# United States Patent [19]

**Termohlen et al.**

[11] **3,732,655**

[45] **May 15, 1973**


[54] **SUSPENDED BUILDING CONSTRUCTION**


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[22] Filed: **June 22, 1972**

[21] Appl. No.: **265,113**

**Related U.S. Application Data**

[63] Continuation of Ser. No. 866,707, Oct. 15, 1969, abandoned.

[52] **U.S. Cl.** .....**52/73,** 52/83, 52/167, 52/236

[51] **Int. Cl.**.....**E04b 1/34,** E04h 9/02

[58] **Field of Search**.....52/167, 83, 73, 236, 52/64, 66, 169, 122, 296, 297, 292



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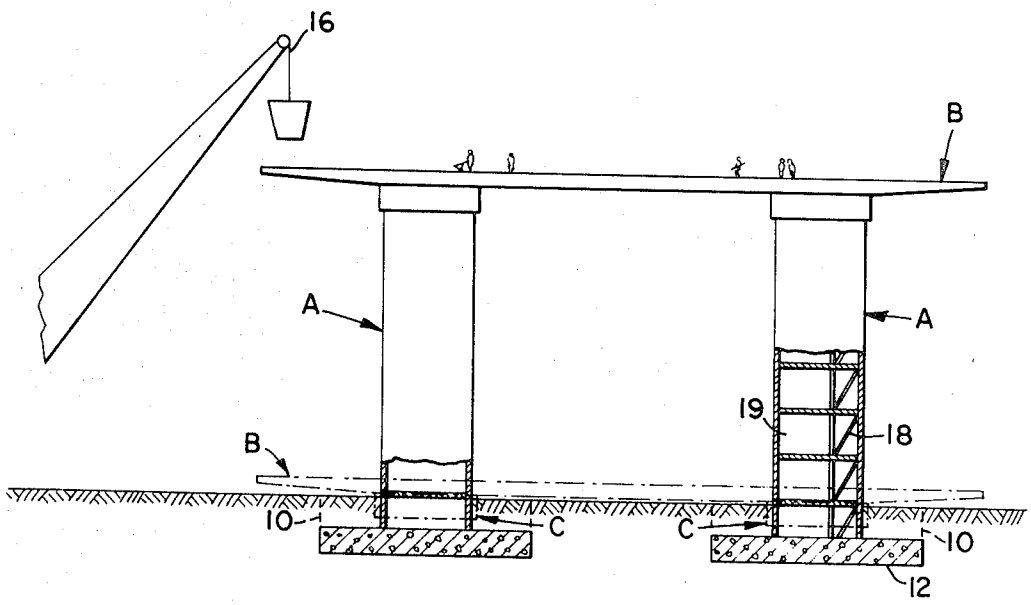
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[57] **ABSTRACT**

A building is dependingly supported from the top of at least one central pier or tower. At the topmost portion the pier is provided with girders which rest on top of the pier and span at their respective ends outwardly and immediately over the sides of the pier. The floors are dependingly supported from the protruding girders at the top of the tower along hanger straps which are disposed immediate the sides of the pier. Floor supporting girders for each successive and depending floor are fastened at preselected intervals to the hanger straps, span outwardly of the towers to support the floors of the building, and provide for pendulous movement of each of the floors with respect to the supporting pier to impart improved earthquake resistance to the structure.

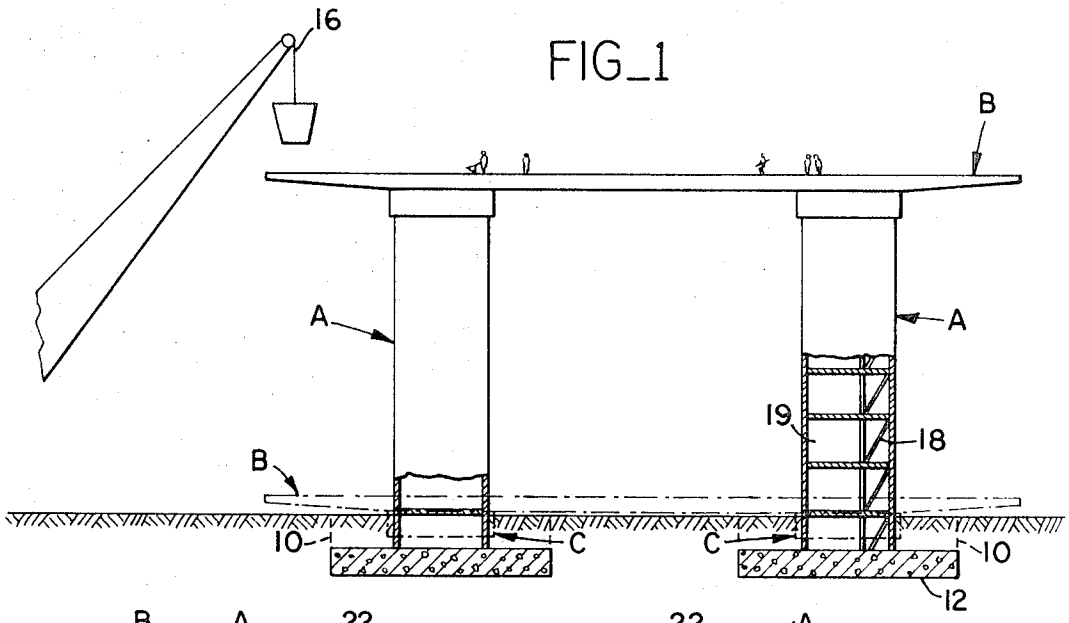

**5 Claims, 11 Drawing Figures**



PATENTED MAY 15 1973 3,732,655



FIG_1



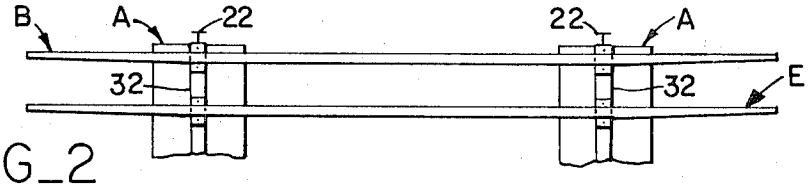




FIG_2

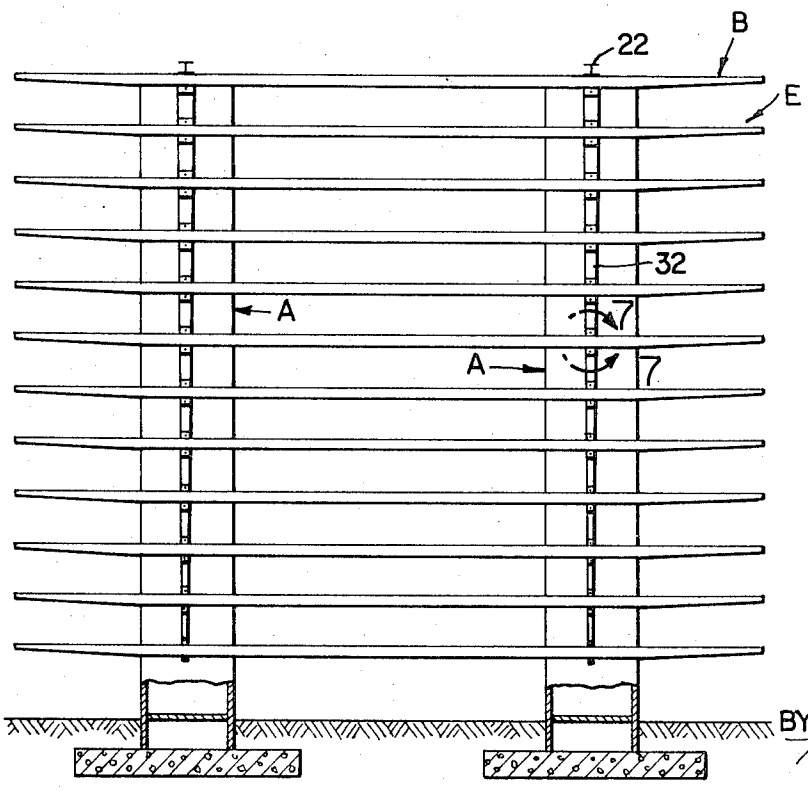



FIG_3

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FIG_4

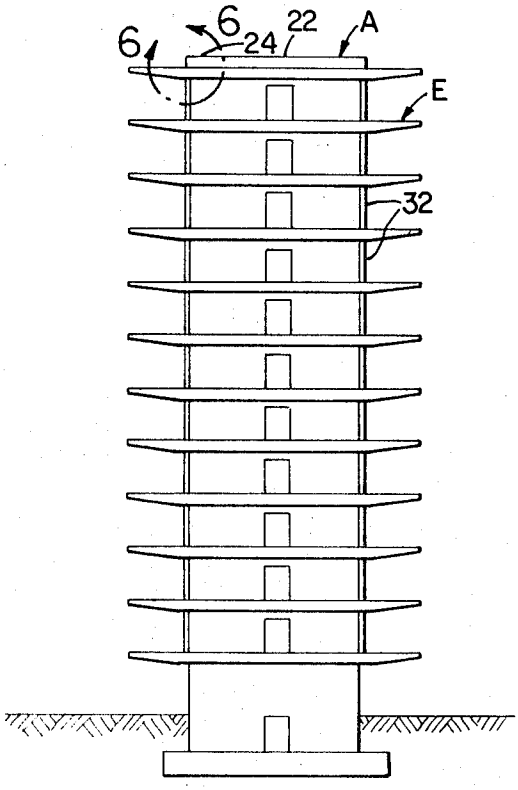



FIG_5

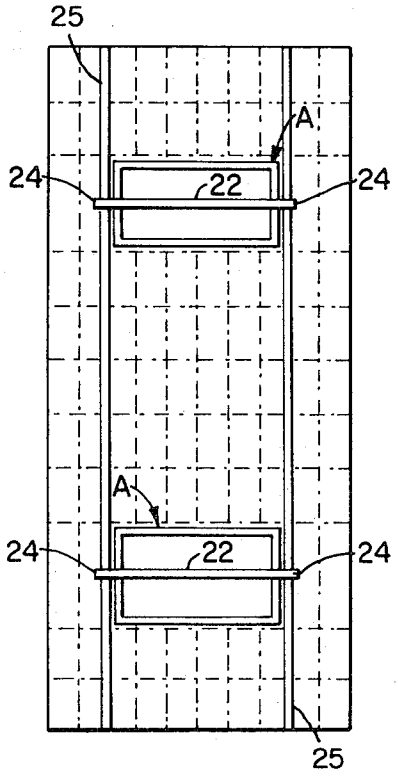



FIG_6

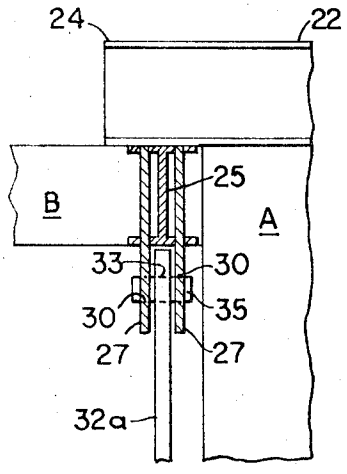



FIG_7

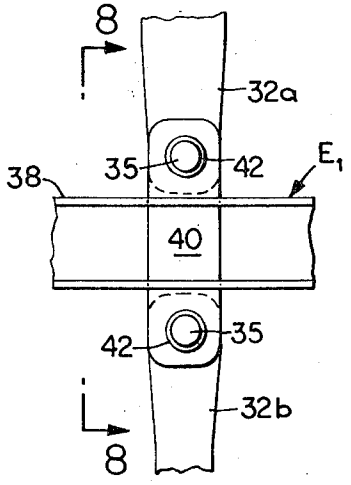
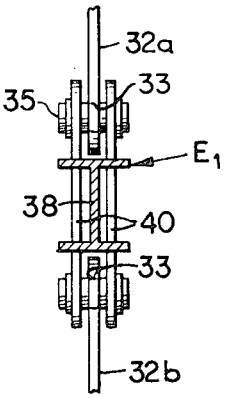



FIG_8




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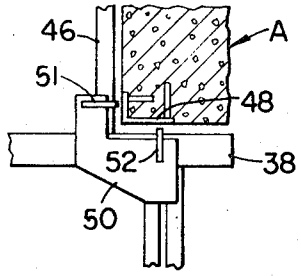



FIG_9

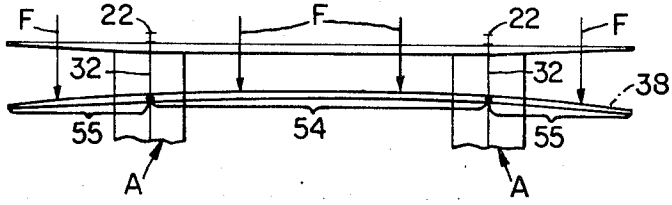



FIG_10

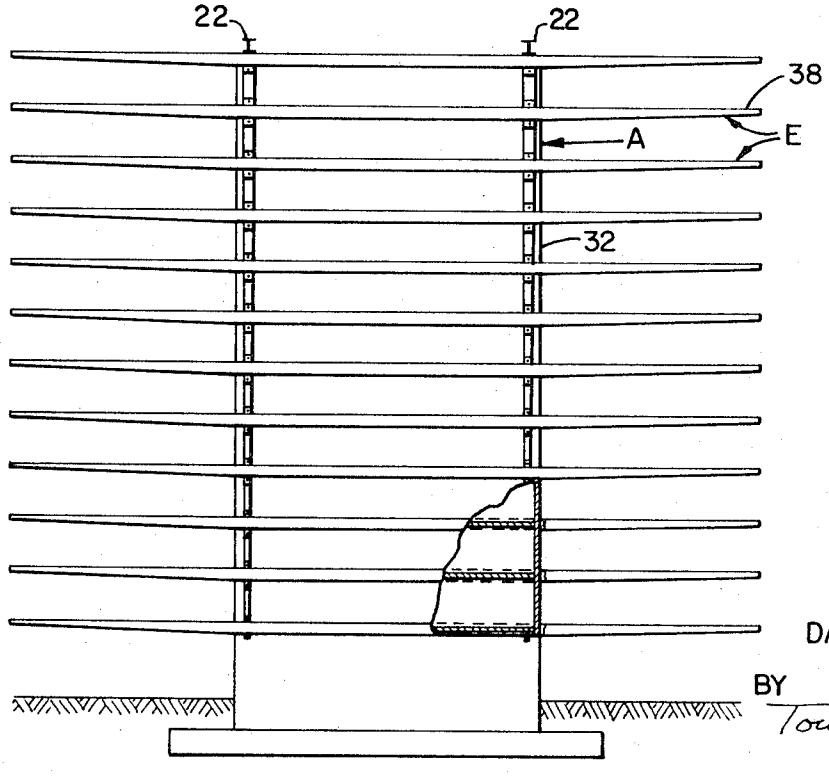



FIG_11

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# SUSPENDED BUILDING CONSTRUCTION

This is a continuation of application Ser. No. 866,707, filed Oct. 15, 1969, and now abandoned.

This invention relates to buildings and more particularly illustrates an improved building construction wherein successive floors are pendulously supported from a central tower or pier to provide improved earthquake resistance and process for constructing such a building.

It is already known to form and support a multi-story building structure on a central tower, having a truss at the top, and the floors dependingly supported from the truss therebelow. Typically, the tower extends upwardly from the building foundation the full height of the building structure. At the top of the tower, the truss is placed and spans outwardly from the tower over the floors therebelow. From the outward ends of the truss, cables or straps dependingly support the building floors.

Heretofore, such structures have included several disadvantages. First, the supporting truss mounted at the top of the tower has been extremely heavy. These trusses commonly are of such weight that they must either be raised on the tower as it is constructed or alternately lifted and assemblied in place by special rigging equipment.

Secondly, trusses at the top of these building structures interrupt the uppermost floor of such buildings by extending through its spatial interval at numerous points. This results in the highest, and often most desirable floor being unfit for many occupancies which require substantial expanses of open space. Moreover, as the bottom of the truss frequently forms the uppermost floor of the building, it is not possible to dependingly support this uppermost floor from the pier or tower to provide the building with optimum earthquake resistance.

Finally, the spaced straps or cables for supporting the floors from the outward portions of the truss pass through the living space of the building defined between the outer edge of the floors and the central pier or tower. They interrupt the working spatial area interior of the building in a manner similar to columns extending vertically the height of buildings of conventional columnar construction.

It is an object of this invention to provide a building construction dependingly supported on a central pier or tower, which construction does not include a truss extending between the topmost portion of the tower and the first successive floor.

An advantage of this invention is that the unsightly internal and external appearance of a truss protruding at the uppermost portion of the building is avoided.

A further object of this invention is to disclose a building structure wherein the depending support members or hanger straps are disposed immediately adjacent the central building core.

An advantage of this positioning of the support members or straps is that they do not interrupt the useable floor space defined about the core and provide a "column free" building construction.

A further object of this invention is to permit the roof of the finished building to be used as a construction platform for the fabrication of the central towers. Absent the requirement of a truss at the top of the tower, the roof can be assembled before the tower or towers are erected and thereafter elevated as the tower or towers are constructed to provide a work platform from which the tower construction can conveniently occur.



An additional object of this building construction is to support the floor on points of support adjacent the tower, which points of support permit the ends of the floors extending beyond the tower to be cantilevered. This cantilevered support of the floors at their respective ends permits the floor portions between the cantilevered ends to be predeflected to oppose their live and dead weight loadings and thus permit these floor portions to be fabricated using a reduced section.

Other objects, features and advantages of this invention will become more apparent after referring to the following specification and attached drawings in which:

FIG. 1 is a side elevation in partial section illustrating the construction of paired towers for supporting a building, the construction here illustrated taking place by utilizing the roof of the finished building as a work platform for construction of the towers;

FIG. 2 is a partial side elevation illustrating the building after the towers are erected to their full height and showing the depending attachment of the successive floors from beams resting on the top of the towers and protruding outwardly immediately over the side edges of the towers;

FIG. 3 is a side elevation illustrating the completed building framing;

FIG. 4 is an end elevation in partial section illustrating the completed building framing;

FIG. 5 is a plan view of the completed building framing;

FIG. 6 is a blown up detail at area 6 of FIG. 4 illustrating an end elevation of one of the four attachments of the depending support members to the tower top;

FIG. 7 is a blown up detail of the area 7 shown in FIG. 3, illustrating a side elevation of one of the four attachments of the floors to the depending support members;

FIG. 8 is a blown up end elevation view of the detail shown in FIG. 7;

FIG. 9 is a horizontal sectional detail illustrating apparatus for limiting the pendulous movement of the floors as they are dependingly suspended from the towers;

FIG. 10 is a schematic diagram for illustrating the advantageous cantilevered floor loading provided by the suspension system of this invention; and,

FIG. 11 is a side elevation in partial section illustrating an alternate building construction utilizing a single tower.

With reference to FIGS. 1–3, the sequential steps necessary for the construction of a building according to this invention are illustrated. With specific reference to FIG. 1, the initial tower construction of a building having two towers A is shown.

Initially two excavations 10 are made, one excavation being at the base of each tower A and being coextensive with a foundation or pad 12 which is subsequently poured and cured within the excavations 10. After placement of the foundation or pad, roof structure B is assembled overlying the foundation pads 12. In the view illustrated in FIG. 1, the initial position of roof structure B is shown at the bottom of the figure in broken lines.

Roof structure B is of a horizontal area coextensive with the upwardly exposed horizontal area of the completed building. Typically, it includes two apertures

therein, one such aperture being placed immediately about the periphery of each tower A.

When roof structure B is assembled and resting on the ground, a slip form C for molding the cross-sectional configuration of each of the towers A is attached to the bottom of the roof. Thereafter, concrete is typically poured and cured interior of the slip form and the roof structure B gradually raised. Such raising is typically accomplished by a combination of hydraulic jacks attached to the slip form at one end and to rods embedded in the concrete at the other end. These rods and jacks raise the slip form and roof a manner well known in the construction field. For purposes of brevity the raising of the tower and slip form will not be further discussed herein.

It will be seen that the upper surface of roof structure B provides a convenient platform from which the respective towers A can be assembled as the roof is raised. As illustrated in FIG. **1**, if the respective towers A comprise hollow concrete cores, the work surface furnished by the upper portion of roof B can be used to transport concrete from a boom **16** to the respective slip forms. Alternately, where the towers A are formed of brick or other module construction, the upper surface of roof structure B can be utilized for the transport of bricks or modules to the towers as they are erected. As is apparent, as soon as the lower portion of the tower is constructed, excavation **10** is back filled so as to bury and embed pad **12** in the ground to provide a secured foundation. Alternately, the top of pad **12** can be at ground level as it has been found that the building weight is sufficient to securely anchor the foundation.

Typically, the interior of each of the hollow cores A will be used for the various service functions of the building. Such service functions will include a stairwell **18** and an elevator shaft **19**. Additionally, the hollow cores of the towers A can be used for the placement of lavatories, pipe ways, conduit ways, and the like.

With reference to FIG. **2**, the completed building structure is illustrated, showing only the top portion of the building. Typically, each of the towers A has placed across the top portion thereof a beam **22**. This beam, as illustrated in FIG. **5**, spans across the respective towers A and protrudes at its ends **24** outwardly immediately over the side edges of the tower A.

Seating of the beam on the top of the respective towers can be accomplished in numerous ways. Where the beam rests across the central section of the tower, the topmost portion of the tower A can be capped with a steel framework, which framework will serve to distribute the loading of the beam **22** onto the sidewalls of each of the towers. Alternately, the beams can be moved to overlie one or the other of the core sidewalls and their loading conveniently absorbed directly by these sidewalls without any interstitial structure between the tower top and beam bottom of any kind.

Referring to FIGS. **2**, **4** and **6**, the fastening of the floors to the outwardly spanning ends **24** of the respective beams **22** is illustrated. Typically, roof structure B is provided with one or more longitudinally extending I beams **25**. These I beams are typically fastened directly to the bottom horizontal web surface of beam **22** by such conventional techniques as welding or rivetting or both.

The floors are dependingly supported from beam ends **24** or two straps **27**, also secured from the bottom horizontal web surface of beam ends **24** and fastened with their length extending through the horizontal webs of roof I beams **25**. These straps extend a distance beyond and below the lower surface of roof structure B and are provided at their lowermost portion with aligned apertures **30**.

Referring to FIG. **3**, each of the respective floors E is supported through a strap **32**. Typically, the strap has a length which extends substantially the height of the respective floors and at either end thereof defines strap apertures **33**. With respect to FIG. **6**, first or uppermost strap **32***a* is shown secured to beam straps **27** by a pin **35**, which pin penetrates through the respective apertures **30** and **33** in straps **27** and **32***a*.

Referring to FIGS. **2**, **7** and **8**, the process and apparatus whereby the respective floors are each fastened to the depending straps can be readily understood. Typically, each of the floors is provided with at least two floor I beams **38**, which I beams extend substantially the entire longitudinal dimension of the building on either side of the towers A. These I beams **38** have rigidly attached on either side of the vertically extending web of their I cross section, paired straps **40**. Straps **40** extend through, and are fastened to, I beams **38** at the upper and lower horizontal web of the beam. Paired straps **40** protrude outwardly above and below the horizontal webs of beam **38** in parallel vertical relation to the central vertical web of the I cross section. Each of the straps **40** has defined in its upper and lower ends aligned pin apertures **42**. These apertures are given a cross section equivalent to that of strap apertures **33** in straps **32** so that pins **35** can be subsequently inserted therethrough.

Referring to FIGS. **6** and **7**, when strap **32***a* is dependingly fastened from end **24** of beam **22**, floor I beam **38** is raised into place. Typically, pin apertures **42** on the straps **40** are registered with the aperture **33** at the lower end of each of the straps **32***a*. Thereafter, pin **35** is inserted between the registered apertures **42** of the straps **40** and **33** of strap **32***a*. This process secures the respective beams **38** for each of the floors in place. Thereafter, the remainder of the floor I beams **38** can each be sequentially fastened by repetition of the process herein illustrated. As shown in FIG. **7**, strap **32***b* will be secured by a pin **35** in the aligned apertures **42** and **33** below I beam **38**. Thereafter, the next sequential floor will be fastened to the lower end of strap **32***b* in a similar fashion.

In the fastening of the floors from the topmost portion of the structure, it will be realized that the straps fastened to the outwardly protruding ends **24** must carry all of the weight of the floors therebelow. As the straps interconnect the lower floors of the building, the tensional loading to which they are subjected will decrease. Accordingly, the straps themselves can be of decreasing cross section. Referring to FIG. **7**, it will be seen that strap **32***a* has a relatively larger cross section than strap **32***b*. As strap **32***b* will not have to support the live and dead weight of floor E1, its cross section may be decreased. Similarly, the cross section of the remainder of the straps for each of the lower floors can be correspondingly decreased. Such a decreasing cross section is illustrated schematically by the tapered straps **32** shown in FIG. **3**.

With specific reference to FIG. **4**, it will be noted that all of the floor supporting straps **32** are immediately adjacent the sidewalls of the respective towers A. It is preferred that straps **32** be as close to the tower sidewalls

as possible; typically, this is limited only by the width of the securing members necessary to attach the straps to the floors and the necessary clearance between the tower sidewalls and floors for providing the anticipated pendulous movement of the floors relative to the tower.

Once each of the two I beams **38** for each floor are in place, they are typically interconnected by structural members extending horizontally of the floor and fastened to each of the beams. As such structural members extending between beams are well understood, they will not be discussed further herein.

The floor construction here illustrated has been shown utilizing I beams **38** as the main supporting members of the floors. While such beamed floor construction is conventional, it should be understood that this building construction is not necessarily limited thereto. Virtually any floor construction can be used; the only limitation required is that the floors be constructed so that they can be supported by the depending straps from the tower tops.

To provide the improved earthquake resistance of this invention, it is necessary that each of the floors E be permitted to pendulously move with respect to its central and supporting tower or towers A. While such pendulous movement is desired within certain limits, it is also necessary that it be restricted so that wind loadings and the like will not cause excessive building floor movement. The apparatus through which such restricted pendulous movement is achieved is illustrated in FIG. **9**.

With reference to FIG. **9**, a longitudinally extending floor beam **38** is illustrated adjacent a section of a corner of tower A. It will be seen that an angle bar **48** is embedded at the corner of the tower A adjacent floor I beam **38** and transverse floor member **46**. The respective bars of angle bar **48** are each positioned to form part of the corner sidewalls of the tower.

Beam **38** and floor member **46** have fastened thereto an angle plate **50**. Plate **50** in turn has two pins **51** and **52** which extend outwardly and toward angle bar **48** at the respective corner forming bars thereof.

Under normal conditions of loading, pins **51** and **52** do not contact or touch angle bar **48** embedded at the corner edge of tower A. When, however, the building is subjected to dynamic loadings such as wind loadings and the like, movement of the pins toward and away from the angle bar **48** can occur. As is apparent, should either the loadings of the building or the settling of the structure cause small movements of the tower A with respect to the floors E, the length of the pins **51** and **52** can be changed to accommodate such unavoidable dimension changes.

As here illustrated, each of the successive floors E has been supported by two straps depending from the top or upper portion of each tower A. As two longitudinally extending I beams **38** are provided extending between and on either side of the supporting towers, each floor is thus dependingly supported at four points. It will be appreciated that the suspension of these floors can occur at more than four points. However, the four point suspension illustrated in this invention includes an advantage which can best be illustrated with reference to FIG. **10**.

Referring to FIG. **10**, it will be seen that each of the beams **38** is subjected to two well understood types of loadings. Beam **38**, as extending between the straps **32** fastened to each of the towers A, will be loaded as a span at section **54** between straps **32**. The ends of the beam, however, will be loaded similar to a fixed end or cantilevered type of beam at sections **55**. As illustrated in FIG. **10**, loadings F on cantilevered section **55** of beam **38** will tend to deflect the beams downwardly about their pinned attachment to straps **32** and deflect medial section **54** of beam **38** upwardly. Such upward deflection, however, of the medial section **54** will be opposed by the normal live and dead weight loadings F on the medial section. As upward flexure of beam **38** in medial section **54** results from the loadings of the cantilevered sections **55**, section **54** is in effect prestressed. This prestressing permits the cross sectional area of the beam **38** in section **54** to be reduced, considerably lessening the weight of the dependingly supported floor E and the entire building structure. It will of course be apparent that such preferred loading is not dependent upon the presence of beams similar to I beams **38**, but will be present in virtually any type of flooring capable of accommodating the cantilevered construction.

Thus far, the construction of this building has been illustrated utilizing two towers A. As will be apparent, this construction can be made using a single tower A as illustrated in FIG. **11**.

Referring to FIG. **11**, a building construction utilizing a single tower A is illustrated in side elevation. As previously described, the single tower A is of a horizontal core cross section. Typically, beams **22** are placed at either end of the core overlying at each end a sidewall of the hollow tower construction. It will thus be seen that the beams **22** when loaded with the weight of the dependingly supported floors, will load directly the sidewalls of the tower. Such a direct loading of the tower sidewalls will permit the load of the beam to be directly transferred to the vertical section of the walls. This will avoid the necessity of embedding the slip form or capping the tower with steel to distribute the loading of the beam on the tower section.

It should be apparent to the reader that buildings practicing the principles of this invention can use more than two towers. Likewise, while several embodiments of this invention have been shown and described, it will be apparent that other adaptations and modifications of this device can be made without departing from the true spirit and scope of the invention.

What is claimed is:

**1.** A building construction comprising: a foundation; a tower having vertical side walls mounted on said foundation and extending upwardly from said foundation the height of said building; a plurality of two-ended horizontal support members resting on the top of said tower and spanning outwardly therefrom immediately beyond the side walls of said tower only; tensive support members supported from said ends of said horizontal support members and depending vertically downwardly therefrom immediately adjacent the side walls of said tower; a first platform attached to said horizontal support members for forming the roof of said building; a second platform for forming the uppermost floor of said building, said second platform defining an aperture for receiving said tower therethrough and for permitting movement of said floor relative to said tower; means for attaching said second platform to each of said first tensive support members immediately adjacent said defined aperture only with said second platform being cantilevered outwardly from said ten-

sive support members to all the edges thereof, whereby said second platform is pendulously suspended from the top of said tower.

2. The building construction of claim 1 further comprising: a third platform for forming a floor below said uppermost floor of said building, said third platform defining an aperture for receiving said tower therethrough and permitting movement of said floor relative to said tower; second tensive support members dependingly supported at their upper end by said first tensive support members; and means for attaching said third platform to each of said second tensive support members immediately adjacent said defined apertures only with said third platform being cantilevered outwardly from said second tensive support members to the edges thereof, whereby said third platform is pendulously suspended from the top of said tower.

3. A building construction comprising: first and second foundations; first and second towers, each tower having vertical side walls and being mounted on a corresponding one of said foundations and extending vertically upward therefrom substantially the entire height of said building; two-ended horizontal support members attached intermediate said ends to the top of each of said towers and spanning outwardly immediately beyond the side walls of the supporting tower only, with the horizontal support members mounted on each of said towers being formed independently of and separate from the horizontal support members mounted on the other of said towers and the spatial interval between said towers being unoccupied by said horizontal support members; tensive support members supported from said ends of said horizontal support members and depending vertically downwardly therefrom immediately adjacent the side walls of each of said towers; a first platform suspended from said horizontal support members for forming the roof of said building; a second platform defining first and second apertures for receiving said first and second towers therethrough and for permitting movement of said second platform relative to said tower; means for attaching said second platform to said tensive support members immediately adjacent said defined apertures only with said second platform being cantilevered outwardly from said tensive support members to the edges thereof whereby said second platform is pendulously suspended from the tops of said towers.

4. The building construction of claim 3 further comprising: a third platform for forming a floor below said uppermost floor of said building said third platform defining the first and second apertures for receiving said first and second towers therethrough and permitting movement of said third platform relative to said tower; second tensive support members attached at their upper end to said first tensive support members and depending downwardly therefrom; and means for attaching said third platform to said second tensive support members immediately adjacent said defined apertures only with said third platform being cantilevered outwardly from said second tensive support members to the edges thereof whereby said third platform is pendulously suspended from the top of said towers.

5. A building structure comprising: a foundation; a tower having vertically extending side walls mounted on said foundation and extending upwardly therefrom the height of said building structure; a plurality of horizontal spanners resting on the top of said tower, the end of said spanners extending horizontally outward from the top of said tower immediately beyond the side walls of said tower only; at least four vertical support members supported from the ends of said spanners and depending vertically downwardly therefrom immediately adjacent the side walls of said tower; a building floor constructed about said tower and defining an aperture for receiving said tower therethrough and permitting movement of said floor relative to said tower; and means for attaching said floor to said vertical support members immediately adjacent said defined aperture only with said floor being cantilevered outwardly from said vertical support members to the edges thereof whereby said floor is pendulously suspended from the top of said tower.

* * * * *