

PATENT SPECIFICATION

(11)

1 308 105

DRAWINGS ATTACHED

(19)



1 308 105

- (21) Application No. 21242/71 (22) Filed 19 April 1971
(31) Convention Application No. 7 001 896 (32) Filed 11 Feb. 1970 in
(33) Netherlands (NL)
(44) Complete Specification published 28 Feb. 1973
(51) International Classification F16F 15/04
(52) Index at acceptance
F2S 9

(54) AN ARRANGEMENT FOR COUPLING TWO OBJECTS

(71) We, NV. HOLLANDSE SIGNAALAP-
PARATEN, of 40, Zuidelijke Havenweg,
Hengelo (O), The Netherlands, a company
organized and existing under the laws of
The Netherlands, do hereby declare the in-
vention for which we pray that a patent may
be granted to us, and the method by which
it is to be performed, to be particularly de-
scribed in and by the following state-
ment:—
The present invention relates to an
arrangement for coupling two objects.
It is an aim of the present invention to pro-
vide a coupling arrangement which permits
relative translational motion of the coupled
objects but prevents relative rotational
motion of these objects about any axis.
The present invention provides in an
assembly including two objects, an arrange-
ment for coupling the two objects including
at least one resilient support connected to
and extending between the objects, and at
least three coupling devices, each device
comprising two parallelogram shaped sys-
tems in which one side of each system is
coupled together and the side opposite said
one side in each system is coupled to a
different one of the objects, each system
comprising members which are connected
for rotation about parallel axes, in which
one of the two systems of a coupling device
can pivot as a unit relatively to an adjoin-
ing object about an axis, hereinafter called a
first axis, having a direction which differs
from the direction of the rotational axes of
the members of the said one system, and in
which the other system of the coupling de-
vice can pivot relatively to either an ad-
joining object or the said one system about
another axis, hereinafter called a second
axis, parallel to the first axis.
An arrangement according to the inven-
tion can be applied successfully to couple
to a support an apparatus or instrument
which is liable to be subjected to severe

shocks and/or vibrations. The arrangement
ensures that this apparatus or instrument
will not be damaged by said shocks and/or
vibrations and, nevertheless, will maintain
its angular position with respect to the sup-
port. Since the supported apparatus or in-
strument is allowed to perform translational
motion in arbitrary directions with respect
to the support, the inertial forces will not
affect said apparatus or instrument.
Nevertheless, the angular position of said
apparatus or instrument remains unchanged
with respect to the support, because the
arrangement according to the invention pre-
vents any mutual rotation of the coupled
objects about at least three axes, no two
of these axes being either coincidental or
parallel.
The arrangement according to the inven-
tion is especially suitable for coupling a
pedestal carrying an apparatus for measur-
ing angular coodinates in space (such as a
theodolite or a radar aerial) to a support,
which is fixed to a ship or a vehicle that
may be subjected to shocks and/or vibra-
tions. Although the arrangement substan-
tially suppresses the transmission of shocks
and vibrations to the apparatus, the sup-
ported apparatus will nevertheless measure
the angular coordinates with respect to the
support (fixed to a ship or vehicle).
Play and torsion in the coupling devices
of the arrangement may result in very small
mutual rotational motion of the coupled
objects. The extent of said motion also de-
pends on the mutual positions of the axes
about which the coupling devices oppose
said motion. In a preferred example of
the invention, the three planes defined by
the first and second axes of the three
coupling devices are mutually perpendicular
or almost perpendicular to each other.
The arrangement may be designed so
that the two systems of a coupling device
can each pivot relatively to an adjoining ob-

[Price 25p]

ject but cannot pivot relatively to one another. Various methods can be applied to enable said systems to pivot as described above.

5 In one method at least one system of a coupling device is coupled to an adjoining object by universal joints.

In another method, at least one system includes a member which extends along
10 either said first or second axis.

It is not essential that the two systems in the same coupling device be connected in the same way to the two objects, nor is it necessary that the coupling between said
15 objects and the systems of different coupling devices of the same arrangement be effected in the same way. It would be possible to couple one system of a coupling device to an object by means of universal joints and
20 to couple the other system of said coupling device to an object by means of hinges fixed to a part of said system. Furthermore, it would be possible to couple the two systems constituting one of the coupling devices to the objects by means of universal joints,
25 whilst in another coupling device of the same arrangement the systems are coupled to the objects by means of hinges.

In this specification, the term "hinge" means a coupling which permits rotation of the coupled members about one axis only.

If insufficient space is available or if the shape of certain coupling devices must be adapted to the shape of other parts, it may
35 be desirable to design the arrangement in such a way that one of the two systems in each of the coupling devices can pivot, as one unit, relatively to the adjoining object about one axis and also relatively to the
40 other system about another axis, the axes being kept parallel by the former system, whilst the latter system cannot pivot, as one unit, relatively to the adjoining object; however, in the latter system the two oppositely situated parts extending from said
45 adjoining object to the former system can pivot relatively to said object about parallel axes.

The invention will now be explained with reference to the Figures, of which;

Fig. 1 shows a diagram in perspective of one arrangement according to the invention;

Fig. 2 gives a schematic diagram of the location of the coupling devices in the embodiment according to Fig. 1;

Figs. 3a-d and Figs. 4a-f show ten different embodiments of coupling devices that can be applied in arrangements according to the invention.

60 In the Figures, like components are denoted by like reference numerals. It was therefore necessary to denote, in some Figures, certain components by combined numerals, as the function of each of these
65 components is performed by two com-

ponents in other Figures. For example, in Fig. 1 the hinge's pin 2/5 performs the functions of the hinge's pins 2 and 5 in Fig. 3a.

The embodiment of a mechanism according to the invention as shown in Fig. 1 will
70 be described first.

This mechanism is fitted with coupling devices of the type shown in fig. 3a. The mechanism joins a base plate 16/18 mounted on a vehicle or ship to a supporting
75 plate 9/17 on which a supporting column 34 carrying an apparatus that can be directed into space, such as a theodolite, is mounted. This apparatus is not shown. The two plates are connected by means of three elastic devices 25, 28 and 31. Such an elastic device may comprise a cylindrical housing that is connected to the base plate
80 16/18 by means of a universal joint, such as a ball and socket joint 26, 29, 32. At the opposite side of the housing a bar can slide longitudinally in guides in the housing and the part of the bar that protrudes from the housing is connected to the supporting plate
85 9/17 by means of a universal joint such as a ball and socket joint 27, 30, 33. Cylindrical coil springs in the housing tend to keep the bar in a midway position but forces exerted between the universal joints will cause the bar to shift longitudinally against the forces exerted on it by the springs. The complete mechanism is constructed in such a way that in its quiescent state, due to the influence of the elastic devices and the three coupling devices that are still to be described, each of the lines passing through the centres of rotation of the universal joints pertaining to the same elastic device, also passes through or, at any rate, nearly through the centre of gravity Z of the combination consisting of the supporting plate
90 9/17, the column 34 and the measuring apparatus carried by said column. In such a situation the exertion of torques on said combination will be less probable.
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The elastic devices are not the only connections between the base plate and the supporting plate; these plates are also joined by means of three coupling devices of which the device that can pivot relatively
100 to the coupled objects about axes lying in the plane C will be described in greater detail. The latter coupling device comprises a bar 12/13 which carries near its ends at 2/5 and 3/6 the parallel pins which are perpendicular to the longitudinal axis of the bar. Two arms can pivot about each of said pins. An arm 10, which is attached to the supporting plate 9/17 by means of a universal joint 1/19, such as a ball and
105 socket joint, can rotate around the pin 2/5. A second arm 14 can also rotate around the pin 2/5 and is connected to the base plate 16/18 by means of a universal joint 7/21. In a similar way, two arms can pivot about
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the pin 3/6, viz. the arm 11 attached to the supporting plate 9/17 by means of a universal joint 4/20 and the arm 15 coupled to the base plate 16/18 by means of the universal joint 8/22. The length of these arms is such that the distance between the pin 2/5 and the centre of rotation of the universal joint 1/19 is the same as the distance between the pin 3/6 and the centre of rotation of the universal joint 4/20 and, moreover, the distance between the pin 2/5 and the centre of rotation of the universal joint 7/21 is equal to that between the pin 3/6 and the centre of rotation of the universal joint 8/22. Furthermore, the distance between the centres of rotation of the universal joints 1/19 and 4/20 as well as the distance between the centres of rotation of the universal joints 7/21 and 8/22 are equal to the distance between the pins 2/5 and 3/6. If the part of the base plate situated between the universal joints 7/21 and 8/22 and the part of the supporting plate 9/17 situated between the universal joints 1/19 and 4/20 are considered as parts of the coupling device, then, in view of the equalities mentioned above, this coupling device comprises two systems each consisting of four parts which are linked by hinged joints to form a closed loop in which the joints lie on the vertexes of a parallelogram. Consequently, the straight line through the centres of rotation of the universal joints 1/19 and 4/20 is always kept parallel to the straight line joining the centres of rotation of the universal joints 7/21 and 8/22 by the coupling device. A plane C passes through these lines and the coupling device prevents mutual rotation of the coupled objects, viz. the base plate 16/18 as well as the supporting plate 9/17 with the parts mounted on said plate, about an axis that is perpendicular to the plane C.

In addition to the coupling device already described in more detail, the mechanism shown in Fig. 1 contains two other, similar coupling devices, viz. one that keeps two axes situated in the plane D mutually parallel and one that keeps two axes situated in the plane E mutually parallel. These coupling devices prevent mutual rotation of the base plate 16/18 and supporting plate 9/17 around axes that are perpendicular to the planes D and E. The three coupling devices are so mounted that, when the mechanism is in the quiescent state, the planes C, D and E:

- (1) pass through or, at any rate, nearly through the centre of gravity Z of the combination of supporting plate 9/17, supporting column 34, and any apparatus mounted on the column 34;
- (2) constitute three pairs of planes which are, at any rate, nearly perpendicular to each other.

Under these circumstances the coupling devices prevent any mutual rotation of base plate 16/18 and supporting plate 9/17 around three axes, no two of these axes being either parallel or coincident. This infers that any mutual rotation of the coupled parts is prevented. Actually, in the mechanism described with reference to Fig. 1 the three axes, around which no mutual rotation is possible when the mechanism is in the quiescent state, are, at any rate, nearly perpendicular to each other. In this way the most effective situation is obtained for maximum suppression of any mutual rotation.

The relative positions of the parts in the mechanism can be seen more clearly from Fig. 2 which shows the mechanism schematically. Base plate 16/18 and supporting plate 9/17 are shown as open triangles so that no parts of the coupling devices are concealed by these plates.

Universal joints are shown as large dots, joints operating as hinges are shown as small dots. The three planes C, D and E, each containing a pair of axes kept parallel to each other by means of a coupling device, are also visible. These planes form a tetrahedron and pass through or, at any rate, nearly through the centre of gravity Z of the combination consisting of the supporting plate, the column and the supported instrument; said planes are also perpendicular to each other.

The coupling devices will not prevent mutual translational motion of the coupled objects, for the mechanism not only permits translational motion of the parallel axes lying in the planes, but also rotation of the coupling devices relative to the base plate and the supporting plate; these coupling devices are attached to said plates by means of universal joints, such as ball and socket joints, and during this rotation said axes remain parallel.

In various embodiments of mechanism according to the invention ball bearings are used as universal joints and this is highly recommendable because excellent ball bearings with spherical ball races and very small play can be obtained at low prices.

However, it is possible to avoid the use of universal joints in the coupling devices applied in a mechanism according to the invention. A coupling device will now be described with reference to fig. 3b in which device only hinges are applied; these hinges permitting rotation of the joined parts around one axis only.

As in the coupling device already described, also the device shown in Fig. 3b comprises a central bar 12/13 which is part of each of the two systems in the device. This bar carries four parallel pins 2, 3, 5 and 6, the axes of which are perpendicular

to the bar 12/13. A bar 10 is mounted so as to be able to rotate around the pin 2 and it can also rotate around the pin 1 carried by the bar 9. A bar 11 can rotate
 5 around the pin 3, whilst it can also rotate around the pin 4 carried by the bar 9. The four bars coupled in this way constitute one of the two systems of the coupling device. The lengths of these bars between the
 10 various pins are such, that these pins form the vertexes of a parallelogram, so that the bars 9 and 12/13 remain parallel. In a similar way, the bar 12/13 is joined to the bar 16 by means of the bars 14 and 15.
 15 Consequently, the coupling device keeps the bar 16 parallel to the bar 9. The bar 9 is joined to the object by means of the hinges 19 and 20 connected to said object. Similarly, the bar 16 is joined to the other
 20 object 18 by means of the hinges 21 and 22, so that the coupling device can rotate relatively to the object 18 around an axis that is determined by said two hinges. The coupling device keeps the axis determined
 25 by the hinges 19, 20 parallel to the axis determined by the hinges 21, 22.

The coupling device shown in Fig. 3b differs in two ways from the device described with reference to Fig. 1; in the
 30 former device no universal joints are used and the bars situated at one end of the central bar 12/13 rotate around different pins, whilst the corresponding bars in the device shown in Fig. 1 rotate around the same pins.
 35 It is obvious that, on the one hand, the coupling device shown in Fig. 1 can be built in such a way that the bars situated at one end of the bar 12/13 can rotate around different pins—see Fig. 3a showing
 40 an embodiment of such a coupling device—whilst, on the other hand, the device according to Fig. 3b may be built in such a way, that at least one pair of bars situated at one end of the bar 12/13—e.g. the bars
 45 10 and 14—can rotate around the same pin.

Also, the coupling device can be so constructed that in one of its systems universal joints are applied as shown in Fig. 1 for the coupling of one of the objects, whilst
 50 the other system uses hinges, as shown in Fig. 3b, for the hinged connection of the other object. Fig. 3c shows such a coupling device. Description in greater detail of this device appears superfluous.

55 It is important that none of the angles in the parallelograms that determine the positions of the pins in the systems becomes too acute; if this were so, only slight play in the hinged joints would lead to considerable
 60 mutual rotation of the coupled objects. Fig. 3d shows an embodiment of a coupling device for a mechanism according to the invention in which device, as a rule, said acute angles can be avoided. In order to
 65 avoid such acute angles, the direction of the

bar 12 of one system in the coupling device differs to that of the bar 13 belonging to the other system of the same device. These bars are arranged as to form such an angle
 70 that the smaller angles in the parallelograms are increased. The figures show a symmetrical embodiment in which the angle between the bar 9 and the axis determined by the hinges 19 and 20 is equal to the angle
 75 between the bar 16 and the axis defined by the hinges 21 and 22. However, such a symmetry is not necessary; the angles mentioned above need not be equal, it is even possible that in one of the two systems of a coupling device such a bar (e.g. the bar 9
 80 in the upper system) has the same direction as the axis around which the coupling device can swing relatively to the object at that side. In that case the coupling of the object at that side can even be established
 85 by means of universal joints or ball and socket joints. In such an embodiment the angle between the side of the other system nearest to the adjoining object and the axis about which said system can swing, as one
 90 unit, relatively to said object, must usually be greater, but this will not be disadvantageous.

Up till now it has been assumed that the two systems of a coupling device are parallel
 95 to one and the same plane, but this is not necessary. It may even be desirable, e.g. for utilisation of space, to adapt the shape of a coupling device to the shape of certain
 100 objects, i.e. the systems must be made parallel to the intersecting planes.

Furthermore, it is not necessary for the axes determined by the hinges in Fig. 3b to have the same direction as, or to coincide
 105 with the bars 9 and 16. The direction of these axes may differ from that of said bars and the angle of difference may be in the plane formed by these axes as well as in the plane perpendicular thereto, provided that these axes remain parallel and are kept
 110 parallel by the coupling device. In the embodiment according to Fig. 3b these axes might be at an angle to the plane of the drawing.

In the embodiments described up till now,
 115 each of the systems in a coupling device can pivot, as one unit, relatively to the object coupled thereto, but the systems are not arranged as to pivot as one unit relatively to each other. However, in
 120 certain cases it is possible and advantageous to build the coupling device in such a way that only one of its systems can pivot, as one unit, relatively to the other system of said device about another axis which is kept
 125 parallel to the first axis by means of the first system. However, the second system cannot pivot, as one unit, relatively to the adjoining object; only two oppositely situated parts of said second system, extending from
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the object connected to said second system to the first system, can pivot relatively to said object about parallel axes.

Fig. 4a shows one embodiment of such a coupling device. The upper system of this device is built in the same way as the upper system in the device shown in fig. 3a, but in the lower system the bars 14 and 15 between the object 16/18 and the upper system are coupled to said object so as to be able to pivot about the parallel axes 7 and 8, whilst the bars 14 and 15 are attached to the bar 12/13, which is common to both systems, by means of universal joints 5 and 6. Because both systems form parallelograms, mutual rotation of the coupled objects around an axis, which is perpendicular to the plane through the axes around which the upper system can pivot relatively to the adjoining object and to the lower system (the axis through the centres of rotation of the universal joints 1/19 and 4/20 and the axis through the centres of rotation of the universal joints 5 and 6), is prevented. Mutual translational motion of the coupled objects are, however, possible owing to changes in the shape of the parallelograms of the systems and to the pivotal movement of the upper system relatively to the adjoining object 9/17 about an axis passing through the centres of rotation of the universal joints 1/19 and 4/20 and also relatively to the lower system about an axis through the centres of rotation of the universal joints 5 and 6.

Fig. 4b shows a similar coupling device that comprises no universal joints. The upper system consists of the bars 9, 10, 11 and 12 capable of pivoting about parallel axes 1, 2, 3 and 4. This system can pivot as one unit relatively to the object 17, because the bar 9 can rotate by the hinges 19 and 20 mounted to said object. The lower system consists of the bars 13, 14, 15 and the part 16 of the object 18. These bars form a parallelogram and can pivot relatively to each other about parallel axes 5, 6, 7 and 8 two of which, viz. 7 and 8, are attached rigidly to the object 18. Consequently, the lower system cannot pivot as one unit relatively to the adjoining object 18. The bar 12 of the upper system can, however, rotate relatively to the bar 13 of the lower system by means of the hinges 23 and 24; hence, the upper system can rotate, as one unit, relatively to the lower system about the axis determined by these hinges, said axis being kept parallel to the axis determined by the hinges 19 and 20 by means of the upper system. The upper system can therefore pivot, as one unit, similarly to the upper system in the coupling device shown in Fig. 4a and, consequently, permits the same relative translational motion of the coupled objects as the device shown in Fig. 4a.

It will be shown that it is possible to build coupling devices of the type which uses hinges, permitting rotation around a fixed axis in the way shown in Fig. 4b, as well as universal joints in the way shown in Fig. 4a. Fig. 4c shows a coupling device in which the upper system is arranged so as to be able to swing, as one unit, relatively to the object 17 directly coupled to this system by means of hinges permitting rotation around a fixed axis in the way shown in Fig. 4b, whilst the lower system is coupled to the upper one in the way shown in Fig. 4a by means of universal joints. Fig. 4d shows a coupling device in which the upper system is linked to the object 9/17 by means of universal joints which permit it to pivot, as one unit, relatively to said object, whilst the upper system can pivot, as one unit, relatively to the lower system because these systems are joined by means of hinges 23 and 24, permitting mutual rotation around a fixed axis.

Fig. 4e shows a coupling device in which the hinges, that permit the upper system to pivot, as one unit, relatively to the adjoining object 17 and also relatively to the lower system, all form part of the upper system. The bar 9 in said upper system, can rotate relatively to the object 17 by hinges permitting rotation around one single fixed axis. Bars 10 and 11 can rotate relatively to the bar 9 around parallel pins 1 and 4 mounted to said bar 9 by near the ends. The other ends of the bars 10 and 11 are attached to the bar 12/13, which forms part of both the upper and the lower system by means of universal joints, such as ball and socket joints, 2/23 and 3/24. The joints 3/24 and 2/23 permit changes in the shape of the parallelograms, which constitute the upper system, and also permit pivotal movement of the upper system relatively to the lower system about an axis passing through the centres of rotation of said universal joints. Bars 14, 15 rotate relatively to object 18 around parallel pins 7, 8.

It should be noted that the maximum number of universal joints in a system is two, because otherwise such a system would no longer be able to keep two axes parallel.

It needs no further explanation that, also in coupling devices in which the two systems can pivot, as one unit, relatively to each other, it is possible to avoid the occurrence of too-acute angles in the system by changing the direction of the parts of the systems in the way shown in Fig. 3d. A coupling device constructed as to avoid such acute angles is shown in Fig. 4f. This coupling device need not be further described. Also in this embodiment it is not necessary for bars with corresponding positions in the two systems to be at the same angle relative to the axes around which the systems can pivot as one unit. This may lead to constructions

in which universal joints can be used. If, for instance, the bar 13 coincides with the axis around which the two systems can pivot, as one unit, relatively to each other, the joints comprising the pins 23 and 5 may be combined to one universal joint and the same applies to the joints comprising the pins 6 and 24.

It is possible to build the mechanism with more than three elastic devices and it is also possible to use elastic devices that can exert forces, the directions of which differ from the direction of the lines joining the points at which such devices are coupled to the two objects.

Furthermore, it is not necessary that the forces exerted by the elastic devices pass through or, at any rate, nearly through the centre of gravity of one of the coupled objects when the mechanism is in the quiescent state, and it is not even necessary that these forces pass through the same point during this quiescent state. Nevertheless, embodiments, in which the lines of these forces do not pass through the same point and, especially, do not pass through said centre of gravity, are disadvantageous, as this will give rise to torques between the coupled objects. Although these torques, due to the presence of the coupling devices, will not cause mutual rotation of the objects, they will nevertheless constitute an unnecessary load on the coupling devices.

As may be derived from Fig. 1, the forces exerted by the elastic devices, even in the quiescent state of the mechanism need not coincide or nearly coincide with the intersecting line of the planes which, in each of the coupling devices, pass through the two axes about which the systems can pivot.

Furthermore, even in the quiescent state of the mechanism, said planes need not be mutually perpendicular or nearly perpendicular. Also, even in the quiescent state of the mechanism, it is not necessary that said planes pass or pass nearly through the centre of gravity of one of the two coupled objects.

The parallel axes, around which certain parts (such as bears) of a system can pivot relatively to other parts (such as bars) of this system, need not be perpendicular to such parts or, more specifically, to the lines joining the positions of the two axes of the same parts.

A mechanism similar to that, according to the invention, may be constructed with more than three coupling devices and in this case it is not necessary that, even in the quiescent state of the mechanism, the planes, which—in each coupling device—pass through the axes about which the systems of such a device can pivot, pass through the same point.

It may be desirable to damp the move-

ments of the coupled objects with respect to each other. Damping devices for this purpose may be combined with each of the elastic devices; for instance, more or less in the same way in which, in certain constructions, shock absorbers of a motor vehicle are combined with the springs.

WHAT WE CLAIM IS:

1. In an assembly including two objects, an arrangement for coupling the two objects including at least one resilient support connected to and extending between the objects, and at least three coupling devices, each device comprising two parallelogram shaped system in which one side of each system is coupled together and the side opposite said one side in each system is coupled to a different one of the objects, each system comprising members which are connected for rotation about parallel axes, in which one of the two systems of a coupling device can pivot as a unit relatively to an adjoining object about an axis, hereinafter called a first axis, having a direction which differs from the direction of the rotational axes of the members of the said one system, and in which the other system of the coupling device can pivot relatively to either an adjoining object or the said one system about another axis, hereinafter called a second axis, parallel to the first axis.

2. A coupling arrangement as claimed in Claim 1, comprising three coupling devices, in which the three planes defined by the first and second axes of the three coupling devices pass through a common point, and intersect one another along three non parallel lines.

3. A coupling arrangement as claimed in Claim 2, in which the three planes are mutually perpendicular.

4. A coupling arrangement as claimed in any preceding claim, in which the two systems of a coupling device can each pivot relatively to an adjoining object, and in which the said two systems cannot pivot relatively to one another.

5. A coupling arrangement as claimed in any one of Claims 1 to 3, in which only one system of a coupling device can pivot relatively to an adjoining object, and in which the two systems of the device can pivot relatively to one another.

6. A coupling arrangement as claimed in Claims 5, in which the two systems of a coupling device are connected by universal joints.

7. A coupling arrangement as claimed in Claim 5 in which corresponding members of the two systems remote from the adjoining objects are connected for relative rotation about an axis parallel to said first and second axis.

8. A coupling arrangement as claimed in any preceding claim, in which at least one



in which universal joints can be used. If, for instance, the bar 13 coincides with the axis around which the two systems can pivot, as one unit, relatively to each other, the joints comprising the pins 23 and 5 may be combined to one universal joint and the same applies to the joints comprising the pins 6 and 24.

It is possible to build the mechanism with more than three elastic devices and it is also possible to use elastic devices that can exert forces, the directions of which differ from the direction of the lines joining the points at which such devices are coupled to the two objects.

Furthermore, it is not necessary that the forces exerted by the elastic devices pass through or, at any rate, nearly through the centre of gravity of one of the coupled objects when the mechanism is in the quiescent state, and it is not even necessary that these forces pass through the same point during this quiescent state. Nevertheless, embodiments, in which the lines of these forces do not pass through the same point and, especially, do not pass through said centre of gravity, are disadvantageous, as this will give rise to torques between the coupled objects. Although these torques, due to the presence of the coupling devices, will not cause mutual rotation of the objects, they will nevertheless constitute an unnecessary load on the coupling devices.

As may be derived from Fig. 1, the forces exerted by the elastic devices, even in the quiescent state of the mechanism need not coincide or nearly coincide with the intersecting line of the planes which, in each of the coupling devices, pass through the two axes about which the systems can pivot.

Furthermore, even in the quiescent state of the mechanism, said planes need not be mutually perpendicular or nearly perpendicular. Also, even in the quiescent state of the mechanism, it is not necessary that said planes pass or pass nearly through the centre of gravity of one of the two coupled objects.

The parallel axes, around which certain parts (such as bears) of a system can pivot relatively to other parts (such as bars) of this system, need not be perpendicular to such parts or, more specifically, to the lines joining the positions of the two axes of the same parts.

A mechanism similar to that, according to the invention, may be constructed with more than three coupling devices and in this case it is not necessary that, even in the quiescent state of the mechanism, the planes, which—in each coupling device—pass through the axes about which the systems of such a device can pivot, pass through the same point.

It may be desirable to damp the move-

ments of the coupled objects with respect to each other. Damping devices for this purpose may be combined with each of the elastic devices; for instance, more or less in the same way in which, in certain constructions, shock absorbers of a motor vehicle are combined with the springs.

WHAT WE CLAIM IS:

1. In an assembly including two objects, an arrangement for coupling the two objects including at least one resilient support connected to and extending between the objects, and at least three coupling devices, each device comprising two parallelogram shaped system in which one side of each system is coupled together and the side opposite said one side in each system is coupled to a different one of the objects, each system comprising members which are connected for rotation about parallel axes, in which one of the two systems of a coupling device can pivot as a unit relatively to an adjoining object about an axis, hereinafter called a first axis, having a direction which differs from the direction of the rotational axes of the members of the said one system, and in which the other system of the coupling device can pivot relatively to either an adjoining object or the said one system about another axis, hereinafter called a second axis, parallel to the first axis.

2. A coupling arrangement as claimed in Claim 1, comprising three coupling devices, in which the three planes defined by the first and second axes of the three coupling devices pass through a common point, and intersect one another along three non parallel lines.

3. A coupling arrangement as claimed in Claim 2, in which the three planes are mutually perpendicular.

4. A coupling arrangement as claimed in any preceding claim, in which the two systems of a coupling device can each pivot relatively to an adjoining object, and in which the said two systems cannot pivot relatively to one another.

5. A coupling arrangement as claimed in any one of Claims 1 to 3, in which only one system of a coupling device can pivot relatively to an adjoining object, and in which the two systems of the device can pivot relatively to one another.

6. A coupling arrangement as claimed in Claims 5, in which the two systems of a coupling device are connected by universal joints.

7. A coupling arrangement as claimed in Claim 5 in which corresponding members of the two systems remote from the adjoining objects are connected for relative rotation about an axis parallel to said first and second axis.

8. A coupling arrangement as claimed in any preceding claim, in which at least one



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system is coupled to an adjoining object by universal joints.

5 9. A coupling arrangement as claimed in any one of claims 1 to 7, in which at least one system includes a member which extends along either said first or second axis.

10 10. A coupling arrangement as claimed in Claim 2, in which the three planes pass through the centre of gravity of one of the objects.

15 11. A coupling arrangement as claimed in Claim 2, including at least three resilient supports arranged to exert forces along lines which pass through the intersection point of the three planes.

20 12. A coupling arrangement as claimed in Claim 11, in which the said intersection point is the centre of gravity of one of the objects.

13. A coupling arrangement as claimed in any one of Claims 1 to 10, including a plurality of resilient supports arranged to exert forces along lines which pass through a common point.

25 14. An assembly including two objects coupled by a coupling arrangement as in any preceding claim.

15. In an assembly a coupling arrangement substantially as herein described with reference to the accompanying drawings.

30 16. An assembly substantially as herein described with reference to the accompanying drawings.

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