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(54) **A collapsible membrane structure.**

(57) A collapsible membrane structure is devised so as to reduce the total volume when the structure is collapsed for such as transportation.

The framework comprises a plurality of frames, each frame including rafter members and leg members which are pivotably coupled through hinge blocks which are designed so as to withstand the stresses during the transportation and after erection. Since pivoting of the members is effected substantially at the intersecting points of the straight members, the overall height of the structure is made smaller than those of prior art wherein the members are conventionally bent to form shoulder roundness. Further, for installing or coupling some members, retaining members are designed to reduce the possibility of outwardly directed projections in the membrane structure and attached to appropriate portions of the framework which also facilitate the erection of the structure or attaching of members to the framework.

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A COLLAPSIBLE MEMBRANE STRUCTURE

The present invention relates to an improvement of a collapsible membrane structure such as a so-called temporary housing structure comprising a multiplicity of frame members connected to one another, the outer surfaces being covered with a membrane covering.

It is necessary that a structure such as a temporary housing and the like be easy to transport and to erect. For this reason, such structures are normally constructed to be extensible and/or contractable. In such a conventional foldable construction, the leg members are arranged to be foldable relative to the roof members in order to reduce the overall dimensions of the structure when it is to be transported, stored, etc. To such end, either of the rafter members or the leg members are bent to form the juncture portion of the roof and legs and these members are connected to the other members at the straight portions by suitable hinge means for convenience of transportation. The radius of curvature of the bend at the position corresponding to the shoulder part of the structure had to be relatively large due to the bending limitation of the material for such frame members. Consequently, the drawback of such construction was that the shipping package for such collapsible membrane structure became so bulky that it caused inconvenience in handling and transportation as well as risk of deformation and/or breakage of the membrane or components.

Furthermore, this hinge connection system at the shoulder part (juncture of legs and roof members) has not been satisfactory in respect of structural strength and, therefore, has not been widely adapted for practical use.

Furthermore, in the conventional structure of this sort, where connection of the required frame members was provided by bolts and brackets, the brackets being fixed at the outer surfaces of the members to be connected, the connection parts tended to project from the framework surface. Such projections are not desirable for transportation under collapsed condition and may damage the membrane. In addition, since the bolts and/or bands for connection were welded to the required parts of the frame, there were problems in terms of stability, strength and easy damage in addition to such welded portion projections.

Furthermore, the membrane was secured to the outerside of the frame members by means of cord or tapping screws with liner members in between. Consequently much working time was required for securing the membrane.

Accordingly, it is an object of the invention to provide a collapsible membrane structure which obviates the drawbacks mentioned above.

More specifically, it is the object of this invention to design and provide a novel and improved collapsible membrane structure which enables the transportation and erection easy with maintaining the suitable rigidity.

According to the present invention, the solution to eliminate the firstly mentioned drawback is to provide hinge means which connect the rafter members and the adjacent leg members at the intersecting point of the extended lines of the straight parts of both members and to design the hinge connection having the required strength, a smooth and small radius for protecting the membrane. Furthermore, since the membrane is in close contact with the outer surface of the shoulder part consideration is given to minimizing the number of projections of the frame structure where the membrane contacts therewith and so as to reduce the packing height, the radius of curvature at the shoulder part, namely the hinge portion has been reduced to the greatest extent possible without sacrificing necessary

structural strength. In the detailed construction of the shoulder part, it comprises a main body, a fixed plate at the lower portion of the main body and a movable plate pivotably attached to the fixed plate at the portion adjacent the end thereof, the fixed plate forming a box-like construction downwardly opened and the movable plate being sized to be adequately accommodated in the fixed plate without leaving substantially any clearance between both plates when the leg is erected so that a strong and stable hinge connection may be provided. Furthermore, at the upper surface of the shoulder connection part and the lower surface of the movable plate respectively, connection members are attached by welding or the like and extend therefrom and these connection members serve to join the rafter members or beam members to the leg members through the main body of the shoulder part, i.e. connection blocks, the respective extended connection members being fit into the rafter members, beam members and the leg members respectively. Thus, the shoulder part serves to provide a compact but strong frame structure. By using a plurality of these shoulder frame structures and auxiliary members such as expandable and contractable bracing members or connection members, and with use of some convenient connecting means as required, respective frame structures may be collapsibly joined to form a whole framework. And after the membrane is placed to cover the upper surface of the framework, a collapsible membrane structure having adequate strength and fewer projection directed outwardly of the framework even at the time of frame members being folded may be obtained.

Further, the novel collapsible membrane structure may be made still more compact in size and easy to collapse, yet having sufficient strength with additional use of connector hinge blocks at the ridge part of the frames.

Now referring to the solution according to the present invention to eliminate the secondly mentioned drawback of the conventional structure, retaining members of novel construction and function are used as a means to connect the required auxiliary members or the like to the framework. The retaining members are fixed beforehand to the required frame members at such

location as will come inwardly or laterally when they are installed in the framework except for the portions necessary to be facing outwardly such as for securing the membrane. Accordingly, when the membrane structure is collapsed, the possibility of attaching part projecting outwardly may be reduced while the auxiliary members may be firmly attached. The retaining member is formed in channel configuration in section or, as required, in channel-like configuration with the corners being made round. The retaining member is further provided at center of the outer surface with a longitudinal slot having a width adapted to correspond to the size of the shank of the bolt and one end of the slot is enlarged or provided with a through-bore large enough for the head of the bolt to pass through.

As an alternative embodiment of connecting means of the required auxiliary members, a retaining member having channel-shaped section may be provided with a space to enable the head of the bolt to be received therein and a longitudinal slot is formed so as to be opening at one end edge of the retaining member to receive the shank of the bolt at the end edge as movable to the middle of the retaining member beforehand secured to the frame members. A holding member having a through-hole adapted to receive the bolt shank or threaded part of the bolt and one end thereof being bent to form a locking projection is used in combination with this retaining member. This combination provides easier assembly, and more stable construction.

A solution according to the present invention to eliminate the thirdly mentioned drawback of the conventional construction and improve the attachment of the membrane to the assembled framework is to provide a retaining member of channel-like section, opposite ends of which are rounded and having a longitudinal slot sized to receive the shank of the bolt and one end of the slot being opened at the end edge of the retaining member or provided with a through-bore adapted to receive the head of the bolt. A plurality of such retaining members are spaced on the outer surface of the framework and bolts are inserted in the longitudinal slot to stand up therefrom, while the membrane is also provided with holes to receive the bolt at distances and locations corresponding to the positions of the

retaining members, whereby the membrane may be very efficiently and firmly secured to the framework by means of the standing bolts. Furthermore, if the retaining members are properly located, only those used for directly attaching the membrane will project from the framework, and thus the number of projections from the framework may be substantially reduced. At the same time, this provision may provide many other advantages compared with the conventional structure, such as when the framework is extended and erected to be covered with the membrane or collapsed for transportation, there is less possibility of the retaining members contacting the membrane except for those directly touching the membrane, so that possibility of the membrane being damaged may be substantially avoided. The invention will be further explained hereinafter following the brief explanation of the drawings summarized below.

Fig. 1 is a perspective view partially broken of an embodiment of the collapsible membrane structure according to the present invention;

Fig. 2 is a series of enlarged sectional views illustrating the major part of different embodiments of a shoulder block to be used for the collapsible membrane structure according to the present invention, in which:

Fig. 2A illustrates an embodiment wherein the pin and bolt are provided at the side to be folded;

Fig. 2B illustrates an embodiment wherein the pin is provided at the side to be folded, while the bolt is at the opposite side, viz. outer side;

Fig. 2C illustrates an embodiment wherein both bolt and pin are provided at the side to be folded, but completely outside of the connection block;

Fig. 3 is a front view of the portion where the frame members to be used for the collapsible membrane structure of the present invention are folded at the shoulder block;

Fig. 4 is a perspective view of an embodiment of the shoulder block and its associated elements;

Fig. 5 is a front view showing how the leg members on both sides are folded inwardly at the shoulder blocks to be used for the collapsible membrane structure according to the present

invention;

Fig. 6 is a front view illustrating the embodiment where a block including a hinge means is utilized at the ridge of the roof for reducing the volume of the structure when it is collapsed;

Fig. 7 shows various embodiments of retaining members to be used for the collapsible membrane structures according to the present invention, wherein,

Fig. 7A is a perspective view showing an embodiment including a bolt and a nut;

Fig. 7B is a plan view showing another embodiment of the retaining member;

Fig. 7C is a perspective view of still another embodiment of the retaining member;

Fig. 8 illustrates a connection assembly to be used for the collapsible membrane structure according to the present invention, wherein,

Fig. 8A is a perspective view thereof;

Fig. 8B is a side view showing how the assembly is used;

Fig. 9 illustrates another embodiment of a connection assembly to be used for the collapsible membrane structure according to the present invention, wherein,

Fig. 9A is a perspective view showing the components including bolt, etc;

Fig. 9B shows the liner member;

Fig. 9C is a partially sectioned side view showing how the retaining member is used; and

Fig. 10 is an explanatory perspective view showing the construction to attach the membrane using the retaining members and so forth illustrated in Fig. 9 wherein,

Fig. 10A is an overall perspective view;

Fig. 10B is a perspective view showing an example of the membrane provided with holes for bolts at predetermined positions.

Now, the present invention will be further described hereinafter with reference to the accompanying drawings. In Fig. 1, numeral 1 designates framework, numeral 2 designates the connection block used to join the left and right rafter members at the top of the roof ridge, and numeral 3 designates the shoulder blocks on both opposite sides comprising a hinge 5 at the lower

part thereof and serving to connect the rafter members 4 and the leg members 6. In case that it is desirable to strengthen the roof, a beam member 7 is provided, and the roof may be made of a truss structure by attaching a number of support members 9 via some connection means 8 and connected at both ends to the top of the leg members 6 and the end of the rafter members 4 through the shoulder blocks 3. As it will be seen, in this embodiment, the frame members are adapted to be folded at the shoulder part at the position adjacent to the intersecting point of extended lines of the straight parts of both rafter and leg members. As illustrated in the enlarged details in Fig. 2A, 2B and 2C, the rear side of the shoulder block 3 may be made remarkably smaller in the radius of curvature (shown at 3") than otherwise required in the conventional construction which is formed by bending of the elongated material. Furthermore, at the lower part of the shoulder block is provided a hinge means 5 comprising a fixed plate "p", a movable plate "q" and a pin "r". From the bottom surface of the fixed plate "p" of the shoulder block 3, the lower edge part "p'" extends downwardly approximately at right angle to said bottom surface so that said movable plate "q" may be pivotably attached to said lower edge part "p'" through a pin "r". In order to connect the rafter member 4 and leg member 6 or the beam member 7 when required, with the shoulder block 3, the connection members 3' are provided at the shoulder block at the required location and angular position and to the connection members 3' are connected the corresponding frame members, i.e. rafter members 4, leg members 6 and the beams 7. As illustrated, the connection members 3' for the leg frame members 6 in particular are secured to the movable plate 9 by a suitable method such as welding. In this manner, variation is provided with regard to the relative positions of attaching the pin or bolt to the respective fixed and movable plates. Namely, Fig. 2A shows an example where both the pin "r" and the bolt 13 are provided at inner side of the shoulder block 3. Fig. 2B shows an example where the bolt is provided at the outer side of the shoulder block 3, while Fig. 2C shows an example where the bolt 13 is provided completely outside of the shoulder block but inwardly of the framework.

In the meantime, there are a variety of constructions in respect of the pivoting pin and its relative part. Namely, as shown in Fig. 2C, the distal end of the movable plate "q" is bent round downwardly at the inner side of the bending part of the leg member 6 to form a hole for receiving the pin "r" or the distal end of the fixed plate p is suitably bent (not shown) to form such a hole or other methods will be available.

Fig. 3 shows how the leg member 6 is folded at the shoulder block so as to reduce the bulkiness of the frame structure. Fig. 4 is a perspective view showing the detail of the shoulder block 3 and the condition where the movable plate has been swung out with the pin "r" as the pivoting center. Numeral 13' designates the bore for the bolt. This particular case exemplifies the example where the movable plate "q" is of relatively thick material and when the leg member 6 is connected and tightened with the bolt 13, the plate "q" is adequately accommodated in the box-like space provided by the lower edge part "p'", thus affording a sturdy construction. Now, Fig. 5 shows the condition in which the leg members at both sides of the framework 1 used for the collapsible membrane structure of the invention have been inwardly folded respectively to become compact and tightly joined together by suitable fastening means 15 and 16 to become ready for storage or transportation. Due to the fact that the radius of curvature of the shoulder block at the folding position has been so reduced that it may be possible to minimize the bulkiness of the framework in the vertical direction as viewed in Fig. 5 when the legs are folded.

Furthermore, due to the fact that the hinge structure of this invention differs considerably from the conventional hinge type structure wherein two parts, each comprising a series of depressions and protrusions complementarily coupled through a hinge pin, the construction according to the present invention may afford sufficient strength against the stress working at the folding part, whereby there is less possibility of the hinge part being damaged due to irregular or incidental external force which may be caused during use or transportion of the collapsible membrane structure.

Now proceeding to Fig. 6 showing another modification of

the collapsible membrane structure of the present invention, the details thereof are illustrated in front view where the frame structure with use of a ridge block 2a comprising 2 sets of hinge means 5a, 5a in a similar manner to Fig. 2 as the connection means at the top of the ridge of the right and left rafter members 4, 4 is shown in a condition suitable for transportation. Namely, since the connecting ridge block 2a comprises 2 sets of hinge means 5a and the rafter members 4 may be pivotably moved relative to the ridge block 2a through said hinge means, the rafter members 4, 4 may be pivoted to be in a substantially straight line, whereby the height of the framework may be remarkably reduced compared with the conventional one. The bolt 13a will be used to reinstate the rafter members to the roof shape. In Fig. 6, the beam similar to the beam 7 in Fig. 1 is eliminated; however, it may be used provided that each beam may be separated to agree with the extended condition of the rafter members.

Figs. 7 and 8 illustrate examples of a retaining member to provide easier connection of the required frame members and/or auxiliary members and enable it to reduce projection of such retaining members outwardly of the framework. Fig. 7 shows the several configurations of the specially designed retaining member to be used as the connecting means at the locations at which the required frame members, and other reinforcement members and/or auxiliary members and the like are to be attached. Fig. 7A is a perspective view of such retaining member assembly and if such assemblies are fixed beforehand at the preselected locations of the respective members anticipated to be connected with other members, the other members would be easily connected with use of the bolt 13b. Furthermore, as shown in Fig. 7A, if a longitudinal slot "i" dimensioned to accommodate the shank of the bolt 13b is provided together with a bore "j" at one end of the slot and adapted to pass the head of the bolt therethrough, it will be possible to quite efficiently connect the other members. Furthermore, by providing a sub-guide "k" underneath the bolt head which is adapted to slide but not to rotate in the slot "i", at the lower part of the bolt head, efficient tightening of the nut is made easy because the sub-guide

"k" will serve to prevent the bolt from being turned. As an alternative, with a retaining member 8b shown in Fig. 7B, it is possible to make one end of the longitudinal slot "i" open to provide such slots at two places. This configuration will provide convenience in selection of the fixing positions and reliable attachment of the other members. If it is preferable to fasten some members securely, two bolts may be used for fixing purposes so as to reduce the possibility of missing bolts by loosening at the specific portions. Furthermore, as shown at 8c in Fig. 8C safety may be increased by using an auxiliary plate "n" having a stopper "m" and providing a bore "m'" for receiving the stopper "m" and attaching the bolt through the bore of the auxiliary plate "n", then the bolt 13b may not tend to move toward the through-bore "j" where the bolt may be loosened from the retaining member.

Now, reference is made to Fig. 8 in which the retaining member 8d similar to the one shown in Fig. 7B is used as the connection means. In this case, as shown in Fig. 8B, the retaining member is fixed to the leg member 6 for example, beforehand at the predetermined locations and is used as the connection means for the other members. In this particular case, it is used to connect a pipe 23 to the leg member 6 by means of a bolt 22a and a nut 22b. And by use of liner plate 21 having a bent locking projection 21', it will substantially avoid the possibility of the bolt 22a tending to move toward the open end of the longitudinal slot during use, thus easily providing a quite safe construction.

Furthermore by providing these retaining members at suitable places with suitable orientation with respect to the members forming the truss construction for the roof or the leg members to be folded condition as shown in Figs. 3, 5 or 6, it is possible to reduce the possibility that these retaining members may project outwardly of the framework or may cause interference with the other elements when the membrane structure is folded and collapsed. It is also possible to reduce the bulkiness of the membrane structure when collapsed by making the radius of curvature at the shoulder block of the hinge means between the rafter member and leg member smaller than that

of the radius produced by bending of the elongated members as is done conventionally, resulting in convenience in stacking the frame structures for storage, less damage to the membrane and easier transportation leading to reduction in the transportation cost.

Reference is then made to Figs. 9 and 10 illustrating another form of the retaining member and the collapsible membrane structure. In this embodiment, the retaining members 8e having both ends made round as shown in Fig. 9A are secured to the outer surface of the frame members at the predetermined spaced positions and the bolts 13d are provided beforehand to stand through the longitudinal slot "i", while the through-holes 31 are provided beforehand in the membrane 12 at the positions and distances corresponding to those of the bolts and the membrane is spread over the frame members in a manner to match with the positions of the bolts and the holes in the membrane and the nuts 22 are tightened on the bolts 13d with the washers 23, thus making it easy to attach the membrane to the framework. Fig. 9B shows an auxiliary plate "n". Use of this auxiliary plate makes it possible to prevent the bolt 13d from dislocating and moving toward the through bore "j" where the bolt head is passed through. Fig. 9C shows in section an example of attaching the membrane to the rafter member, in which the retaining members 8e are provided on the rafter members 4 and the membrane 12 is placed over the rafter members with the through holes 31 of the membrane aligned with the bolt and then the washers 23 are put on the retaining members and finally the nuts 22 are used to tightly secure the membrane. Fig. 10B shows how the membrane can be made much stronger and easier to install, thus improving working efficiency. Such a membrane includes the through-holes 31 for receiving bolts and is configured to enclose bands 32 made of hard plastic or metal plate wrapped integrally with the membrane, through-holes 31 being provided through the plastic bands as well. The retaining members 8e to be provided at outer surface of the framework for the collapsible membrane structure of the present invention are, as earlier mentioned, made round at the corner portions to provide various advantages such as improving the working efficiency for attaching the

membrane, avoiding the possibility of damage to the membrane and so forth.

The present invention has been explained in detail referring to the specific embodiments; however, it should be understood that the further modification and the changes are readily available to those skilled in the art within the scope and sprit of the invention defined in the claims appended herewith.

Claims:

1. A collapsible membrane structure comprising;

a plurality of frame members including rafter members joined at the ridge and leg members;

connection means connecting a plurality of said frame members collapsibly in one direction to form a framework;

means to fix said frame members in their extended condition;

a flexible membrane to cover said framework in their extended condition, characterized in that the connection blocks are provided to connect said rafter members to the leg members at the shoulders, each of said connection blocks including a hinge assembly adapted to connect said rafter member and said leg member to pivot relative to each other.

2. A collapsible membrane structure as defined in Claim 1 wherein each of said connection blocks is shaped to have a rounded corner of a small radius and a plate member is pivotably attached to said block, said pivotable plate member being of thick material, one part of said block being arranged to form a box-like space adapted to sungly receive said pivotable plate when it is pivoted.

3. A collapsible membrane structure as defined in Claim 1 wherein said rafter members are connected at the ridge of the roof by ridge connection blocks each comprising two pivotable hinge means so that the rafter members are pivotable relative to said ridge connection block.

4. A collapsible membrane structure as defined in Claim 1 wherein retaining members are attached at appropriate predetermined portions of the members constituting said framework, each of said retaining members is formed to have a channel-like section and includes a longitudinal slot, one end of said slot is enlarged or provided with a through-hole adapted to pass the head of a bolt therethrough to fasten other members to said framework.

5. A collapsible membrane structure as defined in Claim 1 wherein retaining means for connecting certain members to said framework are provided at appropriate positions on said framework, said retaining means comprising a bracket of channel-like section

forming a space adapted to receive the head of a bolt and being provided with a longitudinal slot dimensioned correspondingly to the diameter of the bolt shank and opened at one end edge of the bracket so as to receive the bolt shank into the slot, and a liner plate having a hole for the bolt aligned with said longitudinal slot of the bracket and being bent at one end to form the locking projection, the retaining means serving to couple said certain members required in assembly of said collapsible membrane structure, such as connection members, movable brace and the like.

6. A collapsible membrane structure as defined in Claim 1 wherein the construction to attach the membrane to the assembled structure is such that the retaining members are attached to the surface of the framework at a predetermined spaced distance, each retaining member being of channel-like construction and made round at opposite corners longitudinal end each being provided with a longitudinal slot dimensioned to receive the bolt shank and made open at one end or enlarged at one end to pass the bolt but to retain the bolt head inside the channel, a bolt being provided in said longitudinal slot to stand up therethrough and the membrane having holes for receiving bolts at the predetermined locations being attached to the frame members by means of the bolts.

7. A collapsible membrane structure as claimed in Claim 5 wherein said retaining means is mounted so as not to project beyond the range of said framework and/or not interfere with the members of the structure when it is collapsed.

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Fig. 1

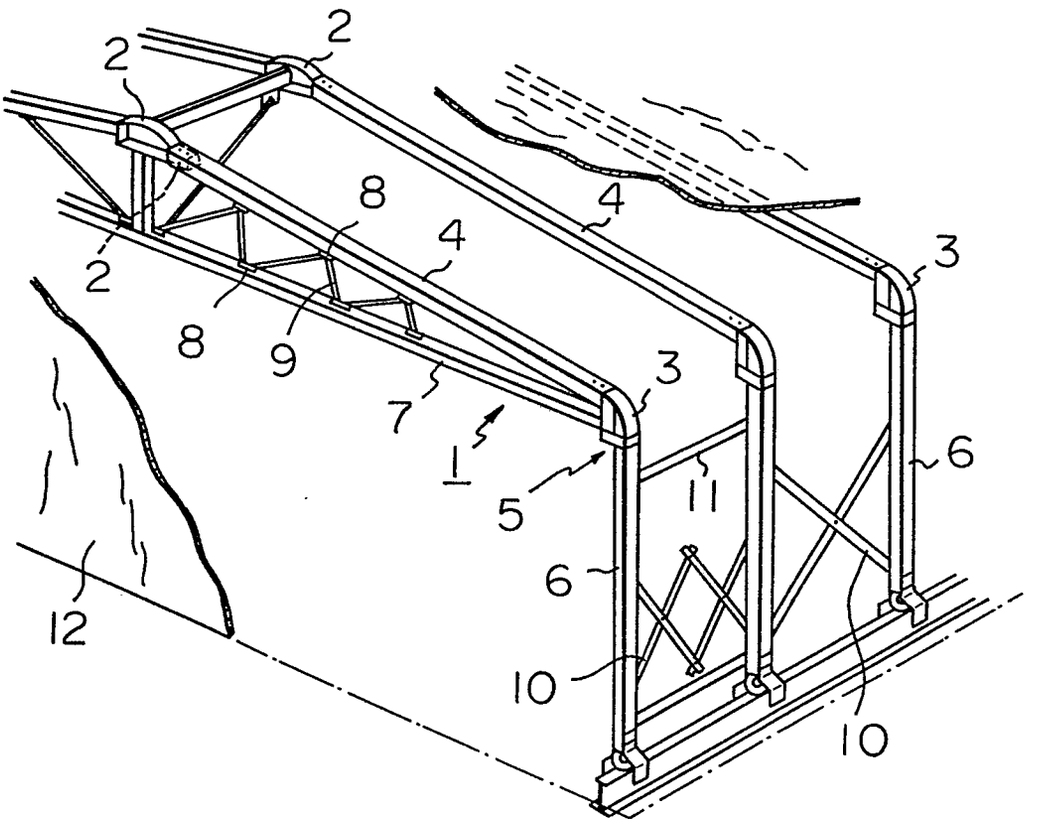


Fig. 2A

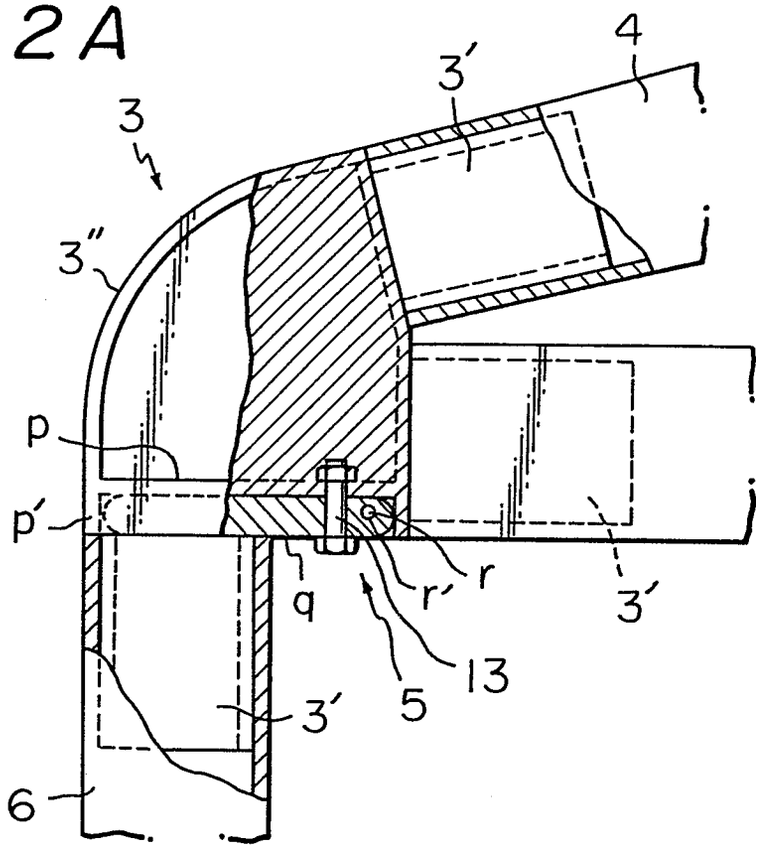


Fig. 2B

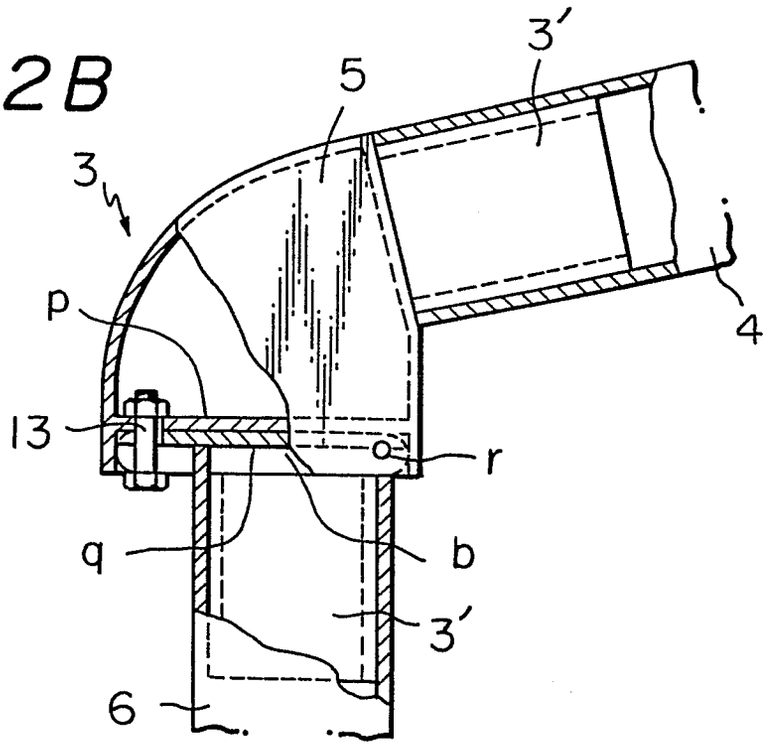


Fig. 2C

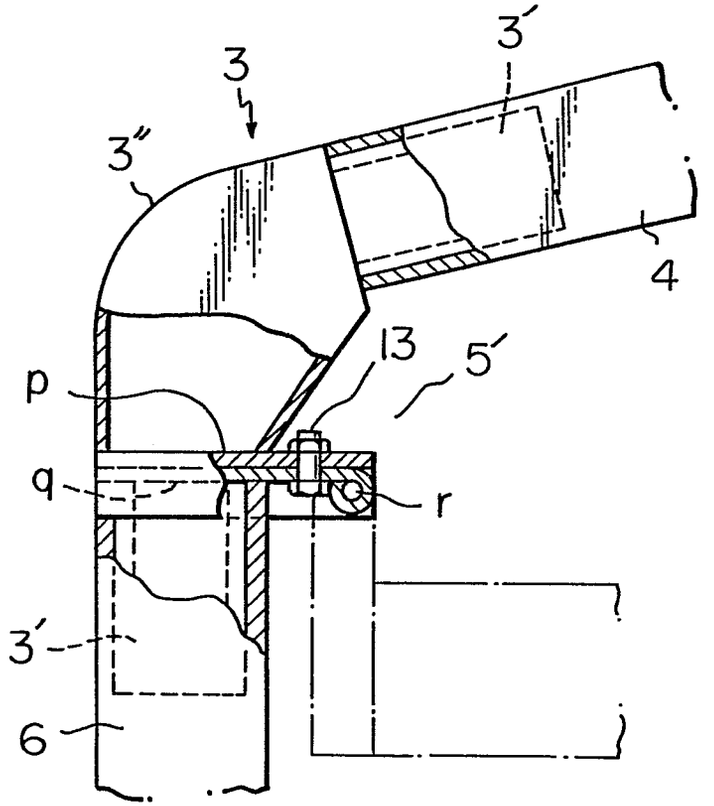


Fig. 3

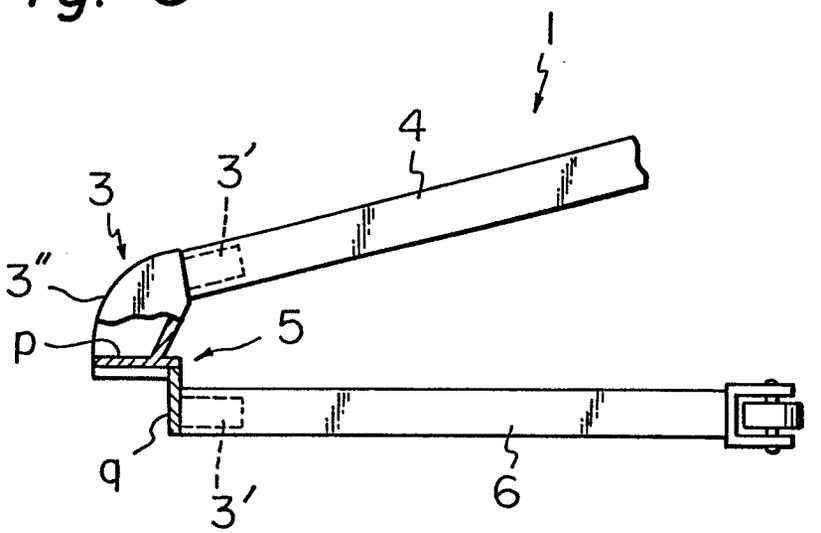


Fig. 4

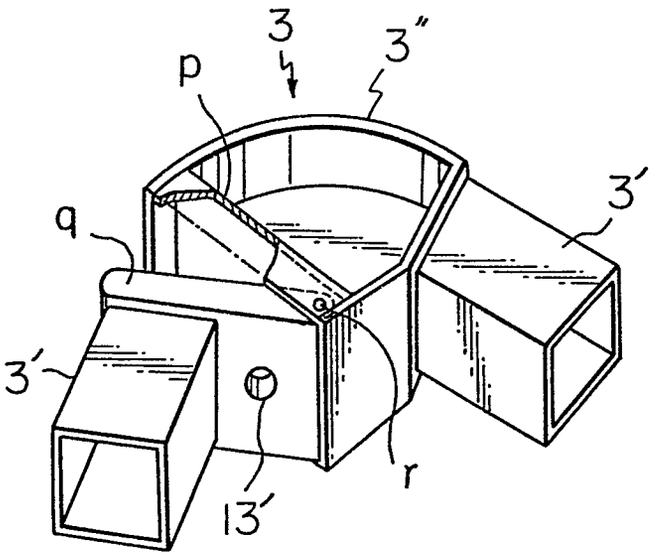


Fig. 5

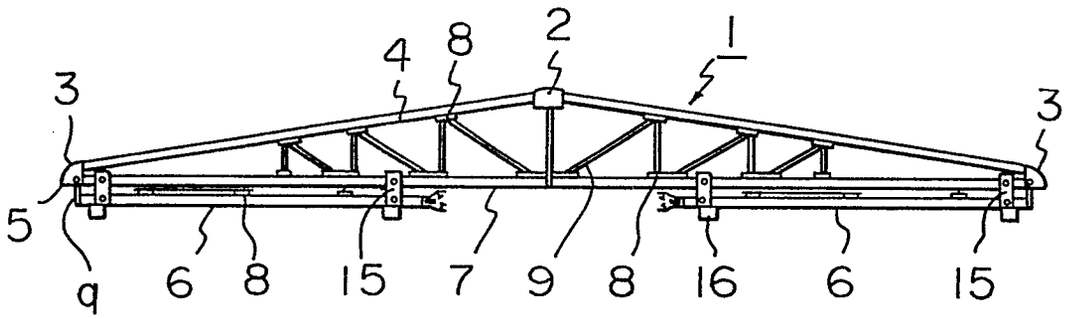


Fig. 6

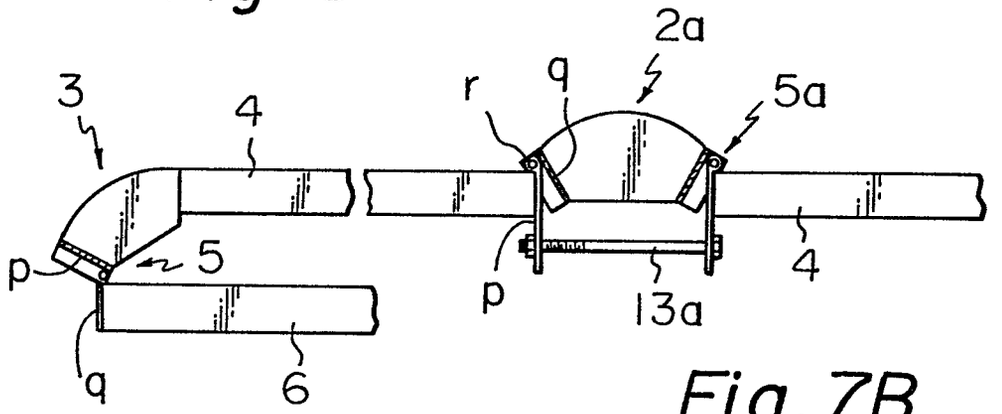
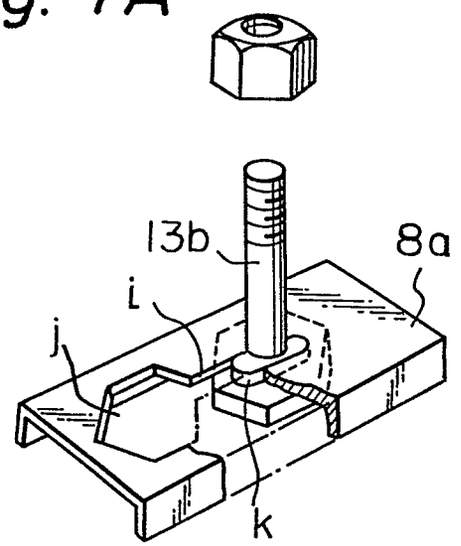


Fig. 7B

Fig. 7A



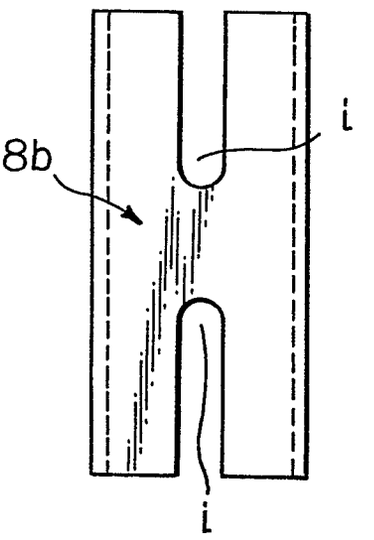


Fig. 7C

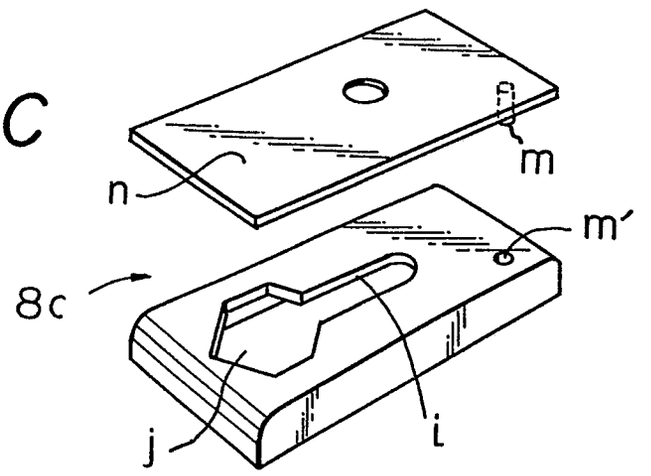


Fig. 8A

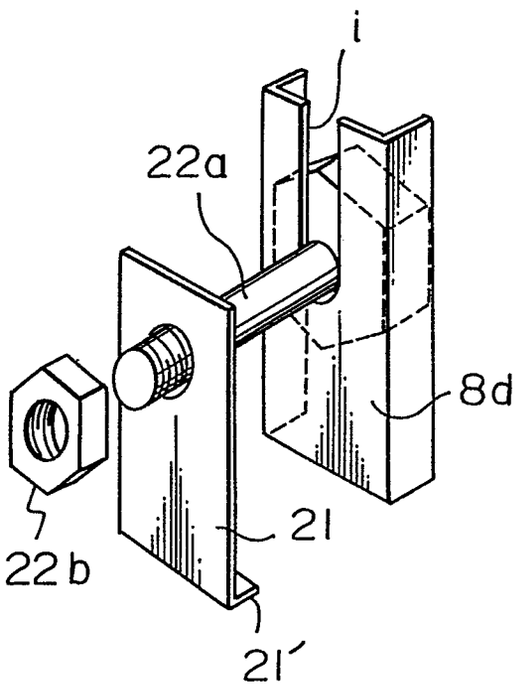


Fig. 8B

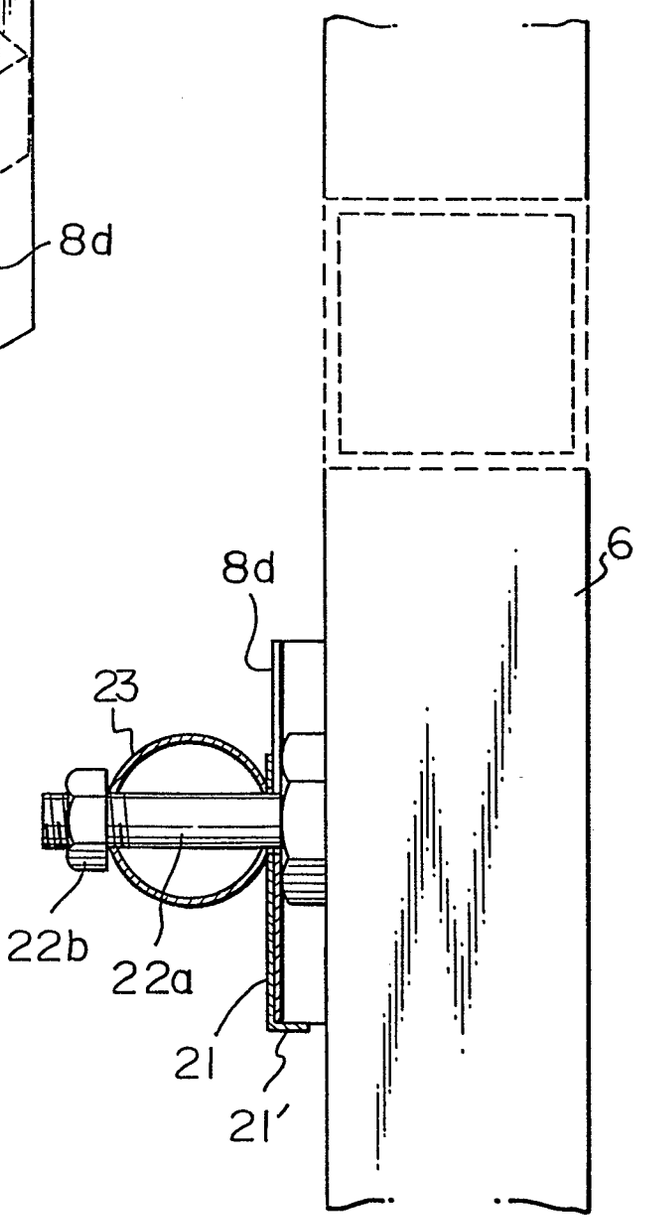


Fig. 9A

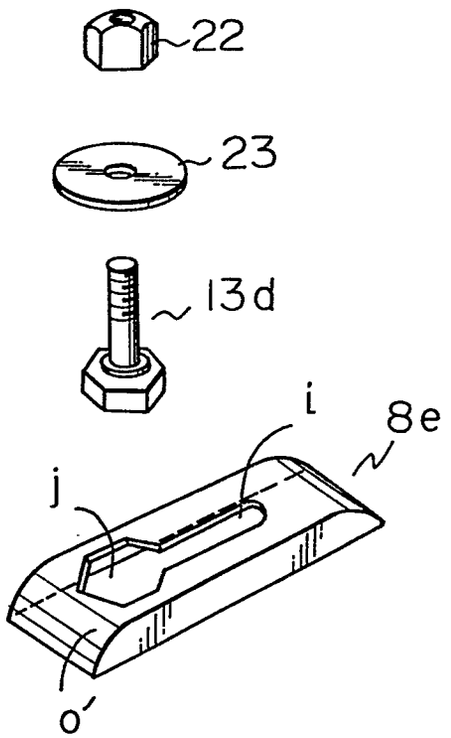


Fig. 9B

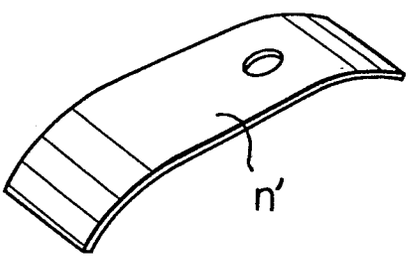


Fig. 9C

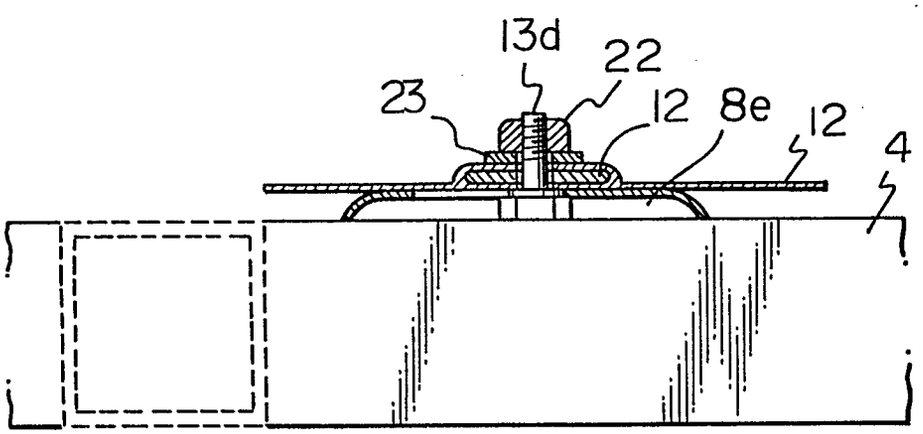


Fig. 10A

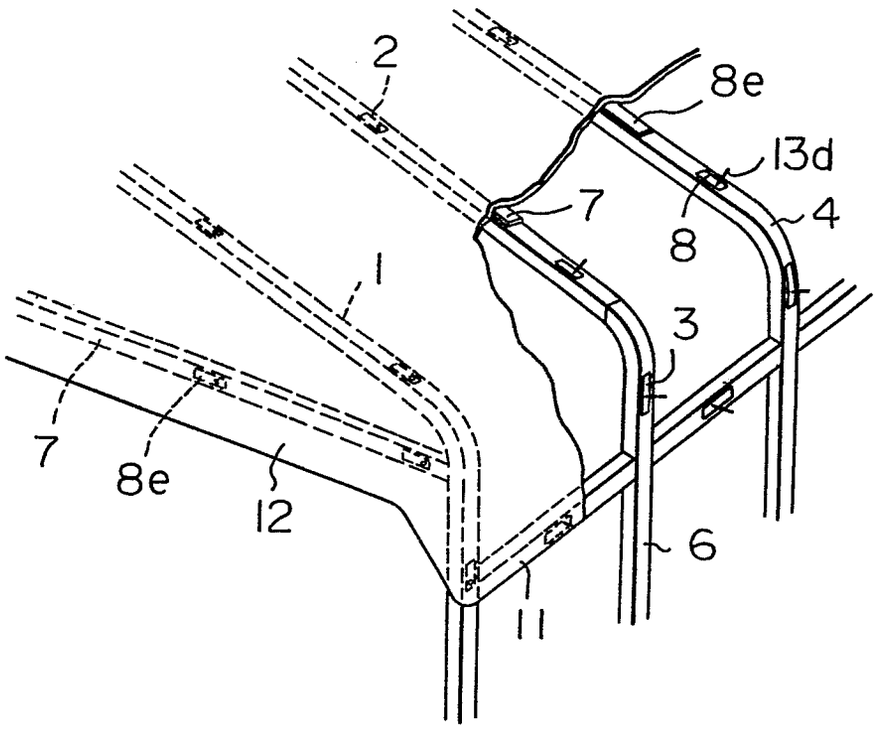


Fig. 10B