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(11)

EP 1 479 840 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
24.11.2004 Bulletin 2004/48

(51) Int Cl.7: **E04B 1/348**

(21) Application number: **04011995.0**

(22) Date of filing: **19.05.2004**

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IT LI LU MC NL PL PT RO SE SI SK TR**
Designated Extension States:
AL HR LT LV MK

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(30) Priority: **20.05.2003 JP 2003142427**
06.10.2003 JP 2003347385
06.10.2003 JP 2003347386

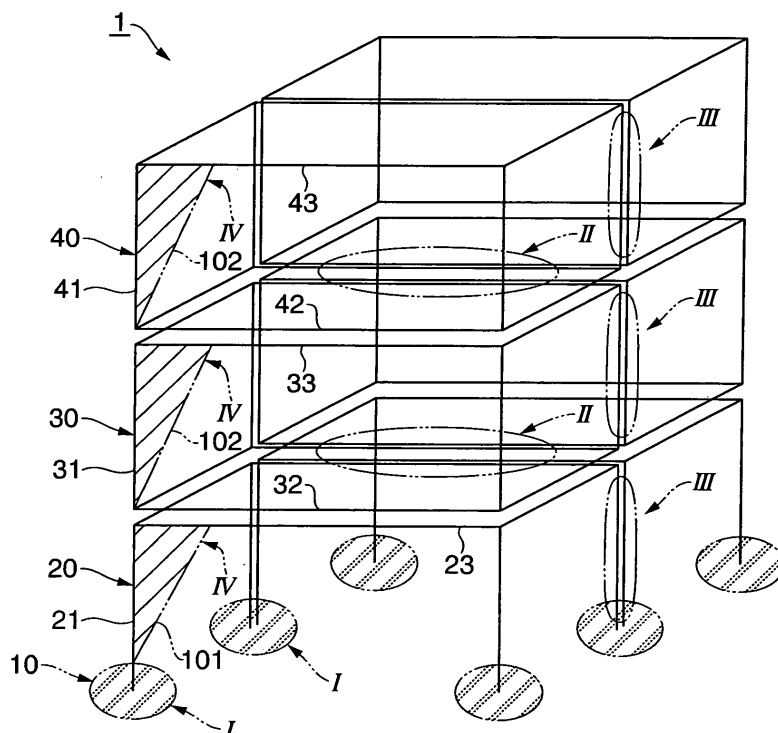
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(54) Unit building

(57) A unit building 1 comprising a building unit 20 having a Rahmen construction including a column 21 and beam 23 rigid-connected to each other and fixed to

a base 10, wherein a column foot of a building unit 20 is rigid-connected to a base 10, and a diagonal member 101 is provided between the column foot of the building unit 20 and a middle portion of a ceiling beam 23.

FIG.2



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Description

[0001] The present invention relates to a unit building.

[0002] In a unit building, a column foot of a building unit, which has a framed construction built of a column and a beam by welding, is pin-connected to a base, as is disclosed in the Japanese Patent Application Laid-Open No. 8-302823 (JP-A)(see page 3, FIG. 2).

[0003] Further, a trapezoidal reinforcing frame can be provided between a ceiling beam and a floor beam of a building unit, which has a Rahmen construction built of a column and a beam by rigid connection, to increase the frame rigidity of the building unit, as is disclosed in the JP-A No. 8-199689.

[0004] Yet further, a plate can be provided between a floor beam of an upper floor unit and a ceiling beam of a lower floor unit of a unit building so as to be fastened together with the beams thereof by a bolt intending to prevent deflection of the floor, as is disclosed in the Japan Utility Model Application Publication (JP-Y) No. 51-45847.

[0005] Still further, webs can be provided respectively in the middle of a floor beam of an upper floor unit and a ceiling beam of a lower floor unit of a unit building so as to be joined together through a joining plate intending to increase the rigidity of the floor beam as well as the ceiling beam, as is disclosed in Japan Patent No. 3330409.

[0006] Still further, with regard to a connecting structure of a unit building, adjacent pipe columns, which are provided in adjacent building units respectively, can be connected across a gap between the building units, as is disclosed in the JP-A No. 06-49911. The connecting structure referred to JP-A 6-49911 comprises a first nut member provided in one of the pipe columns, a second nut member provided opposing the first nut in the other pipe column, a threaded member to fasten both the nut members inside a gap between both the pipe columns, and a spacer in a round pipe shape, which spacer is placed to cover over the threaded member inside the gap between both the pipe columns.

[0007] Still further, a unit building which is capable of providing a wide continuous space eliminating a column is disclosed in the Japan Patent No. 3260266. According to the patent, firstly, the respective predetermined column-eliminated corner portions of adjacent building units are disposed abuttingly to each other at a column-eliminated connection portion. Next, a reinforcing beam is laid on ceiling beam sides from one of the building units to the other building unit. Then, the construction is completed by connecting one end portion of the reinforcing beam to a column of one of the building units and by connecting the other end portion of the reinforcing beam to a column of the other building unit.

[0008] With regard to JP-A 8-302823, since the rigidity of a beam is not sufficient, a column foot rotates with respect to its base and the horizontal rigidity is not improved even though the cross section of a column would

be strengthened. Accordingly, it becomes necessary to add an inner column inside a wall or to add a horizontal brace inside a ceiling. These requirements restrain the planning of a building and increase the building cost.

[0009] With regard to JP-A 8-199689, it teaches to provide a trapezoidal reinforcing frame between a ceiling beam and a floor beam of a building unit. However, the reinforcing frame has such a complicated structure that a diagonal member is connected to both ends of a horizontal member. In addition, a horizontal member of the reinforcing frame overlaps a ceiling beam of the building unit.

[0010] With regard to the JP-Y 51-45847 and JP 3330409, these references disclose nothing more than connecting an upper and a lower beam (a floor beam and a ceiling beam) to each other at their middle portions. Therefore, in these references there is no rational consideration for improving the proof strength against a vertical load by means of increasing the rigidity of two beams, or improving the proof strength against a horizontal load by means of increasing the rigidity of a frame of a building unit.

[0011] In addition, the connecting structure disclosed in JP-A 06-49911 has the following problems.

(1) In the manufacturing of a building unit, it is required to attach a first nut member to a pipe column of one of adjacent building units by welding and to fix a threaded member protrudingly to the first nut member. This causes decreased productivity during manufacturing and inconvenience in the handling of a unit building during transportation and stock.

(2) At a building site, it is required to fix a spacer over a threaded member of one of building units before placing the other unit building into an adjacent position to the first one. This makes the installation of unit buildings inconvenient.

(3) It is required to handle a spanner, which is a tool for screwing a second nut member onto a threaded member, within a gap between both pipe columns of adjacent building units. In addition to this, the spanner has to be inserted through a window provided in a spacer toward a second nut member. These makes the handling of nut members difficult.

[0012] In addition, the conventional art of JP 3260266 includes the following problems.

(1) When a reinforcing beam is provided additionally to a ceiling beam, which is disposed intersectingly at a column-eliminated corner portion in a same plane including column-eliminated connection portions of both building units, the reinforcing beam should be a long beam extending from one of building units to the other of the same. This makes the management of materials and the construction difficult.

(2) Since the reinforcing beam is provided in the outside of a ceiling beam, an excess space is required for the reinforcing beam in the peripheries of both building units. When an additional building unit is placed adjacent to both existing building units, a wide gap between the additional unit and the existing building units is required for accommodating the reinforcing beam.

[0013] An object of the present invention is to improve the horizontal rigidity of a unit building.

[0014] Another object of the invention is to improve the vertical rigidity of a unit building.

[0015] Still another object of the invention is to simply recover the reduction in the strength of a unit building, which is due to the elimination of a column for making a wide and continuous space.

[0016] According to the present invention, there is provided a unit building comprising a building unit fixed to a base, the building unit having a Rahmen construction having a column and a beam rigid-connected to each other. A column foot of the unit building is rigid-connected to the base, and a diagonal member is provided between the column foot of the building unit and a middle portion of a ceiling beam or between a column capital and a middle portion of a floor beam.

[0017] According to the present invention, there is provided a unit building comprising building units fixed to a base, the building unit having columns, floor beams and ceiling beams connected to each other. A column foot of the building unit is rigid-connected to the base. A respective predetermined column-eliminated corner portions of a plurality of adjacent building units are disposed adjacently to each other at a column-eliminated connection portion. Ceiling beams are made to a joint ceiling beam, the ceiling beams being disposed in a same plane including the column-eliminated connection portions of the adjacent building units and intersecting at the column-eliminated corner portion. The opposed joint ceiling beams are connected to each other at a column-eliminated connection portion of the adjacent building units.

[0018] The present invention will be more fully understood from the detailed description given below and from the accompanying drawings which should not be taken to be a limitation on the invention, but are for explanation and understanding only.

FIG. 1 is a perspective view showing a unit building;
FIG. 2 is a schematic perspective diagram showing a unit building;
FIG. 3 is a perspective view showing a building unit;
FIG. 4 is schematic front view showing an example of a building unit which has construction method I applied thereto;
FIG. 5 is a cross-sectional view showing an example of a structure of the construction method I;
FIG. 6 is schematic front view showing an example

of a unit building which has construction method II applied thereto;

FIGS. 7A and 7B show an example of a structure according to the construction method II, where FIG. 7A is a front view, and FIG. 7B is a cross-sectional view;

FIGS. 8A to 8C show a strengthening principle of the rigidity of a beam according to the construction method II, where FIG. 8A is a schematic view showing a deformation state of a beam, FIG. 8B is a schematic view of a unit model of a beam, and FIG. 8C is schematic view of a model of a Rahmen construction;

FIGS. 9A and 9B show a strengthening principle of the rigidity of a unit frame according to the construction method II, where FIG. 9A is a schematic view of a deformation state of a beam, FIG. 9B is a schematic view of a model of a Rahmen construction; FIG. 10 is a schematic view showing an example of a connection structure of adjacent building units according to the construction method III;

FIG. 11 is a cross-sectional view showing the details of a part of the connection structure of FIG. 10;

FIGS. 12A to 12D are schematic views showing examples of connection between building units;

FIGS. 13A and 13B show a modified embodiment of the construction method III, where FIG. 13A is a plan view of a connection portion of a lower floor building unit, and FIG. 13B is a section view taken along a line B-B in FIG. 13A;

FIG. 14 is a perspective view showing a holed spacer;

FIGS. 15A and 15B are modified embodiment of the construction method III, where FIG. 15A is a plan view of a connection portion of a lower floor building unit, and FIG. 15B is a cross-sectional view taken along a line B-B in FIG. 15A;

FIG. 16 A and 16B are modified embodiments of the construction method III, where FIG. 16A is a plan view of a connection portion of a lower floor building unit, and FIG. 16B is a cross-sectional view taken along a line B-B in FIG. 16A;

FIGS. 17A and 17B show an example of a building unit which has construction method IV applied thereto, where FIG. 17A is a plan view of a lowest floor building unit, and FIG. 17B is a plan view of an upper floor building unit;

FIG. 18 is a schematic view showing a strengthening principle of the rigidity of a frame according to the construction method IV;

FIG. 19 is a schematic view of an example of strengthening of the rigidity of a frame according to the construction method IV;

FIG. 20 is a plan view showing an example of fixing a diagonal member according to the construction method IV;

FIGS. 21A and 21B show a fixed portion of a lower end of a diagonal member, where FIG. 21A is a plan

view, and FIG. 21B is a cross-sectional view;

FIG. 22 is a cross-sectional view of a middle portion of a ceiling beam, to which an upper end of a diagonal member is fixed;

FIGS. 23A to 23C show a unit building of an embodiment according to the construction method V, where FIG. 23A is a schematic plan view before the reinforcement by means of a joint ceiling beam, FIG. 23B is a schematic plan view after the reinforcement by means of a joint ceiling beam, and FIG. 23C is a schematic side view of FIG. 23B; FIG. 24 is plan view showing a connected state of both building units;

FIGS. 25A and 25B show a unit building of an embodiment according to the construction method V, where FIG. 25A is a schematic plan view before the reinforcement by means of a joint ceiling beam, and FIG. 25B is a schematic plan view after the reinforcement by means of a joint ceiling beam;

FIGS. 26A and 26B show a unit building of an embodiment according to the construction method V, where FIG. 26A is a schematic plan view before the reinforcement by means of a joint ceiling beam, and FIG. 26B is a schematic plan view after the reinforcement by means of a joint ceiling beam;

FIG. 27 is a plan view showing a connected state of building units of an embodiment according to the construction method V;

FIG. 28 is a side view of FIG. 27;

FIG. 29 is a perspective view of a guide collar which is used for the construction method V;

FIG. 30 is a perspective view of an attachment which is used for the construction method V;

FIGS. 31A to 31F are schematic views showing fitting steps of a guide collar in the construction method V;

FIGS. 32A to 32E are schematic views showing removing steps of a guide collar in the construction method V;

FIG. 33 is schematic plan view of a unit building of a modified embodiment according to the construction method I;

FIGS. 34A and 34B show building units, where FIG. 34A is a side view, and FIG. 34B is a schematic view;

FIG. 35 is a cross-sectional view showing a column and a floor beam of a building unit;

FIGS. 36A and 36B show connection structures to a base of a building unit, where FIG. 36A is a longitudinal cross-sectional view, and FIG. 36B is a plan view;

FIG. 37 is a plan view showing a horizontal connection structure of adjacent building units;

FIGS. 38A and 38B show connection structures between a column foot and a core of a building unit, where FIG. 38A is a cross-sectional view of a connection portion along a beam direction, and FIG. 38B is a cross-sectional view of connection

portion along a gable direction;

FIG. 39 is a longitudinal cross-sectional view showing a connection structure at a base of a building unit of a modified embodiment according to the construction method I;

FIGS. 40A and 40B show connection structures between a column foot and a core of a building unit, where FIG. 40A is a longitudinal cross-sectional view, and FIG. 40B is a plan view;

FIGS. 41A and 41B show a core, where FIG. 41A is a longitudinal cross-sectional view, and FIG. 41B is a plan view;

FIG. 42 is a plan view showing a base connection portion of a building unit of a modified embodiment according to the construction method I;

FIG. 43 is a longitudinal cross-sectional view showing a connection structure to a base of a building unit of a modified embodiment according to Construction method I;

FIGS. 44A and 44b show a base construction, where FIG. 44A is a plan view, and FIG. 44B is a longitudinal cross-sectional view;

FIG. 45 is a plan view showing modified embodiments of a base connection portion of a building unit;

FIGS. 46A and 46B show base constructions, and FIG. 46A is a plan view, and FIG. 46B is a longitudinal cross-sectional view;

FIG. 47 is a plan view of a modified embodiment of a base connection portion of a building unit;

FIG. 48 is a plan view showing a base construction;

FIG. 49 is a plan view showing a modified embodiment of a base connection portion of a building unit;

FIG. 50 is a plan view showing a base construction; FIG. 51 is a cross-sectional view showing a guide pin;

FIG. 52 is a perspective view showing connection steps of a column foot into a base;

FIG. 53 is a cross-sectional view showing a modified embodiment of a guide pin;

FIG. 54 is a longitudinal cross-sectional view showing a base connection structure of a building unit of a modified embodiment according to the construction method I; and

FIG. 55 is a chart showing a priority of applying the construction methods I to IV to a unit building.

[0019] A unit building 1 of FIG. 1 and FIG. 2 is constructed to have a lowest floor building 20 supported on a base 10, and upper floor building units 30, 40 mounted on the lowest floor unit 20 in order.

[0020] Namely, the unit building 1 is constructed by placing a plurality of building units 20, 30, 40 adjacently in a horizontal direction as well as a vertical direction. As shown in FIG. 3, the building unit 20 (also building unit 30, 40) has a framework construction which is constructed by connecting a pipe column 21 of a square steel, a floor beam 22 of a structural steel, and a ceiling

beam 23 of a structural steel each other into a box shape. The building unit 20 is built by fixing the floor beam 22 by welding to a lower end of the pipe column 21 via a joint piece 22J, and by fixing the ceiling beam 23 by welding to an upper end of the pipe column 21 via a joint piece 23J. The floor beam 22 can be eliminated from the building unit 20.

[0021] The unit building 1 can be constructed as a multiple-story, such as 3-story, building by stacking a plurality of building units 20 in a vertical direction. In addition, the unit building 1 can be constructed as a column-eliminated unit building, wherein a column-eliminated building unit is constructed by making a column-eliminated corner portion of at least one of corner portions of the building unit 20, connecting a plurality of the column-eliminated building units adjacently, and the column-eliminated corner portions of the respective column-eliminated building units are connected to each other abuttingly to form a column-eliminated connection portion.

[0022] As shown in FIG. 4 and FIG.5, a base 10 is formed by supporting a base construction 13 made of a steel on a mat foundation 11 made of concrete by using anchor bolts 12. The lowest floor building unit 20 is supported on this base construction 13.

[0023] The lowest floor building unit 20 is formed by eliminating the floor beam 22. It has a Rahmen construction, which is constructed in such a manner as ceiling beams 23 of a structural steel are laid over four pipe columns 21 of a square steel pipe, and the ends of the ceiling beams 23 are rigid-connected to the upper ends of columns 21. A joint piece 23J (FIGS. 7A and 7B) is welded to an upper end of the column 21, and an end of the ceiling beam 23 is welding to the joint piece 23J. Note that the lowest floor unit 20 can be provided additionally with a floor beam 22 of a structural steel, which floor beam is laid over the lower ends of the column 21. An end of the floor beam 23 may be rigid-connected to the lower end of the column 21.

[0024] The upper floor unit 30 (same with 40) has a Rahmen construction, wherein a ceiling beam 33 (43) of a structural steel is laid over the upper ends of four pipe columns 31 (41) of a square steel, and an end of the ceiling beam 33 is rigid-connected to the upper end of the column 31, and in addition, a floor beam 32 (42) of a structural steel is laid over the lower ends of the column 31, and the end of the floor beam 32 is rigid-connected to the lower end of the column 31. Joint pieces 33J (not shown) and 32J (FIGS. 7A and 7B) are welded to the upper and lower ends of the column 31 respectively, and the ends of the ceiling beam 33 and floor beam 32 are welded to the joint pieces 33J and 32J, respectively.

[0025] In the unit building 1, the ceiling beam 23 of the lowest floor building unit 20 and the floor beam 32 of the upper floor building unit 30 are stacked together vertically between the lowest floor building unit 20 and the upper floor building unit 30, and the ceiling beam 33

of the upper floor building unit 30 and the floor beam 42 of the upper floor building unit 40 are stacked together vertically between the upper floor building unit 30 and the upper floor building unit 40.

[0026] The construction methods I, II, III, IV, and V for strengthening the rigidity are applied to the unit building 1.

[0027] The construction method I is a rigid connection structure between a base and a column,

the construction method II is a connection structure between upper and lower beams,

the construction method III is a connection structure between adjacent columns,

the construction method IV is a reinforcing structure with a diagonal member,

the construction method V is a column-eliminated reinforcing structure.

(Construction method I: Connection structure between a base and a column) (FIG.4, FIG. 5)

[0028] The construction method 1 is applied between the base 10 and the lowest floor building unit 20 (FIG. 1, FIG.2). According to this, the column 21 and the column foot 21F of the column 21 of the lowest floor building unit 20 can be connected to the base 10 not to shift to each other substantially (FIG.4).

[0029] As shown in FIG. 5, the base 10 comprises a base construction 13 and a mounting piece 14 which is fixed to the upper end of the base construction 13 by welding. A mounting piece 24, which is fixed to the column foot 21F of the lowest building unit 20 by welding, is connected to the mounting piece 14 with a high strength bolt 15 so as not to shift with respect to each other substantially.

[0030] According to the construction method I, in a unit building 1, the column foot 21F can be prevented from rotating with respect to the base 10 due to the connection of the column 21F of the lowest floor building unit 20 to the base 10 so as not to shift with respect to each other substantially. As a result, the horizontal rigidity of the building unit 20 can be improved. In addition, by virtue of the construction method I, it is not required to strengthen the cross section of the column 21, nor to add an inner column or a horizontal brace in order to improve the horizontal rigidity of the building unit. As a result, the degree of freedom for planning of the building unit 20 can be widened, and the manufacturing cost can be reduced.

(Construction method II: Connection structure between upper and lower beams) (FIG. 6 to FIG. 9B)

[0031] The construction method II is applied between the ceiling beam 23 of the lowest building unit 20 and the floor beam 32 of the upper building unit 30 and/or the ceiling beam 33 of the upper building unit 30 and the floor beam 42 of the upper building unit 40 (FIG. 1 and

FIG. 2). Hereunder, the application of the construction method II between the ceiling beam 23 of the lowest building unit 20 and the floor beam 32 of the upper building unit 30 will be described.

[0032] In order to increase the rigidity of the beam 23 of the lowest floor building unit 20 and the floor beam 32 of the upper floor building unit 30 with respect to a vertical load (floor load), the respective ends of the ceiling beam 23 are rigid-connected to the corresponding respective ends of the floor beam 32 at rigid-connection portion R1 and R2 so as not to shift with respect to each other substantially (FIG.6).

[0033] In addition, in order to increase the rigidity of frame of the lowest floor building unit 20 and the upper floor building unit 30 with respect to a horizontal load, in addition to the foregoing rigid-connection portion R1, R2, the middle portions (the central portions in this embodiment) of respective ceiling beam 23 and floor beam 32 in the longitudinal direction are rigid-connected at a rigid-connection portion R3 so as not to shift with respect to each other substantially (FIG.6).

[0034] The rigid-connection portions R1 to R3 can be, as schematically shown in FIG. 6, constructed with four wire rods, but also with a plate 50 as shown in FIGS. 7A and 7B. The plate 50 is mounted additionally over a web w of the ceiling beam 23 and a web w of the floor beam 32, and is fastened to the web w of the ceiling beam 23 with two high strength bolts 51, 51 and to the web w of the floor beam 32 with two high strength bolts 52, 52. The plate 50 shown in FIGS. 7A and 7B is such a type as is held between the ceiling beams 23, 22 of the adjacent lowest floor building units 20, 20 and between the floor beams 32, 33 of the adjacent upper floor building units 30, 30. However, the plate 50 may be such a type as is mounted additionally over one side of the ceiling beam 23 and floor beam 32 of the building units 20, 30. The plate 50 may be of a type which is connected by welding.

[0035] In addition, the plate 50 may be of a type which is mounted additionally over a flange f of the ceiling beam 23 and a flange f of the floor beam 32. The plate of this type can be connected to flange(s) f, f by means of high strength bolt or welding not to shift the ceiling beam 23 substantially with respect to the floor beam 32.

[0036] According to the construction method II in the unit building 1, since both ends of the vertically stacked two beams 23, 32, each of which is the floor beam 32 of the upper floor building unit 30 and the ceiling beam 23 of the lower floor building unit 20, are rigid-connected at rigid-connection portion R1, R2 so as not to shift with respect to each other substantially, a phase difference between the respective ends of two beams 23, 32 can be constrained when the beams 23, 32 are forced to be deformed with curvature under a vertical load (FIG. 8A). Thus, the combined two beams 23, 32 come to exhibit a cross sectional property $\alpha(I1+I2)$ which is larger than a simple sum of the individual cross sectional property $I1, I2$ ($I1+I2$) of the respective beams 23, 32. As a result,

the beams are improved in the rigidity, and have a higher proof strength against a vertical load. Note that there is no need to provide a rigid-connection portion R3 for increasing the rigidity of the beams according to the construction method II.

[0037] A single beam model (FIG. 8B), which has only two beams 23, 32, exhibits a proof strength as high as 2.6 times of that of a conventional model. A Rahmen construction model (FIG. 8C), in which the columns 21, 31 are rigid-connected to the both ends of two beams 23, 32, exhibits a proof strength as high as 1.3 to 1.4 times of that of a conventional model. Note that, in FIG. 8B and Fig. 8C, a reference character S provided between the respective middle portions of the ceiling beam 23 and the floor beam 32 represents a spacer to fill a gap generated between the ceiling beam 23 and the floor beam 32. This spacer serves to permit a floor load, which acts on the floor beam 32, to be transmitted to the ceiling beam 23.

[0038] In addition, according to the construction method II, in the unit building 1, the respective both ends of two beams 23, 32, which are stacked vertically, and which are included in the two Rahmen constructions which consist the floor beam 32 of the upper floor building unit 30 and the ceiling beam 23 of the lower floor building unit 20 respectively, are connected at the rigid-connection portions R1, R2 so as not to shift with respect to each other substantially and the respective both middle portions are connected at the rigid-connection portion R3 so as not to shift with respect to each other substantially. Therefore, when the two beams 23, 32 are forced to deform in the shape of letter S by a horizontal load P acting on the column 31 of one of the building units 30, the phase differences at both ends of the two beams 23, 32, and at the both middle portions thereof are constrained. (FIG. 9A). Thus, the building units 20, 30 are improved in their frame strength, and come to have a higher proof strength with respect to a horizontal load.

[0039] The frame rigidity of the building units 20, 30 according to the invention is improved to approximately 1.3 times that of a conventional model (FIG. 9B).

[0040] When performing the construction method II, the connection of the floor beam 32 of the upper floor building unit 30 and the ceiling beam 23 of the lower floor building unit 20 for preventing the substantial shift therebetween can be done easily by using the plate 50 which is mounted additionally over the web w of the floor beam 32 and the web w of the ceiling beam 23, or the plate 50 which is mounted additionally over the flange f of the floor beam 32 and the flange f of the ceiling beam 23. Note that the plate 50 mounted additionally over the webs w can serve to increase the frame strength of the building units 20, 30 more.

(Construction method III: Connection structure between adjacent columns) (FIG. 10 to FIG. 16B)

[0041] The construction method III is applied between the adjacent columns 21, 21 of the lowest floor building units 20, 20, between the adjacent columns 31, 31 of the upper floor building units 30, 30 and between the adjacent columns 41, 41 of the upper floor building units 40, 40. (FIG. 1, FIG. 2)

[0042] However, with regard to the unit building 1 for constructing a multiple-story building or a column-eliminated unit building or the like, this embodiment relates to the increase of the horizontal rigidity of the unit building 1, wherein the pipe columns 21, 21, which are placed adjacently making a gap between the adjacent building units 20, 20 in the unit building 1 as shown in FIG. 10, are connected to each other with bolts as described hereunder.

[0043] The adjacent pipe columns 21, 21 of the adjacent building units 20, 20 are connected to each other at three positions of the upper end, lower end, and the middle portion as shown in FIG. 11 with bolts. The methods of the bolt fastening will be described in (1) to (3).

(1) Bolt holes 61A, 61A are provided coaxially in side walls 21A, 21A, which are facing to each other, of the adjacent pipe columns 21, 21 of the adjacent building units 20, 20. And in one of the pipe columns 21, an operation hole for bolt fitting 61B is provided in a side wall 21B, which is in the back of the side wall 21A having the bolt hole 61A, and in the other pipe column 21, an operation hole for nut fitting 61C is provided in a side wall 21B, which is in the back of the side wall 21A having the bolt hole 61A. The bolt holes 61A and 61A have the same diameter, and the operation hole for bolt fitting 61B and the operation hole for nut fitting 61C have also the same diameter.

(2) The building units 20, 20 are placed adjacently on a mat foundation at a building site. Then, a holed spacer 60 is disposed in the gap between 21A, 21A coaxially with the bolt holes 61A, 61A, which have been provided on the opposed side walls 21A, 21A of the adjacent pipe columns 21, 21.

(3) A bolt 61, which has been inserted through the operation hole for bolt fitting 61B provided in the side wall 21B of one of the column pipes 21, is inserted through the bolt holes 61A, 61A in the both pipe columns 21, 21, and through a bolt hole 60A formed in the holed spacer 60, which is provided in the gap between the opposed side walls 21A, 21A of both pipe columns 21, 21. A nut 62, which has been inserted through the operation hole for nut fitting 61C provided in the side wall 21B of the other pipe column 21, is screwed on the forgoing bolt 61. The bolt 61 is a type of high strength bolt, and particularly a Torshear type high strength bolt is employed in this embodiment. A Torshear type tool is

inserted through the operation hole for nut fitting 61C and operated for screwing the nut 62 on the bolt 61.

[0044] Note that other types of bolt like a high strength hexagonal bolt can be used for the bolt 61.

[0045] The following working-effects are possible according to the present embodiment.

(a) The horizontal rigidity of the unit building 1 constructed of the adjacent building units 20, 20 can be improved rationally by means of bolt connecting of the adjacent pipe columns 21, 21 of both building units 20, 20. Accordingly, the unit building 1 such as a multiple-story building having three stories for example or a column-eliminated unit building can be improved in their strength.

(b) In a manufacturing site of the building unit 20, there is no need of additional processes other than providing the bolt hole 61A and the operation hole for bolt fitting 61B in the pipe column 21 of one of the adjacent building units 20 and the bolt hole 61A and the operation hole for nut fitting 61C in the pipe column 21 of the other building unit 20. Thus, the productivity can be improved and the handling of the building unit during transportation and stocking can be also improved.

(c) In a building site, one of the building units 20 can be placed adjacently to the other building unit 20, and the spacer 60 can be inserted simply between the side walls 21A, 21A of the adjacent pipe columns 21, 21 of the building unit 20. Thus, the building units 20 can be installed more conveniently, and the spacer 60 can be placed easily.

(d) A tool for fitting the bolt 61 and/or the nut 62 may be operated through the operation hole for fitting bolt 61B or the operation hole for nut fitting 61C, both of which are provided in the pipe column 21. This improves the ease of operation.

(e) The high strength bolt 61 is capable of connecting the adjacent pipe columns 21 of the adjacent building units 20 strongly to each other, so that the horizontal rigidity of the unit building 1 can be improved.

(f) The Torshear type high strength bolt 61 can make the fastening operation of the bolt 61 with the nut 62 easy.

(g) The adjacent pipe columns 21, 21 of the adjacent building units 20, 20 are bolt connected to each other at a plurality of positions including their upper ends, lower ends and the middle portions, so that the connecting strength between the pipe columns 21 can be increased as well as the horizontal rigidity of the unit building 1 can be improved more.

[0046] The horizontal rigidity of the unit building 1 according to FIG. 12B to FIG. 12D of the invention, namely the allowable horizontal load P with respect to the col-

umn capital of the building unit 20, becomes 1.2 to 1.9 times as high as the allowable horizontal load P_a of a conventional model (FIG. 12A). FIG. 12B shows an example of a bolt connection of the pipe columns 21, 21 to each other at their upper and lower ends, resulting in $P = 1.2P_a$. FIG. 12C shows an example of a bolt connection of the pipe columns 21, 21 to each other at their upper ends, lower ends and one of the middle portions, resulting in $P = 1.7P_a$. FIG. 12D shows an example of bolt connection of the pipe columns 21, 21 to each other at their upper ends, lower ends and three of the middle portions, resulting in $P = 1.9P_a$.

[0047] FIGS. 13A and 13B show a unit building 1, which is constructed in such a manner that four corner portions of adjacent building units 20 are disposed abuttingly to each other, and upper floor building units 30 are disposed on the respective building units 20. The construction method III is applied to this case using a cross-shaped holed spacer 70. In this case, the pipe columns 21 of the four building units 20 are disposed with respect to each other making gaps in a cross shape, and the pipe columns 31 of the four upper floor building units 30 are also disposed with respect to each other making gaps in a cross shape. In addition, the ceiling beam 23, which is laid over the adjacent columns 21 of the building unit 20 by rigid-connection to the columns at the upper ends thereof, and the floor beam 32, which is laid over the adjacent columns 31 of the upper floor building unit 30 by rigid-connection to the columns at the lower ends thereof, are stacked vertically between the building unit 20 and the building unit 30 which are disposed vertically with respect to each other.

[0048] The holed spacer 70 comprises, as shown in FIG. 14, a girder plate 71, which is disposed in the direction of beam, and a gable plate 72, which is disposed orthogonally to the girder plate at the lower half of the middle portion along the beam direction of the girder plate 71.

[0049] The lower half portion of the gable plate 71 of the holed spacer 70 is inserted into a gap between the opposed side walls 21A, 21A of the adjacent columns 21, 21 of the building units 20, 20 which are disposed adjacently in the direction of gable. A bolt 61, which is inserted through the operation hole for bolt fitting 61B which is formed in the side wall 21A of one of the columns 21, is continued to be inserted through the bolt holes 61A, 61A in the pipe columns 21, 21, and further through the bolt hole 71A which is formed in the lower half portion of the girder plate 71 which is mounted in the gap between the side walls 21A, 21A of both pipe columns 21, 21. Finally, the bolt 61 is screwed with a nut 62 which is inserted through the operation hole for nut fitting 61C which is formed in the side wall 21B of the other pipe column 21. Also, the gable plate 72 of the holed spacer 70 is placed in a gap between the opposed side walls 21A, 21A of the adjacent pipe columns 21, 21 of the building units 20, 20 which are disposed adjacently in the direction of beam. A bolt 61, which is inserted

through the operation hole for bolt fitting 61B which is formed in the side wall 21B of one of the columns 21, is continued to be inserted through the bolt holes 61A, 61A of both pipe columns 21, and further through the bolt hole 72A which is formed in the gable plate 72 which is placed in the gap between the side walls 21A, 21A of both pipe columns 21, 21. Finally, the bolt 61 is screwed with a nut 62 which is inserted through the operation hole for nut fitting 61C which is formed in the side wall 21B of the other pipe column 21. Thus, the adjacent pipe columns 21 of the four building units 20 which are disposed adjacently to each other may be bolt-connected to each other, so that the horizontal rigidity of the unit building 1 comprising these building units 20 can be improved rationally as is similar to the embodiment shown in FIG. 10 to 12.

[0050] The upper half portion of the girder plate 71 of the holed spacer 70, which extends from the lower half portion of the girder plate 71, is placed in a gap between the opposed side walls 31A, 31A of the adjacent pipe columns 31, 31 of the upper floor building units 30, 30 which are disposed adjacently in the direction of gable. A bolt 61, which is inserted through the operation hole for bolt fitting 61B which is formed in the side wall 31B of one of the columns 31, is continued to be inserted through the bolt holes 61A, 61A of both pipe columns 31, 31, and further through the bolt hole 71B which is formed in the upper half portion of the girder plate 71 which is placed in the gap between the side walls 31A, 31A of both pipe columns 31, 31. Finally, the bolt 61 is screwed with a nut 62 which is inserted through the operation hole 61C which is formed in the side wall 31B of the other pipe column 31. Thus, the adjacent pipe columns 31 of the four upper floor building units 30 which are disposed adjacently to each other may be bolt-connected to each other, so that the horizontal rigidity of the unit building 1 comprising these upper floor building units 30 can be improved rationally as is similar to the embodiment shown in FIG. 10 to 12.

[0051] Further, in the unit building 1, the respective one ends of the ceiling beam 23 of the building unit 20 and the floor beam 32 of the upper floor building unit 30, which building units are to be disposed vertically, connected to each other via their pipe columns 21, 31 and the girder plate 71 of the holed spacer 70 as aforementioned, so that the ceiling beam 23 and the floor beam 32 may be connected for preventing the substantial shift therebetween as is the case of aforementioned construction method II, in which respective other ends of the beams are connected. When the two beams 23, 32 are subjected to a vertical load to deform incurvatingly, the phase differences between both ends of the respective beams 23, 32 are constrained. Accordingly, a cross sectional property of the beams connected to each other becomes superior to the sum of the respective cross sectional properties of the respective beams 23, 32, so that the connected beams are improved in the rigidity as well as the proof strength with respect to a vertical

load. Also, when the two beams 23, 32 are subjected to a horizontal load which acts on the column 31 of one of the building units 30 to make a deformation in the shape of letter S, the phase differences at both ends and a middle portion of the two beams 23, 32 can be constrained. Thus the frame strength of the building units 20, 30 can be improved and the proof strength thereof with respect to a horizontal load can be increased. Note that, the construction method II and III may be applied to unit building 1 in combination, so that the unit building 1 is successfully improved in the horizontal rigidity as well as the vertical rigidity.

[0052] In addition, returning to FIGS. 13A and 13B, when there mounted two upper floor building units 30 onto only the two building units 20, which are parts of the four building units 20 and disposed in a side along the beam direction, and the rest of building units 20 are left as a one-story building without the upper floor building 30, the beam direction side of the upper half portion of the girder plate 71 of the holed spacer 70 is removed as shown in FIG. 13B by a two dotted chain line.

[0053] FIGS. 15A and 15B are modified embodiments of FIGS. 13A and 13B. In this case of the unit building 1, the corner portions of the adjacent two building units 20 are disposed abuttingly, and the upper floor building units 30 are disposed onto the respective building units 20. the construction method III is applied to this unit building 1 making use of a holed plate spacer 80.

[0054] A lower half portion of the holed spacer 80 is placed in a gap between the opposed side walls 21A, 21A of the adjacent pipe columns 21, 21 of the adjacent building units 20, 20. As is similar to the embodiment shown in FIGS. 13A and 13B, the construction method III is performed by bolt connection of the pipe columns 21, 21 to each other by means of the bolts 61.

[0055] Also an upper half of the holed spacer 80 is placed in a gap between the opposed side walls 31A, 31A of the adjacent pipe columns 31, 31 of the adjacent upper floor building units 30, 30. As is similar to the embodiment shown in FIGS. 13A and 13B, the construction method III is performed by bolt connection of the pipe columns 31, 31 to each other by means of the bolts 61.

[0056] Further, a protrude 81 of the lower portion of the holed spacer 80 is placed in a gap between the opposed joint pieces 23J, 23J of the adjacent pipe columns 21, 21 of the adjacent building units 20, 20. The joint pieces 23J, 23J facing with respect to the protrude 81 are connected with a bolt 61 to each other. Then, in this unit building 1, the respective one ends of the ceiling beam 23 of the building units 20 and the floor beam 32 of the upper floor building unit 30, both building units being stacked vertically, are connected via their columns 21, 31, and the holed spacer 80. Accordingly, the respective other ends of the ceiling beam 23 and the floor beam 32 come to be connected preventing the substantial shift therebetween, and thus, the construction method II can be performed also.

[0057] FIGS. 16A and 16B are modified embodiments

of FIGS. 13A and 13B. In this case of unit building 1, the corner portions of the adjacent three building units 20 are disposed abuttingly, and the respective building units 20 are mounted with the respective upper floor building units 30. This is an example of performing the construction method III making use of a holed spacer 90 in the shape of letter L.

[0058] The holed spacer 90 comprises a girder plate 91 which is disposed along the beam direction and a gable plate 92 which is disposed orthogonally to one of vertical edges of the girder plate 91.

[0059] In the respective directions along gable and beam, lower portions of the respective girder plate 91 and gable plate 92 of the holed spacer 90 are placed in a gap of opposed side walls 21A, 21A of the adjacent pipe columns 21, 21 of the adjacent building units 20, 20. As is similar to the embodiment shown in FIGS. 13A and 13B, the adjacent pipe columns 21, 21 are bolt connected to each other with a bolt 61, and the construction method III is performed.

[0060] Also in the respective directions along gable and beam, upper portions of the girder plate 91 and the gable plate 92 of the holed space 90 are placed in a gap between the opposed side walls 31A, 31A of the adjacent pipe columns 31, 31 of the adjacent upper floor building units 30, 30. As is similar to the embodiment shown in FIGS. 13A and 13B, the adjacent pipe columns 31, 31 are connected to each other with a bolt 61, and the construction method III is performed.

[0061] In the unit building 1, the respective one ends of the ceiling beam 23 of the building unit 20 and the floor beam 32 of the upper floor building unit 30 are connected to each other via their pipe columns 21, 31 and the girder plate 91 or gable beam 92 of the holed spacer 90. Accordingly, the respective other ends of the ceiling beam 23 and the floor beam 32 are connected to each other preventing the substantial shift therebetween, and the construction method II can perform also.

[0062] In addition, in FIGS. 16A and 16B showing the unit building 1 having three building units 20, when only the building unit 20, which is in a side along the gable direction, is mounted with the upper floor building unit 30, and the other building units 20 are left as one-story unit building without the upper floor building unit(s) 30, the upper half portion of the gable plate 92 of the holed spacer 90 is removed as shown in FIG. 16B by a two dotted chain line.

(Construction method IV: Reinforcing structure with diagonal member) (FIGS. 17A to FIG. 19)

[0063] The construction methods IV is applied between a column foot 21F of a column 21 of a lowest floor building unit 20 and a middle portion of a ceiling beam 23, a column foot 31F of a column 31 of an upper floor building unit 30 (same with 40) and a middle portion of a ceiling beam 33, and a column capital 31H of a column 31 of an upper floor building unit 30 (same with 40) and

a middle portion of a floor beam 32 (FIG. 1, FIG. 2).

[0064] FIG. 17A shows a diagonal member 101 provided between the column foot 21F of the column 21 of the lowest floor building unit 20 and the middle portion of the ceiling beam 23. The diagonal member 101 is pin connected (rigid connection allowable) to the column foot 21F of the column 21 and the middle portion of the ceiling beam 23 respectively.

[0065] FIG. 17B shows a diagonal member 102 provided between the column foot 31F of the column 31 of the upper floor building unit 30 and the middle portion of the ceiling beam 33. The diagonal member 102 is pin-connected (rigid connection allowable) to the column foot 31F of the column 31 and the middle portion of the ceiling beam 33 respectively. Alternatively, said diagonal member 102 may be provided between the column capital 31H of the column 31 and the middle portion of the floor beam 32, because the upper floor building unit 30 includes the floor beam 32.

[0066] According to the construction method IV, when a diagonal member 101 is provided in the unit building 1 between the column capital 21F of the lowest floor building unit 20 and the middle portion of the ceiling beam 23, column 21, which consists in part of a frame of a Rahmen construction, part of the ceiling beam 23 and the diagonal member 101 form a right angle triangle, which is an invariant construction (invariant truss). Then, noting an apparent length L2 of the ceiling beam 23 of the building unit 20, which apparent length L2 is obtained by subtracting the length of the invariant truss portion L1 from the total length L of the ceiling beam 23, and which apparent length L2 corresponds to the length of the deformed portion, the frame rigidity is improved and the proof strength with respect to a horizontal load P is increased by shortening this apparent length L2 of the ceiling beam 23 (FIG. 18).

[0067] Also, when a diagonal member 102 is provided between the column foot 31F of the upper floor building unit 30 (same with 40) and the middle portion of the ceiling beam 33 (or between the column capital 31H and the middle portion of the floor beam 32), the column 31, which consists in part of the frame of a Rahmen construction, part of the ceiling beam 33 and the diagonal member 102 form a right angle triangle, which is an invariant construction (invariant truss). Then, noting the apparent length L2 of the ceiling beam 33 of the building unit 30, which apparent length L2 is obtained by subtracting the length L1 of the invariant truss part from the total length L of the ceiling beam 33, and which apparent length L2 corresponds to the length of the deformed portion, the frame rigidity is improved and the proof strength with respect to a horizontal load P is increased by shortening this apparent length L2 of the ceiling beam 23.

[0068] The aforementioned invariant construction (invariant truss) can be formed simply by adding the diagonal members 101, 102 to the existing frames consisting of the column 21 and beam 23, and the column 31 and the beams 32,33, those frames having a Rahmen con-

struction, so that the aforementioned increase of the frame rigidity can be established easily.

[0069] Through the use of pin connection of the diagonal members 101, 102 to the columns 21, 31 and the beams 23, 33(32) respectively, the aforementioned invariant construction (invariant truss) can be formed easily at part of the frame of a Rahmen construction. This results in making connection of the diagonal members 101, 102 simple.

[0070] Since the reinforcement of the frame rigidity is achieved by only adding the diagonal members 101, 102, it does not obstruct the formation of an opening in a Rahmen construction of the building units such as 20, 30. Namely, relatively large openings may be formed.

[0071] The frame rigidity of the building units 20, 30 (same with 40) according to the present invention becomes 1.3 to 2.0 times as high as that of a conventional model. With regard to the building unit 20 and 30 (same with 40), when the connecting position of the diagonal members 101, 102 to the ceiling beam 23 of the building unit 20 and the ceiling beam 33 of the building unit 30 is arranged in such a manner that the length of the invariant truss portion L1 is 450mm and 900mm respectively, the allowable horizontal load Pa of the building unit 20 is increased to 1550kg, 1700kg respectively, and the same of the building unit 30 is increased to 1200kg, 1400kg respectively. On the other hand, the allowable horizontal load Pa for a conventional model without the diagonal members 101, 102 is 1300kg, 900kg respectively. These results can be seen in FIG. 19.

[0072] Note that, shown in FIG. 19 in the lowest building unit 20, the right and left diagonal members 101, 101 may be provided between the column foots 21F of the right and left columns 21 and the respective right and left middle portions of the ceiling beam 23. Also as shown in FIG. 19, in the upper floor building units 30 (same with 40), the right and left diagonal members 102, 102 may be provided between the column foots 31F (or the column capitals 31H) of the right and left columns 31 and the respective right and left middle portions of the ceiling beam 33 (or floor beam 32). According to this, even if the length of the invariant truss portion L1, which invariant truss is formed by connecting the right and left diagonal members 101, 101, 102, 102 to the ceiling beam 23 of the lowest floor building unit 20 and the ceiling beam 33 of the upper floor building unit 30 respectively, is as short as 450mm for example, the allowable horizontal load Pa of the building unit 20, 30 can be increased to 2050kg and 1800kg.

[0073] FIG. 20 to FIG. 22 show a specific example of fixing the diagonal member 101 (same with 102) according to the construction method IV. The building unit 20 (same with 30, 40) is provided with the floor beam 22 as an example. A reinforcement frame 25 including the diagonal member 101 is fixed between the floor beam 22 and the ceiling beam 23.

[0074] The reinforcement frame 25 comprises a reinforcement column 26, which is provided additionally to

the column 21, and a intermediate column 27. The reinforcement frame 25 is constructed in such a manner that a lower end of the diagonal member 101 is welded to a fixing plate 26A which is extended horizontally from the lower end of the reinforcement column 26, an upper end of the diagonal member 101 is welded to a side surface of an upper end of the intermediate column 27, a tie beam 28 is laid between a lower middle portion of the diagonal member 101 and a lower middle portion of the intermediate column 27, and a tie beam 29 is laid between an upper middle portion of the diagonal member 101 and a upper middle portion of the reinforcement column 26.

[0075] In the reinforcement frame 25, a fixing plate 26A, which includes the lower ends of the reinforcement column 26 and the diagonal member 101, is bolt connected to a joint piece 22J, which is connected to the column foot 21F of the column 21, and a fixing plate 26B which is extended horizontally from the upper end of the reinforcement column 26, is bolt connected to a joint piece 23J, which is connected to the column capital 21H of the column 21. Further, a floor beam reinforcement piece 103, which has a cross section in the shape of letter L, is welded to an upper flange of the floor beam 22, which is held by the joint piece 22J, and to an inside surface of a web. The fixing plate 26A of the diagonal member 101 is placed onto the joint piece 22J, and connected with a bolt 104, which is inserted through the floor beam reinforcement piece 103, floor beam 22, the joint piece 22J and the fixing plate 26A, and a nut 104A.

[0076] The lower end of the intermediate column 27 of the reinforcement frame 25 is bolt connected to the upper flange of the floor beam 22, and the upper end of the intermediate column 27 is bolt connected to the lower flange of the ceiling floor 23. At this time, a ceiling beam reinforcement piece 105, which has a cross section in the shape of letter C, is welded between the upper and lower flanges of the ceiling beam 23, to which beam the upper end of the intermediate column 27 is to be bolt connected.

[0077] Note that, in this embodiment, the term of "connection for preventing the substantial shift" means, for example, "connection for keeping the shape of the connecting portion rectangular", and "connection for preventing the shift between the upper and lower beams", and also that this term includes not only the rigid connection but also any connection weaker than the rigid connection. Further note that the term "end" in the "connection of the ends of beams to each other" includes an adjacent area of the end itself.

(Construction method V: column-eliminated reinforcement structure) (FIGS. 23A to FIG. 28)

[0078] The construction method V is applied at the column-eliminated corners of the building unit 20 (same with 30, 40) (FIG. 1 and FIG.2).

(Embodiment 1) (FIGS. 23A to 23C and FIG. 24)

[0079] The unit building 1A shown in FIGS. 23A to 23C is part of the unit building 1 shown in FIG. 1 and FIG. 2, which is of a type where a plurality of building units 20 are disposed adjacently to each other in the horizontal and vertical directions. The four column-eliminated building units 120, which form a part of said unit building, may contribute to form a wide and continuous space due to eliminated columns.

[0080] A building unit 20 has, as typically shown in FIG.3, a framework construction, wherein four columns 21 of a square steel pipe, four floor beams 22 of a structural steel and four ceiling beams 23 of a structural steel are connected into a shape of box. The building unit 20 is constructed in such a manner that floor beams 22 intersecting to each other are connected to a lower end of the column 21 with a joint piece 22J at four corners, and ceiling beams 23 intersecting to each other are connected to an upper end of the column 22 with a joint piece 23J.

[0081] A column-eliminated building unit 120 is, as shown in FIG. 24, of a type where one of the four columns 21 of a conventional building unit 20 is eliminated. The column-eliminated building unit 120 is constructed with respect to the floor beams in such a manner that floor beams 22 intersecting each other are connected to the lower end of the column 21 with the joint piece 22J at the three corners except the column-eliminated corner, and the floor beams 22 intersecting each other are connected to each other with a joint piece 22K at the column-eliminated corner. The column-eliminated building unit 120 is constructed with respect to the ceiling beams 23 in such a manner that the ceiling beams 23, which are disposed intersectingly to each other at the column-eliminated corner, and which are aligned in the gable direction, are formed into a joint ceiling beam 121, the rest of ceiling beams 23 are left as the normal ceiling beams 23, the respective normal ceiling beams 23 is connected to the upper end of the column 21 with a joint piece 23J, the joint ceiling beam 121 is connected to the upper end of a column 21 with the joint piece 23K, and the ceiling beams 121 is connected to the ceiling beam 23 with a joint piece 23L.

[0082] In the column-eliminated building unit 120, the cross sectional strength of the joint ceiling beam 121 is increased compared with that of the other normal ceiling beams. The joint ceiling beam 121 is formed of a C-shape steel with lip. The end of the joint ceiling beam toward the column-eliminated corner is welded to an end plate 122. In order to prevent the joint piece 23L, which is to be welded afterwards on said end, to cover the end plate 122, part of the joint piece 23L is removed like a cut-off 123 along the periphery of the end plate 122. In the column-eliminated building unit 120, the positional accuracy of the surface of the end plate 122 in the longitudinal direction of the joint ceiling beam 121 is kept with respect to the reference position, which corre-

sponds to the column 21 connected to the joint piece 23K.

[0083] The column-eliminated building unit 120 is provided with a temporary column 124 detachably at the column-eliminated corner portion. The temporary column 124 is detachably connected to the aforementioned joint piece 22K of the floor beam 22 and the joint piece 23L of the ceiling beams 23 and 121 with fitting means such as a bolt or a pin.

[0084] As shown in FIG. 23A, in part of the lower floor of the unit building 1A, the respective predetermined column-eliminated corners of the four column-eliminated building units 120 (120A to 120D) are disposed abuttingly to each other at the column-eliminated connection portion 2.

[0085] The ceiling beams 23, which are disposed intersectingly at the column-eliminated corner in the same plane including both column-eliminated connection portions 2 between the column-eliminated building unit 120A and the column-eliminated building unit 120B corresponding to each other, serve as the aforementioned joint ceiling beam 121 (FIG. 24). As such, the end plates 122 of the joint ceiling beams 121, which correspond at the column-eliminated connection portion 2 of both building units 120A and 120B, sit in parallel with a gap of a predetermined dimension. Accordingly, a spacer 110 is inserted into the gap from the top or from the side thereof, which gap is formed between the end plates 122 of the opposed joint ceiling beams 121. The thickness of the spacer is determined to fit the gap.

[0086] In this embodiment, two spacers 110 are inserted into the upper and lower sides of the end plates 122. Then, the end plates 122 of the opposed joint ceiling beams 21 and the spacers 110 are connected together with a high strength bolt 111 (not shown). The high strength bolt 111 is inserted through bolt holes 122A formed in the opposed end plates 122 and bolt holes 110A formed in the spacers 110 and finally screwed with a nut 112 at the forward end thereof. In this embodiment, two high strength bolts 111 are used at right and left per one piece of the spacer 110. Thus, the rigid-connection is established in the longitudinal direction of the joint ceiling beam 121 as well as the horizontally perpendicular direction to the former, so that the substantially perfect rigid-connection can be established as a whole. The high strength bolt 111 may be of a Torshear or a hexagonal type or the like.

[0087] Also, the end plates 122 of the opposed joint ceiling beams 121 between the corresponding column-eliminated building unit 120C and the column-eliminated building unit 120D are connected to each other including the spacers 110 with a high strength bolt 111 for establishing the rigid-connection, in the same manner regarding the building unit 120A and the building unit 120B as aforementioned.

[0088] When connecting the end plates 122 of the opposed joint ceiling beams 121 between the corresponding building unit 120A and building unit 120B, and cor-

responding building unit 120C and building unit 120D, the temporary columns 124 are provided at the column-eliminated corner portions of the respective building units 120. The temporary columns 124 are removed after the connection between the end plates 122 of the opposed joint ceiling beams 121 has been completed.

[0089] The following working-effects are possible according to the present embodiment.

(a) The joint ceiling beams 121, which intersect each other at the column-eliminated corner portions of the respective adjacent building units 120, are connected to each other. As a result, the joint ceiling beams 121 are united into a continuous beam extending over both building units 120 like a long beam. Hence, the column-eliminated unit building 1A can be reinforced without using a separate long beam, so that the material management and the workability can be improved.

(b) The joint ceiling beam 121 itself, which is part of the ceiling beam 23 consisting the building unit 120, serves to reinforce the unit building 1A, so that there is no need to provide additionally a separate reinforcement member around the building unit 120. In the case of disposing another building unit 20 adjacent to the building unit 120, there is no need to provide a space for the reinforcement members between the building unit 120 and another building unit 20.

(c) The cross sectional strength of the joint ceiling beam 121, which intersects at the column-eliminated corner portion of the unit building 1A for reinforcing said unit building 1A, may be increased enough for compensating the strength reduction due to the elimination of the column. In addition, the cross sectional strength of the other ceiling beams 23 is kept at a normal level. As a result, all of the ceiling beams 23 of the building unit 120 are provided with sufficient cross sectional strength, and contribute to keep strength economically.

(d) The rigid-connection of the end plates 122 of the joint ceiling beam 121 of the adjacent building units 120 via the spacers 110 by means of high strength bolts 111 is advantageous for connecting easily the joint ceiling beams 121 to each other, and for improving the accuracy in the dimension of the unit building 1A.

(e) The temporary column 124, which is provided at the column-eliminated corner portion of the building unit 120, is not removed during the steps of manufacturing of the building unit 120, transportation, stocking, field erection and the connection of the joint ceiling beam 121. Thus, the building unit 120 may be kept strong during the connection of the joint ceiling beam 121, so that the building strength during construction may be secured and good workability may be maintained.

(Embodiment 2) (FIGS. 25A and 25B)

[0090] A unit building 1B shown in FIGS. 25A and 25B includes a large wellhall space which has two lower floor building units 120 and an upper floor building unit 30 which is disposed thereon.

[0091] The column-eliminated building unit 120 of the embodiment 2 is different from the column-eliminated building unit 120 in that two columns 21, standing adjacently in the beam direction, out of four columns 21 of a normal building unit 20 are eliminated, two ceiling beam 23 aligning in the gable direction are connected to a joint ceiling beam 121, ceiling beams 23 extending in the beam direction and intersecting with the joint ceiling beam 121 are made to serve as temporary beams 125, and the temporary beams 125 are connected detachably to the free ends of the joint ceiling beam 121 with attaching means such as bolt or pin and made removable by cutting.

[0092] With regard to the unit building 1B, in part of the lower floor as shown in FIG. 25A, the two predetermined column-eliminated corner portions of the two column-eliminated building units 120 (120A, 120B) are disposed abuttingly to each other at the column-eliminated connection portions 2, 3.

[0093] Between the column-eliminated building unit 120A and the column-eliminated building unit 120B, the end plates 122 of the opposed ceiling beams 121, as shown in FIG. 25B are connected to each other, as is similar to the Embodiment 1. Then, the temporary columns 124 are removed, and the temporary beams 125 are cut off (or simply removed).

[0094] Subsequently, the building unit 30, which is to construct an upper floor, is disposed on the column-eliminated building unit 120. The floor beam 22 of the upper floor building unit 30, which floor beam corresponds to the temporary beam 125 of the lower building unit 120, is eliminated from the outset, or cut off after the disposition in order to form a wellhall space in an upper portion of the lower building unit 120.

[0095] As such, the unit building 1B may assure the structural strength by means of the joint ceiling beam 121 as well as form a large wellhall space over the lower floor building unit 120 to the upper floor building unit 30.

(Embodiment 3) (FIGS. 26A and 26B)

[0096] The unit building 1C shown in FIGS. 26A and 26B is intended to form a stair well with two lower floor units 120, which consist in part of the unit building 1C, and an upper floor building unit 30, which is to be disposed thereon.

[0097] The column-eliminated building unit 10 used in the embodiment 3 is different from the column-eliminated building unit 120 used in the embodiment 1 in that the ceiling beam 23, which intersects the joint ceiling beam 121, consists of a temporary beam 126A, which is part of the ceiling beam 23 in the intersecting side with

said ceiling beam 121, and a partial beam 126B, which is the rest of said joint ceiling beam 121. The respective ends of the temporary beam 126A are connected to the free end of the joint ceiling beam 121 and the end of the partial beam 126B with attaching means such as bolt or pin, and is removable by cutting. The end of the partial beam 126B, which is to be connected to the temporary beam 126A, is supported by an intermediate column 127 (not shown).

[0098] In part of the lower floor of the unit building 1C, as shown in FIG. 26A, the predetermined column-eliminated corner portions of the two respective column-eliminated building units 120(120A, 120B) are disposed abuttingly at the column-eliminated connection portion 2.

[0099] Between the column-eliminated building unit 120A and the column-eliminated building unit 120B, as shown in FIG. 26B, the end plates 122 of the opposed joint ceiling beams 121 are connected as is similar to the embodiment 1, then the temporary columns 124 are removed, and the temporary beams 126A are cut off (or simply removed).

[0100] Subsequently, the floor unit 30, which is to constitute the upper floor, is disposed on the column-eliminated building unit 120. With regard to the floor beam 22 of the upper floor building unit 30, which floor beam corresponds to the temporary beam 126A and the partial beam 126B of the lower floor building unit 120, part of the floor beam 22, which corresponds to the temporary beam 126A, is eliminated from the outset or cut after the disposition.

[0101] As such, the unit building 1C may assure the structural strength by means of the joint ceiling beam 121 as well as form a stair well over the lower floor building unit 120 to the upper floor building unit 30.

(Embodiment 4) (FIG. 27, FIG. 28)

[0102] The unit building 1D shown in FIG. 27 and FIG. 28 is intended to form a wide and continuous column-eliminated space using the four lower floor column-eliminated building units 120 as is similar to the unit building 1A. The unit building 1D is intended further to dispose the upper floor column-eliminated building units 130 on the respective column-eliminated building units 120 and to form also a wide and continuous column-eliminated space using the four upper floor column-eliminated building units 130.

[0103] Accordingly, the unit building 1D is constructed such that the joint ceiling beam 121 of the column-eliminated building unit 120A, which is arranged in one side with respect to the column-eliminated connection portion 2 of the lower floor, corresponds to the joint ceiling beam 121 of the column-eliminated building unit 120B in the other side; the joint floor beam 131 of the column-eliminated building unit 130A, which is arranged in one side with respect to the column-eliminated connection portion 2 of the upper floor, corresponds to the joint floor

beam 131 of the column-eliminated building unit 130B in the other side; and the joint floor beam 131 of the column-eliminated building unit 130A (130B) in the upper floor is arranged stackingly on the joint ceiling beam 121 of the column-eliminated building unit 120A (120B) of the lower floor.

[0104] Accordingly, the joint ceiling beam 121 and the joint floor beam 131 of the column-eliminated building unit 120A, 130A which are arranged in one side with respect to the respective column-eliminated connection portions 2, and the joint ceiling beam 121 and the joint floor beam 131 of the column-eliminated building unit 120B, 130B arranged in the other side connected as follows;

(1) A plate-like joint member 141 and a V-sectioned joint member 142 are placed extendingly over a lower flange of the joint ceiling beam 121 of the column-eliminated building unit 120A and a lower flange of the joint ceiling beam 121 of the column-eliminated building unit 120B. The joint member 141 is placed additionally on an inner surface of the lower flange of both joint ceiling beams 121. The joint member 142 is placed additionally on outer surfaces of the lower flange, a lower portion of a web and a lower lip of both joint ceiling beams 121.

At one side of the respective joint members 141, 142, two high strength bolts 143 are inserted through bolt holes formed in the joint members 141, 142 and the lower flange of the joint ceiling beam 121, and fastened with nuts 143A at the inserted end thereof. At the other side of the respective joint members 141, 142, two high strength bolts 143 are inserted through bolt holes formed in the joint members 141, 142 and the lower flange of the joint ceiling beam 121, and fastened with nuts 143A at the inserted end thereof. As such, the joint members 141, 142 are rigid-connected in one side to the joint ceiling beam 121 of the column-eliminated building unit 120A, and the joint members 141, 142 are rigid-connected in the other side to the joint beam 121 of the column-eliminated building unit 120B.

(2) A plate-like joint member 151 and U-sectioned joint member 152 are placed extendingly over an upper flange of the joint ceiling beam 121 of the column-eliminated building unit 120A and an upper flange of the joint ceiling beam 121 of the column-eliminated building unit 120B. The joint member 151 is placed additionally on an inner surface of the upper flange of both joint ceiling beams 121. The joint member 152 is placed additionally on an outer surface of the upper flange, an upper portion of a web and an upper lip of both joint ceiling beams 121.

[0105] At one side of the joint members 151 and 152, two high strength bolts 153 are inserted through bolt holes formed in the joint members 151, 152, the upper flange of the joint ceiling beam 121, the lower flange and

a joint piece 131J of the joint floor beam 131 of the column-eliminated building unit 130A and a square washer 131A, and the inserted end thereof is fastened with a nut 153A of strength bolts 153. Note that the joint piece 131J is placed for connecting a short column 131C to the column-eliminated end of the joint floor beam 131. At the other side of the joint members 151 and 152, two high strength bolts 153 are inserted through bolt holes formed in the joint members 151, 152, the upper flange of the joint ceiling beam 121, the lower flange and the joint piece 131J of the joint floor beam 131 of the column-eliminated building unit 130B and a square nut 131A, and the inserted end thereof is fastened with a nut 153A. Note that said joint piece 131J is placed for connecting a short column 131C to the column-eliminated end of the joint floor beam 131. As such, the one side of the joint members 151 and 152 are rigid-connected with the joint ceiling beam 121 and the joint floor beam 131 of the column-eliminated building units 120A and 130A respectively. Also the other side of the joint members 151 and 152 are rigid-connected with the joint ceiling beam 131 and joint floor beam 131 of the column-eliminated building units 120B and 130B respectively.

[0106] In addition, in the upper floor of the unit building 1D, the joint ceiling member 132 of the column-eliminated building unit 130A on one side with respect to the column-eliminated connection portion 2 and the joint ceiling beam 132 of the column-eliminated building unit 130B on the other side are connected with a joint member which is similar to the joint members 141, 142, 151 and 152 described in foregoing (1) and (2).

[0107] According to the present embodiment, the joint ceiling beams 121, 121 corresponding to each other and the joint floor beams 131, 131 corresponding to each other of the adjacent building units 120A, 130A and 120B, 130B are rigid-connected with high strength bolts 143, 153 through the joint member 141, 142, 151, and 152, so that joint ceiling beams 121 and the joint floor beams 131 can be easily connected to each other. In addition, the accuracy in the dimension of the unit building 1D may be improved.

[0108] FIG. 29 to 32 show a guide collar 200 and a attachment 210 which are preferable for connecting the end plates to each other, which end plates 122 are to be placed on the opposed joint ceiling beams 121 of, for example, unit building 1A according to the construction method V. The guide collar 200 and attachment 210 serves to align the bolt holes 122A formed in the end plates 122 of the opposed joint ceiling beams 121 (also the bolt holes 110A formed in the spacer 110) in order to cause the high strength bolt 111 to be inserted easily. The method of alignment will be described hereunder.

[0109] Note that the guide collar 200 is configured to have, as shown in FIG. 29, a length shorter than that of the threaded portion of the high strength bolt 111, an outer diameter smaller than those of the bolt hole 122A in the end plate 122 and bolt hole 110A in the spacer 110, a hexagonal head 201 at its base end, a tapered

front end 202 and a threaded hole for the high strength bolt 111 to be inserted therethrough. Also note that the attachment 210 is configured to have a slit 211 and a stopper 212, as shown in FIG. 30. The clearance of the slit is smaller than the diameter of the head 111A of a high strength bolt 111 and larger than the diameter of the threaded stem thereof, so that the threaded stem can be inserted through the slit 211. When the threaded stem of the bolt 111, which is attached with the guide collar 200, is inserted through the slit 211, the outer surfaces of the hexagonal head 201 of the guide collar 200 engages the slit 211, and the collar 200 comes to be stopped to rotate.

(1) A guide collar 200 is screwed on the circumference of a high strength bolt 111 except for the front portion (FIG. 43A).

(2) The front portion of the high strength bolt 111 is inserted through a bolt hole 122A formed in an end plate 122 of opposed joint ceiling beams 121 (FIG. 31B). At this time, if the bolt holes 122A in both end plates 122 or bolt hole 110A in spacer 110 are not aligned to each other, the guide collar 200 may be stopped after entering through a single bolt hole 122A or 110A of the first plate of the end plate 122.

(3) When the nut 112 is put on the front portion of the high strength bolt 111, which front portion is protruded from the bolt hole 122A in the end plate 122, and screwed about the bolt, the high strength bolt 111 and the guide collar 200 may be drawn through the bolt holes 122A in the two end plates 122 and the bolt holes 110A in the spacer 110. Thus, the bolt holes 122A and 110A are aligned coaxially respectively (FIG. 31C to FIG. 31E).

(4) Then, the nut 112 is removed from the high strength bolt 111 (FIG. 31F).

(5) The high strength bolt 111 is loosen from the guide collar 200, and the attachment 210 is inserted between the head 111A of the high strength bolt 111 and the outer surface of the first plate of the end plate 122. The guide collar 200 is received in the attachment 210, and the outer surface of the hexagonal head 201 of the guide collar 200 is made to engage the stopper 212 of the attachment 210, so that the attachment 210 serves to stop the rotation of the guide collar (FIG. 32A and FIG. 32B).

(6) When the high strength bolt 111 is screwed up against the attachment 210, a reaction force is generated between the high strength bolt and the end plate 122 or the spacer 110. The guide collar may be drawn out from the bolt hole 122A in the end plate 122 or the bolt hole 110A in the spacer 110 with the aid of the reaction force making the attachment 210 as a support point (FIG. 32C and FIG. 32D).

(7) The guide collar 200 and the attachment 210 are removed together with the high strength bolt 111 out of the bolt hole 122A in the end plate 122 (FIG. 32E).

(8) The high strength bolt 111 (the same removed from the guide collar 200 may be used) are inserted into the aligned bolt holes 122A in both end plates 122 and the bolt holes 110A in the spacer 110, the nut 112 is screwed completely about the inserted front end of said high strength bolt. Thus, the end plates 122 of the opposed joint ceiling beam 121 are connected to each other completely.

[0110] In the case of bolt holes 122A (110A) being prepared in three or more positions in the end plates 122 (spacer 110), the alignment according to the aforementioned steps (1) to (7) making use of the guide collar 200 and the attachment 210 may be carried out for bolt holes 122A (110A) in at least two positions, or preferably for the same taking two positions on a diagonal. Then, the alignment for the rest of the bolt holes 122A (110A) may be carried out automatically.

[0111] Note that the foregoing alignment method for a plurality of opposed holes making use of the guide collar 200 and the attachment 210 may be applied not only to the construction method V, but also to the construction method II in which the bolt holes formed in the opposed two beams (may include the plates) are to be aligned, and to the construction method III in which the bolt holes formed in the respective opposed side walls of the adjacent pipe columns are to be aligned.

[0112] According to the present embodiment, the guide collar 200 and the attachment 210 may be effectively used for making correction of the misalignment of the bolt holes 122A of the opposed joint ceiling beam 121, and as a result, the alignment of the bolt holes 122A is easier and the insertion of the high strength bolt 111 into the bolt holes 122A is also easier.

[0113] Further, in the case of holding the spacer 110 between the opposed joint ceiling beams 121, the bolt holes 122A and 110A, which are formed in the joint ceiling beam 121 and the spacer 110 respectively, may be aligned easily.

[0114] The building unit of the present invention can be of a type where the column-eliminated corner portions of the three or more column-eliminated building units are connected abuttingly to each other at the column-eliminated connection portion.

[0115] Next, a modified embodiment of the construction method I will be described hereunder.

[0116] As shown in FIG. 33 and FIGS. 34A and 34B, a unit building 1 is constructed in such a manner that a plurality of the building units 20, which are built at a manufacturing site, are disposed adjacently to each other in the horizontal direction on foundations 10 at a building site.

[0117] As shown in FIGS. 34A and 34B, the building unit 20 has a rectangular parallelepiped framework construction wherein floor beams 22 of a structural steel are laid over four pipe columns 21 of a square steel and welded to column foots 21F thereof, and ceiling beams 23 of a structural steel are laid over the foregoing col-

umns 21 and welded to column capitals thereof.

[0118] In the building unit 20, as shown in FIG. 35 and FIGS. 36A and 36B, one of ends of a joint piece 22J, which has a cross section in a shape of half-square, is welded to the outer surface of the column foot 21F of the column 21, and an end of the floor beam 22 is inserted into the half-square shaped cross section of the joint piece 22J, and said floor beam 22 is secured by welding to the joint piece 22J. At this time, since the column foot 21F of the column 21 is not provided with a column lid on the lower end opening thereof, the floor beam 22 is pin-connected to the column foot 21F of the column 21. Note that the column foot 21F may be provided with a temporary lid 21C on the lower end opening, which temporary lid is used during manufacturing and transportation. Also note that the column capital of the column 21 is provided with a column lid on the upper end opening, so that the ceiling beam 23 is rigid-connected to the column capital of the column 21.

(Modified example 1)

[0119] According to the modified embodiment 1, as shown in FIGS. 34A and 34B and FIGS. 36A and 36B, the base connection structure of the building unit 20 is of a type where the column foot 21F of the column 21 is rigid-connected to a base 10 and secured to the same. Specifically, a steel base construction 223 is secured to a concrete mat foundation 221 of the base 10 with anchor bolts 222, a support member 224 of a square steel pipe is welded to a base plate 223A of the base construction 223, which support member 224 is reinforced by a diagonal member 223B, a lower end of a steel core 225 is inserted into the support member 224 through the top end thereof, which lower end is welded to the support member so that the core 225 will be installed upright. In this embodiment, the outer size of the cross section of the steel pipe support member 224 is to be identical to the outer size of the column 21F. When the building unit 20 is built on the base 10, the core 225 of the base 10 is inserted into a hollow portion of the column foot 21F of the column 21 of the building unit 20. Then, the column foot 21F and the core 225 are connected with two high strength bolts 231, which are configured to penetrate through the column foot 21F as well as the core 225 and disposed adjacently in an above-and-below relation, washers 232 and nuts 233. The core 225 attaches to a inside surface of the column foot 21F without making any gap therebetween in the beam direction of the building unit 20, which direction is same as that of the axial direction of the high strength bolt 231. On the contrary, the core 225 attaches to the inside surface of the column foot 21A with a gap in the gable direction of the building unit 20 (FIGS. 36A and 36B).

[0120] In addition, when the adjacent building unit 20 is not provided with a corresponding column 21 in the beam direction, the column foot 21F of a single column 21 and a single core 225 is connected with a single high

strength bolt 231 (FIG. 36B). On the contrary, when two building units 20 are disposed adjacently in the beam direction, a spacer 234 is held between both column foots 21F, and said two column foots 21F and a core 225 are connected together with a single high strength bolt 231 (FIG. 37).

[0121] With regard to the strength of the aforementioned base connection structure of a building unit 20, in which the internal width of the column foot 21F is given as d and the span in the vertical direction between the adjacent high strength bolts 231 is given as e , a following relation is found in the beam direction of the building unit 20; $d \times f_1 + e \times f_2 > Ma$, where f_1 is a vertical load, f_2 is a horizontal load and Ma is a bending moment as shown in FIG. 38A. In the gable direction of the building unit 20, it is found that $e \times f > Mb$, where f is a horizontal load and Mb is a bending mode as shown in FIG. 38B. Accordingly, it should be noted that the column foot 21F and the core 225 may be rigid-connected in both beam and gable directions by means of the core 225, which attaches firmly the internal surfaces of the column foot 21F in the beam direction of the building unit 20, with two high strength bolts 231 which are disposed in an above-and-below relation.

[0122] In the aforementioned base connection structure of the building unit 20, the joint piece 22J of the floor beam 22 is welded to the outer surface of the hollow portion, where the core 225 is to be inserted, of the column foot 21F of the column 21, so that said joint piece 22J serves to constitute one of the reinforcing pieces of this invention.

[0123] The following working-effects are possible according to the aforementioned base connection structure of the building unit 20.

- (a) By virtue of the rigid-connection of the column foot 21F of the building unit 20 to the base 10, the column foot 21F may be constrained to rotate with respect to a base 10 and the horizontal rigidity of the building may be improved. There is no need to strengthen the cross section of a column 21, or to add an intermediate column or a horizontal brace in order to improve the horizontal rigidity of the building, so that the degree of freedom for planning of the building is increased, and the cost is decreased.
- (b) A core 225 mounted on the base 10 is inserted into a hollow portion of a column foot 21F, and the column foot 21F and the core 225 are firmly attached to each other and connected with the high strength bolt 231, which are configured to penetrate through the column foot 21F as well as the core 225. By virtue of this, the column 21F and the core 225 may be made rigid-connection in the beam direction in which the column foot 21F and the core 225 are attached firmly to each other, and in the gable direction in which the column foot 21F and the core 225 are attached holding a gap therebetween. Hence, the column foot 21F may be made by rigid-

connection easily to the base 10.

(c) A reinforcing piece 22J is connected to an outer surface of the hollow portion of the column 21F where the core 225 of the column foot 21F is to be inserted. As a result, the reinforcing piece 22J serves to prevent the decrease of the rigidity of the column foot 21F, and consequently to prevent the local deformation thereof.

(d) The joint piece 22J, which is provided for the column foot 21F to be connected to the floor beam 22, may be used as the aforementioned reinforcing piece 22J.

(e) Since the floor beam 22 is pin-connected to the column foot 21F, the building unit 20 is assured to keep enough horizontal rigidity according to foregoing (a), while the framework of the building unit 20 is simplified.

[0124] In addition, by virtue of the aforementioned base connection structure of the building unit 20, it was found that the horizontal rigidity of the building concerned is 1.65 times of that of a conventional example, in which a column 21F is pin-connected to a base 10.

(Modified example 2)

[0125] FIG. 39 shows a base connection structure of the modified embodiment 2, which is configured for a building unit 20 constructing a piloties, garage and the like. In this case, the framework construction of the building unit 20 is not provided with a floor beam 22 at least in a side plane. A lower end of a steel pipe support structure 241 is implanted into a mat foundation 221 of a base 10. A lower end of a steel core 225 is inserted into the steel pipe support structure 241 from the top thereof and welded so that the core 225 will be installed upright. Note that the steel pipe support structure 241 is not accompanied by a base plate 223A, a diagonal member 223B or the like, which are shown in FIG. 35, in the inside of the side plane of the building unit 20, which side plane does not include a floor beam 22 as mentioned just above. Therefore, said steel support 241 is strengthened by being provided with the implants, which are built into the mat foundation 221, with locking protrusions 241A, or by being made with the outside size of the cross section thereof larger than that of the column foot 21F. When the building unit 20 is built on the base 10, the core 225 of the base 10 is inserted into the hollow portion of the column foot 21F of the column 21 of the building unit 20, then the column foot 21F and the core 225 are connected by two high strength bolts 231, washers 232 and nut 233, which bolts are configured to penetrate the column foot 21F and the core 225, and are disposed in an above-and-below relation. The core 225 is attached firmly without gap to the inside surface of the column foot 21F in the beam direction of the building unit 20, which direction is identical to the axial direction of the high strength bolts. On the contrary, the core

225 is attached to the inside surface of the column foot 21F making a gap in the gable direction of the building unit 20 (FIGS. 36A and 36B).

[0126] In the aforementioned base connection structure of the building unit 20, a reinforcing piece can be connected to the outside surface of the hollow portion of the column foot 21F, in which hollow portion the core 225 is to be inserted. Said reinforcing piece is similar to the aforementioned joint piece-cum-reinforcing piece 22J, and has a short length and protrudes shortly toward the inside of the building unit 20. The reinforcing piece may prevent the reduction of the rigidity of the column 21F as well as the local deformation thereof.

[0127] FIG. 39 shows a modified embodiment of the core 51, which is used for the aforementioned steel pipe support member 224 (or steel pipe support structure 241) of the base 10. As shown in FIGS. 41A and 41B, the core 251 includes two steel additional plates 252A, 252B and two steel thick plates 253A, 253B held between said additional plates. These plates are welded together into a core 251. There are provided bolt holes in said two additional plates 252A, 252B, and a gap for bolts to penetrate therethrough between the two thick plates 253A, 253B. A lower end of the core 251 is inserted into the steel pipe support member 224 (or steel pile support structure 241) of the base 10. Then, the steel pipe support member 224 and the core 251 are connected with two high strength bolts 254, washers and nuts, which bolts are configured to penetrate the steel pipe support member 224 and the core 251, and disposed in an above-and-below relation. The core 251 is inserted into the hollow portion of the column foot 21F of the column 21 of the building unit 20, the column foot 21F and the core 251 are connected with two high strength bolts 255, washers and nuts, which bolts are configured to penetrate the column foot 25F and the core 251, and disposed in an above-and-below relation. The core 251 is attached firmly without gap to the inside surface of both column foot 21F and steel pipe support member 224 in the beam direction of the building unit 20, which direction is along the axial direction of the high strength bolts 254, 255. On the contrary, the core 251 makes a gap between the steel pipe support member 224 as well as the column foot 21F (FIGS. 40A and 40B).

(Modified example 3)

[0128] FIG. 42 and FIG. 43 show a base connection portion of the building unit 20 according to modified embodiment 3, in which a column foot 21F of one of the columns 21 of the building unit 20, which is disposed at a peripheral corner of a unit building 1, is fixed to a base 260 by rigid-connection.

[0129] As shown in FIG. 43, the base 260 serves to secure a steel base construction 263 thereon with an anchor bolt 262, which is fixed to an implant plate 261A in a concrete mat foundation 261. As shown in FIGS. 44A and 44B, the base construction 263 includes a body

263A, which is in the shape of letter L in a plan view. In three positions in the L-shaped bottom of the body 263, there provided a bolt fixing plate 263A respectively, which is fixed respectively with an anchor bolt 262 to the mat foundation 261. The base construction 263 is provided with a plurality (four pieces for example) of sleeve-like steel mounting pieces 264 at the top of the body 263A. The respective mounting pieces 264 are provided with respective mounting holes 264A, and fixed by welding to the body 263A. On the other hand, the column foot 21F of the column 20 of the building unit 20 is provided with respective receiving pieces 265 in a plurality (four positions for example) of positions inside a hollow portion at the lower end thereof. The respective receiving pieces 265 is provided with a threaded hole 265A, and fixed to the column foot 21F by welding. Accordingly, when the building unit 20 is built on the base 260, the column foot 21F may be made by rigid-connection to the mounting pieces 264 of the base 260 in such a manner that, firstly the mounting holes 264A in the mounting pieces 264 of the base 260 are aligned with the threaded holes 265A in the receiving pieces 265 of the column foot 21F, then high strength bolts 266 are inserted through the mounting holes 264A of the mounting pieces 264 and screwed into the threaded holes 265A of the receiving pieces 265.

[0130] FIGS. 44A and 44B show a modified embodiment of the base connection portion of the building unit 20, in which respective column foots 21F of two columns of adjacent building units 20 of the unit building 10 are fixed to a base 260 by rigid-connection. The base 260 in FIG. 45 is different from the base 260 in FIG. 42 in that the base construction 263 has a body 263A which is in the shape of letter T in a plan view as shown in FIGS. 46A and 46B. Bolt fixing plates 263B are provided in the bottom of the T-shaped body 263A at the four positions respectively including the intersecting portion like a letter T. Said bolt fixing plates 263B are fixed to the mat foundation 261 with anchor bolts 262.

[0131] FIG. 47 shows a modified embodiment of the base connection portion of the building unit 20, in which column foots 21F of three columns 21 of three building units 20, which are adjacent to each other, of the unit building 10 are fixed to a base 260 by rigid-connection. The base 260 in FIG. 47 is different from the base 260 in FIG. 42 in that the base construction 263 has a body 263A which is in the shape of a modified-cross in a plan view as shown in FIG. 48. Bolt fixing plates 263B are provided in the bottom of the modified-cross-shaped body 263A at the five positions respectively including the intersecting portion of the modified cross. Said bolt fixing plates 263B are fixed to the mat foundation 261 with anchor bolts 262.

[0132] FIG. 49 shows a modified embodiment of the base connection portion of the building unit 20, in which column foots 21F of four columns 21 of four building units of the unit building 1, which are disposed adjacently to each other, are fixed to a base 260 by rigid-connec-

tion. The base 260 in FIG. 49 is different from the base 260 in FIG. 42 in that the base construction 263 has a body 263A which is in the shape of a cross in a plan view as shown in FIG. 50. Bolt fixing plates 263B are provided in the bottom of the cross-shaped body 263A at the five positions respectively including the intersecting portion of the cross. Said bolt fixing plates 263B are fixed to a mat foundation 261 with anchor bolts 262.

[0133] At this time, a guide pin 270 is used for making alignment between the threaded hole 265A of the receiving piece 265 of the column 21F and the mounting hole 264A of the mounting piece 264 of the base 260. As shown in FIG. 51, the guide pin 270 includes a threaded male portion 271, which is screwed into the threaded hole 265A of the receiving piece 265 of the column 21F, a stem 273, which is continuous with the threaded male portion via incompletely threaded portion 272, and a collar guide portion 274, which is covered around the periphery of the stem 273. The guide pin 270 serves to support the collar guide portion 274 between the outer diameter stopper portion 275, which is formed by forging at the front end of the stem 273, and the incompletely threaded portion 272 for preventing the collar guide portion 274 from dropping off. The collar guide 274 is formed to have the maximum diameter being slightly larger than the outer diameters of the threaded male portion 271 and the incompletely threaded portion 272. Also, the front end periphery of the collar guide 274 and the front end periphery of the stem 273 form a tapered and continuous portion 276, so that the guide pin 270 is easily inserted into the mounting hole 264A. The collar guide 274 has a lubricant oil groove 274A in the inside circumference thereof. In addition to this, the collar guide 274 is provided with a clearance between the inside circumference thereof and the outside circumference of the stem 273. By virtue of these features, the collar guide 274 may be rotatable about the stem 273 smoothly. In the top end of the stem 273, there provided a tool engaging hole 273A, which has a shape of a hexagon or the like. The threaded male portion 271 may be attached to or detached from the threaded hole 265A by rotating a tool which engages the tool engaging hole 273A.

[0134] Next, the method of connecting the column foot 21F to the base 260 will be described hereunder.

(1) Just before mounting a building unit 20 onto a base 260, as shown in FIG. 52, a threaded male portion 271 of a guide pin 270 is screwed into a threaded hole 65A of a receiving piece 65 provided in a column foot 21A of the column 21 with the aid of a tool engaging hole 273A of a guide pin 270.

(2) The collar guide portion 274 of the guide pin 270, which has been screwed into the threaded hole 265A of the column foot 21F, is inserted into a mounting hole 264A of a mounting piece 264 of the base 260 as shown in FIG. 52. Thus, the threaded hole 265A and the mounting hole 264A are com-

pleted to be aligned.

(3) The guide pin 270, which has been screwed to the threaded hole 265A of the column foot 21F, is removed from the threaded hole 265A and the mounting hole 264A with the aid of the tool engaging hole 273A of a guide pin 270. Then, a high strength bolt 266, which is inserted through the mounting hole 264A, is screwed into the threaded hole 265A of the column foot 21F and fixed temporarily.

(4) High strength bolts 266 are inserted through all the mounting holes 264A of the mounting pieces 264 of the base 260, and screwed into the threaded holes 265A of the column 21F for the full fastening.

[0135] The guide pin 270A shown in FIG. 52 is a modified embodiment of the guide pin 270 shown in FIG. 51. Instead of the outer diameter stopper portion 275 of the guide pin 270, an annular groove 275A is provided in the top portion of the periphery of the stem 273, which periphery extends axially and continuously over the whole length of the stem. This annular groove 275A is engaged with a stopper ring 275B. In the case of a guide pin 270A, a collar guide 274 is supported between the stop ring 275B provided on the stem 273 and the incomplete threaded portion 272 for preventing the drop off.

[0136] According to the aforementioned base connection structure of the building unit 20, the mounting hole 264A of the mounting piece 264 provided in the base 260 is aligned with the threaded hole 265A of the receiving piece 265 provided in the column foot 21F, then said receiving piece 265 and said mounting piece 264 are connected together with the high strength bolts 266. Thus, the column foot 21F may be made by rigid-connection to the base 260 easily.

[0137] In addition, with the aid of the guide pin 270, the shift between the mounting hole 264A of the mounting piece 264 provided in the base 260 and the threaded hole 265A of the receiving piece 265 provided in the column foot 21F may be corrected, so that the threaded hole 265A of the receiving piece 265 and the mounting hole 264A of the mounting piece 264 may be aligned easily. As a result, the high strength bolt 266 comes to be inserted through the mounting hole 264A and screwed into the threaded hole 265A easily.

(Modified example 4)

[0138] FIG. 54 shows a base connection structure of the modified embodiment 4 for the building unit 20, which constitutes the piloties, garage or the like. The framework construction of the building unit 20 concerned is not provided with a floor beam 22 in at least one of the side planes as is similar to the building unit 20 of the modified embodiment 2. A steel base construction 280 is secured to an implant plate 261A in a mat foundation 261 of a base 260. The base construction 280 includes a body 281 which is fixed to the mat foun-

ation 261 with anchor bolts 262, and a steel mounting piece 282 is fixed by welding to an upper portion of the body 281, and the mounting piece 282 is provided a plurality (four for example) of mounting holes 282A. On the other hand, receiving pieces 265 are provided in a plurality (four for example) of positions inside a hollow portion in a lower end of a column 21F of the column 21 of the building unit 20 as is similar to the modified embodiment 3. The receiving pieces 265 are fixed by welding to the column foot 21F and provided respective threaded holes 265A. Accordingly, when installing a building unit 20 onto the base 260, the mounting hole 282A of the mounting piece 282 of the base 260 is aligned with the threaded hole 265A of the receiving piece 265 of the column 21F by using the guide pin 270 of the modified embodiment 3 and the like, and the high strength bolt 266 inserted through the mounting hole 282A of the mounting piece 282 is screwed into the threaded hole 265A of the receiving piece 265. Thus, the column 21F is made by rigid-connection to the mounting piece 282 of the base 260.

[0139] Note that the base construction 280 is not limited to a type in which the body 281 is secured with the anchor bolt 262 which is fixed to the implant plate 261A in the mat foundation 261 of the base 260. Instead, it is possible to provide locking protrusions, such as the locking protrusions 241A provided on the support 241 in the modified embodiment 2, on the implanted portion of the body 281, and the body 281 with the locking protrusions may then be implanted into the mat foundation 261.

[0140] As heretofore explained, embodiments of the present invention have been described in detail with reference to the drawings. However, the specific configurations of the present invention are not limited to the described embodiments but those having a modification of the design within the range of the present invention are also included in the present invention. By way of example, in the present invention, a floor beam of a building unit may be rigid-connected to a column foot. A building unit is not limited to a framework construction, but may be a wall construction. The frameworks for floor as well as ceiling are not limited to a quadrangle.

[0141] Moreover, with regard to a unit building 1 to which the present invention is applied, the construction method I (rigid-connection between base and column) increases the horizontal rigidity of flat building units, the construction method II (connection structure between upper and lower beams) improves the horizontal rigidity of the adjacent building units as well as the vertical rigidity of floor beams of an upper floor building unit, the construction method III (connection structure between adjacent columns) improves the horizontal rigidity of adjacent building units and the construction method IV (reinforcing structure with diagonal member) improves the horizontal rigidity of a building unit. For the sake of the selection of a construction method from the construction method I to IV, the priority is given in FIG. 67 on the basis of the cost effectiveness and the planning affection with

respect to the type of unit building 1, wherein a first type is a single row type including a plurality of building units in a single row either in the beam direction or in the gable direction, and a second type is a plural row type including two or more rows of building units either in the beam direction or in the gable direction.

[0142] With regard to a unit building 1 of single row type, since the construction method IV exerts little influence of the wall planning on the outdoor side, the construction method IV is given the priority. In case of the rigidity being insufficient, the construction method I is applied additionally.

[0143] With regard to a unit building 1 of single row type, since the construction method IV exerts much influence of the wall planning on the indoor side, the construction method II is given the priority. In case of the rigidity being insufficient, the construction method I, and further the construction method IV are applied additionally.

[0144] With regard to a unit building 1 of plural row type, since the construction method III exerts no influence of the wall planning on the outdoor side, and also it is inexpensive, the construction method III is given the priority. In case of the rigidity being insufficient, the construction method IV, and further the construction method I are applied additionally.

[0145] With regard to a unit building 1 of plural row type, all the construction method I to IV may be applied to the indoor side, and the construction methods II, III, I and IV are given the priority in this order.

[0146] Although the invention has been illustrated and described with respect to several exemplary embodiments thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions and additions may be made to the present invention without departing from the spirit and scope thereof. Therefore, the present invention should not be understood as limited to the specific embodiment set out above, but should be understood to include all possible embodiments which can be embodied within a scope encompassed and equivalents thereof with respect to the features set out in the appended claims.

Claims

1. A unit building comprising:

a column foot;
a base;
a diagonal member; and
at least one building unit fixed to the base,

wherein

the building unit has a Rahmen construction comprising a column and a beam rigid-connected to each other,

the column foot of the unit building is rigid-

connected to the base, and

the diagonal member is provided between the column foot of the building unit and a middle portion of a ceiling beam or between a column capital and a middle portion of a floor beam.

2. The unit building according to claim 1, comprising a plurality of the building units connected to each other, each of the building units having a Rahmen construction wherein a column and a beam of said each of the building units are rigid-connected to each other,

wherein a floor beam of the unit building in an upper floor and a ceiling beam of the unit building in a lower floor are stacked with respect to each other, and

wherein the respective both ends of the floor beam and the ceiling beam are connected to each other so as to prevent a substantial shift therebetween.

3. The unit building according to claim 1 or 2, wherein at least two of the plurality of the building units are adjacent to each other,

each of the at least two building units has pipe columns disposed adjacently across a gap made between the at least two adjacent building units,

the adjacent pipe columns are connected to each other by a bolt, wherein bolt holes are provided coaxially in respective opposed side walls of the adjacent pipe columns,

an operation hole for bolt mounting is provided in a side wall of one of the adjacent pipe columns, the side wall being in a back side of the side wall provided with the bolt holes,

an operation hole for nut mounting is provided in a side wall of the other of the adjacent pipe columns, the side wall being in the back side of the side wall provided with the bolt holes,

a holed spacer is provided in a gap formed between the opposed side walls of the respective adjacent pipe columns, the holed spacer being disposed coaxially into the bolt holes provided in the side walls,

a bolt, being inserted from the operation hole for bolt mounting provided in one of the pipe columns, is inserted through the bolt holes in both of the adjacent pipe columns, and

a nut, being inserted from the operation hole for nut mounting provided in the other of the adjacent pipe column, is screwed on the bolt.

4. A unit building comprising:

a base; and

a plurality of building units fixed to the base, each building unit of the plurality of building units comprising columns, floor beams, and

ceiling beams connected to each other, where-
in

a column foot of the building unit is rigid-con-
nected to the base,

respective predetermined column-eliminated 5
corner portions of the plurality of the adjacent
building units are disposed adjacently to each
other at a column-eliminated connection por-
tion,

the ceiling beams of the adjacent building units 10
form a joint ceiling beam, the ceiling beams be-
ing disposed in a plane which includes the col-
umn-eliminated connection portions of the ad-
jacent building units and intersecting at the col-
umn-eliminated corner portion, and 15

the joint ceiling beams which are opposed to
each other are connected to each other at the
column-eliminated connection portion of the
adjacent building units.

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FIG.1

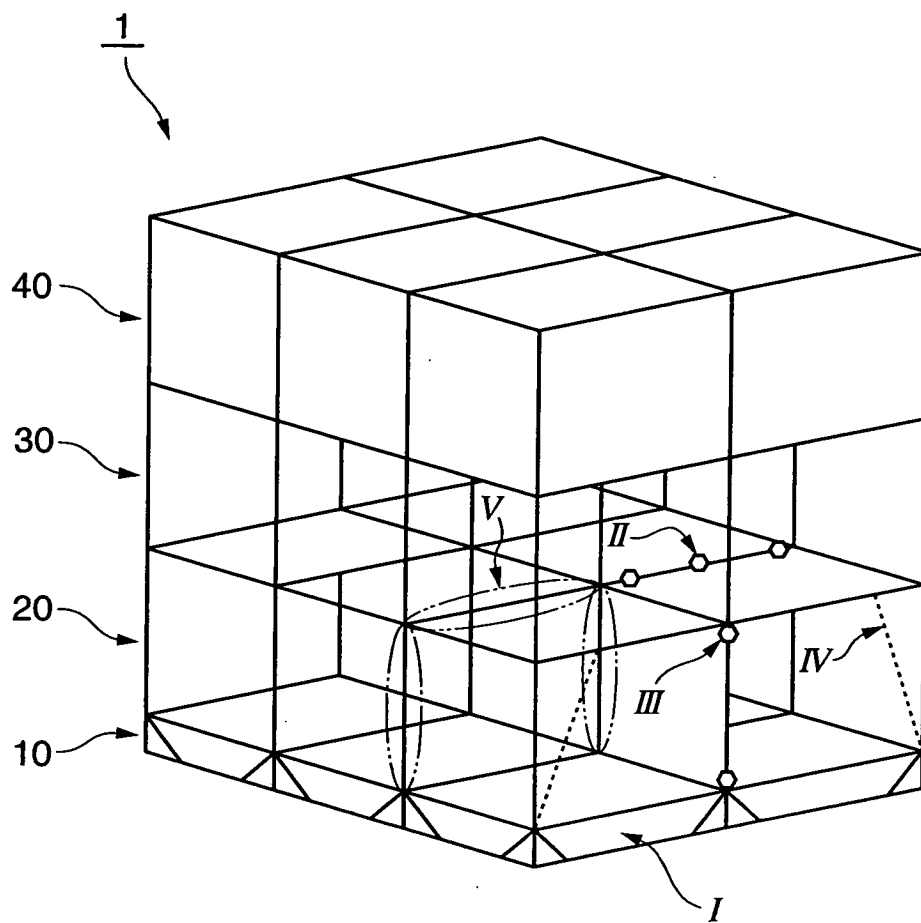


FIG.2

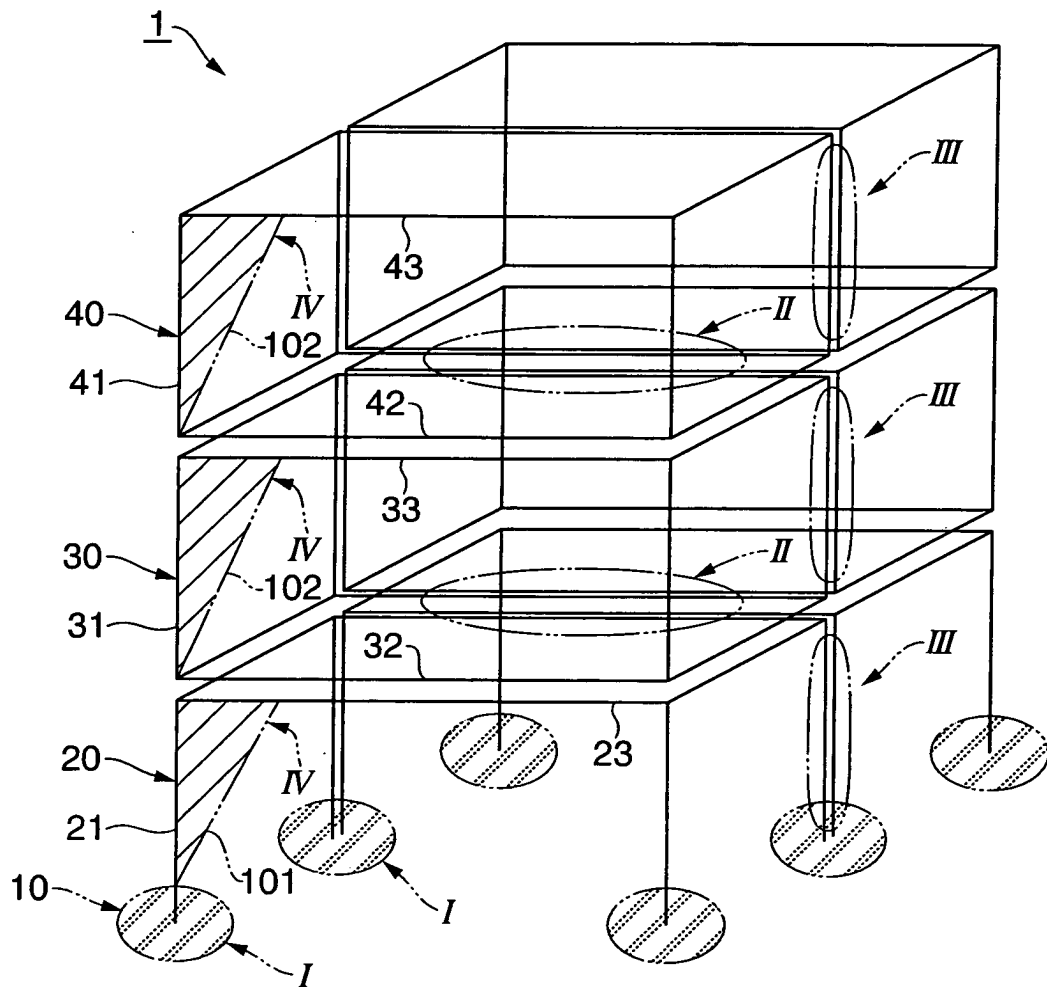


FIG.3

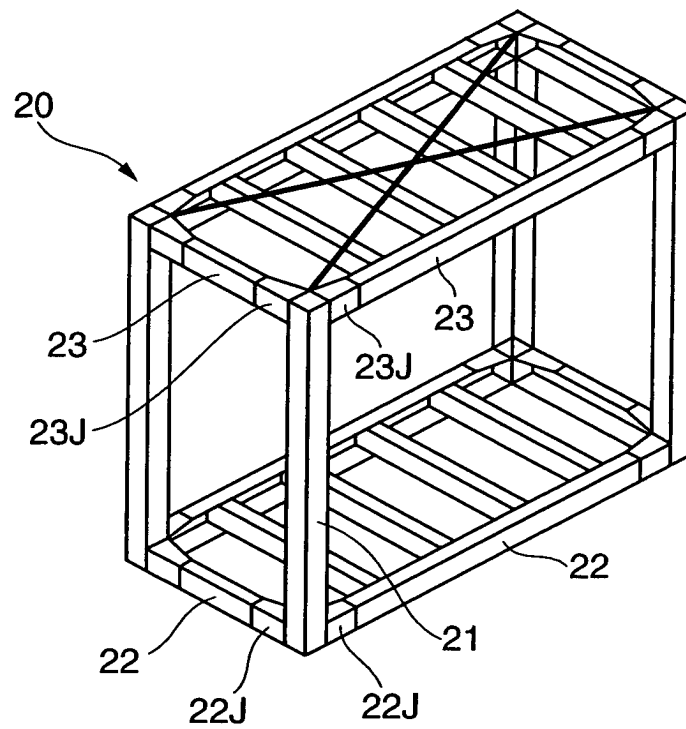


FIG.4

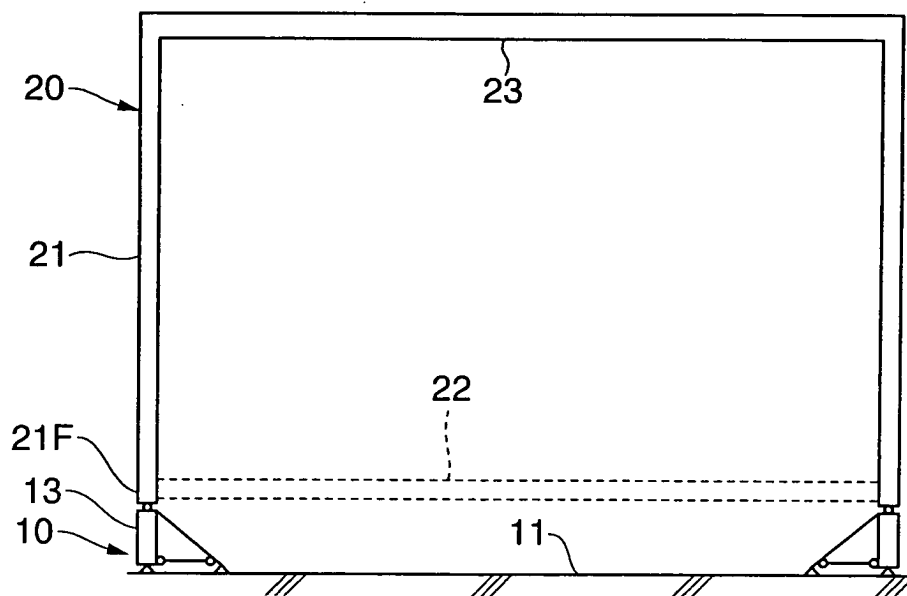


FIG.5

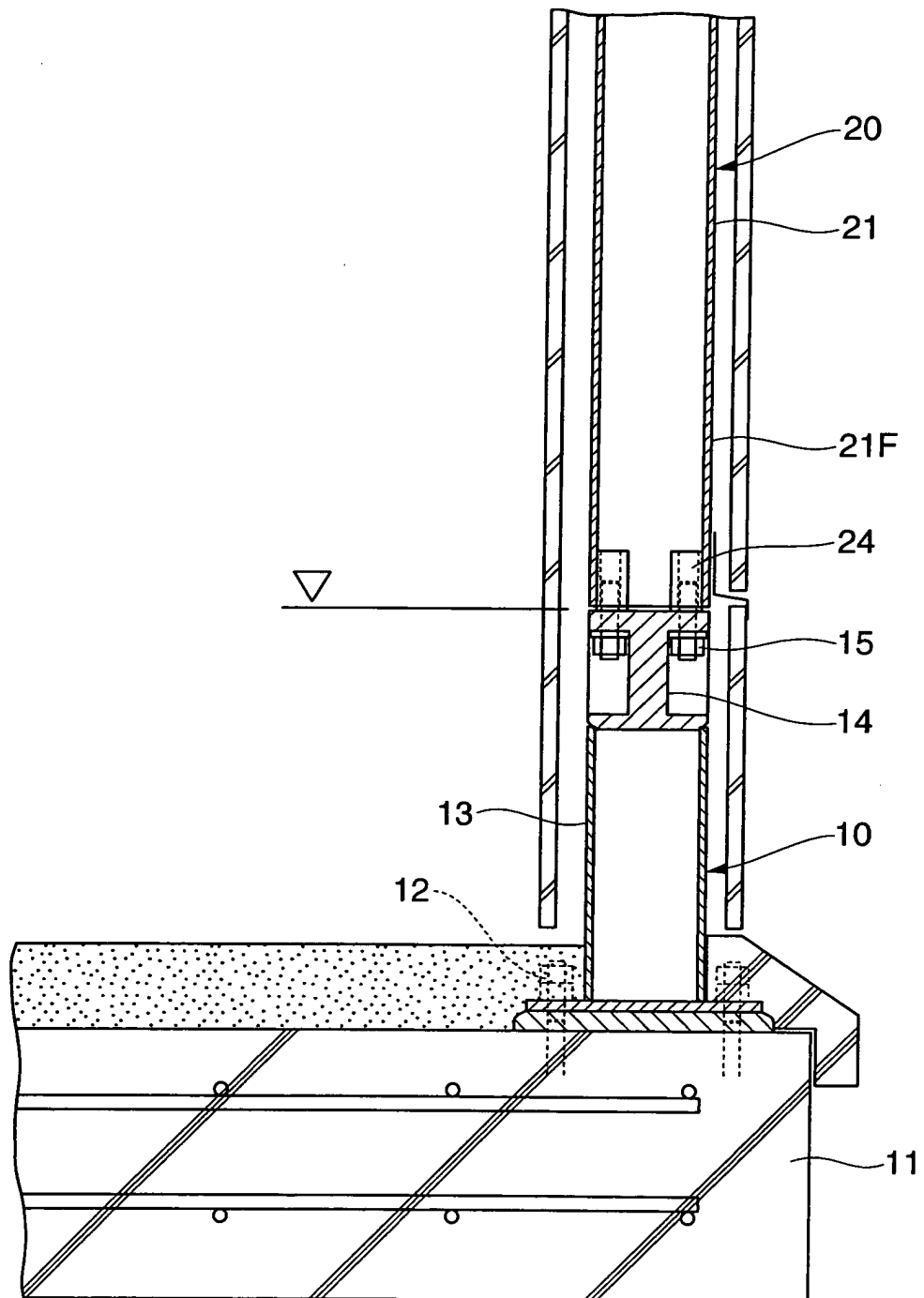


FIG.6

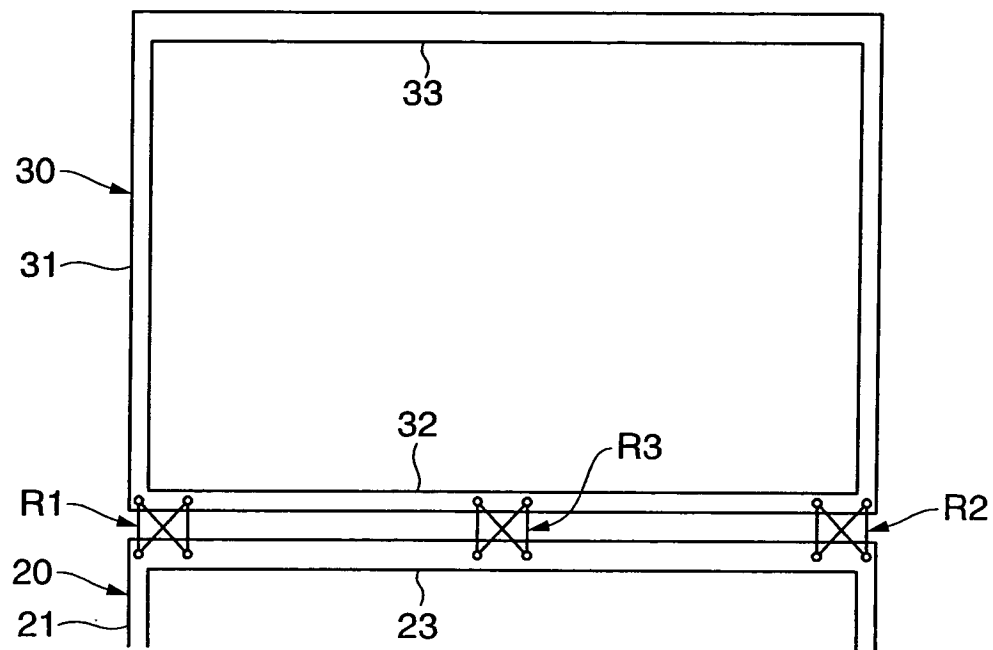


FIG.7A

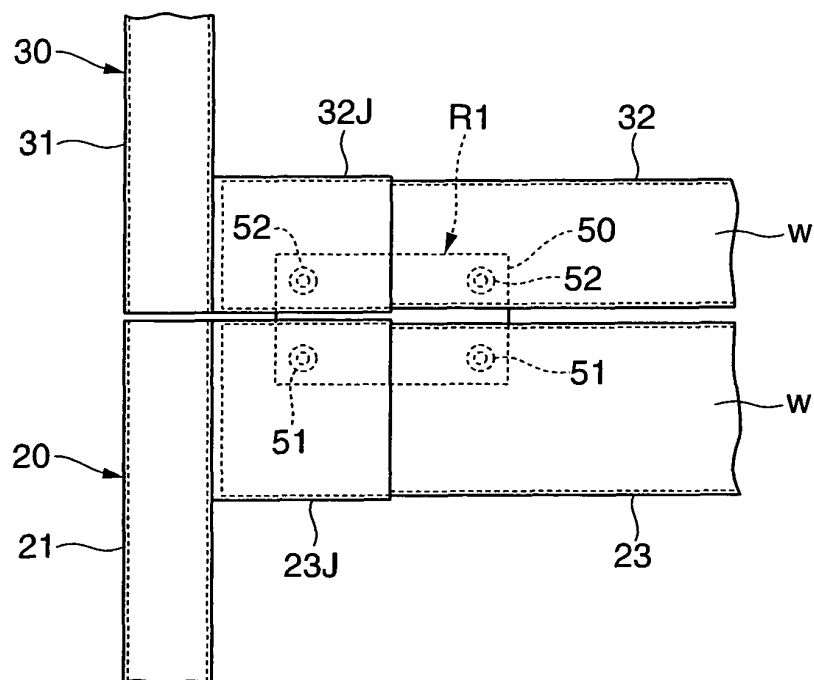


FIG.7B

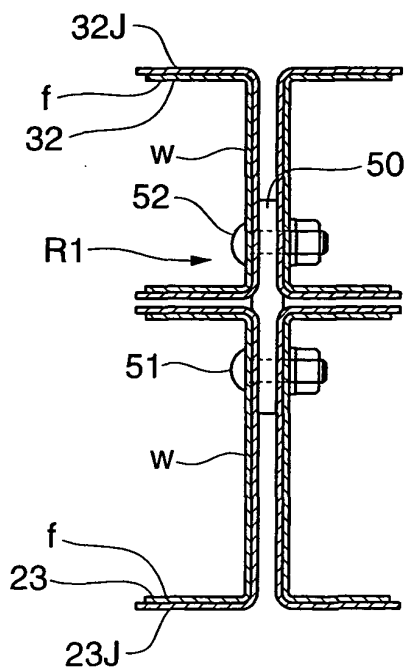


FIG.8A

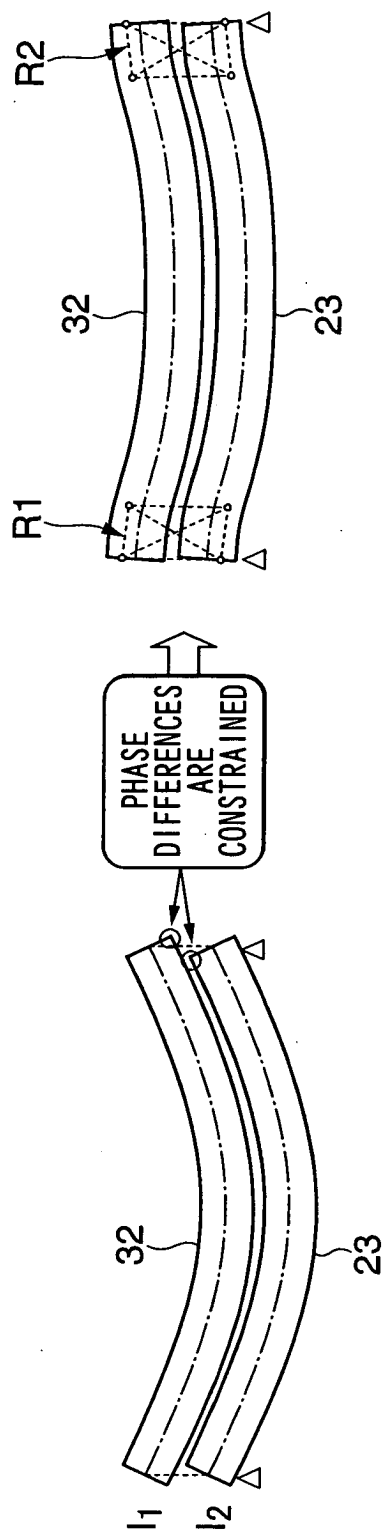


FIG.8B

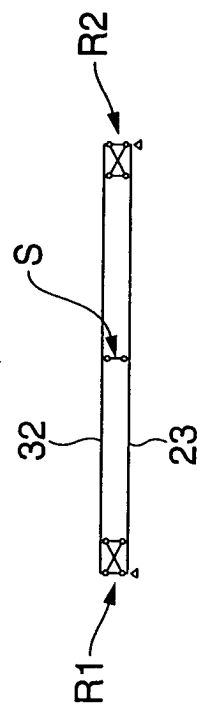


FIG.8C

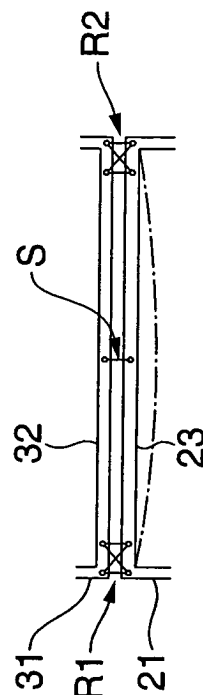


FIG.9A

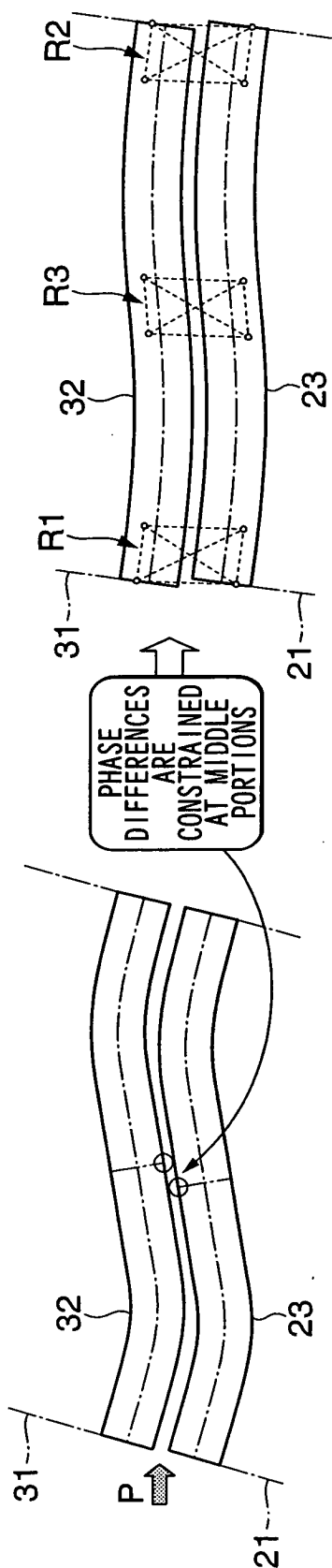


FIG.9B

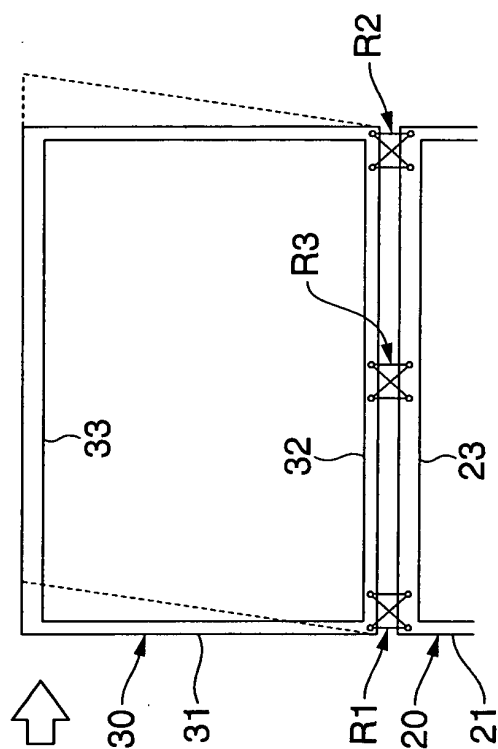


FIG.10

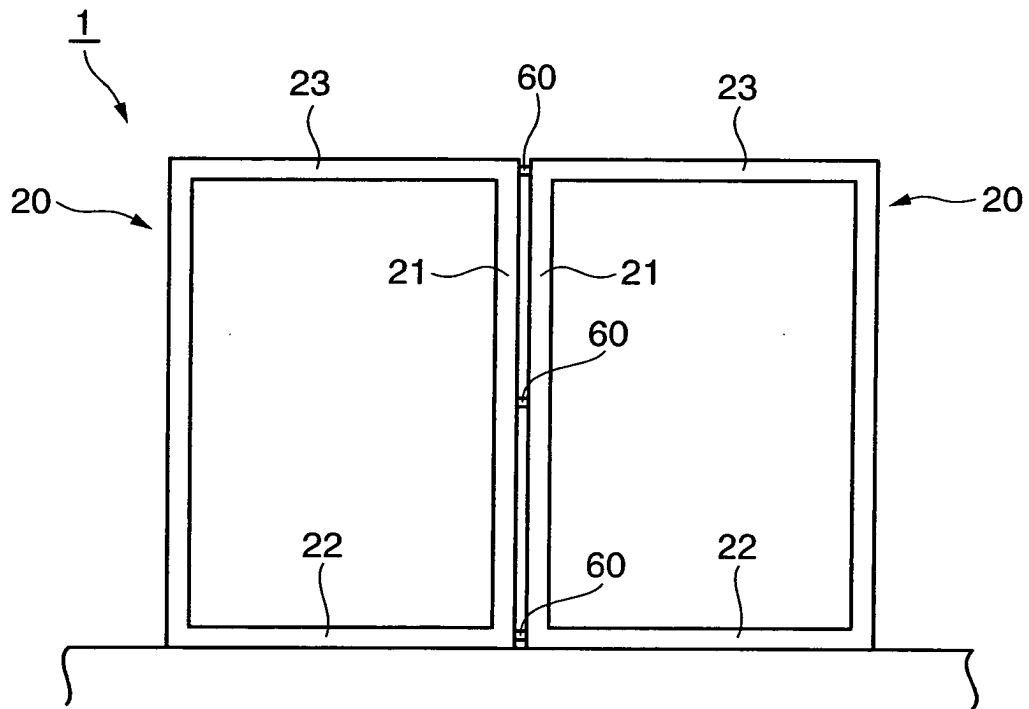


FIG.11

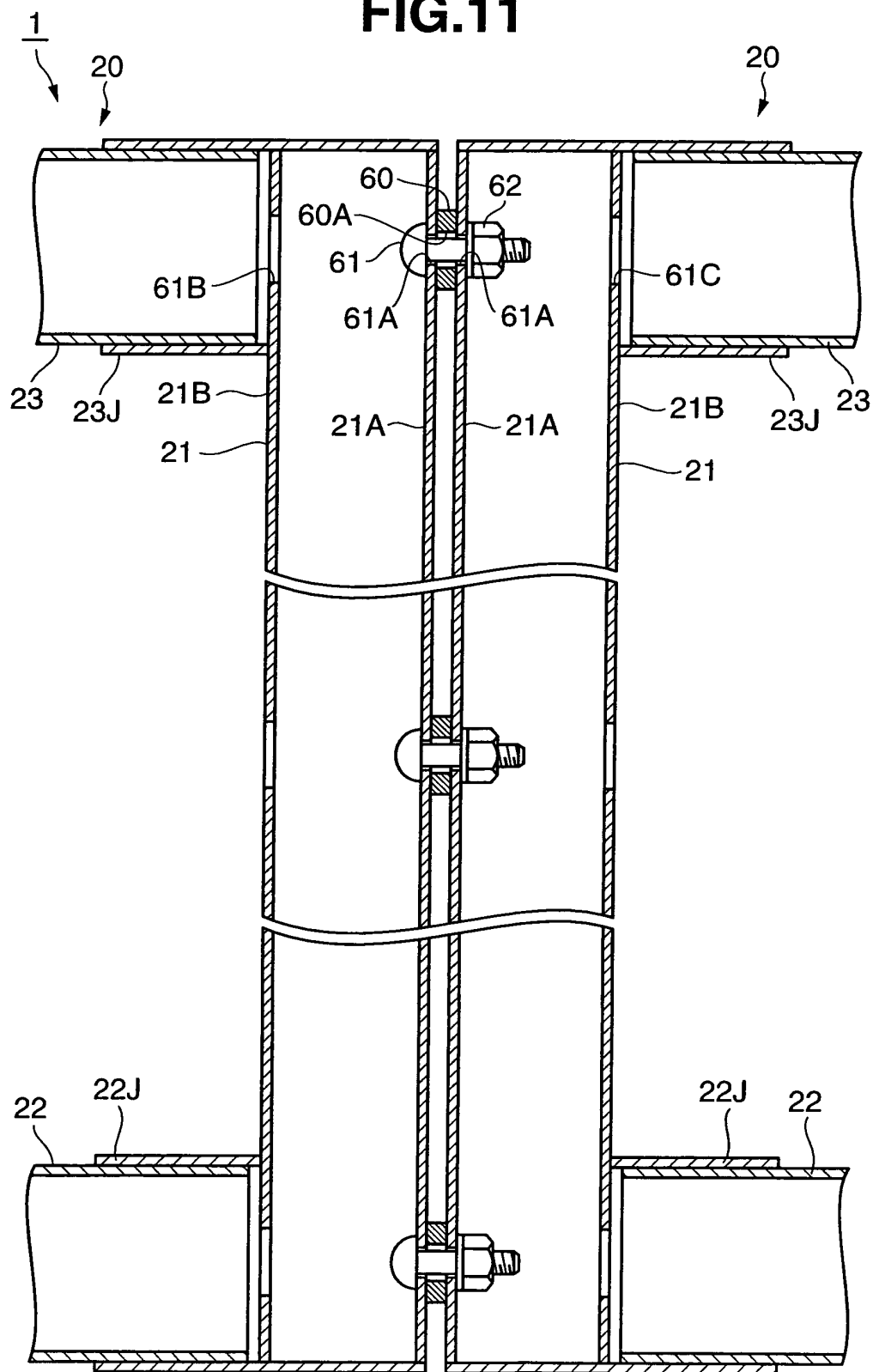


FIG.12A

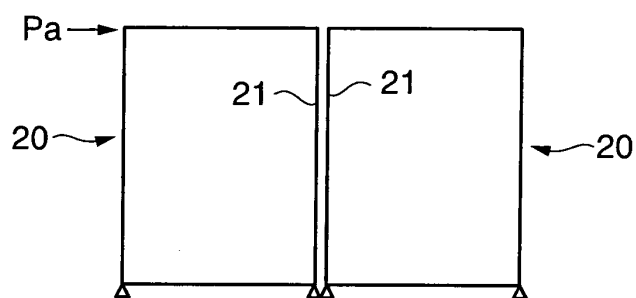


FIG.12B

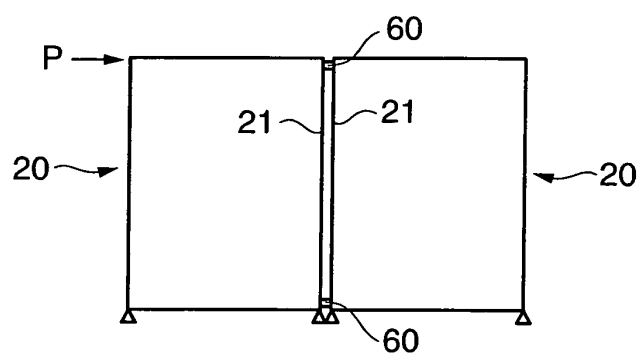


FIG.12C

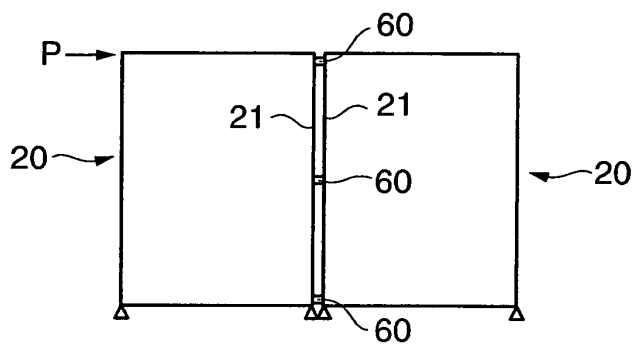


FIG.12D

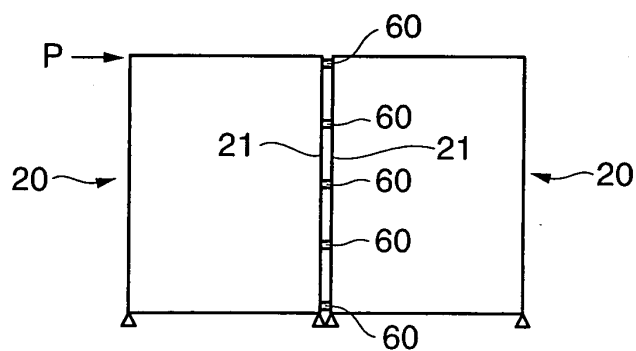


FIG.13A

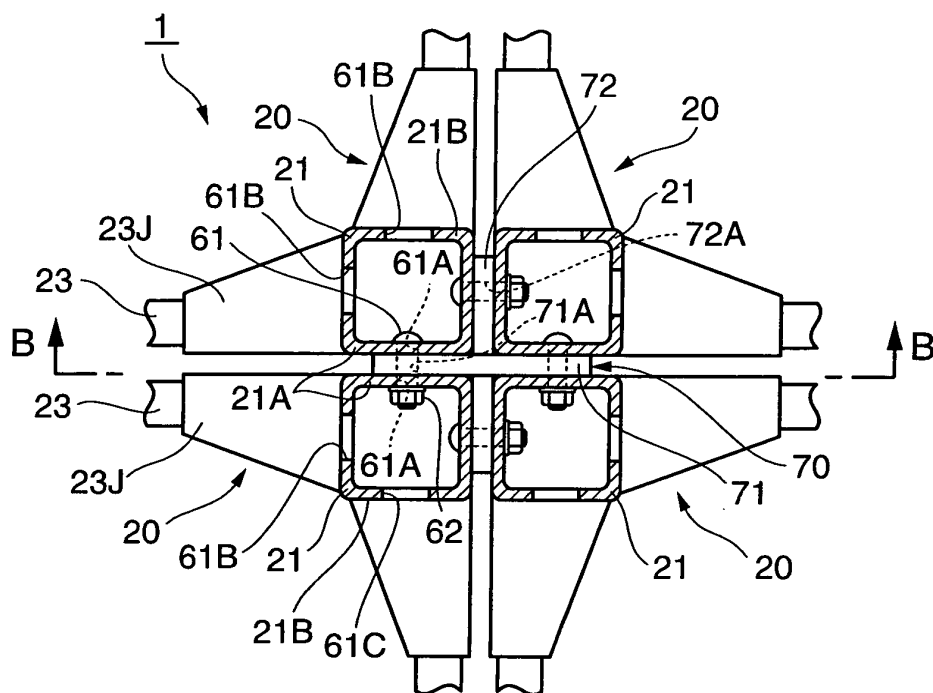


FIG.13B

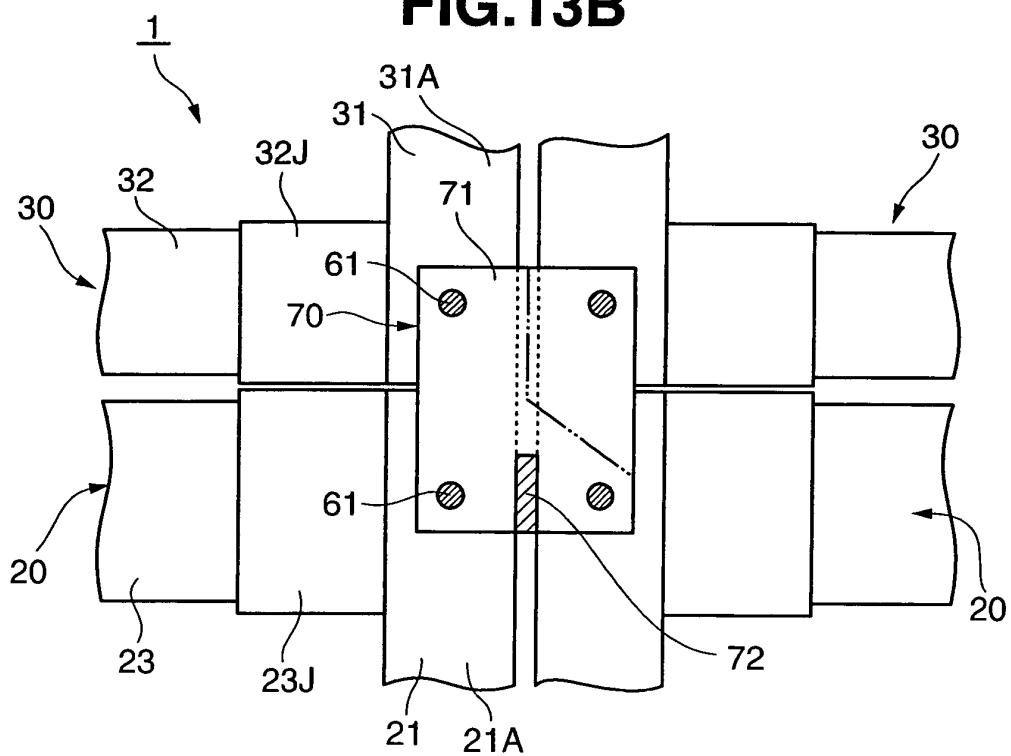


FIG.14

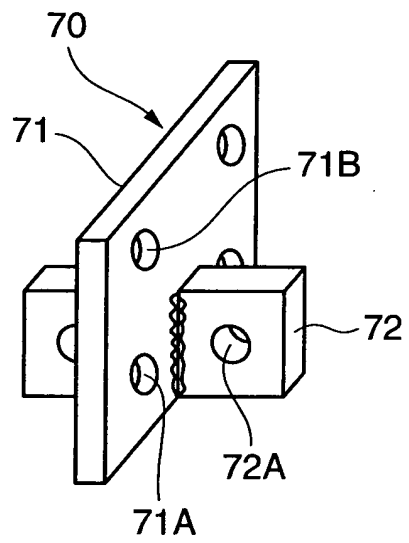


FIG.15A

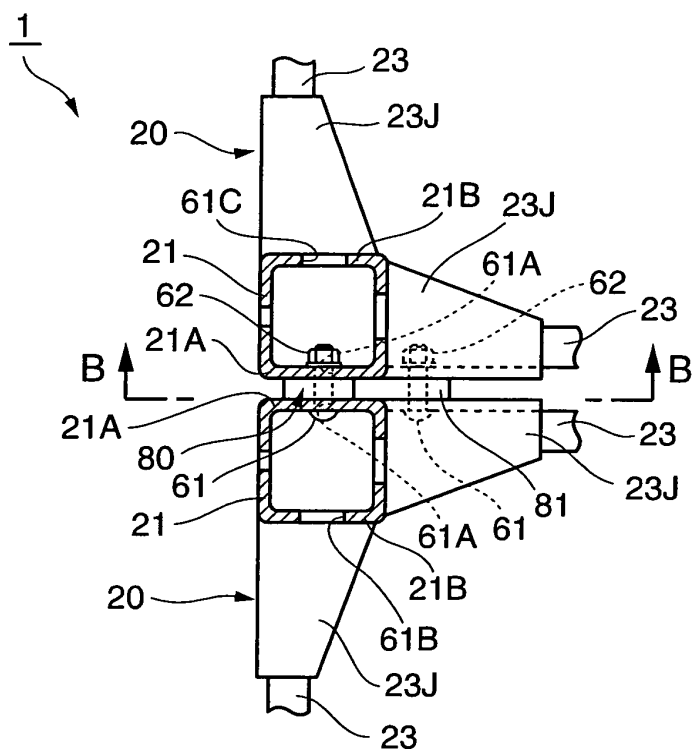


FIG.15B

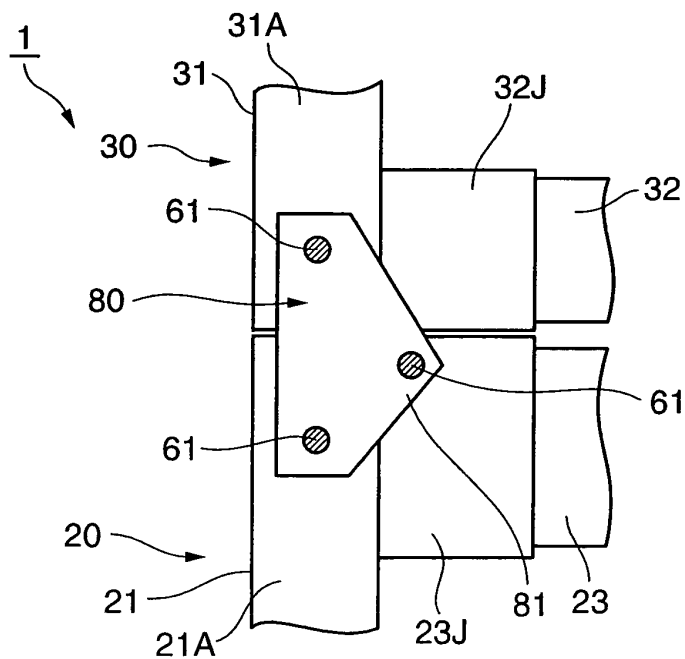


FIG. 16A

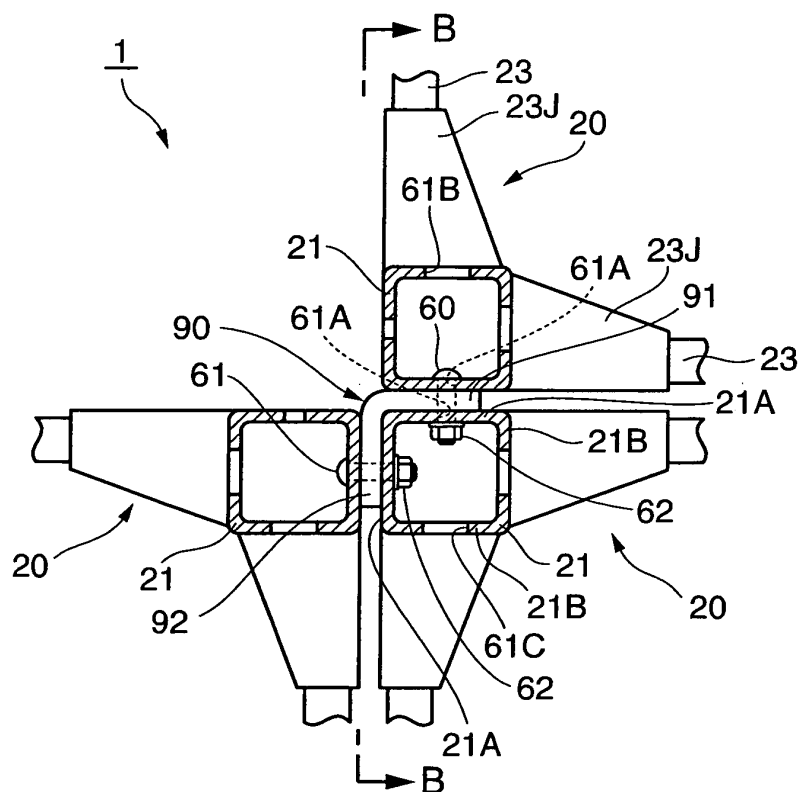


FIG. 16B

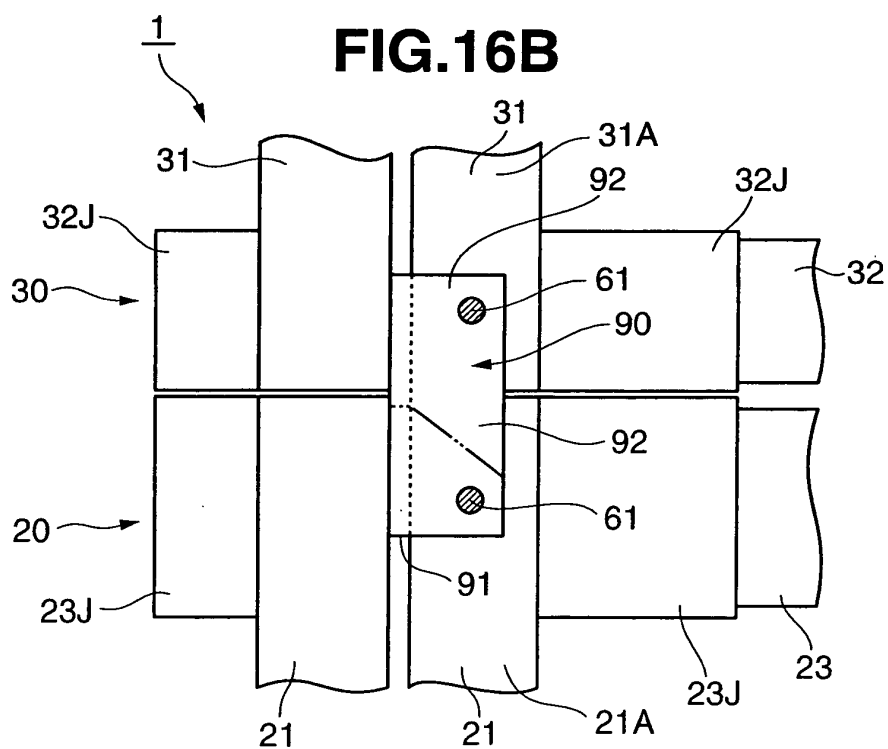


FIG.17A

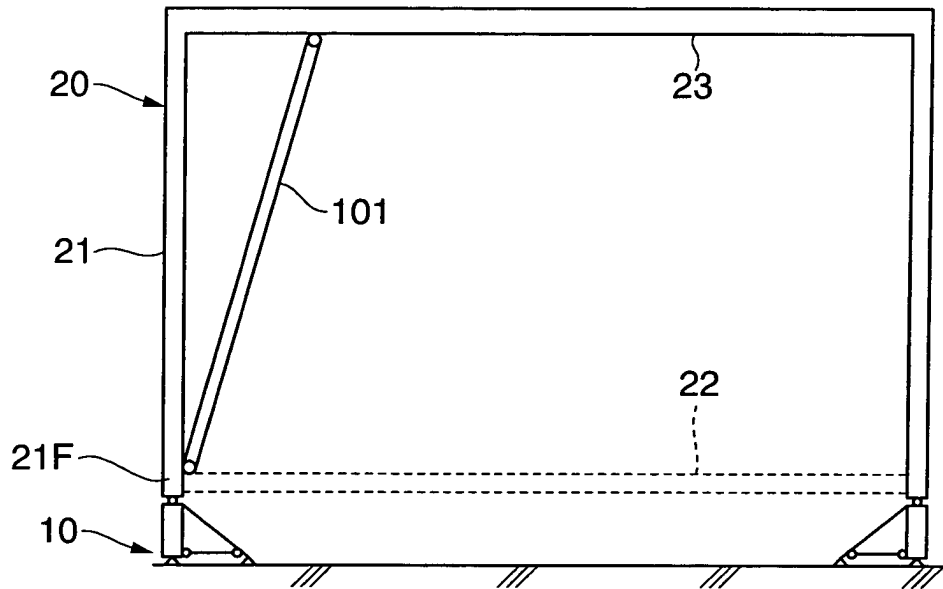


FIG.17B

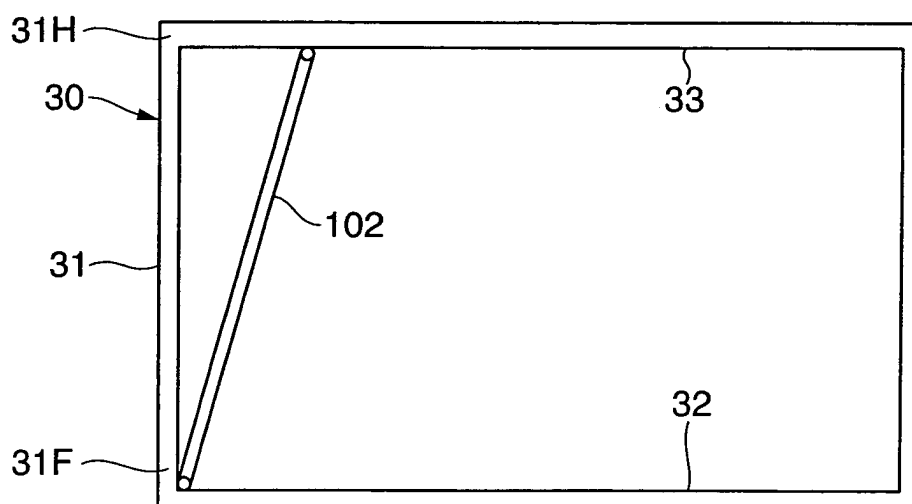


FIG.18

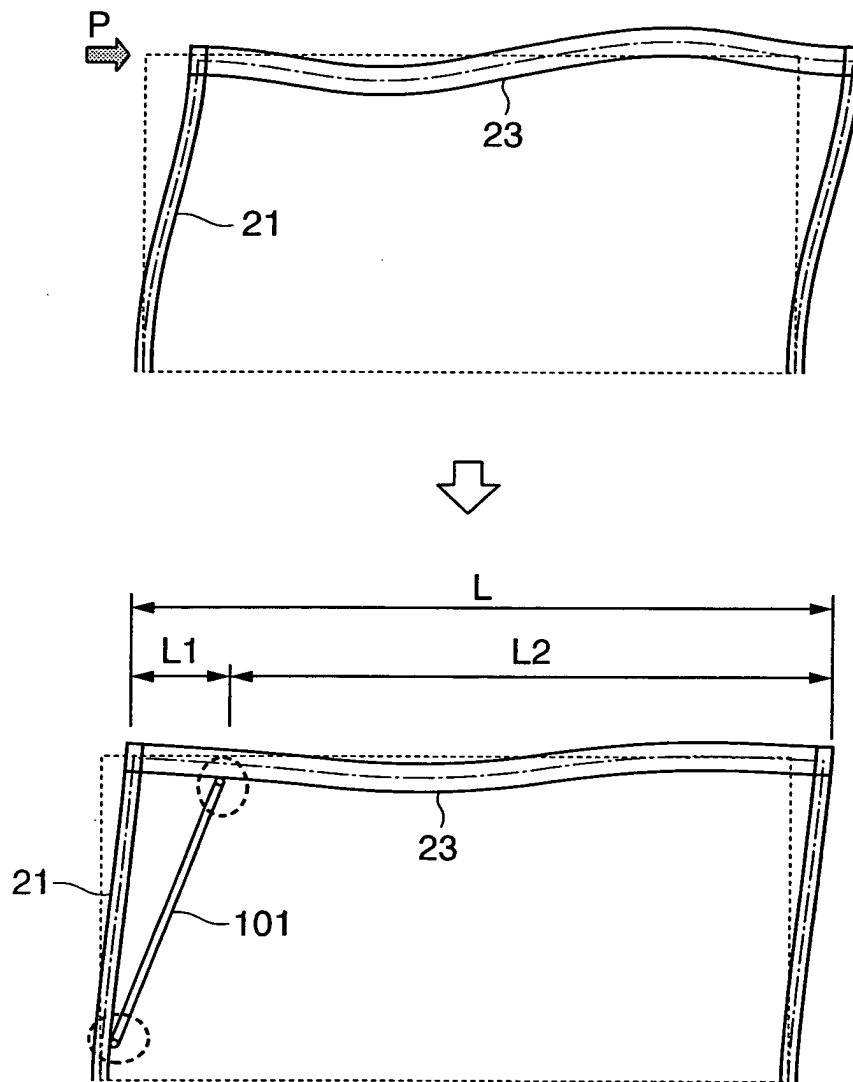


FIG.19

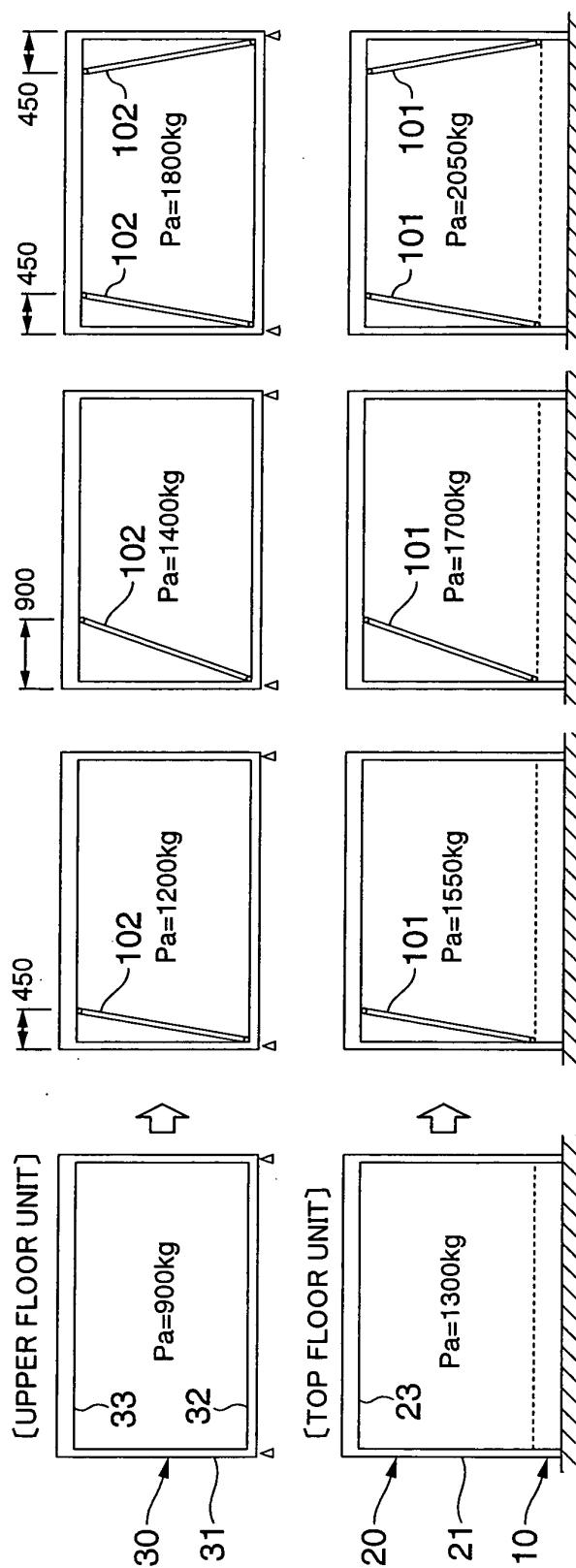


FIG.20

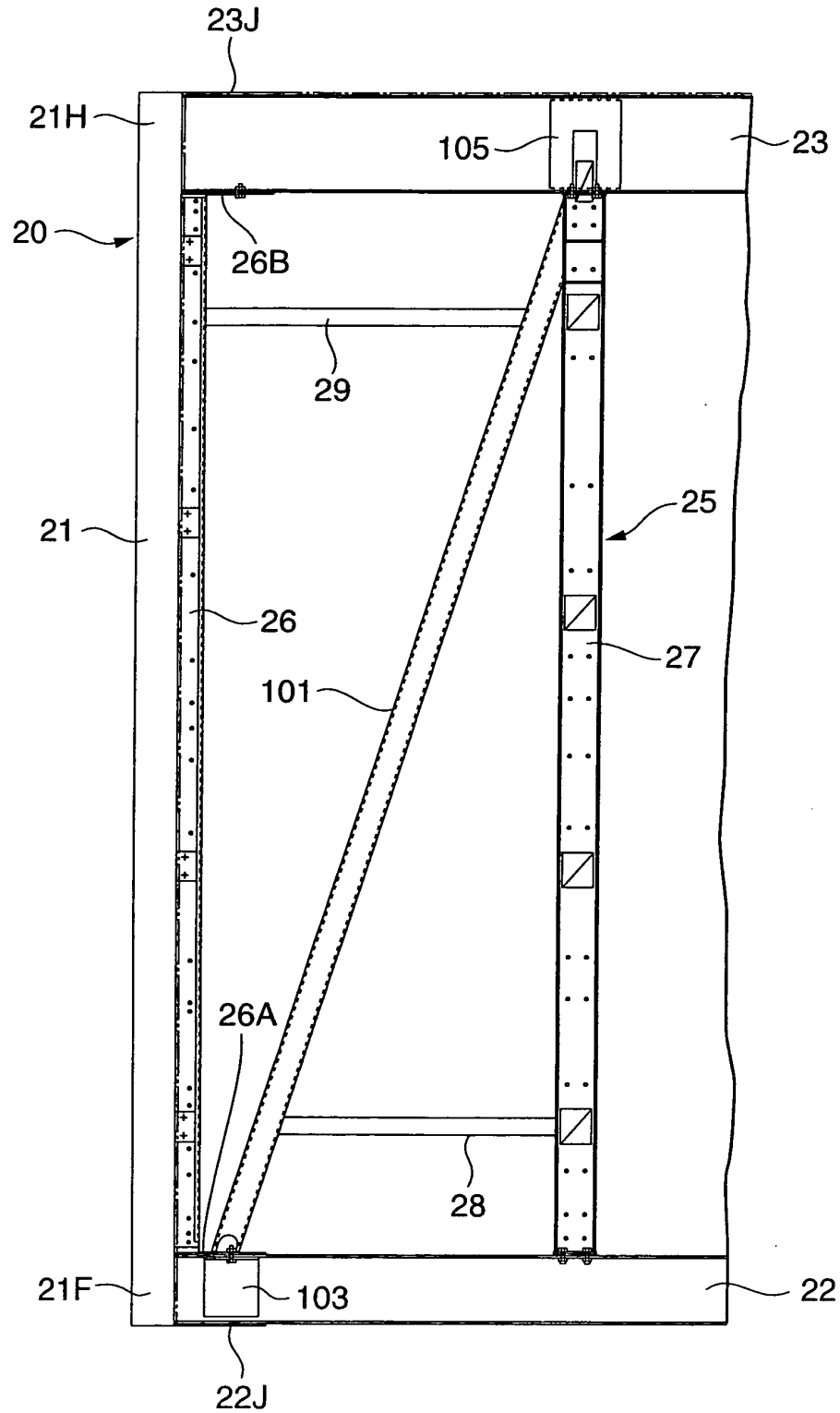


FIG.21A

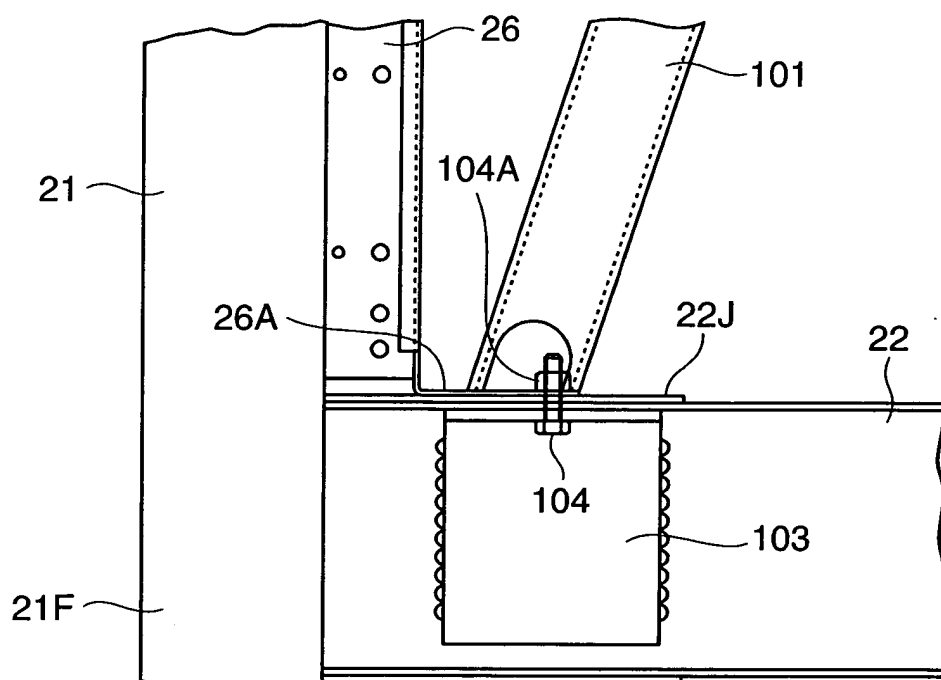


FIG.21B

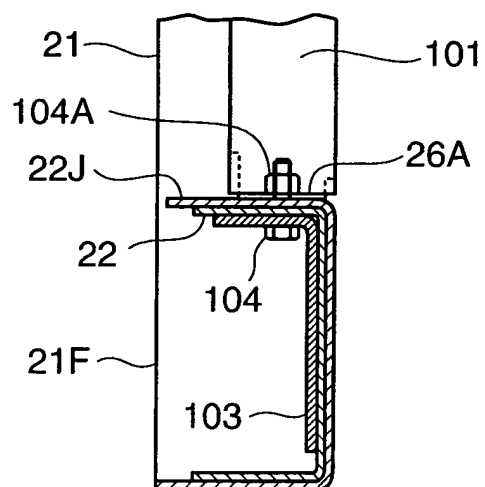


FIG.22

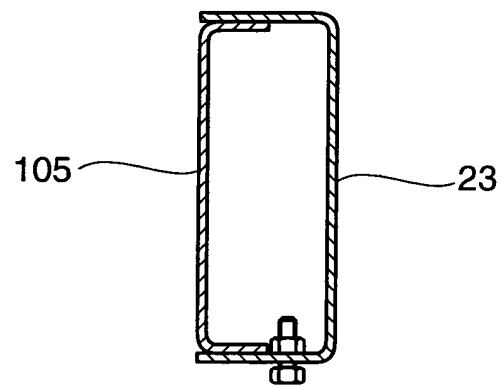


FIG.23A

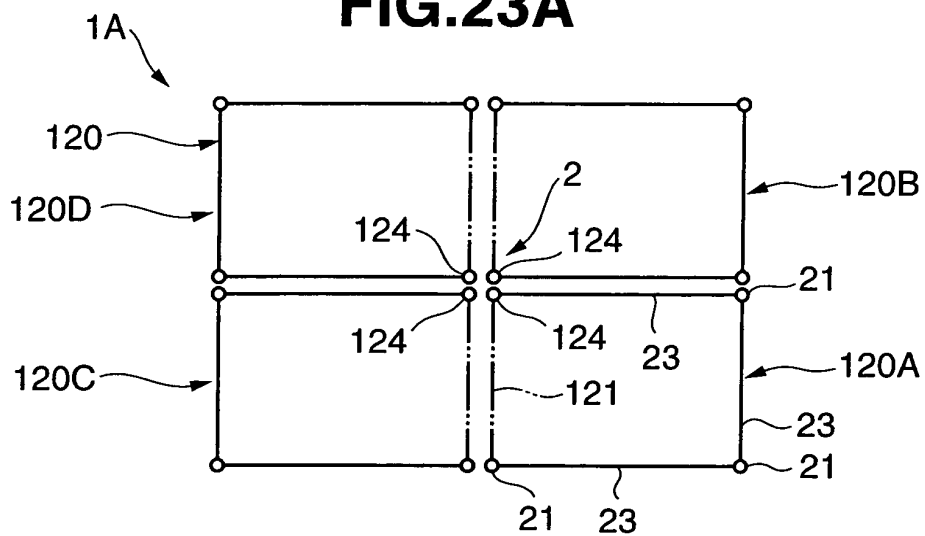


FIG.23B

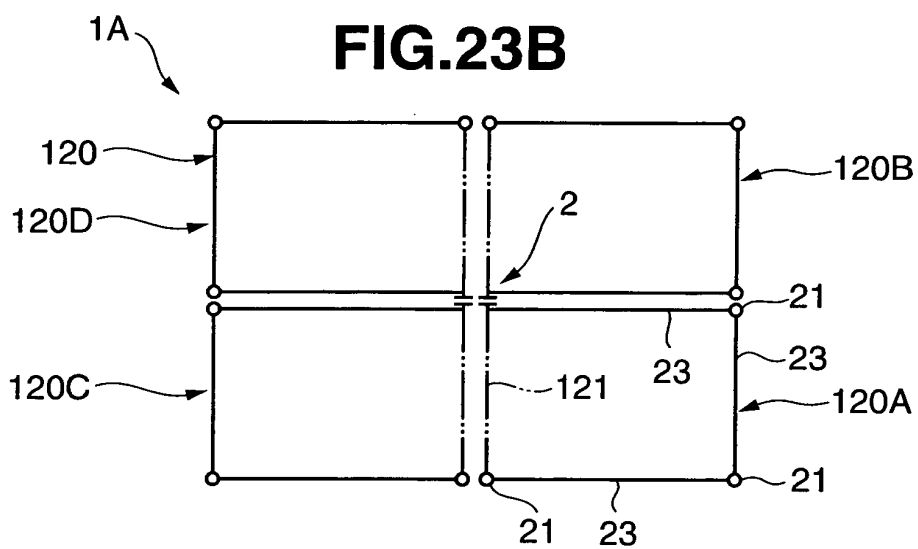


FIG.23C

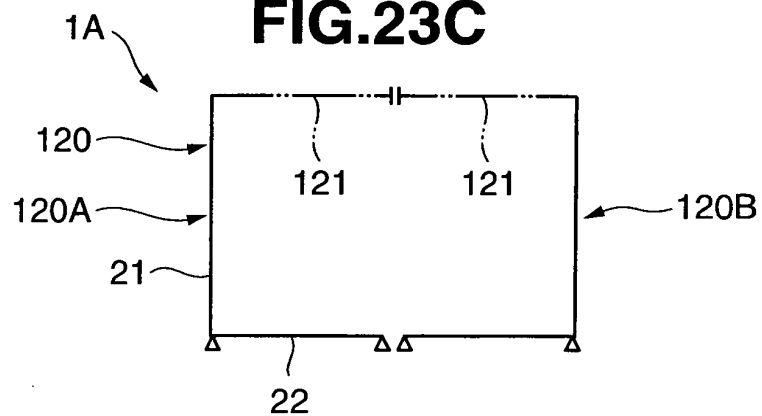


FIG.24

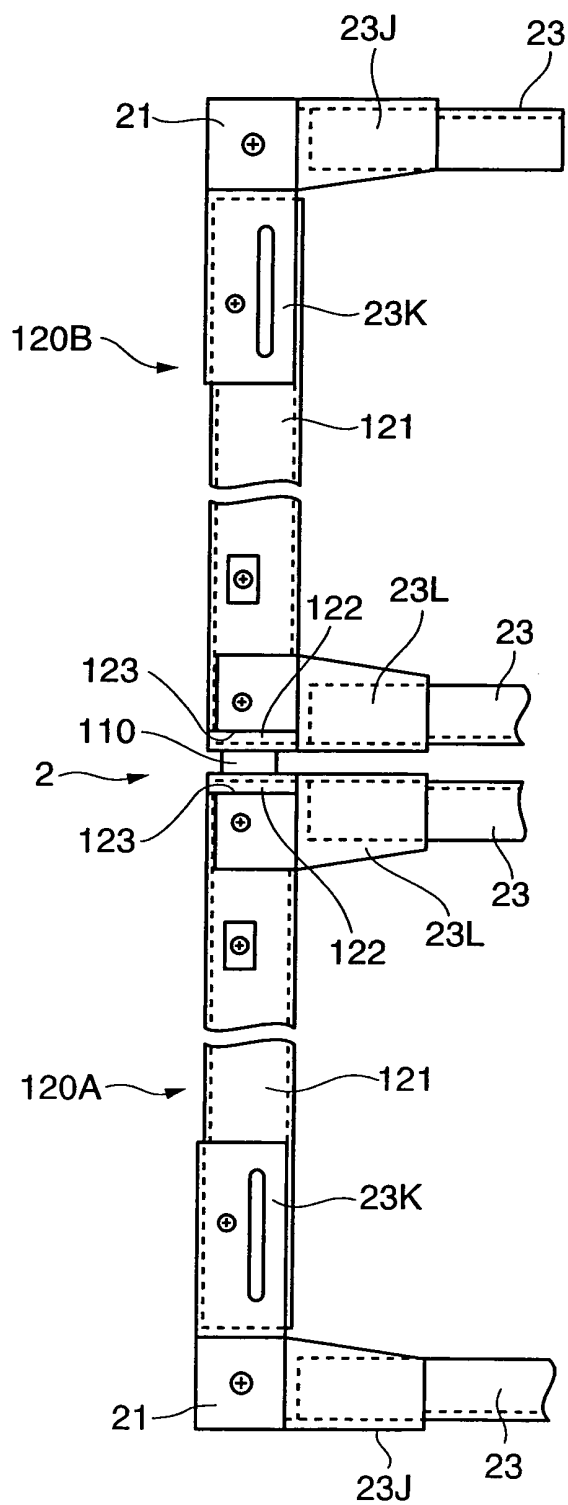


FIG.25A

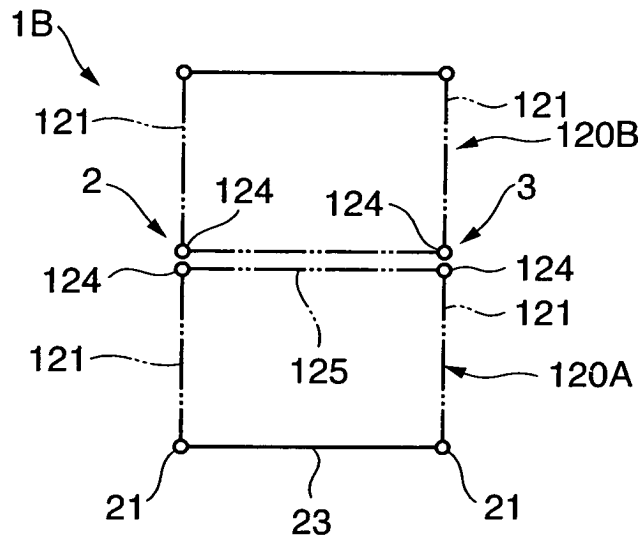


FIG.25B

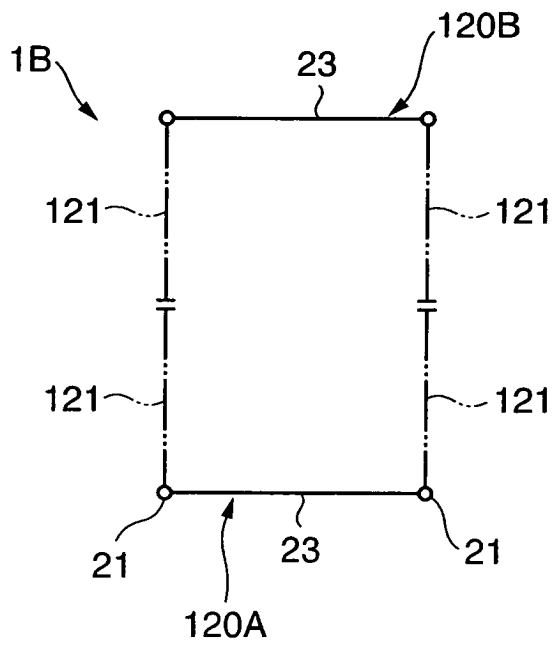


FIG.26A

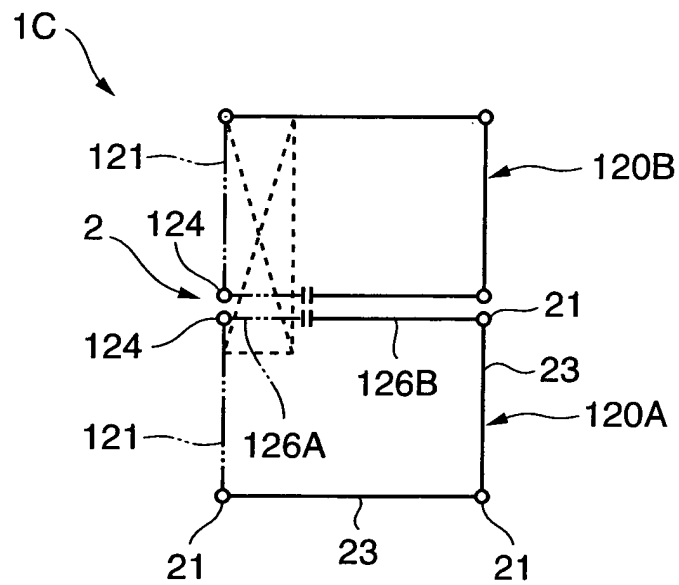


FIG.26B

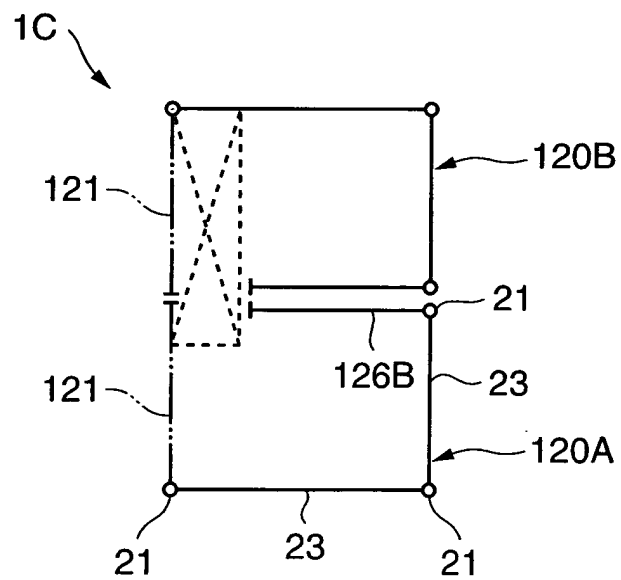


FIG. 27

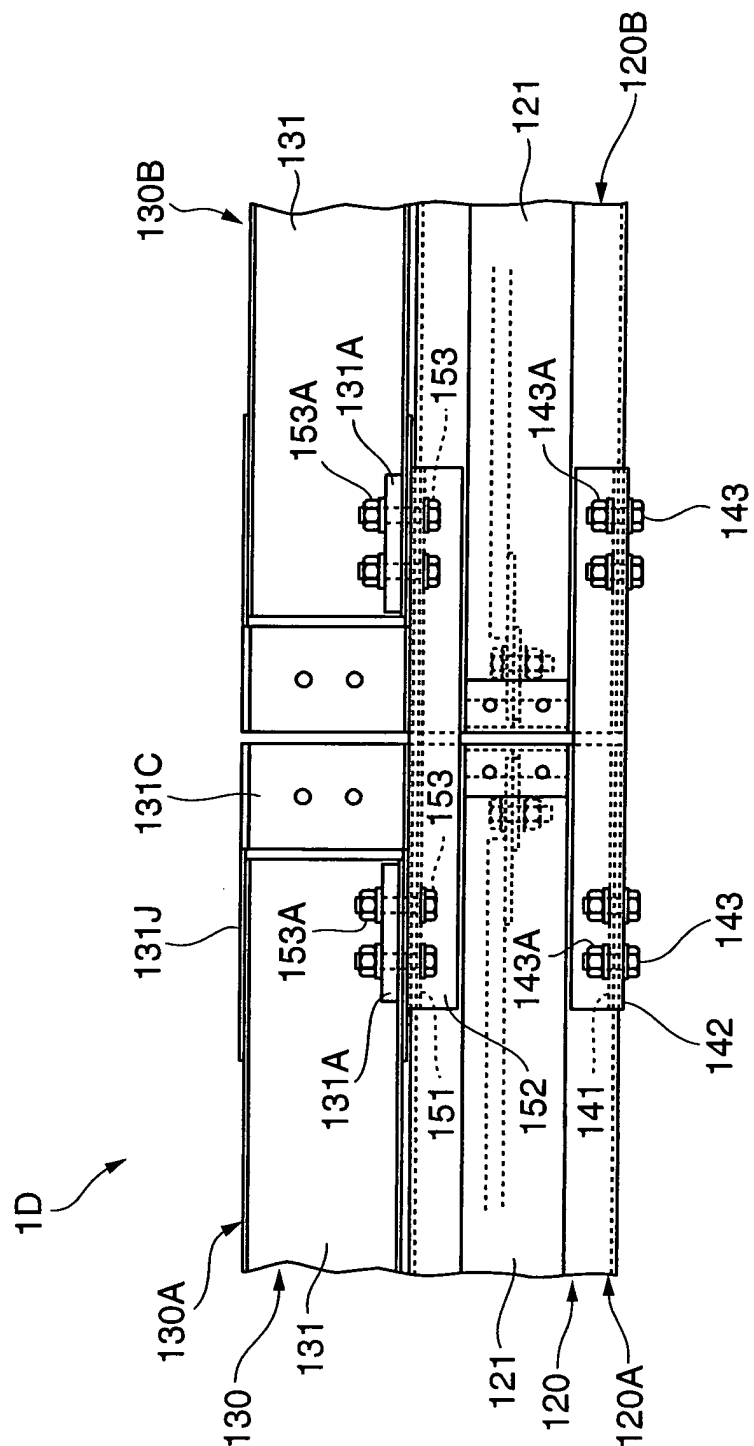


FIG.28

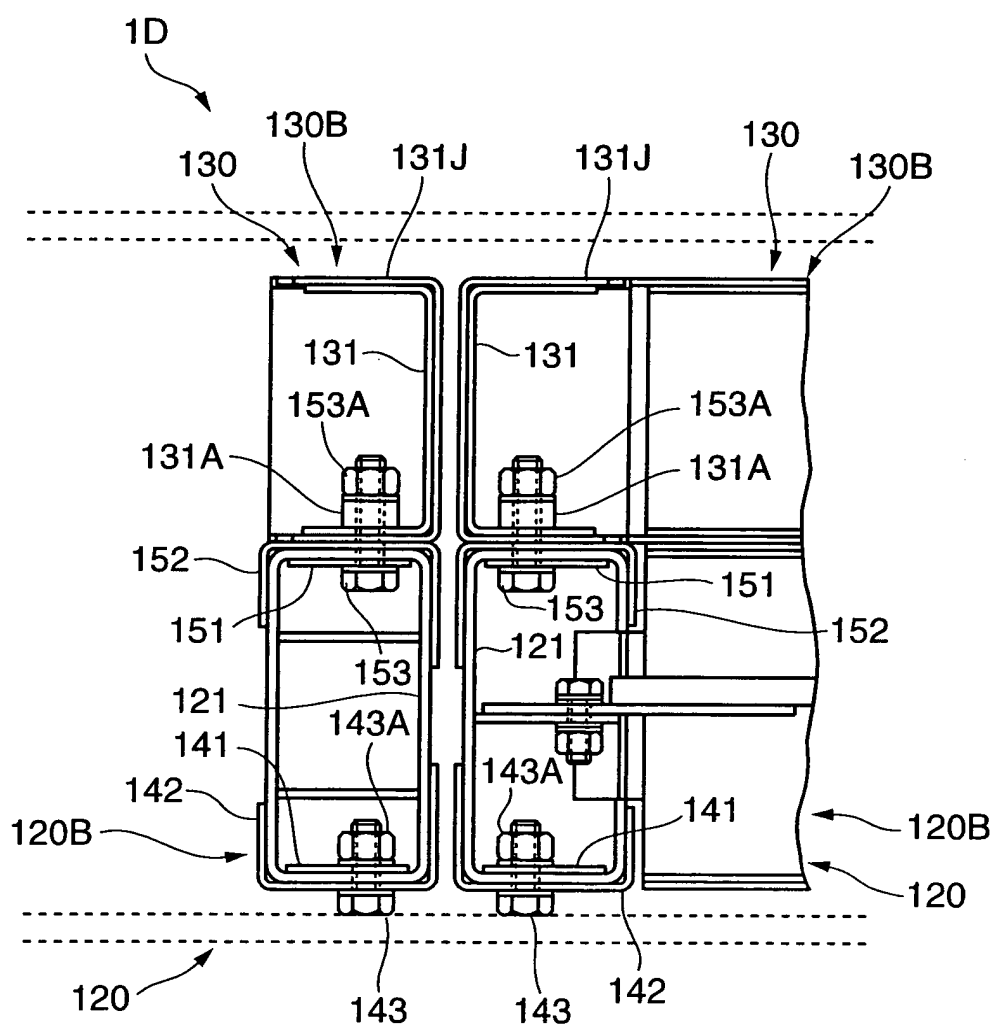


FIG.29

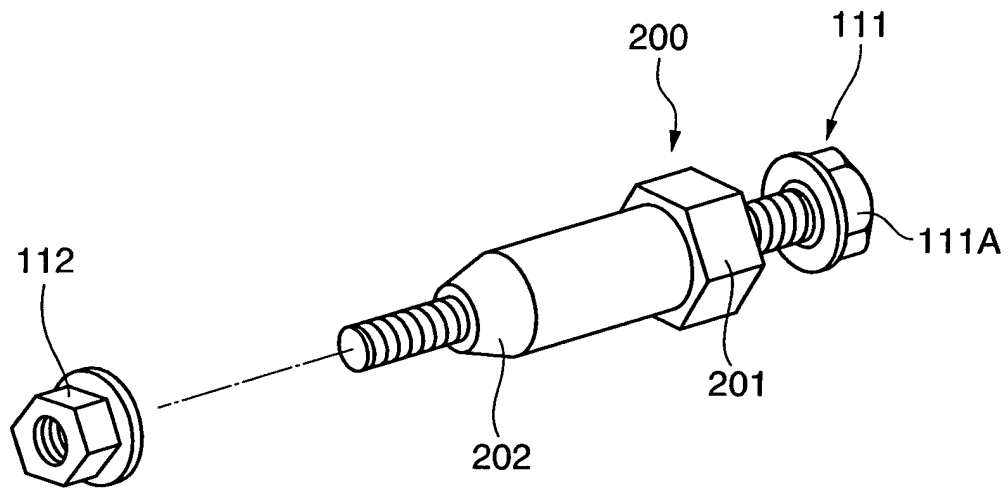


FIG.30

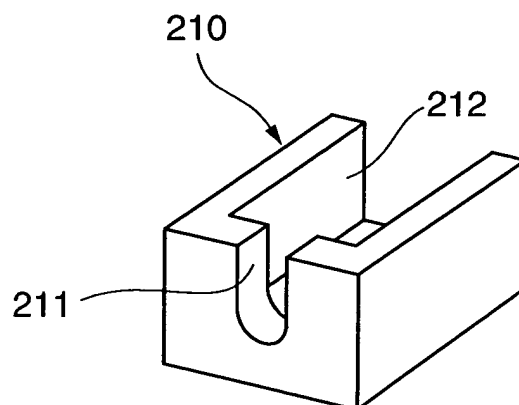


FIG.31A

FIG.31B

FIG.31C

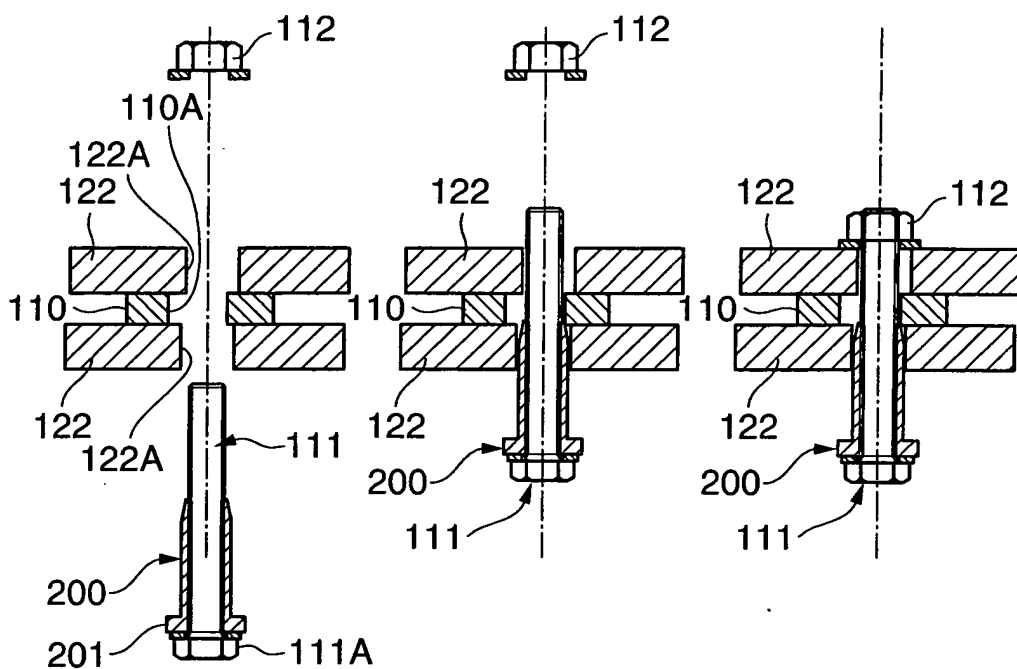


FIG.31D

FIG.31E

FIG.31F

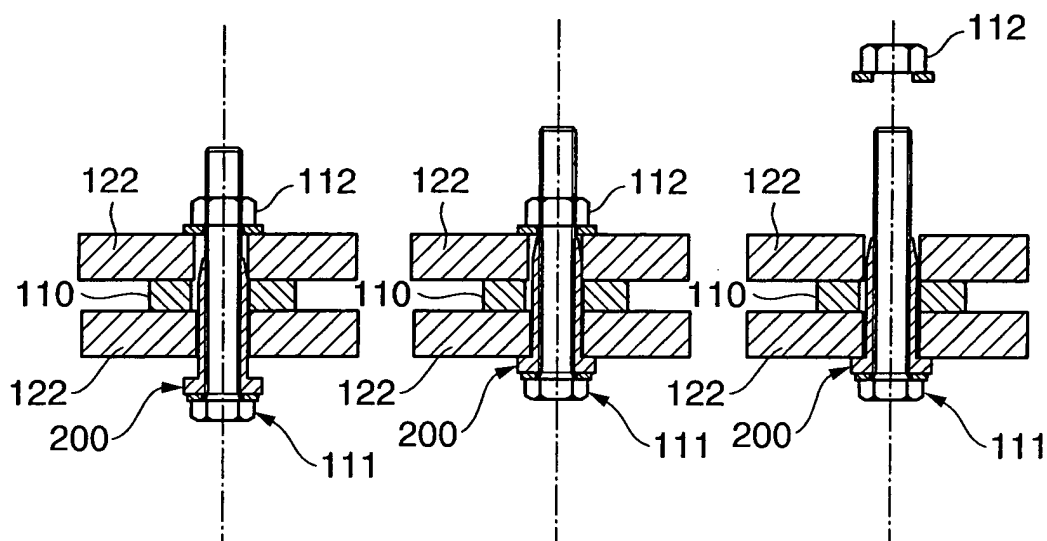


FIG.32A

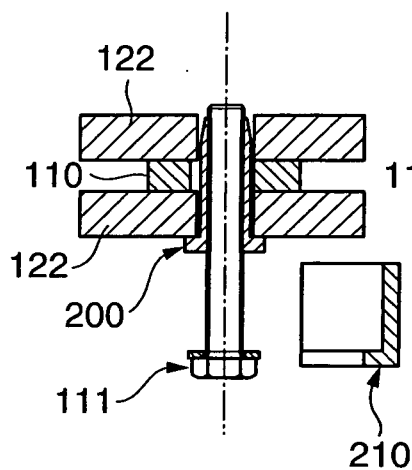


FIG.32B

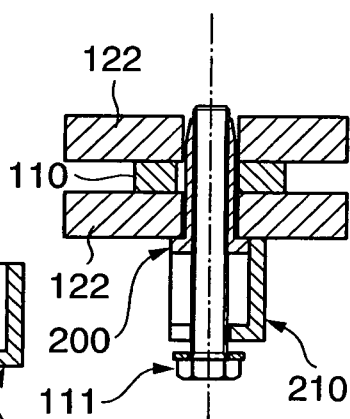


FIG.32C

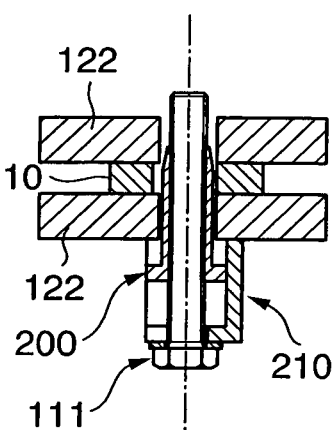


FIG.32D

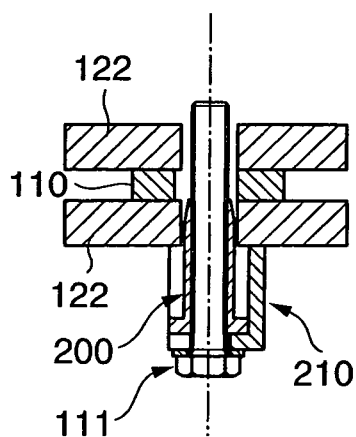


FIG.32E

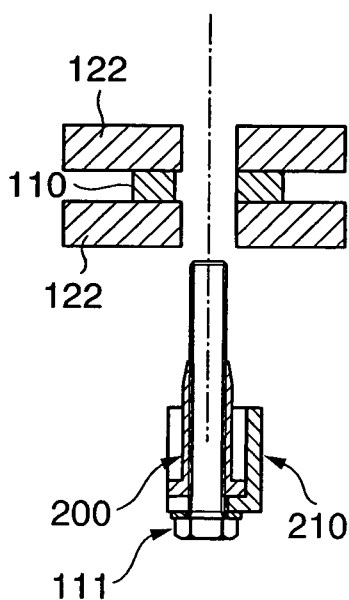


FIG.33

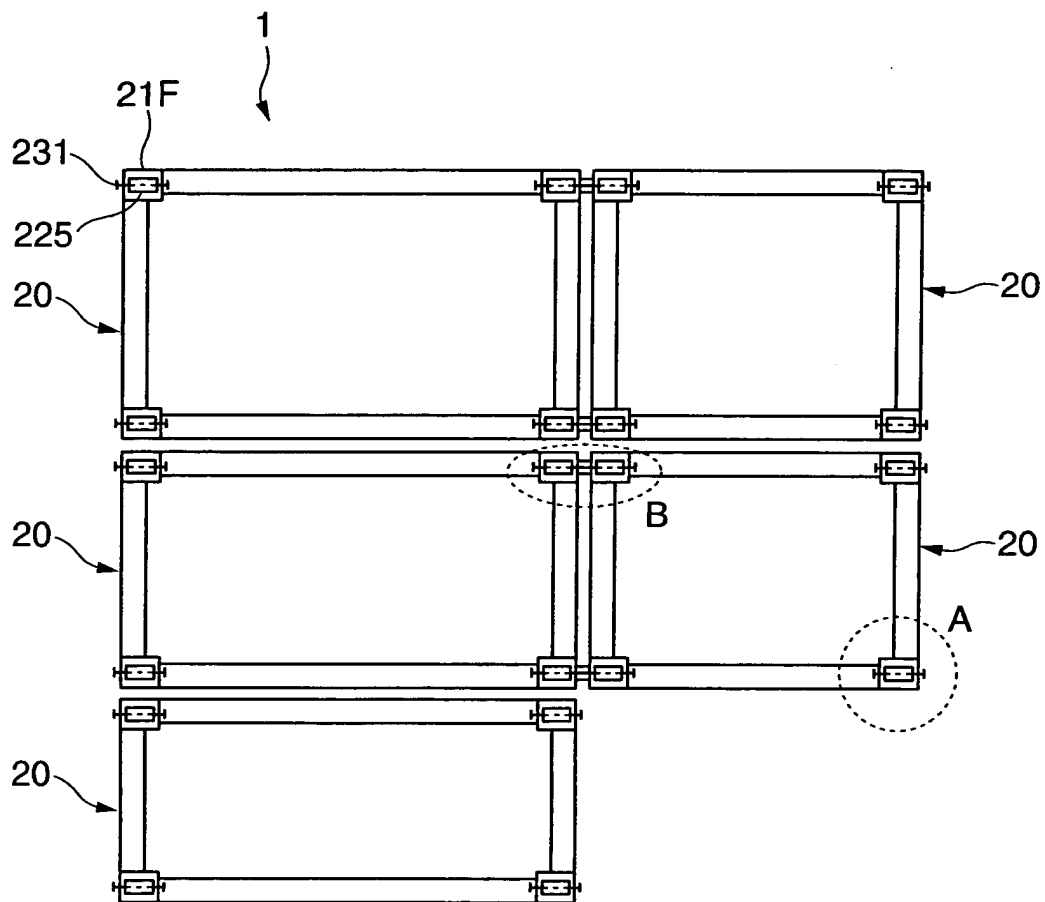


FIG.34A

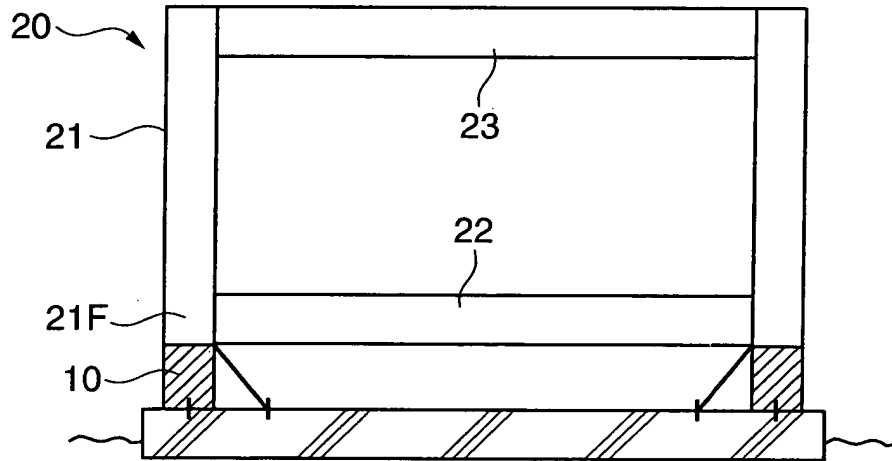


FIG.34B

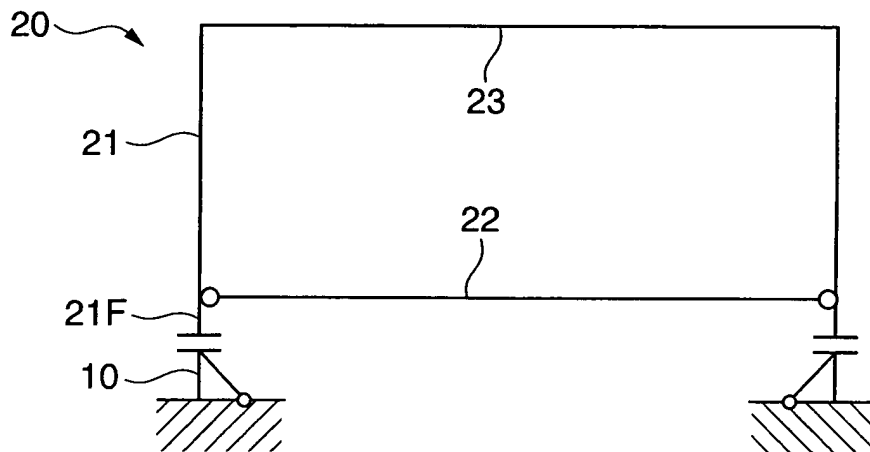


FIG.35

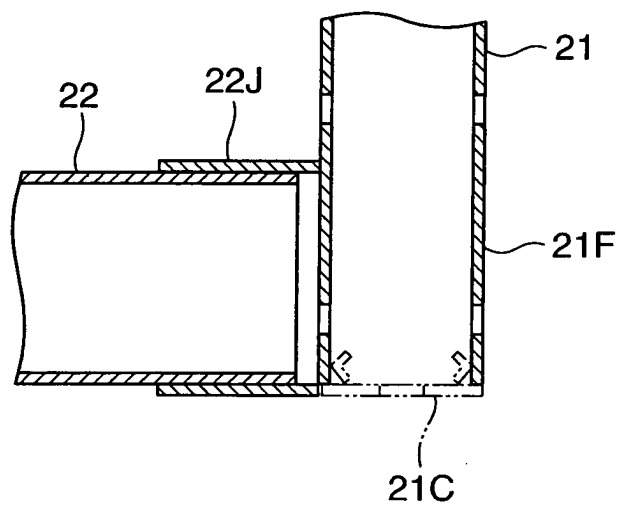


FIG.36A

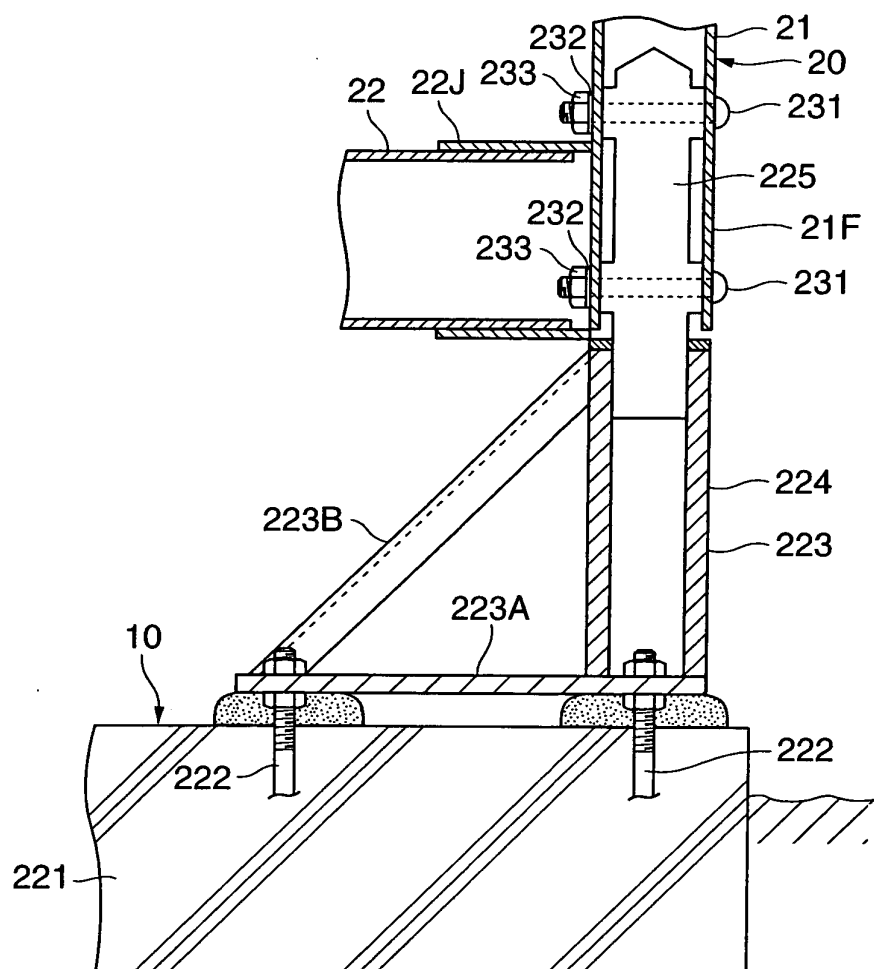


FIG.36B

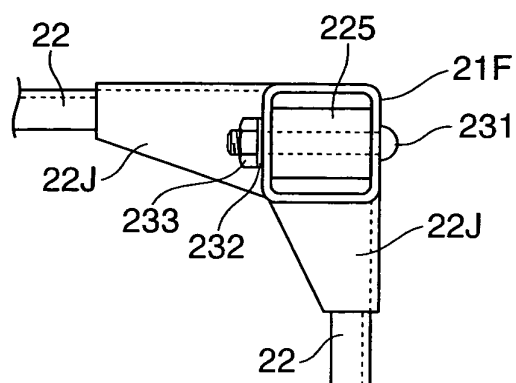


FIG.37

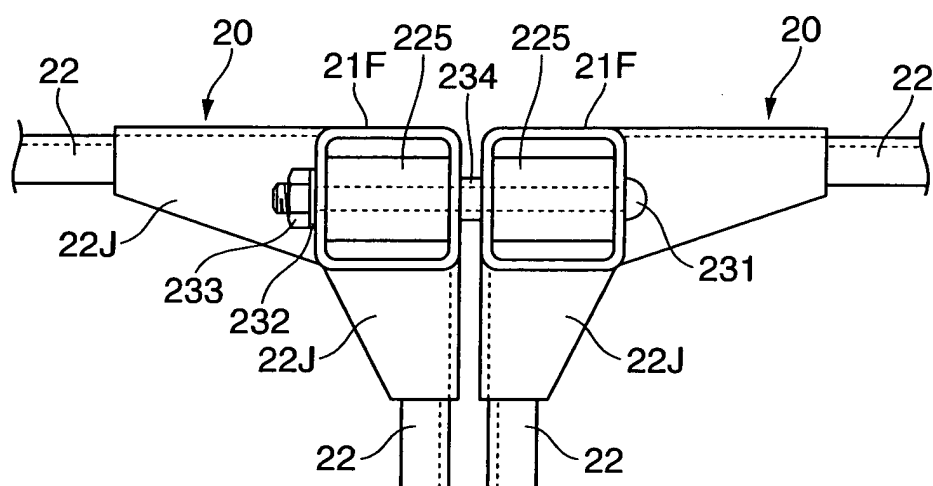


FIG.38A

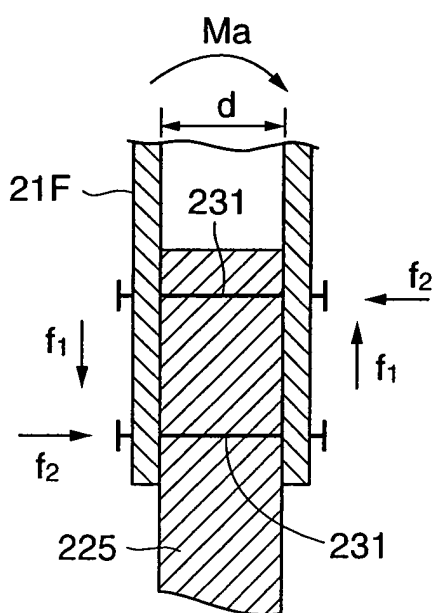


FIG.38B

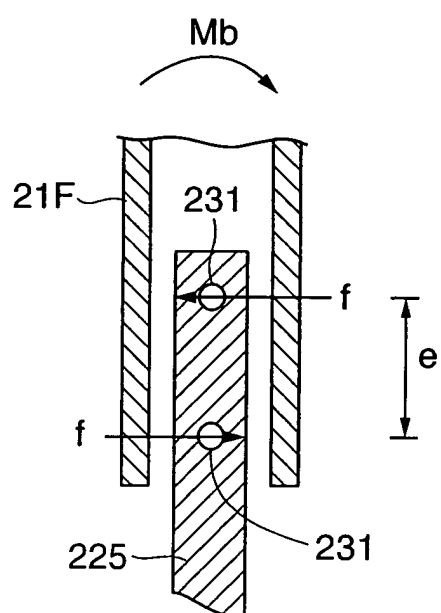


FIG.39

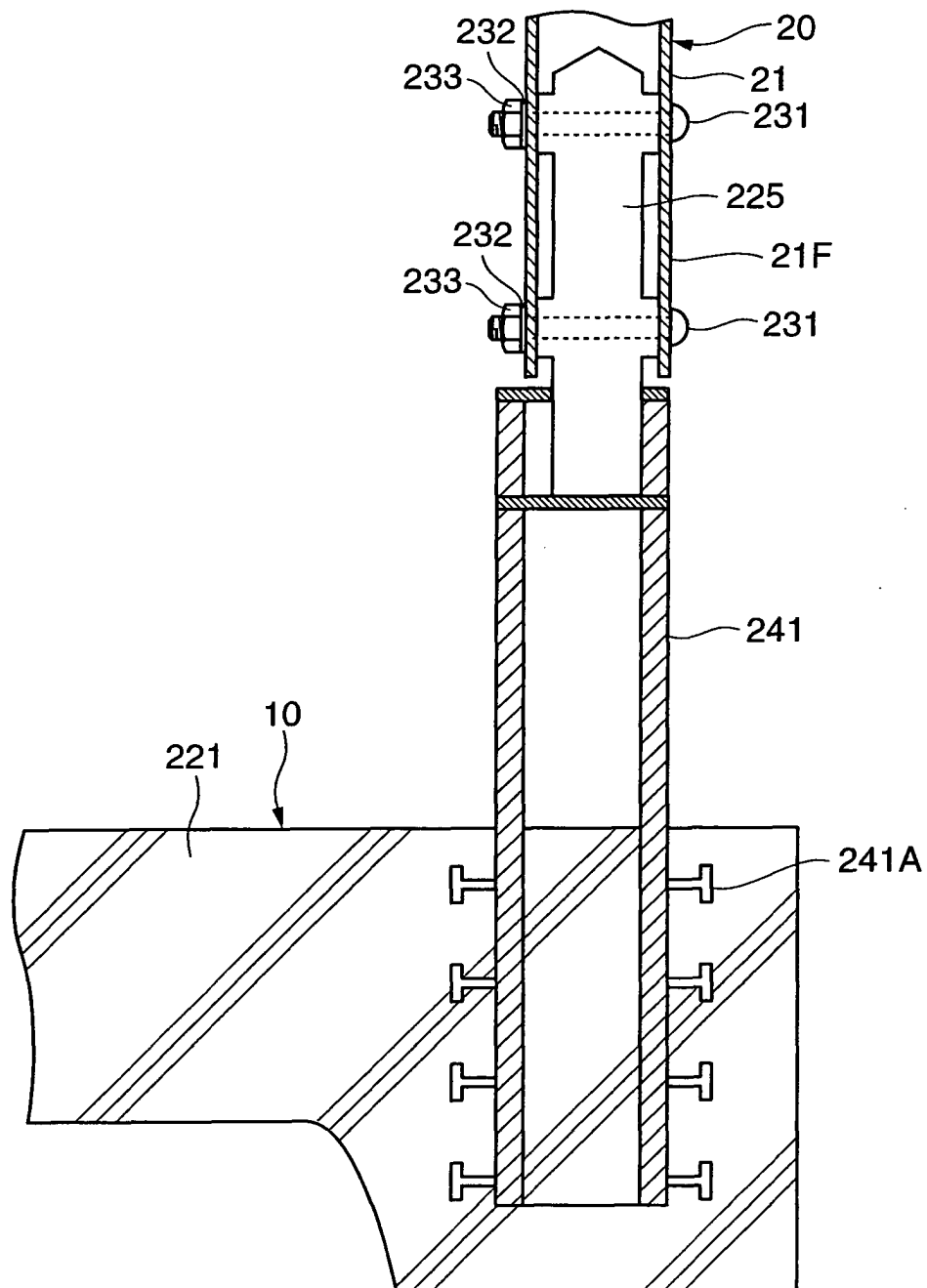


FIG.40A

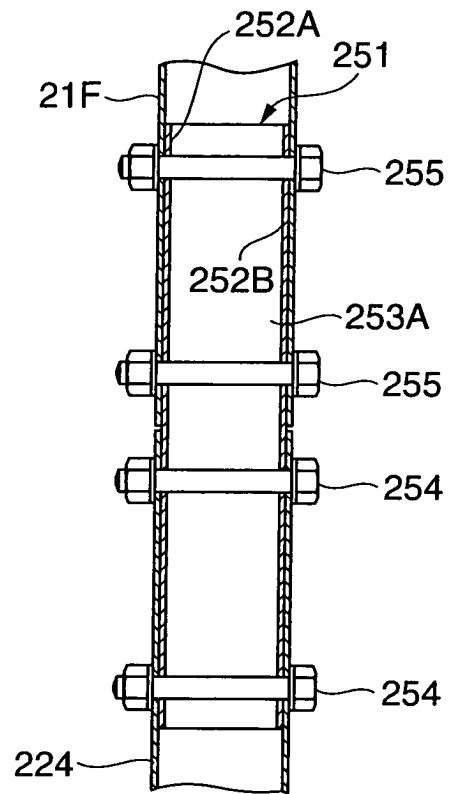


FIG.40B

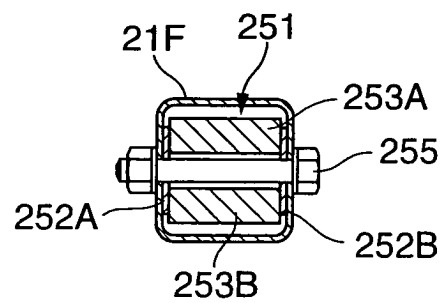


FIG.41A

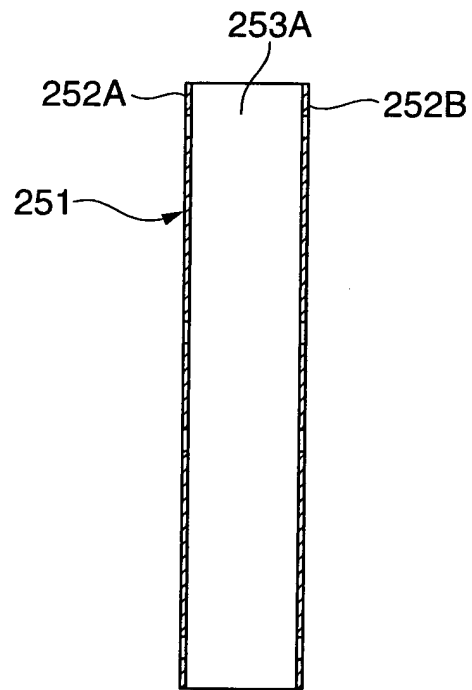


FIG.41B

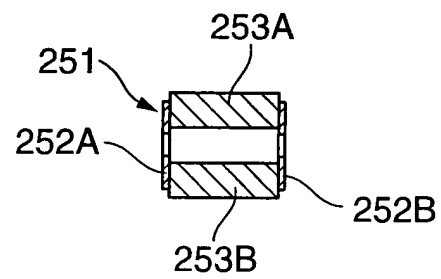


FIG.42

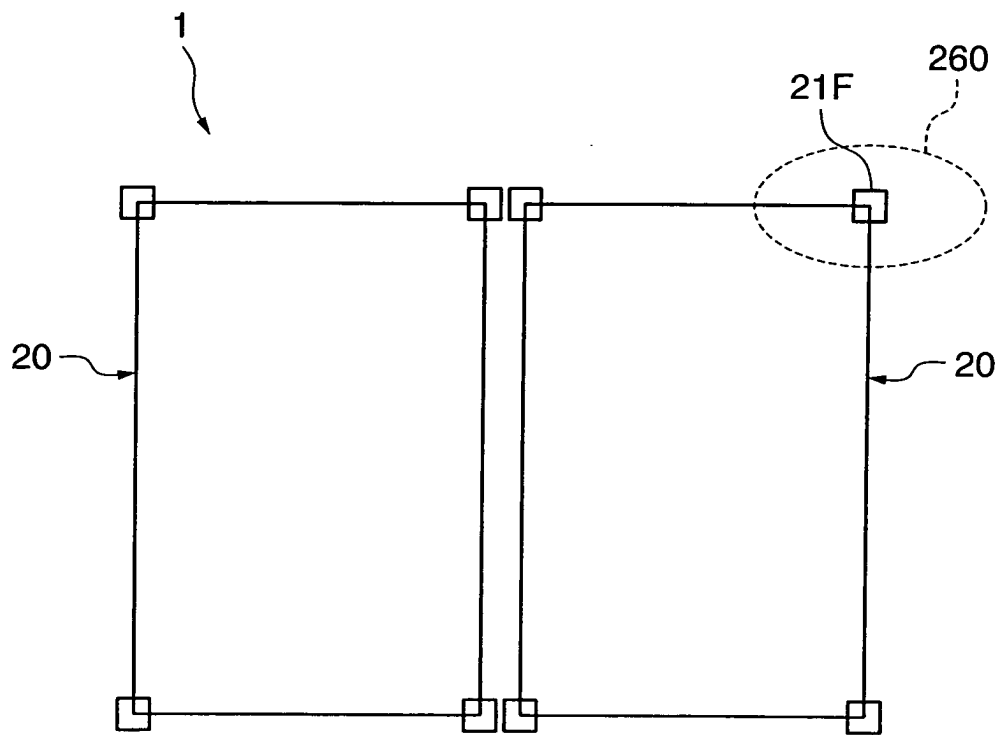


FIG.43

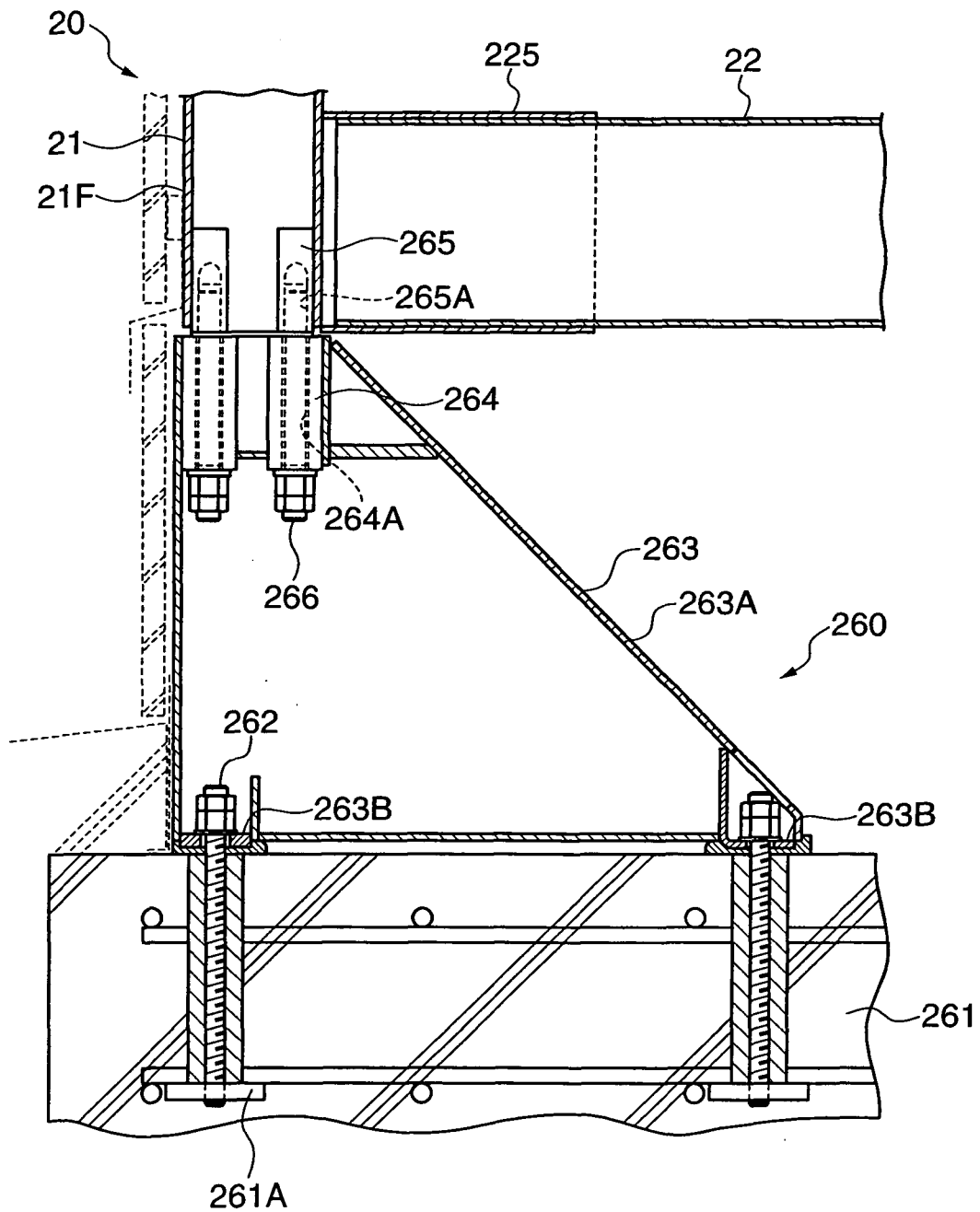


FIG.44A

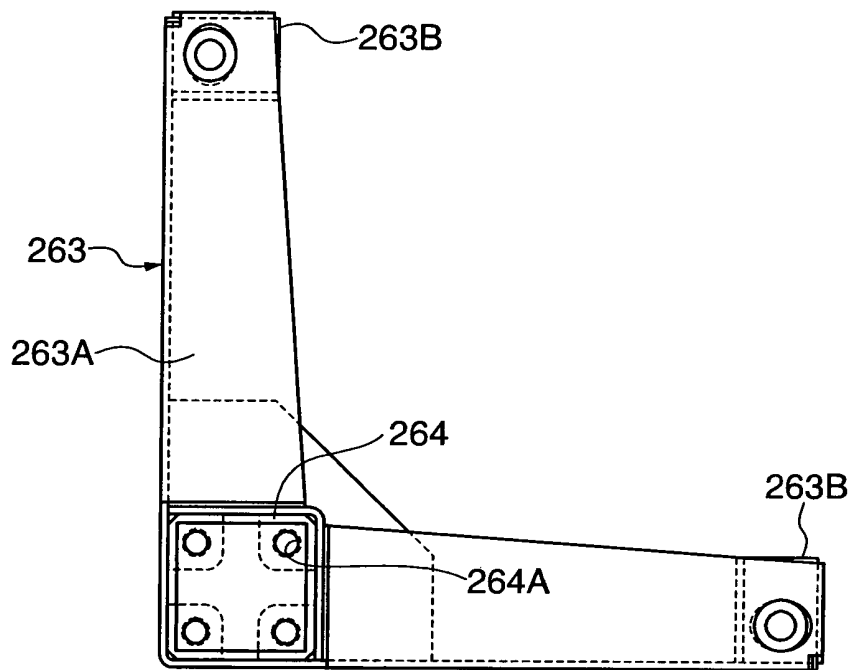


FIG.44B

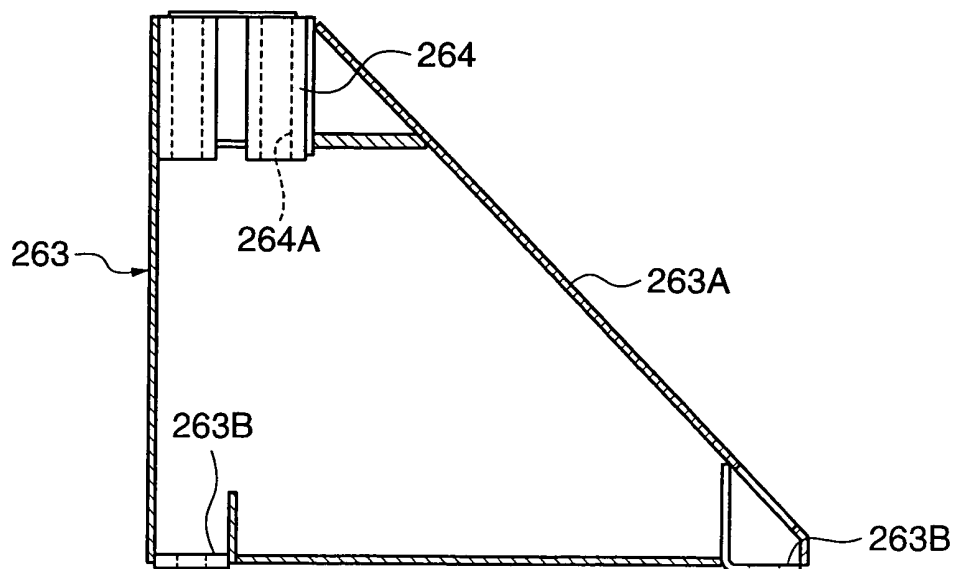


FIG.45

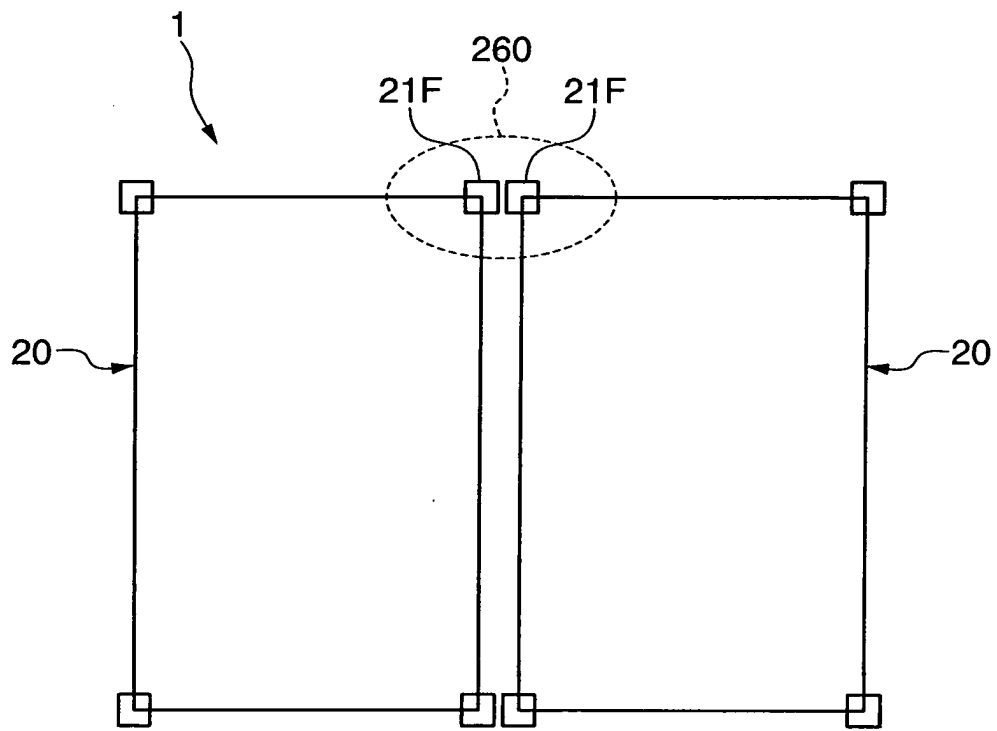


FIG.46A

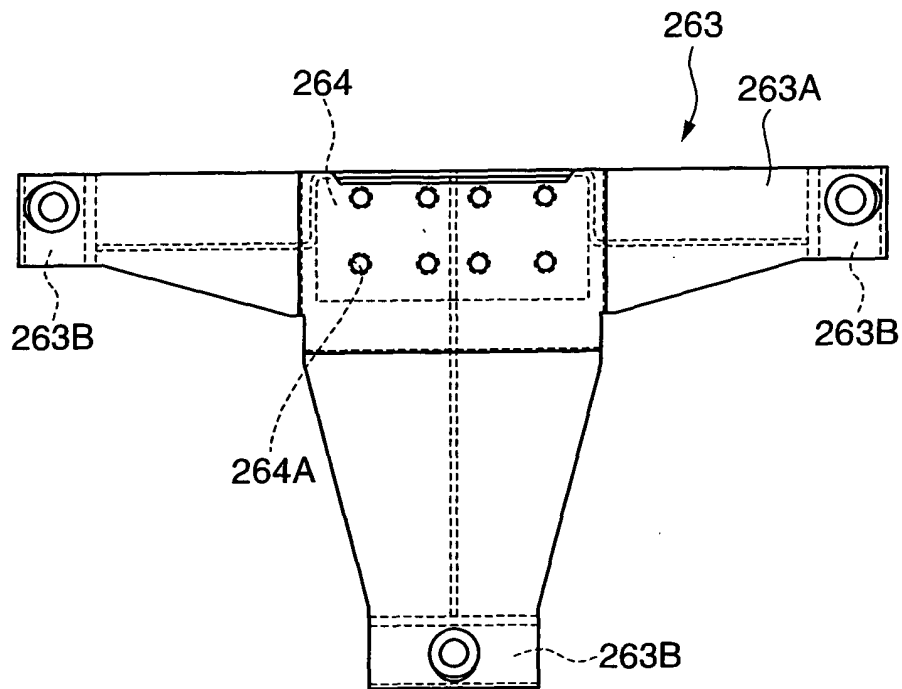


FIG.46B

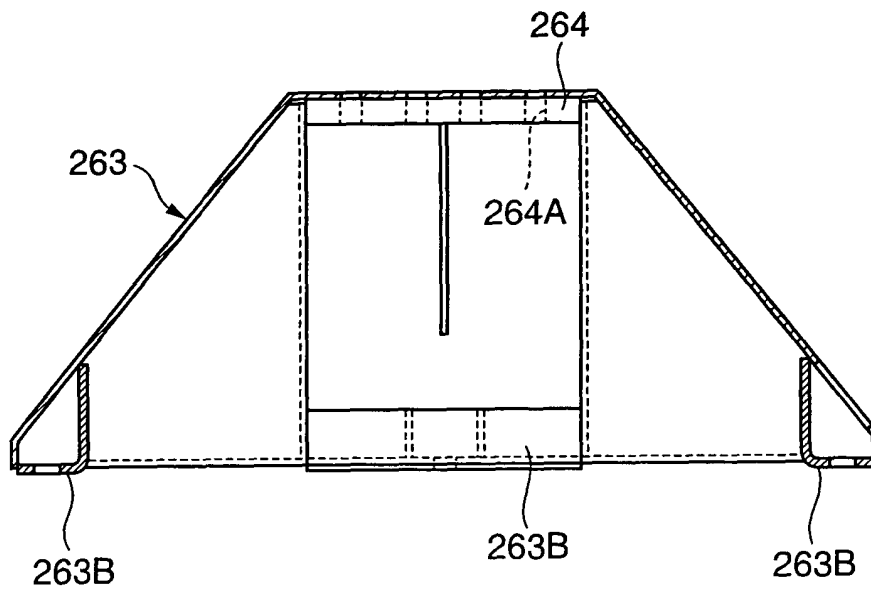


FIG.47

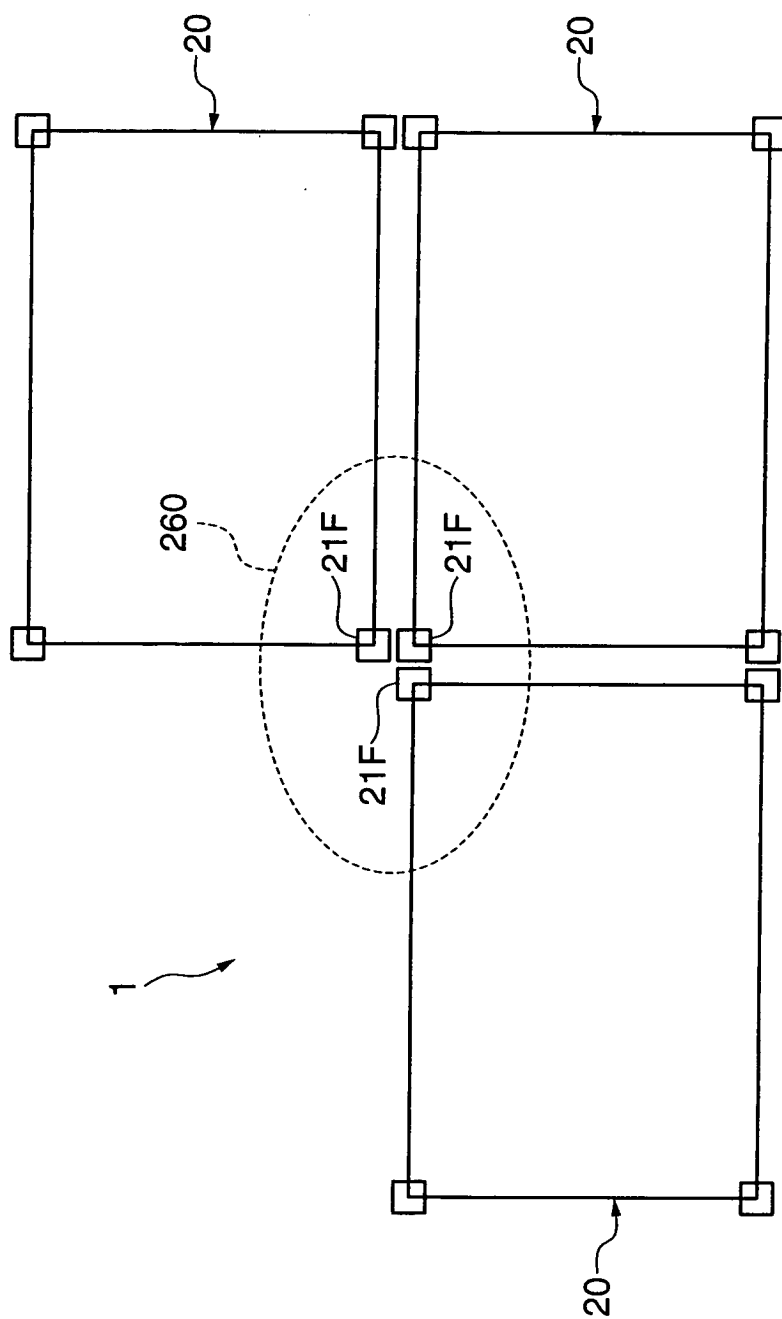


FIG.48

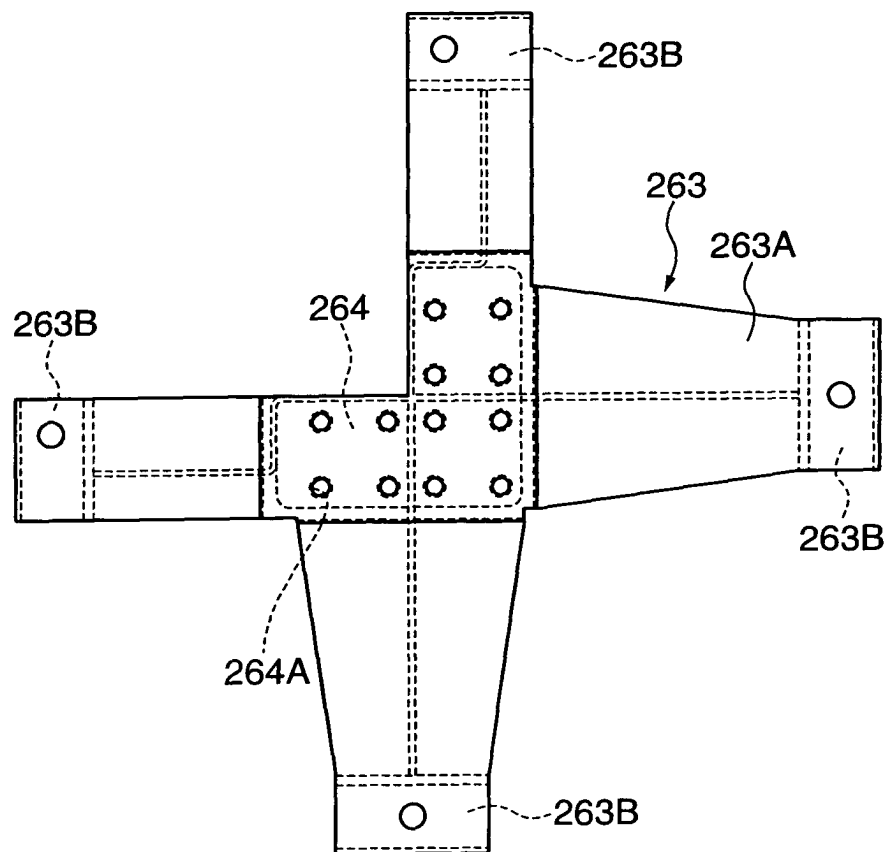


FIG.49

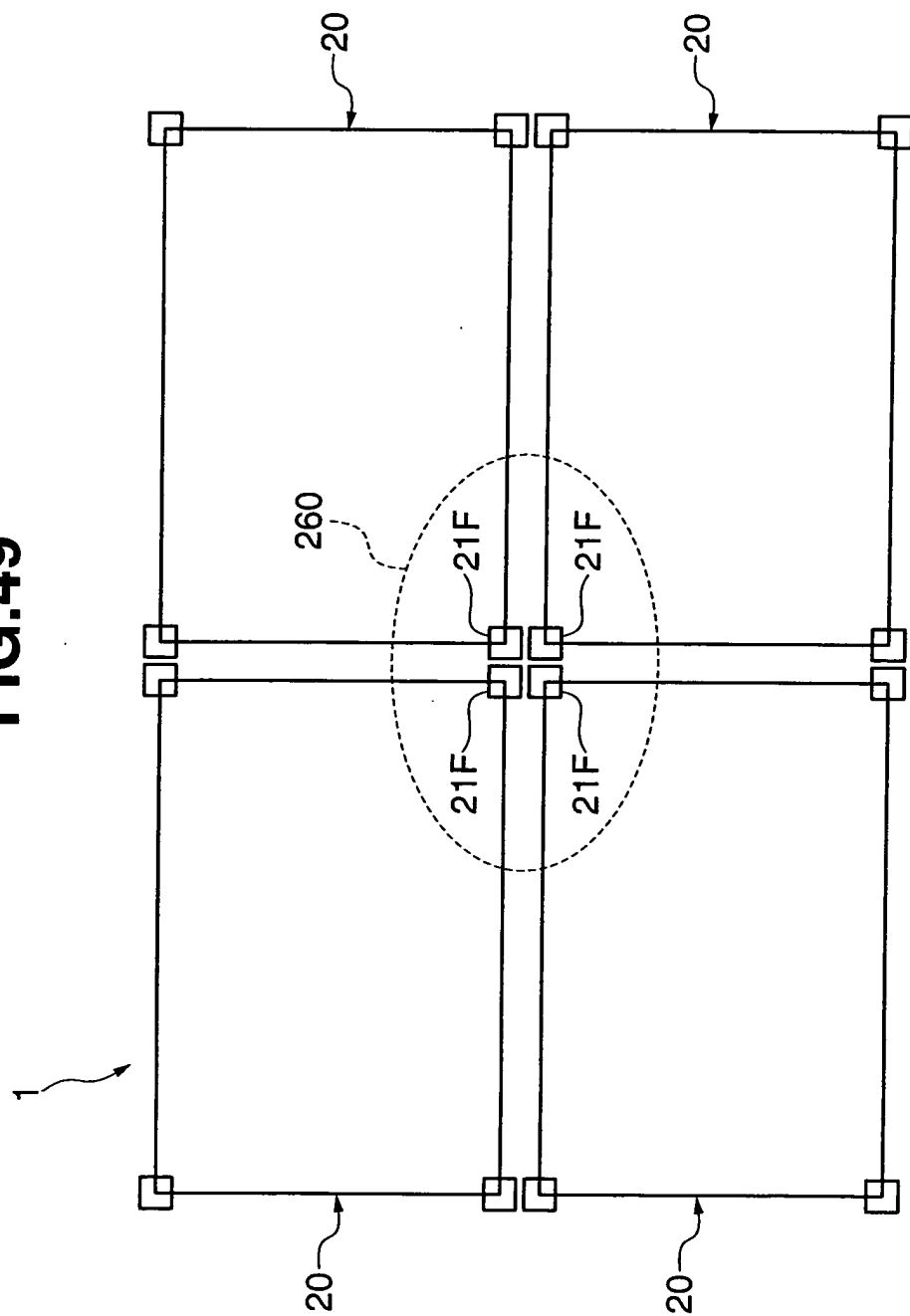


FIG.50

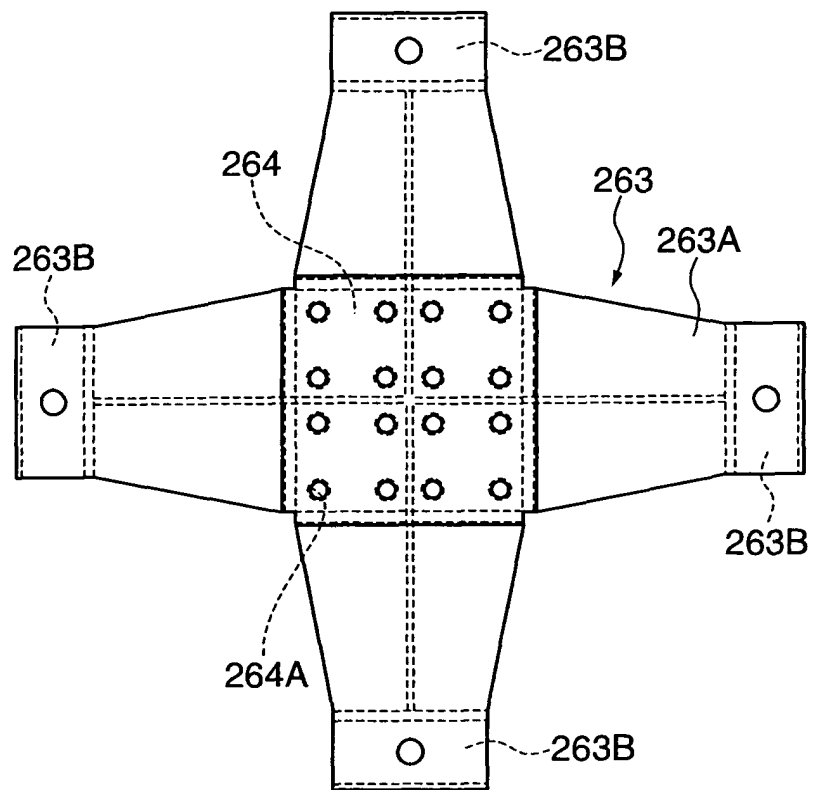


FIG.51

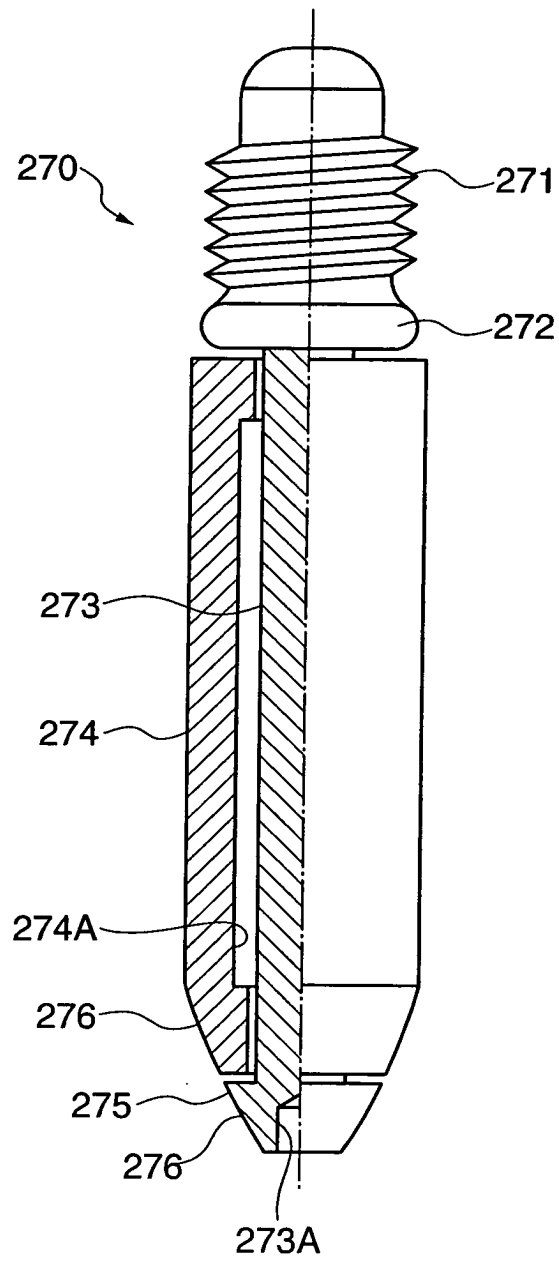


FIG.52

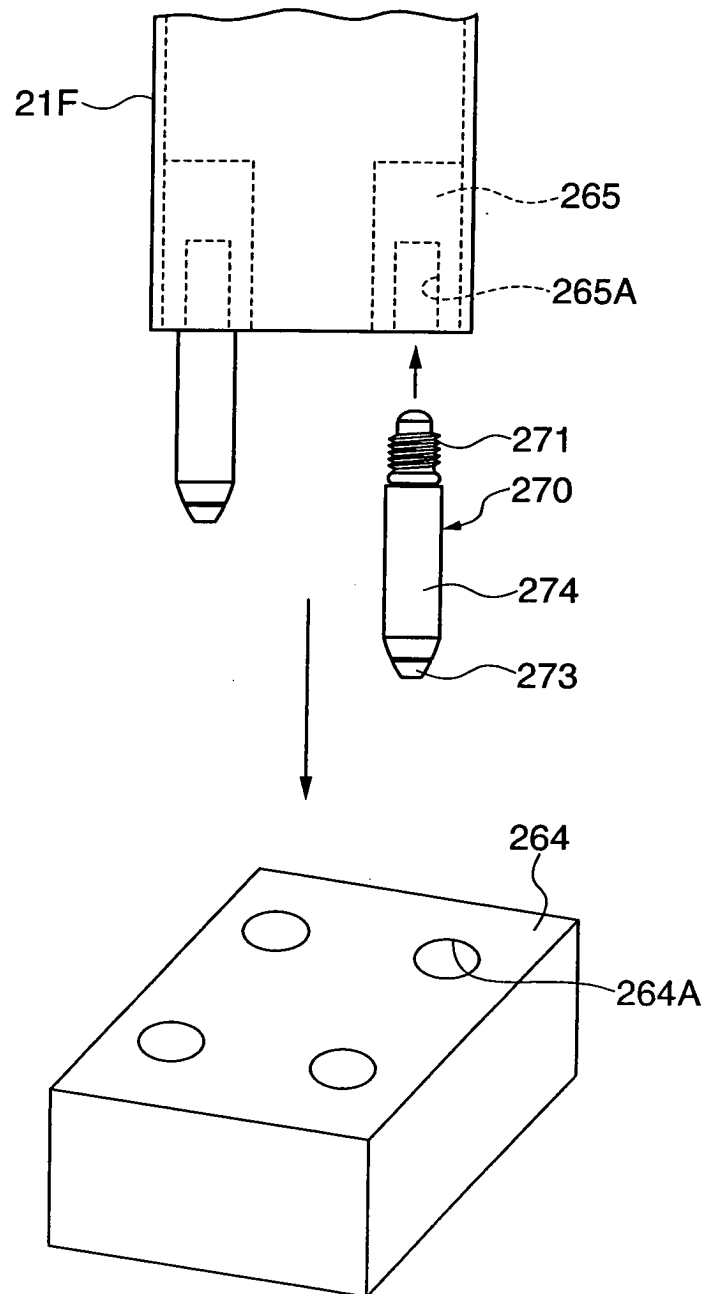


FIG.53

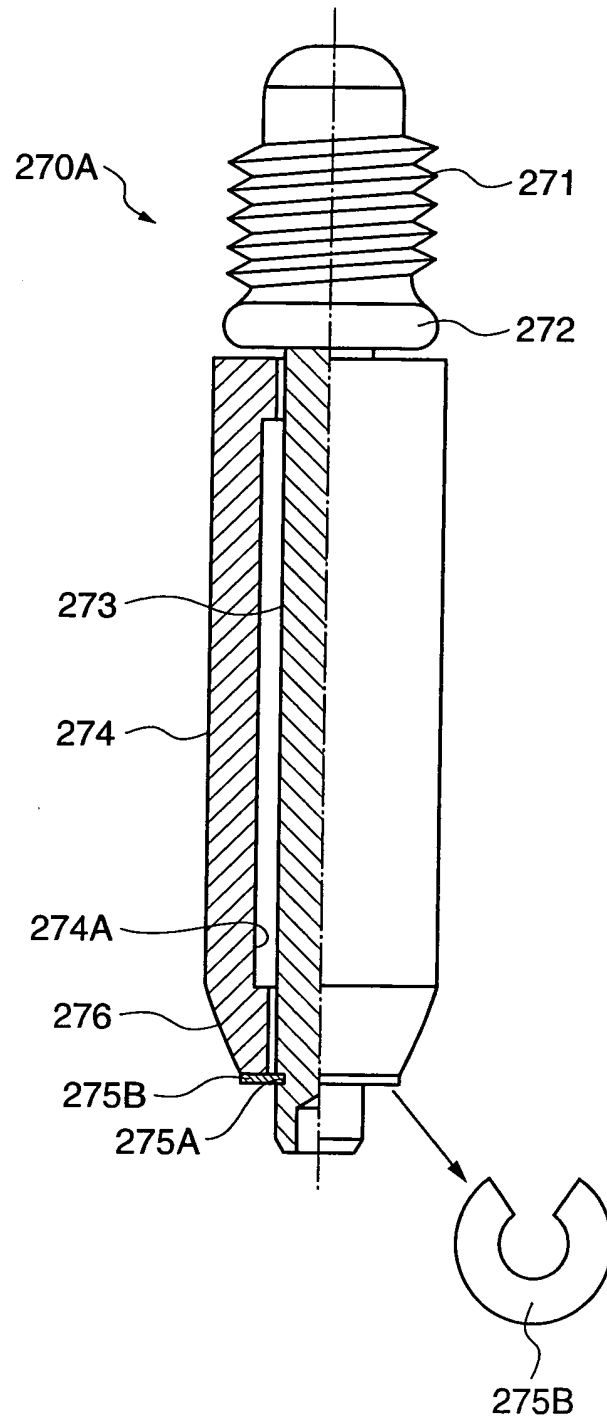


FIG.54

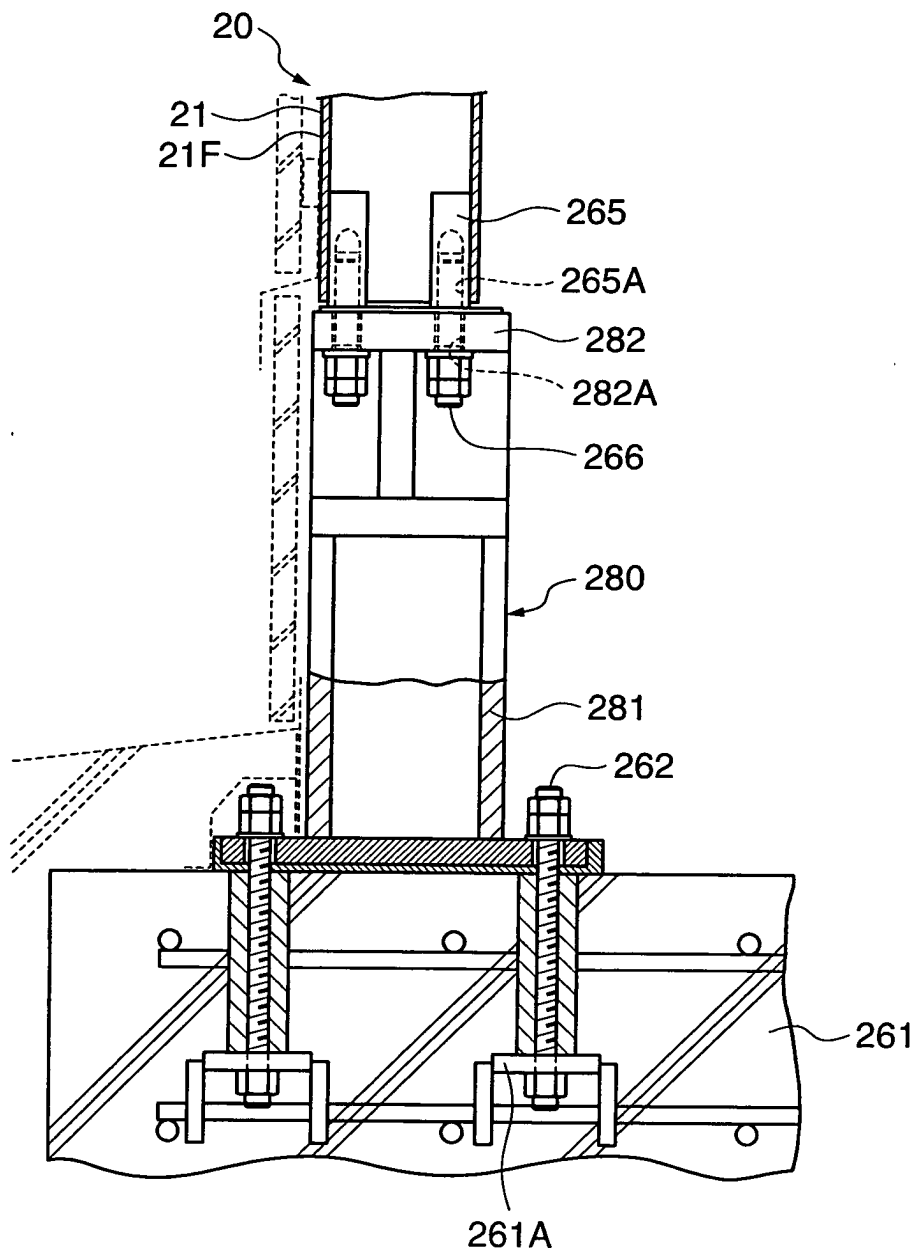


FIG.55

construction method	Priority(Single Row Arrangement)		Priority(Multiple Row Arrangement)		Note
	Outdoor side	Indoor side	Outdoor side	Indoor side	
I	2	2	3	3	Effective for only first floor(High cost, High effect)
II		1		1	For only indoor side (Low cost, Middle effect)
III			1	2	For only multiple row type (Low cost, Middle effect)
IV	1	3	2	4	Include wall planning affection(Low cost, High effect)
Summary	A	B	C	D	
A: Little influence of wall planning affection by the construction method IV at outdoor side. If insufficient, the construction method I is applied or added. B: Since influence of wall planning affection by the construction method IV is much in indoor side, the construction method II is given priority. If insufficient, the construction method I is applied or added. C: the construction method III is given priority because of low cost, no affection. If insufficient, the construction method IV, further the construction method I is applied or added. D: All of the construction method I to IV may be selected. To be applied according to the priority order.					