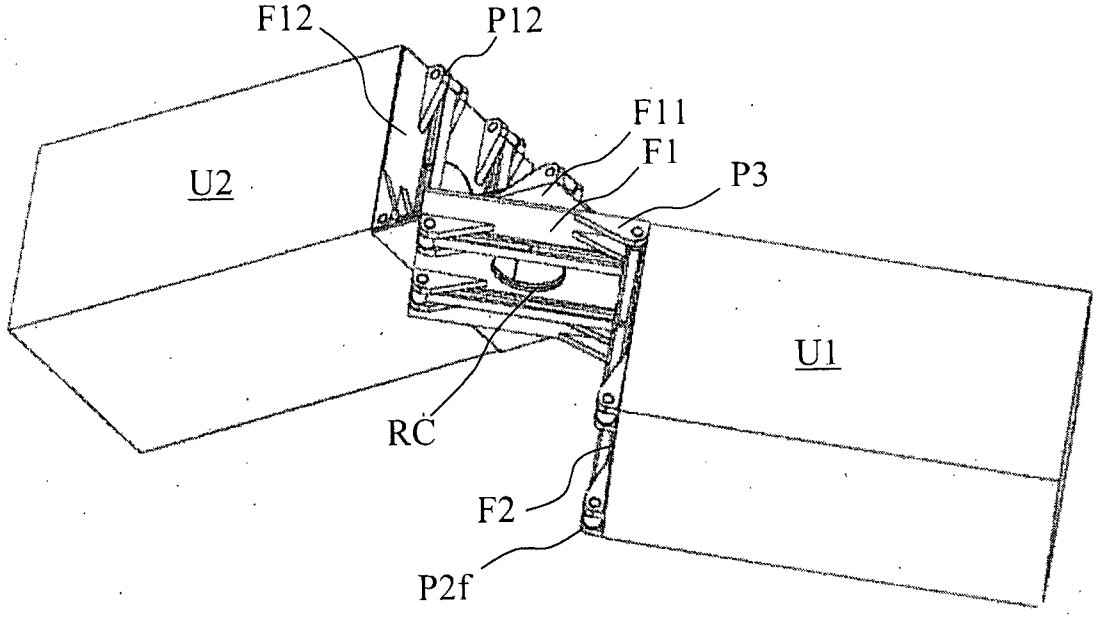
F12
P12
F11
F1
U2
P3
U1
RC
F2
P2f

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2013/000359

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60D5/00 B62D47/02
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60D B62D F16C

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 2 213 548 A2 (BOMAG GMBH [DE]) 4 August 2010 (2010-08-04) paragraph [0033] - paragraph [0046] figures 1,2,4,5,7,8 -----	1
A	EP 1 245 468 A1 (HUEBNER GMBH [DE]) 2 October 2002 (2002-10-02) paragraphs [0034], [0035] figures 1,2 -----	1

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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

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

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

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 December 2013	10/12/2013

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

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2013/000359

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