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(54) Motion conversion arrangement

(57) A motion conversion arrangement for a magnetic actuator having a pivoted armature (14) comprises a link rod (50) having at one end a spindle means, which may take the form of a spacer (51) on the rod, and a pair of restraining means, e.g washers (53), the spindle means fitting loosely in a hole in the armature (14) of the actuator and the restraining means (53) serving to keep the spindle means (51) in the hole. The armature hole describes an arc in a first plane. The other end of the rod is connected to an apparatus (48) which is actuated along a second plane perpendicular to the first plane. Clearances are deliberately provided between the spacer (51) and the hole and between the restraining means (53) and the armature faces so that the rod (50) can skew in the armature (14) in order to execute movement in the second plane.

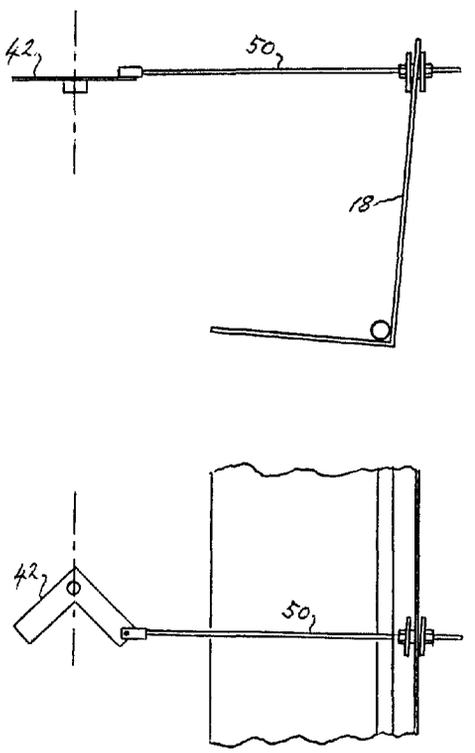

Figure 5

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Description

The invention concerns a motion conversion arrangement for converting a motion in one plane into a corresponding motion in another, orthogonal plane, and especially, but not exclusively, a motion conversion arrangement as incorporated in a magnetic actuator apparatus, in particular a magnetic actuator apparatus for the actuation of one or more vacuum switches.

A known magnetic actuator arrangement is shown in Figure 1. This magnetic actuator arrangement, which is part of a vacuum switch chassis developed by the applicants, comprises a pair of electromagnets 10, 11 fixed to a frame 12 on a transverse member 13 thereof, and an "L"-shaped armature 14 with a welded- or brazed-on spindle 15 resting in a pair of ball-joint bearings 16 fixed to upright flange portions of respective vertical members 17 of the frame 12. Because the ball joints 16 are secured to the flanges and not the main faces of the members 17, it is necessary to strengthen this part of the frame by the addition of screwed rods 32 and associated nuts 33 close to the ball-joint fixing points.

The electromagnets 10, 11 each have a pole piece 21, 22 and a vertical portion 18 of the armature 14 is positioned so that, in an unenergised state of the actuator, it is spaced apart from the pole pieces 21, 22, the necessary gap being maintained by a pair of springs 23,24 which are fixed to the transverse member 13 and act against the vertical portion 18 of the armature 14.

The horizontal portion 19 of the armature 14 is linked by a suitable linkage arrangement (not shown, but may conventionally take the form of universal ball joints such as the joints 16), to the actuator rods 25 of a group of three vacuum switches 26 (shown only very schematically), one for each phase of an AC system with which the switching apparatus is to be used. The switches 26 are mounted on a subframe 20, which is fixed to the vertical members 17, and are equipped with high-voltage terminals 27, 28 for connection to the AC system.

In operation, current is supplied to the electromagnets 10, 11 and the armature portion 18 is attracted against the springs 23, 24 towards the pole pieces 21, 22 of the electromagnets. The armature pivots in the bearings 16 at each side of the frame 12, so that the horizontal portion 19 of the armature is moved downwards, moving the actuator rods 25 of the switches 26 from an "open" to a "closed" position of the switches 26.

At the same time as the switches 26 are actuated, two auxiliary switches 29 are actuated by a further linkage arrangement 40, which is also operated by the armature 14. The auxiliary switches 29 provide auxiliary signals and power for use in other, external equipment.

The further linkage arrangement employed in this apparatus is shown in Figures 1, 2 and 3 (Figure 2 is in partially cut-away form) and consists of a bracket 41 fixed to the vertical portion 18 of the armature 14, a bell crank 42 pivotably secured to the frame member 13, a slave arm 43 and a link rod 44.

The link rod 44 is equipped with a ball joint 45, 46 at each end which allows movement of the rod proper in all planes relative to the fixing axes of the ball joints. Ball joint 45 is secured to the bracket 41, while ball joint 46 is secured to a first arm of the bell crank 42. A second arm of the bell crank 42 is connected to the slave arm 43 by way of an idler rod 47, which is pivotably attached to the bell crank arm. The undersides of the bell crank's second arm and of the slave arm 43 are connected to respective armatures 48 of the auxiliary switching units 29. The armatures 48 are equipped with contacts (not shown) which make or break, as required, with fixed contacts 49 of the auxiliary switching units.

The ball joints 45, 46 are necessary to translate the angular movement of the bracket 41 about the spindle 15 of the main armature 14 into movement of the bell crank and slave arm in a horizontal plane referenced to the frame as shown, and eventually into a linear movement, in that same horizontal plane, of the switch armatures 48.

A similar ball-jointed link-rod arrangement may be employed between the horizontal portion 19 of the armature 14 and the respective moving contacts (not shown) of the vacuum switches 26.

The known linkage arrangement for the and, where required, the main switching components of the actuator apparatus functions well, but suffers from the drawback of excessive cost, in particular because of the use of ball joints. In addition, the precision construction of this type of joint leads to unavoidable wear and tear after many operations of the switches 26, so that the fault rating of the entire apparatus (i.e. the mean time between failures, MTBF) may well be determined not by the vacuum switches themselves, but by the ball joints employed to effect the various switching operations.

In accordance with a first aspect of the invention, there is provided a motion conversion arrangement for converting a first motion along an arc in a first plane to a second motion in a second plane perpendicular to said first plane, said first motion being caused by an angular displacement of a pivoted member about an axis perpendicular to said first plane, the motion conversion arrangement comprising a link rod, the link rod having at one end a spindle means and a pair of retaining means and at the other end a connection means for connection to an apparatus which is required to be displaced in said second plane, and a hole provided in said pivoted member, said spindle means being disposed in said hole and said retaining means being situated on respective sides of said pivoted member, a first clearance being provided between said hole and said spindle means and a second clearance being provided between said retaining means and said member, said first and second clearances being such as to allow said apparatus and said link rod to move in said second plane during angular displacement of said pivoted member.

In accordance with a second aspect of the invention, there is provided a motion conversion arrangement

for converting a first motion in a first plane to a second motion along an arc in a second plane perpendicular to said first plane, said arc being described by a point on a member pivoted on an axis perpendicular to said second plane, the motion conversion arrangement comprising a link rod, the link rod having at one end a spindle means and a pair of retaining means and at the other end a connection means for connection to an apparatus which is displaceable in said first plane, and a hole provided at said point on said pivoted member, said spindle means being disposed in said hole and said retaining means being situated on respective sides of said pivoted member, a first clearance being provided between said hole and said spindle means and a second clearance being provided between said retaining means and said pivoted member, said first and second clearances being such as to allow an angular displacement of said pivoted member about said axis during movement of said apparatus and said link rod in said first plane.

In accordance with a third aspect of the invention, there is provided a magnetic actuator arrangement, comprising an electromagnet attached to a frame, an armature pivotably secured to said frame, a portion of said armature being attracted to said electromagnet when the latter is energised, and a link rod linking said armature to an apparatus to be actuated along a linear path which is fixed relative to said frame, said link rod having at a first end thereof which is connected to the armature a spindle means and a pair of retaining means, said armature having a hole at a point of the armature which moves along an arc when the actuator is energised, said spindle means being disposed in said hole with said retaining means being situated on respective sides of said armature, a first clearance being provided between said hole and said spindle means and a second clearance being provided between said retaining means and said armature, said first and second clearances being such as to allow said apparatus and said link rod to be displaced in a plane perpendicular to a plane of said arc when said electromagnet is energised.

Said spindle means may be constituted by a spacer mounted on said link rod and said retaining means may be constituted by a pair of washers held against respective sides of said spacer.

Said spindle means and one of said retaining means may be constituted by a bush mounted on said link rod and the other retaining means may be constituted by a washer held against said bush.

A second end of said link rod may be connected to one or more moving contacts of one or more switching devices. Said one or more switching devices may be vacuum switches and/or auxiliary switching devices.

A linkage arrangement may be provided between said link rod and respective armatures of said one or more auxiliary switching devices, said linkage arrangement being pivotably secured to said frame.

Said linkage arrangement may comprise a bell crank for converting a motion of said link rod along a first substantially linear path into a motion along a second substantially linear path substantially perpendicular to said first path, said first and second paths being in a common plane.

An embodiment of the invention will now be described, by way of example only, with reference to the drawings, of which:

Figure 1 shows front, side and plan views of a vacuum switch chassis incorporating a known magnetic actuator arrangement;

Figure 2 is a plan view of the chassis of Figure 1 omitting the restoring springs, but showing a known auxiliary-switch actuator arrangement;

Figure 3 is a partial view from the righthand side of the chassis of Figure 2;

Figure 4 is a preferred embodiment of a link rod employed in a motion conversion arrangement according to the invention, and

Figures 5 and 6 show side and plan views, respectively, of a motion conversion arrangement according to the invention as employed in the vacuum switch chassis of Figure 1.

Referring now to Figure 4, instead of using a double-ball-jointed link-rod arrangement as shown in Figure 3, a preferred embodiment of the invention uses a link rod 50 having at one end a spindle means comprising a spacer 51, which is inserted into a hole in the armature portion 18 where the bracket 41 of Figures 2 and 3 is located, and two retaining means in the form of two nylon washers 52 held tight up to the spacer by respective nuts 53. The other end of the rod 50 is provided with a simple pivot bearing 54 for connection to the bell crank 42. To give some idea of the dimensions involved, a prototype of the vacuum switch chassis shown in Figure 1 employed a spacer 7.0mm long and washers 25mm in diameter.

The hole in the armature portion 19 is deliberately made larger than the outside diameter of the spacer 51 (the above-mentioned prototype, for example, employed a clearance between the spacer and the armature hole of approximately 1,0mm). In addition, the distance between the washers 52 is deliberately made greater than the thickness of the armature portion 19 at the point of location of the hole. The reason for this becomes apparent by inspection of Figures 5 and 6.

In an unenergised state of the actuator (see Figure 5), the armature portion 18 is spaced apart from the pole pieces 21, 22 of the electromagnets 10, 11 (see Figure 1) and the bell crank 42 is in a first position by which a first desired make or break condition of the auxiliary contacts in the auxiliary switching units 29 is obtained. In this position, the link rod 50 is horizontal and also slightly skewed clockwise when viewed from the top. This places the spacer/washer arrangement at the righthand end of the rod 50 into the disposition shown, with diametrically opposite portions of the two washers touching op-

posite faces of the armature.

Now, when the actuator is energised, the armature portion 18 is forced towards the pole pieces 21,22 of the electromagnets 10, 11 so that the lefthand washer is now displaced to the left by the armature. The angular displacement of the armature is approximately 7° for the actuator arrangement shown. Once again, the link rod is in a horizontal plane, but this time it is skewed slightly anticlockwise when seen from the top, as shown in Figure 6, due to the linkage with the bell crank 42. Also, since the portion 18 of the armature 14 is now more or less dead vertical, being in contact with the afore-mentioned pole pieces, the washers are not skewed relative to the armature when viewed from the side, as they were in the de-energised condition shown in Figure 5.

It is clear that a "sloppy" fit of the spacer 51 in the hole in the armature and also the clearance between the washers 52 and the armature portion 18 are both necessary in order to accommodate the afore-described skewing of the rod 50 relative to the armature in both the horizontal and the vertical planes.

As well as employing the motion-conversion arrangement for the switching of the auxiliary switches units 29, a similar arrangement may be used to operate the vacuum switches 26. In this case, the link rods 50 can be constituted by the actuator rods 25 themselves, the spindle means 51 and retaining means 52 of these rods engaging with the horizontal portion 19 of the actuator 14 in the same manner as the link rod for the auxiliary switch units engaged with the vertical portion 18 of the actuator in the auxiliary switching arrangement described above. In this case the link rod, as well as moving in a now vertical plane, always follows a strictly linear path defined by the construction of the switches 26 themselves, so that skewing of the retaining means relative to the armature portion 19 occurs only in the side plane of the chassis (i.e. when viewed from a side member 17), not in the front plane.

A drawback of the motion conversion arrangement just described is that there is unavoidably a certain amount of lost motion due to the slackness of the spindle components of the link rod in the armature. However, provided there is sufficient movement of the armature itself, bearing in mind that a degree of mechanical advantage can be obtained by arranging for the link-rod hole in the armature portion 18 to be further away from the armature spindle 15 than that part of the armature which is attracted to the pole pieces 21, 22, as is the case in the vacuum switch chassis of Figure 1, this should not constitute a problem in most applications.

Alternative forms of the link rod 50 are possible. For example, the spacer 51 and one of the washers 52 can be replaced by a bush. Also, various forms of washer and/or bush can be employed, e.g. nylon, steel, or a combination of both (e.g. a compound washer with a nylon washer facing the armature and a steel washer behind the nylon one to provide strength). However, any other suitable material may be used. The washers may also be dished, instead of flat as shown.

While it has been assumed that the link rod 40 will be used to link the actuator 14 with the auxiliary switches via a bell crank 42 , as shown, it may, depending on the application, be connected directly to the auxiliary switch mechanism.

Although the motion conversion arrangement of the invention has been described in connection with an actuator apparatus, it can find use in any application in which it is required to translate an angular displacement into a corresponding, at least substantially linear, displacement in a plane perpendicular to the angular displacement, or vice versa.

Claims

1. A motion conversion arrangement for converting a first motion along an arc in a first plane to a second motion in a second plane perpendicular to said first plane, said first motion being caused by an angular displacement of a pivoted member (14) about an axis (15) perpendicular to said first plane, the motion conversion arrangement comprising a link rod (50), the link rod (50) having at one end a spindle means (51) and a pair of retaining means (53) and at the other end a connection means (54) for connection to an apparatus (48) which is required to be displaced in said second plane, and a hole provided in said pivoted member (14), said spindle means (51) being disposed in said hole and said retaining means (53) being situated on respective sides of said pivoted member (14), a first clearance being provided between said hole and said spindle means (51) and a second clearance being provided between said retaining means (53) and said member (14), said first and second clearances being such as to allow said apparatus (48) and said link rod (50) to move in said second plane during angular displacement of said pivoted member (14).

2. A motion conversion arrangement for converting a first motion in a first plane to a second motion along an arc in a second plane perpendicular to said first plane, said arc being described by a point on a member (14) pivoted on an axis (15) perpendicular to said second plane, the motion conversion arrangement comprising a link rod (50), the link rod (50) having at one end a spindle means (51) and a pair of retaining means (53) and at the other end a connection means (54) for connection to an apparatus (48) which is displaceable in said first plane, and a hole provided at said point on said pivoted member (14), said spindle means (51) being disposed in said hole and said retaining means (53) being situated on respective sides of said pivoted member (14), a first clearance being provided between said hole and said spindle means (51) and a

second clearance being provided between said retaining means (53) and said pivoted member (14), said first and second clearances being such as to allow an angular displacement of said pivoted member (14) about said axis during movement of said apparatus (48) and said link rod (51) in said first plane.

3. A magnetic actuator arrangement, comprising an electromagnet (10, 11) attached to a frame (12), an armature (14) pivotably secured to said frame (12), a portion of said armature (14) being attracted to said electromagnet (10, 11) when the latter is energised, and a link rod (50) linking said armature (14) to an apparatus (48) to be actuated along a linear path which is fixed relative to said frame (12), said link rod (50) having at a first end thereof which is connected to the armature (14) a spindle means (51) and a pair of retaining means (53), said armature (14) having a hole at a point of the armature which moves along an arc when the actuator (14) is energised, said spindle means (51) being disposed in said hole with said retaining means (53) being situated on respective sides of said armature (14), a first clearance being provided between said hole and said spindle means (51) and a second clearance being provided between said retaining means (53) and said armature (14), said first and second clearances being such as to allow said apparatus (48) and said link rod (50) to be displaced in a plane perpendicular to a plane of said arc when said electromagnet (10, 11) is energised.

4. A magnetic actuator arrangement as claimed in Claim 3, in which said spindle means is constituted by a spacer (51) mounted on said link rod (50) and said retaining means are constituted by a pair of washers (53) held against respective sides of said spacer (51).

5. A magnetic actuator arrangement as claimed in Claim 3, in which said spindle means (51) and one of said retaining means (53) are constituted by a bush mounted on said link rod (50) and the other retaining means (53) is constituted by a washer held against said bush.

6. A magnetic actuator arrangement as claimed in any one of Claims 3 to 5, in which a second end of said link rod is connected to one or more moving contacts (48) of one or more switching devices (29).

7. A magnetic actuator arrangement as claimed in Claim 6, in which said one or more switching devices are vacuum switches (26).

8. A magnetic actuator arrangement as claimed in Claim 6, in which said one or more switching devices are auxiliary switching devices (29).

9. A magnetic actuator arrangement as claimed in Claim 8, comprising a linkage arrangement (42) between said link rod (50) and respective armatures (48) of said one or more auxiliary switching devices (29), said linkage arrangement (42) being pivotably secured to said frame.

10. A magnetic actuator arrangement as claimed in Claim 9, in which said linkage arrangement comprises a bell crank (42) for converting a motion of said link rod (50) along a first substantially linear path into a motion along a second substantially linear path substantially perpendicular to said first path, said first and second paths being in a common plane.

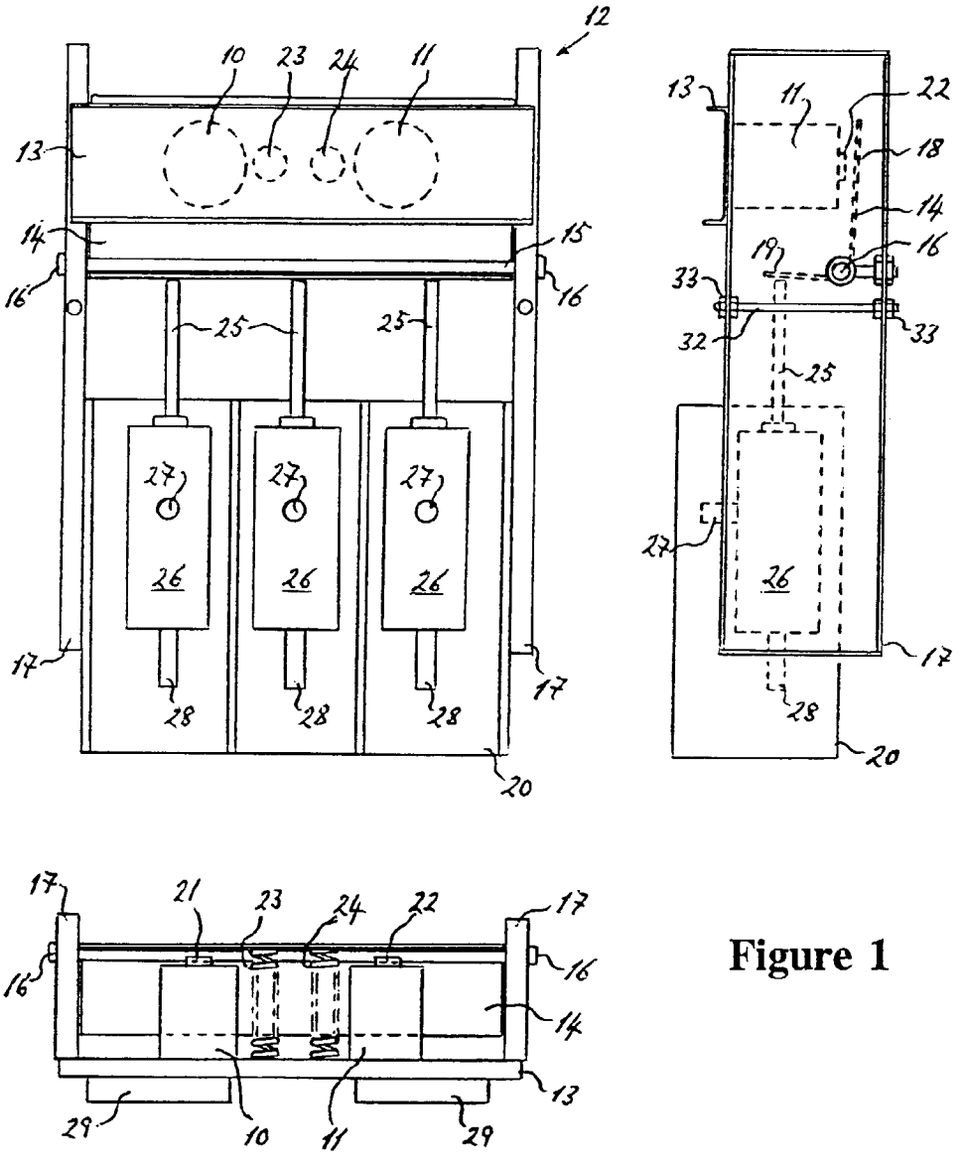
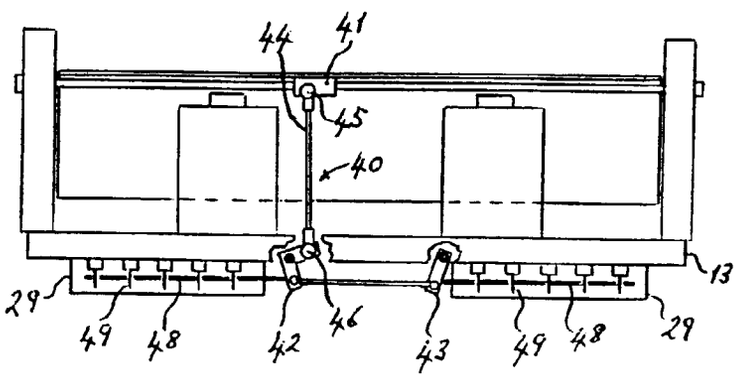


Figure 1

Figure 2



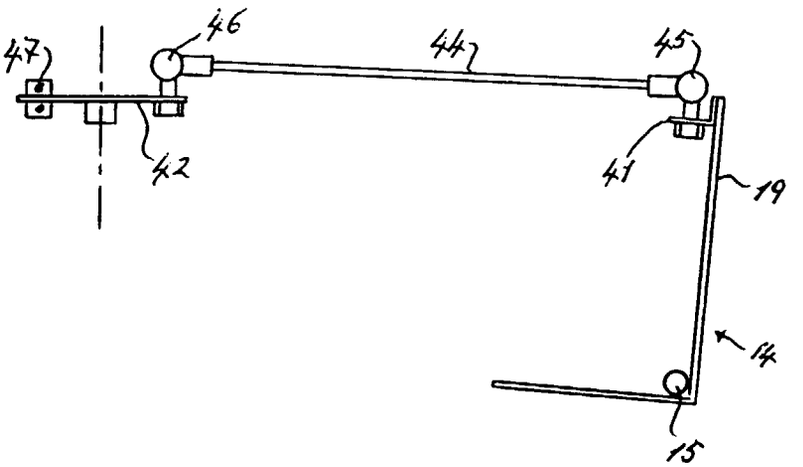


Figure 3

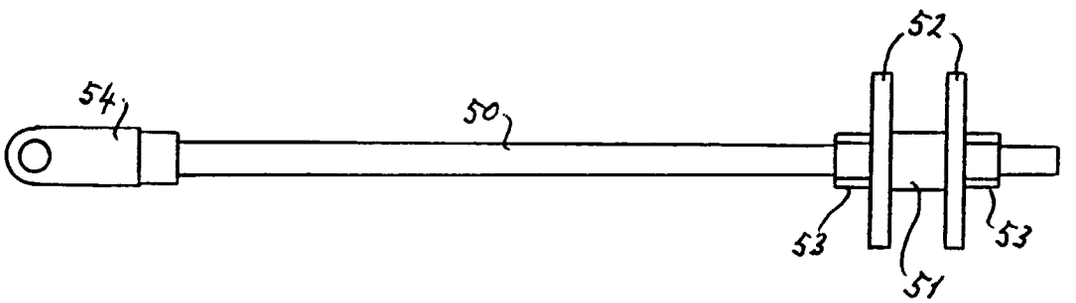
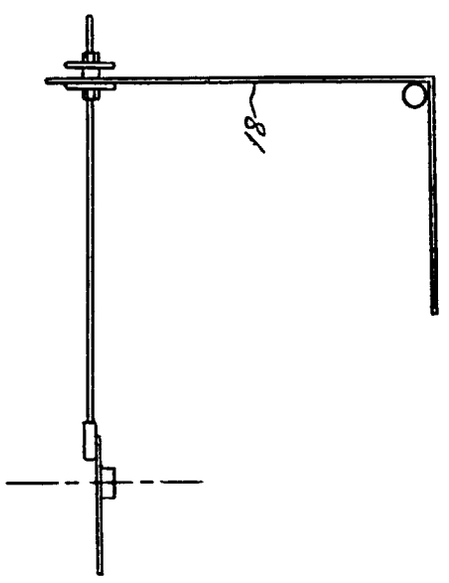


Figure 4



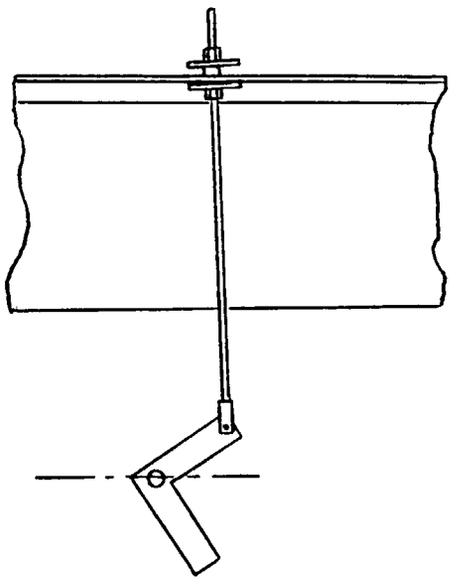
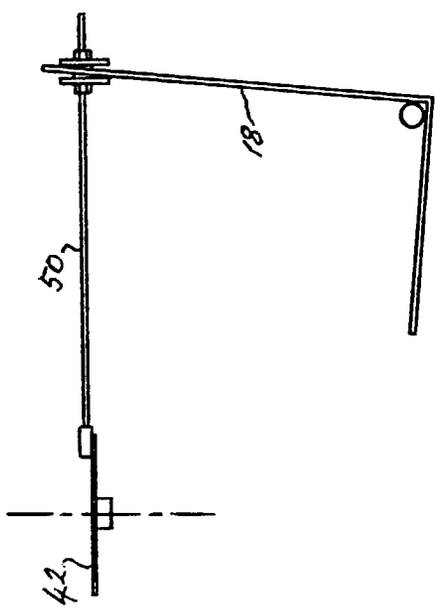


Figure 6



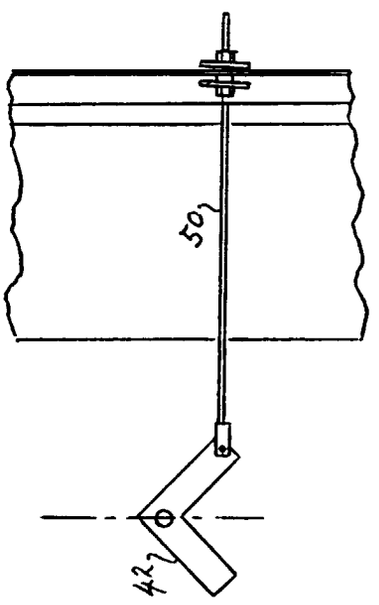


Figure 5