(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 068 676**
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **82302969.9**

(22) Date of filing: **09.06.82**

(51) Int. Cl.³: **E 04 C 3/40**

(30) Priority: **18.06.81 GB 8118847**

(43) Date of publication of application: **05.01.83 Bulletin 83/1**

(84) Designated Contracting States: **AT BE CH DE FR IT LI LU NL SE**

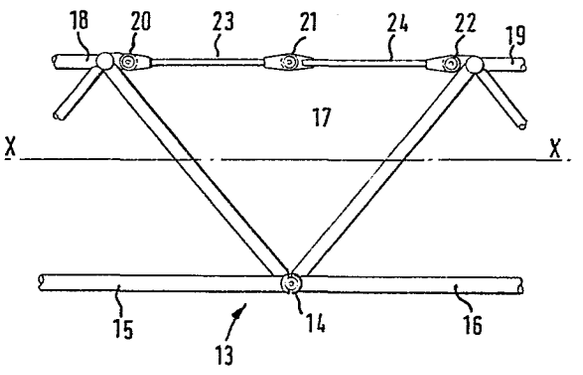
(71) Applicant: **Whitby, Mark, 5 Highbury Place, Walcot Bath (GB)**

(72) Inventor: **Whitby, Mark, 5 Highbury Place, Walcot Bath (GB)**

(74) Representative: **Turner, Paul Malcolm, PAUL M. TURNER AND COMPANY European Patent Attorneys 47 Marylebone Lane, London W1M 6DL (GB)**

(54) Portal frame structures.

(57) A portal frame structure is provided comprising a horizontal truss (10) and vertical supports (11, 12) secured to the respective ends of the truss (10), the truss (10) being provided with a joint arrangement (13) intermediate its end, said joint arrangement (13) being such that outside elements (15, 16) of the truss (10) on one side of its neutral axis (X-X) are maintained in compression in both directions of load on the truss, and that outside truss elements (18, 19) on the other side of said neutral access are subjected to predetermined tension, such that as the load increases in one of said load directions the tension is reduced, and to tension exerted in the other of said load directions. The predetermined tension may be zero, such that the joint arrangement collapses immediately a compressive load is applied. Alternatively, it may have a value such that it reaches zero at any point up to the maximum designed load for a particular building application. The portal frames are for use with cladding secured to the inner side of the frames.



EP 0 068 676 A2

PORTAL FRAME STRUCTURES

This invention relates to portal frame structures.

It is known to provide such structures having a horizontal truss and two vertical supports which are rigidly secured to respective ends of the truss. It is also known to provide such frames with a pivot joint at the centre of the truss, and with two pivot joints at connections between the respective vertical supports and the ground. Such frames are commonly referred to as three-pin portals.

In addition to its own dead load the horizontal truss of a portal frame may be required to support additional downward loads, for example, snow loads if the truss forms part of a roof. Furthermore, wind forces can impose upward loads on a horizontal truss of a roof, these wind loads being considerably greater than the total downward loads. In conventional three-pin portal frames the change from upwards to downwards loading results in a reversal of the stresses in the upper and lower members of the truss, and consequently in a reversal of the bending moment at the rigid connections between the truss and its vertical supports.

It is an object of the invention to provide a portal frame structure in which the aforesaid

reversals of stress and bending moment are taken into account.

According to the invention there is provided a portal frame structure comprising a horizontal truss and vertical supports secured to respective ends of the truss, said truss being provided with a joint arrangement intermediate its ends, said joint arrangement being such that outside elements of the truss on one side of its neutral axis are maintained in compression in both directions of load on the truss, and that outside truss elements on the other side of said neutral access are subjected to tension only, said tension being exerted only in one of said load directions.

In a further aspect of this invention, a portal frame structure is provided comprising a horizontal truss and vertical supports secured to the respective ends of the truss, the truss being provided with a joint arrangement intermediate its end, said joint arrangement being such that outside elements of the truss on one side of its neutral axis are maintained in compression in both directions of load on the truss, and that outside truss elements on the other side of said neutral access are subjected to predetermined tension, such that as the load increases in one of said load directions the tension is reduced, and to tension exerted in the other of said load directions.

In one embodiment the structure is a two-pin portal frame, the joint arrangement providing a tie under tension.

In general when the joint arrangement is subjected to a predetermined tension, the tension is such that with a load increasing in the one of said load directions the tension will reduce to zero and when it reaches zero, the joint arrangement has no effect causing the frame as a whole to convert from a two-pin portal frame to a three-pin portal frame.

In a further embodiment said structure is a three-pin portal frame, said joint arrangement providing one of the pivot points of said frame.

In a particular embodiment said joint arrangement comprises a pivot joint connecting the outside truss elements on said one side of the neutral axis, and a flexible linkage interconnecting the outside truss elements on the other side of said neutral axis.

The joint arrangement can comprise a pivot joint on one side of the truss elements and a flexible linkage made up of three pivot joints linked by two rods on the other side of the neutral axis. A pivot joint links each of the outside members of the truss and with the third pivot joint linking the two rods. The three pivot

flexible linkage can be used in a unstressed state such that the outside truss elements on one side of the neutral axis are subjected to tension only. Immediately the load direction changes the flexible linkage collapses causing the structure to act as a three-point portal frame. By applying predetermined tension to the flexible linkage, e.g. during construction of the building the linkage remains in tension for both directions of load, although it will collapse once a certain load has been exceeded. The structure can be designed such that the tension in the flexible linkage only reaches zero when the maximum designed load is reached in one direction.

Other joint arrangements are also possible. A rigid bar connected to the outside members of the truss may also be used with a pivot connecting the inside members of the truss particularly if it is to be pre-stressed such that the tension will not reduce to zero under any anticipated loads.

For example, careful calculation of all upward loads can be made such that the pre-stressed bar will remain in tension and only reach zero tension when the maximum designed load is reached in one direction.

Another joint arrangement is a cable connecting the outside elements of the truss, the inner

members being connected with a pivot. The cable may be used for both embodiments of the present invention, i.e. the three-pin portal structure such that on the change of load direction there is no tension in the cable, or as a pre-stressed linkage to form a two-pin portal frame until a predetermined load is reacted in one direction. At this point the tension in the joint arrangement reaches zero and the structure will then act as a three-pin portal frame.

In one embodiment said truss is joined to said vertical supports through connecting means for providing lifted pivotal movement in response to a load in the aforesaid one direction.

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

Figure 1 shows, diagrammatically, an elevation of the hybrid portal frame of the present invention;

Figures 2, 3 and 4 show, to an enlarged scale, details of the frame of Figure 1;

Figure 5A shows, to a further enlarged scale, a section on the line 5-5 in Figure 3; and

Figure 5B is a view, corresponding to Figure 5A with an upward load on the frame.

The frame shown in Figure 1 is a modification of a three-pin portal frame having a horizontal truss pin and vertical support structures 11, 12 which are secured to respective ends of the truss 10. A joint arrangement 13 in the middle of the truss 10 is shown in more detail in Figure 2, and comprises a pivot joint 14 interconnecting the lower horizontal members 15, 16 of the truss 10, these members 15, 16 being the outside members below the truss neutral line XX. The joint arrangement 13 also comprises a flexible linkage 17 interconnecting the upper horizontal members 18, 19 of the truss 10, the members 18, 19 being the outside members of the truss above its neutral line XX. The linkage 17 comprises three pivot joints 20, 21, 22, a rod 23 threadly engaging elements of the pivots 20, 21, and a further rod 24 secured to an element of the pivot 21 and threadly engageing an element of the pivot 22. The total length of the linkage 17 may thus be adjusted to provide a required initial tension in the upper members 18, 19 of the truss 10, but will collapse to prevent the members 18, 19 being subjected to compressive load.

The initial tension may be increased such that when the load direction is downwards some tension remains in the upper members 18, 19 of the truss 10. This pre-tensioning may be

induced by tensioning the threadingly engaging elements of the pivots 20, 21 and 22. Alternatively, the pre-tensioning may be induced by pre-loading the truss prior to insertion of the flexible linkage, particularly if the linkage is a rigid bar or a cable.

The joint 30 between the truss 10 and support structure 12 is shown in more detail in Figure 3 and comprises a pivot 31 between the member 19 and an outer member 32 of the structure 12, together with a connection 33 between the member 16 and an inner member 34 of the structure 12. The connection 33 is shown in more detail in Figure 5 and comprises a pin 35 through elongate holes 36, 37 in respective elements 38, 39 which are in turn secured to the members 16, 34 respectively. The arrangement is such that with a downward load on the truss 10 the elements 38, 39 abut the pin 35 as shown in Figure 5A, the arrangement thus being in compression. With upward loading on the truss 10, and depending upon the initial tension applied to the linkage 17 (Figure 2) the elements 38, 39 can move apart to the position shown in Figure 5B, thereby permitting limited movement about the pivot 31. The joint between the truss 10 and support structure 11 is made in a similar manner.

As shown more clearly in Figure 4 the structures 11, 12 are pivotally connected to

supporting feet 40.

In one embodiment, with a downward load on the truss 10, and by virtue of the pivot joint 14 and the pivotal connections of the support structures 11, 12 to the ground, the truss 10 as a whole is under compression. The linkage 17 thus collapses and no compressive load is experienced by the upper members 18, 19 of the truss. The elements 38, 39 in both of the joints between the truss and the support structures 11, 12 are urged into the positions shown in Figure 5A.

In another embodiment, when the linkage 17 is pre-stressed, the downward load on the truss 10 will cause the tension in the linkage to reduce, the truss as a whole being under compression. Once the tension in the linkage 17 reaches zero, it collapses such that no compressive load is applied to the upper members of the truss. The tension in the linkage can be adjusted during building such that the structure acts as a hybrid portal frame. When predetermined loads are reached on the portal frame, it converts from a two-pin hybrid portal frame to a three-pin portal frame with no tension in the linkage 17.

Under an upward wind load the truss 10 hogs and the linkage 17 is subjected to tension, preventing movement in the joint arrangement 13 and causing the structure as a whole to act as a two-pin portal frame. Under an increasing wind load

from, for example, the right-hand side of the frame, as seen in Figure 1, the joint arrangement 13 remains rigid and the elements 38, 39 of the left-hand joint 30 will be maintained in the abutment condition shown in Figure 5A. Dependent on the initial tension set in the linkage 17, any additional hogging of the truss 10 will cause the members 38, 39 of the right-hand joint 30 to move towards the positions shown in Figure 5B, resulting in movement about the pivot 31 of that joint. During this movement the frame acts as a three-pin portal frame, the right-hand one of the joints 30 providing the third pin. It is nevertheless possible by suitable pre-tensioning of the linkage 17 to maintain the frame as a two-pin portal under all anticipated upward loads.

It is principally intended that a plurality of portal frames of the type described shall be used as the external supporting structure for a building, wall and roof cladding being secured to inside members of the frames. The frames are thereby less liable to buckle in the event of an internal fire in the building. The roof cladding also acts to restrain the members 15, 16 of the frames from buckling due to compression. Portal frames according to the present invention, whereby the members 15, 16 are always in compression are

restrained against compressive buckling, and the upper members 18, 19 need not be dimensioned or braced to take compressive loads.

By pre-stressing the joint arrangement in the truss, snow load deflection is reduced without increasing the member forces due to the snow load. The structure will deflect under a snow load, as if it were a two-pin portal frame until the force in the joint arrangement reaches zero. From that point onwards, the structure will act as a three-pin portal frame with the link collapsed. Under wind loads the pre-stress reduces the amount of compression around the knee joint such that the knee joint does not dictate the performance of the structure. The loads of the truss, particularly in the centre, are increased.

It should be borne in mind that the specific embodiment describes a portal frame structure comprising a horizontal truss with a joint arrangement intermediate its end, in which the joint arrangement is on the upper side of the neutral axis. However, depending on the loads anticipated on the truss, the joint arrangement may be positioned on the lower side of the neutral axis.

CLAIMS

1. A portal frame structure comprising a horizontal truss and vertical supports secured to the respective ends of the truss, the truss being provided with a joint arrangement intermediate its end, said joint arrangement being such that outside elements of the truss on one side of its neutral axis are maintained in compression in both directions of load on the truss, and that outside truss elements on the other side of said neutral access are subjected to predetermined tension such that as the load increases in one of said load directions the tension is reduced, and to tension exerted in the other of said load directions.

2. A portal frame structure as claimed in claim 1 wherein the predetermined tension in one of the truss elements is zero or sufficient to provide initial tension in the truss element but will collapse to prevent the truss element being subjected to any compressive load.

3. A portal frame structure as claimed in claim 2 wherein said structure is a three pin portal frame, said joint arrangement providing one of the pivot points of said frame.

4. A portal frame structure as claimed in claim 1 wherein said predetermined tension in one of the truss elements is such that with an increasing load in one direction the tension will reduce to zero causing the frame structure to convert from a two-pin portal frame to a three-pin portal frame.

5. A portal frame as claimed in any one of the preceding claims wherein said joint arrangement comprises a pivot joint connecting the outside truss elements on said one side of the neutral axis, and a flexible linkage interconnecting the outside truss elements on the other side of said neutral axis.

6. A portal frame structure as claimed in claim 5 wherein the joint arrangement is a rigid bar connected by pivots to the members of the truss.

7. A portal frame structure as claimed in any one of the preceding claims forming an inverted U-shape frame having inner and outer horizontal truss members and inner and outer vertical support members wherein each joint between the horizontal truss and the vertical supports comprise a pivot between an outer member of the truss and an outer member of the support and a slidable connector between an inner member of the truss and an inner member of the support.

8. A portal frame structure as claimed in any one of the preceding claims forming an inverted U-shape frame having inner and outer horizontal truss members in which the joint arrangement connects the outer horizontal truss members.

9. A portal frame structure as claimed in any one of claims 1 to 7 forming an inverted U-shaped frame having inner and outer horizontal truss members in which the joint arrangement connects the inner horizontal truss members.

10. A plurality of portal frame structures each as claimed in any one of the preceding claims, supporting wall and roof cladding secured to inside members of the frames to form a building.

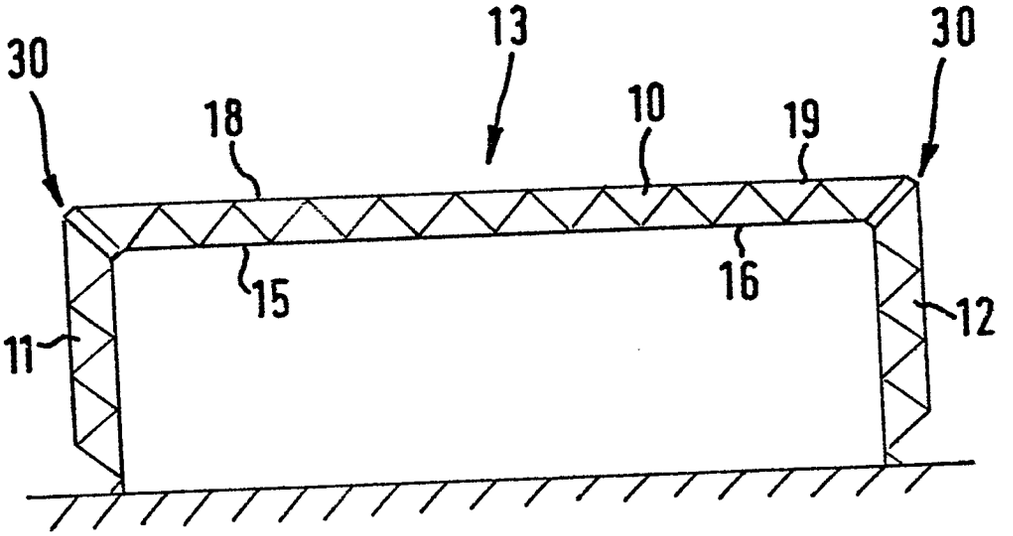


FIG.1

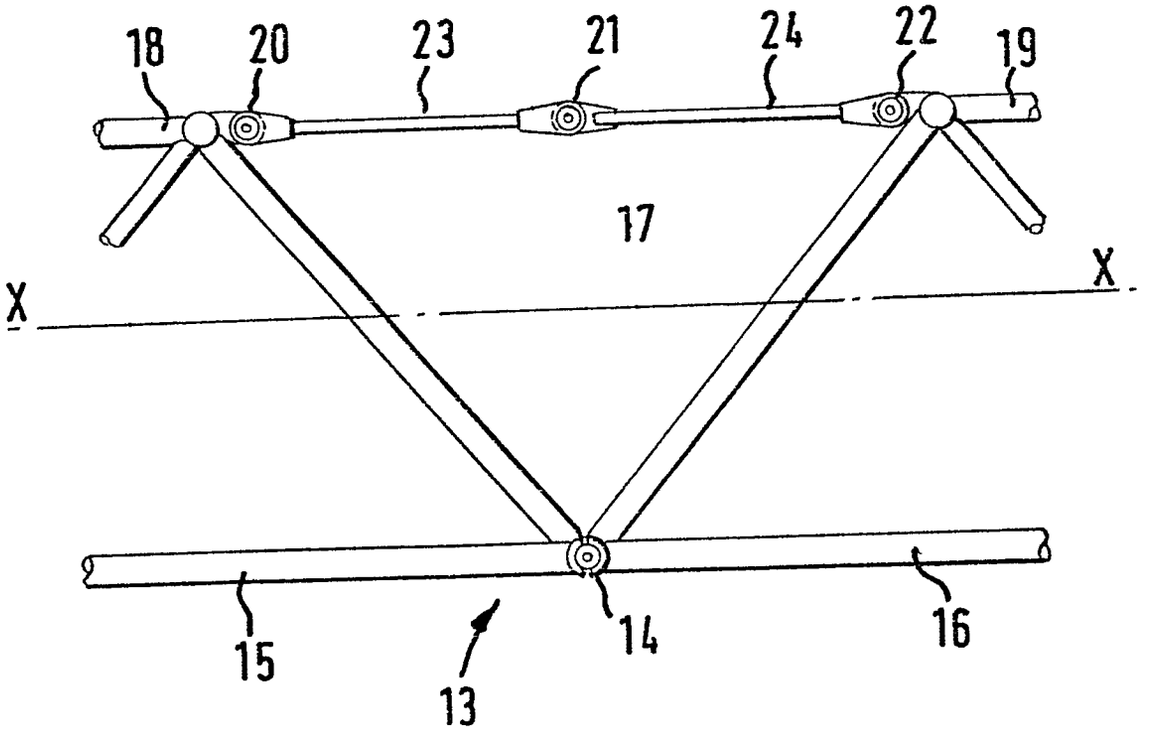


FIG.2

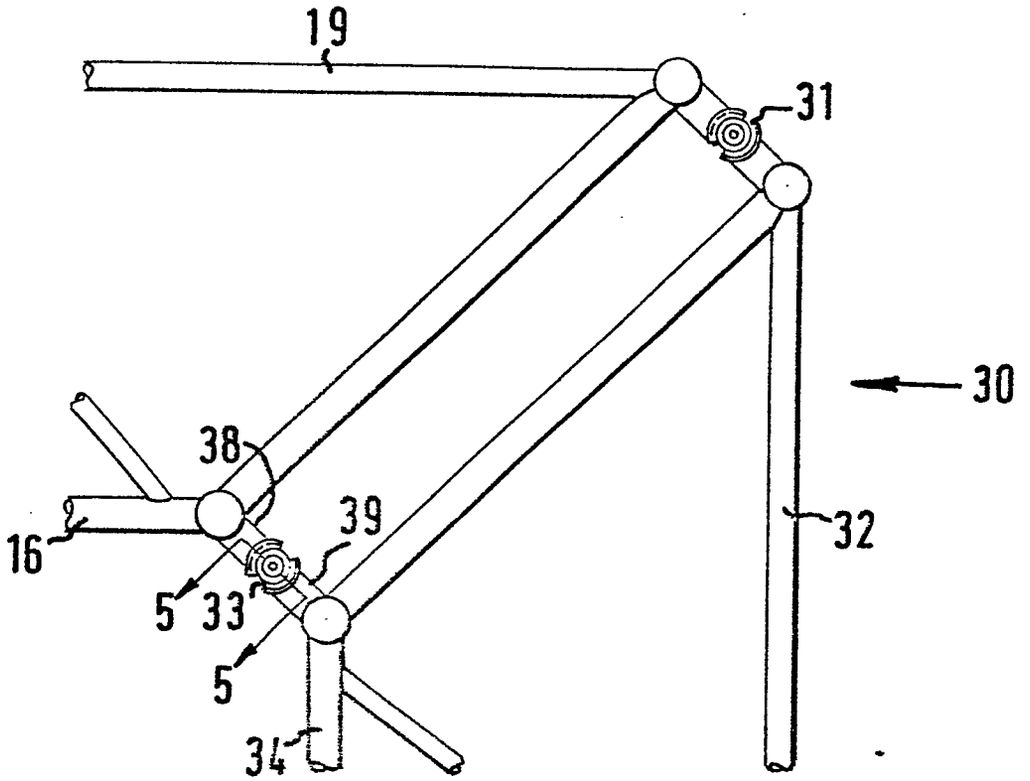


FIG.3

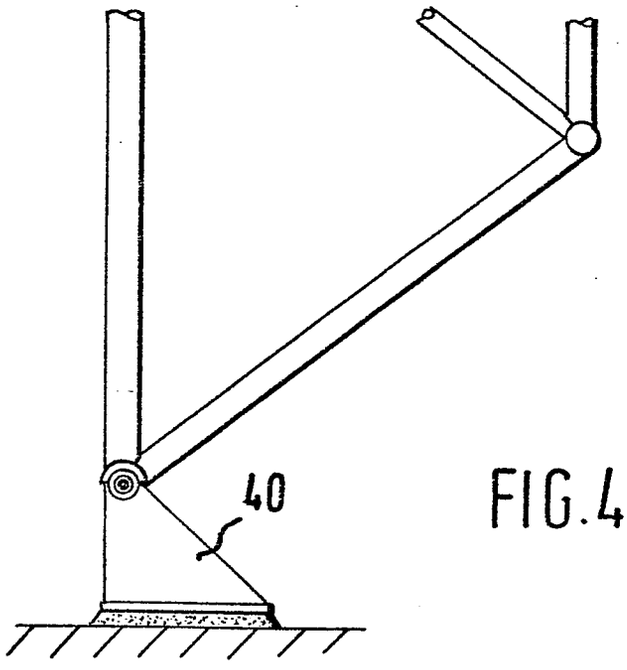
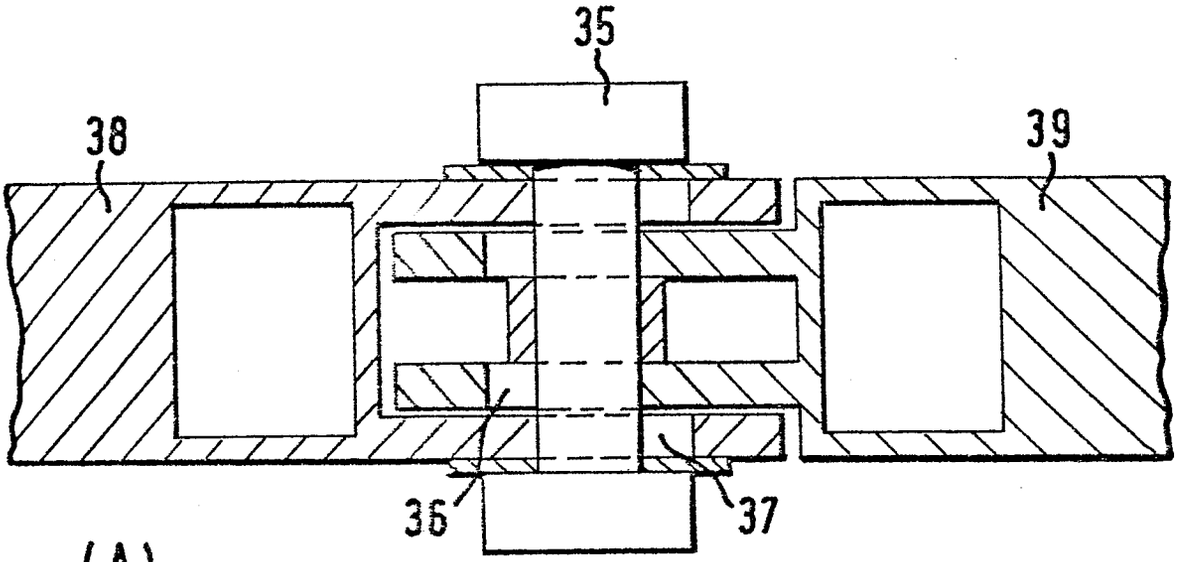
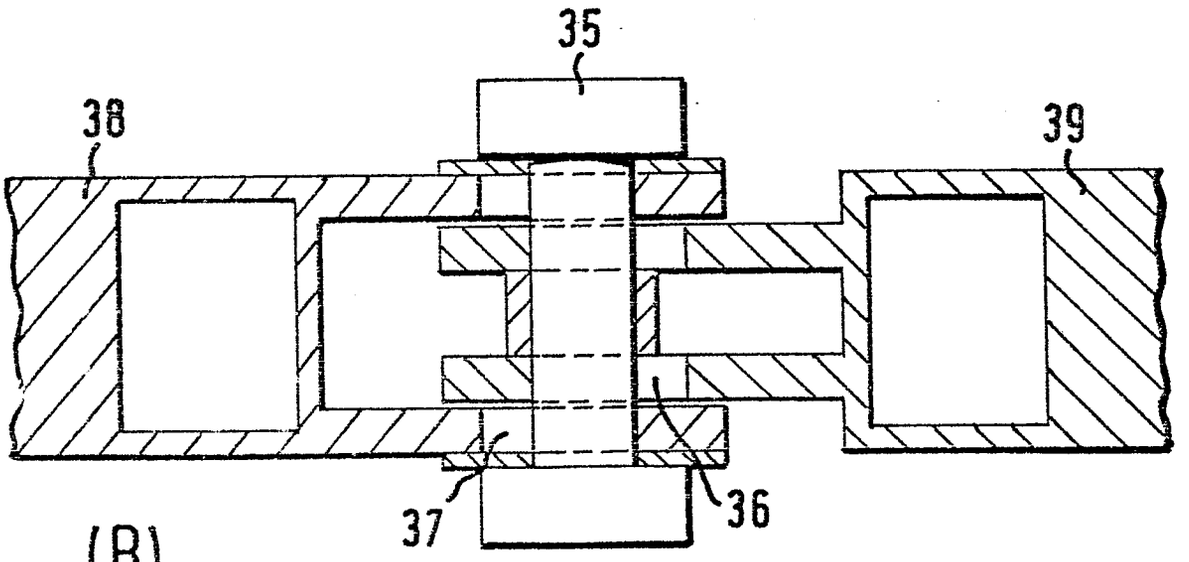


FIG.4



(A)



(B)

FIG.5