May 3, 1966 J. C. SHACKELFORD 3,248,828

WAREHOUSE CONSTRUCTION EMPLOYING INDEPENDENT RACK UNITS

Filed June 6, 1961 4 Sheets-Sheet 1

PRIOR ART

Fig. 1.

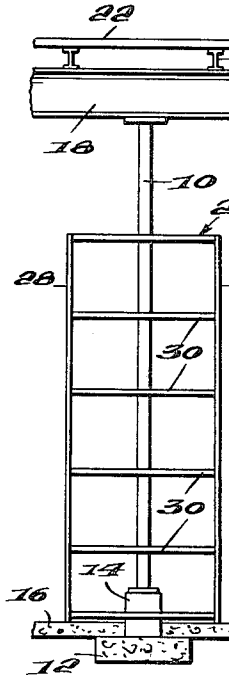


Fig. 2.

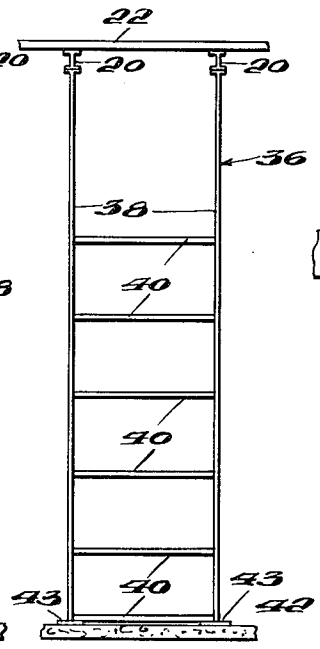


Fig. 22.

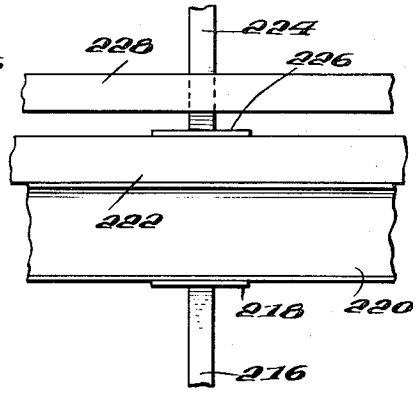


Fig. 21.

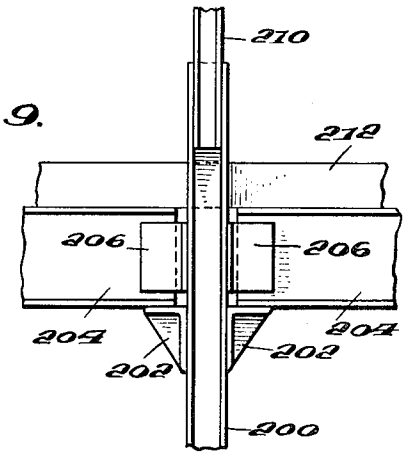


Fig. 8.

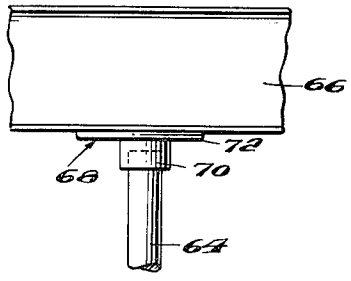


Fig. 9.

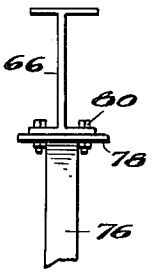
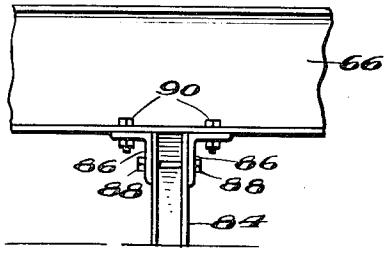


Fig. 10.



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May 3, 1966 J. C. SHACKELFORD 3,248,828

WAREHOUSE CONSTRUCTION EMPLOYING INDEPENDENT RACK UNITS

Filed June 6, 1961 4 Sheets-Sheet 2

Fig. 3.

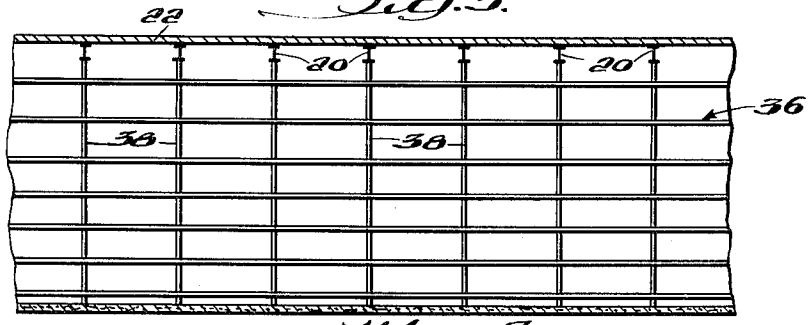


Fig. 4.

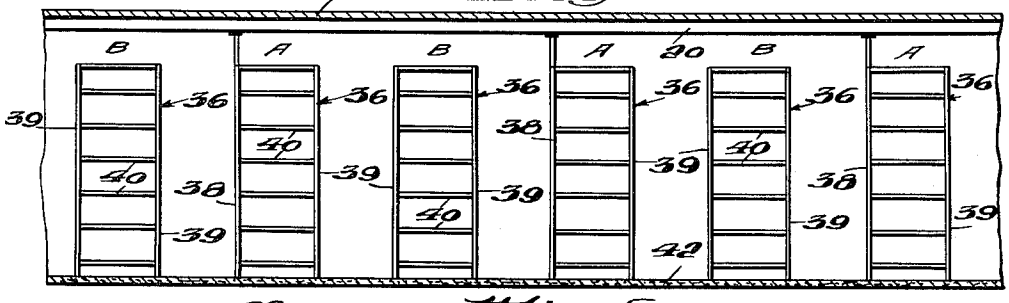


Fig. 5.

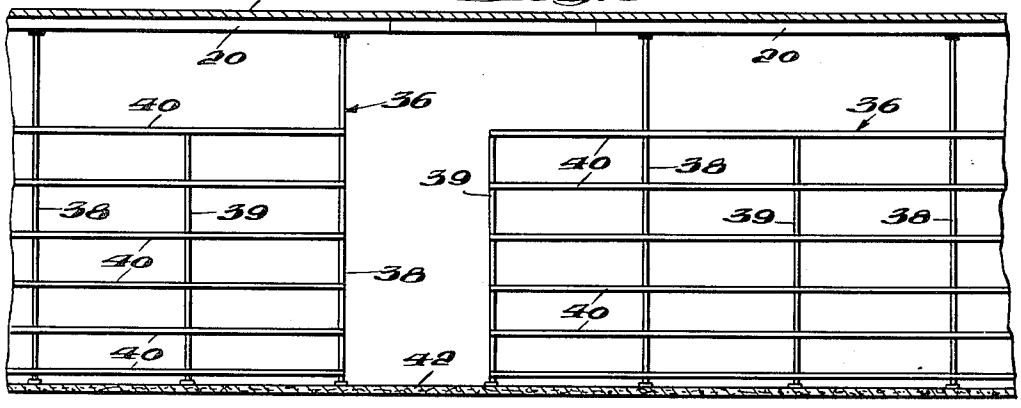
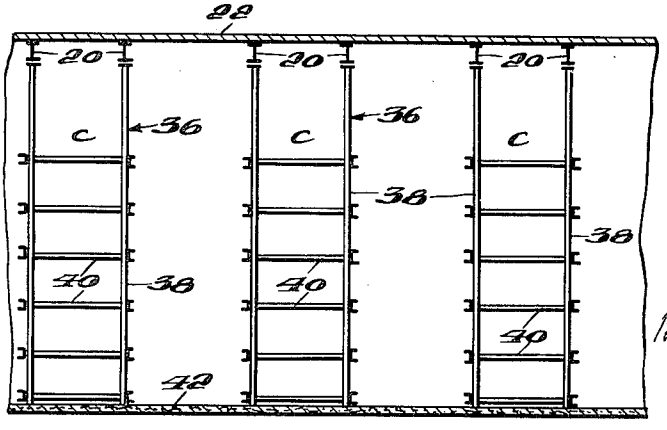


Fig. 6.



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May 3, 1966 J. C. SHACKELFORD 3,248,828

WAREHOUSE CONSTRUCTION EMPLOYING INDEPENDENT RACK UNITS

Filed June 6, 1961 4 Sheets-Sheet 3

Fig. 9.

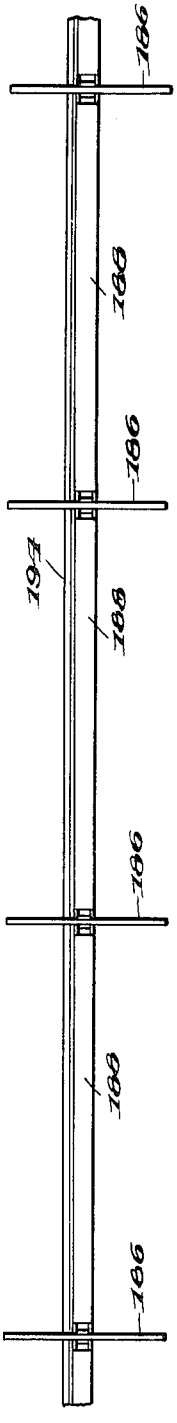


Fig. 7.

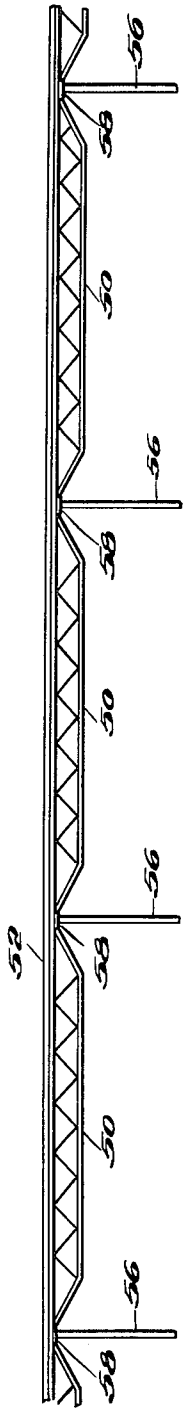


Fig. 8.

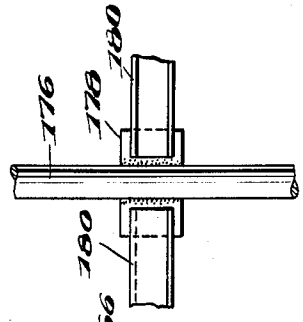


Fig. 17.

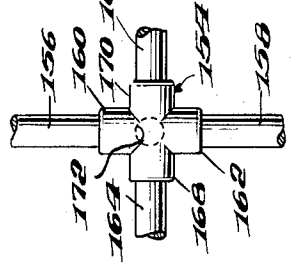


Fig. 16.

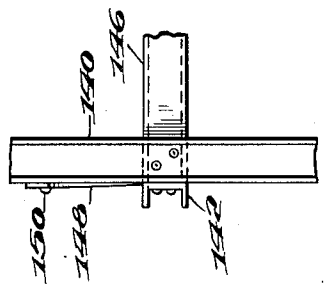
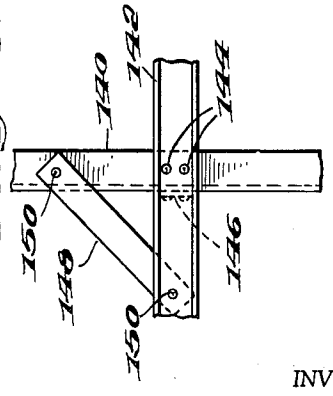


Fig. 15.



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WAREHOUSE CONSTRUCTION EMPLOYING INDEPENDENT RACK UNITS

Filed June 6, 1961 4 Sheets-Sheet 4

Fig. 13.

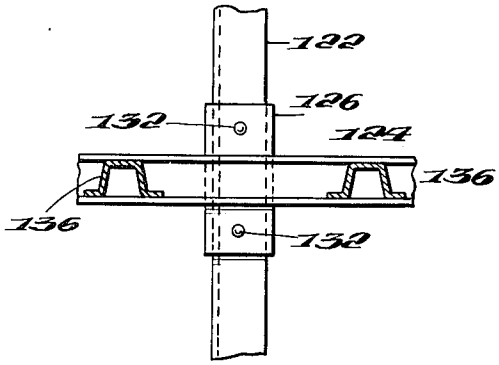


Fig. 14.

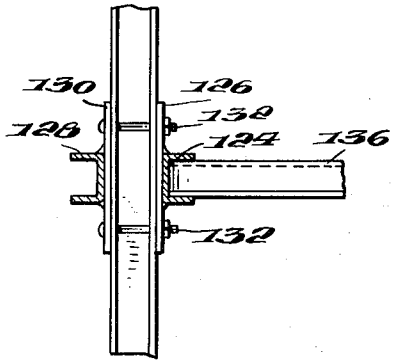


Fig. 20.

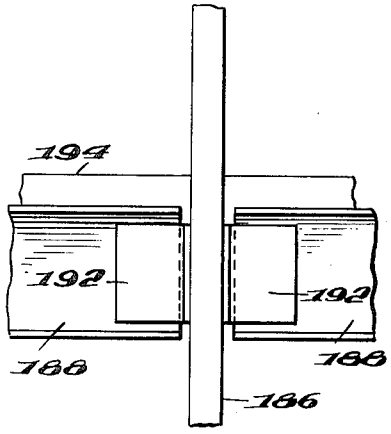


Fig. 11.

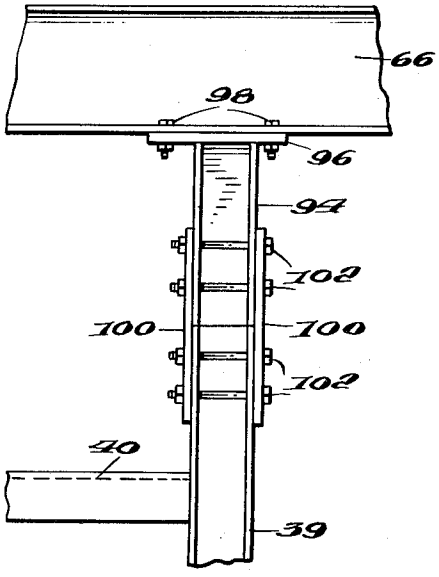
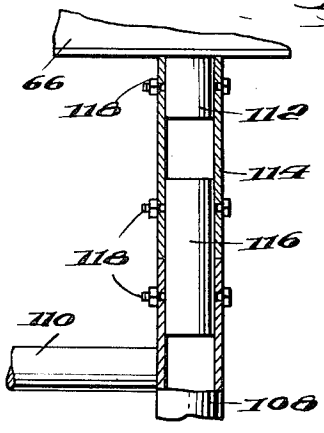


Fig. 12.



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United States Patent Office

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WAREHOUSE CONSTRUCTION EMPLOYING INDEPENDENT RACK UNITS

John Cooper Shackelford, Greenville, S.C., assignor to Potter-Shackelford Construction Company, Greenville, S.C., a corporation of South Carolina

Filed June 6, 1961, Ser. No. 115,176
4 Claims. (Cl. 52—27)

This invention relates to building construction and a method of erecting a building. The particular construction and method involved pertain to warehouses or the like wherein racks, bins, or shelving, for example, are incorporated as an integral part of the building structure.

Warehouses are commonly erected to house series or rows of racks, bins, or shelving structures used for storing a variety of commodities. Considerable effort, expense, and time may be put into the construction of a warehouse and into the designing of a storage system for handling a particular commodity. Various arrangements of racks, bins and shelving have been proposed for certain types of commodities.

However, in the past, regardless of what type of rack, or bin, or shelving arrangement has been used, conventional building methods for warehouses usually are followed. Regardless of the racks, or bins, or shelving, the conventional column and roof members which are well known in the building industry are employed to provide a warehouse structure. In constructing a suitable warehouse, either one of two procedures usually are followed: the building is designed with economical column spacing provided and then the storage structure such as the racks or bins are arranged to try to avoid interference with the columns; or the arrangement of the storage structure is laid out first and then the columns are positioned so as not to interfere with full use of the racks, or bins, or shelves. In either event, the conventional column structure is employed.

In ordinary building construction, such as employed in warehouses, large columns are used for supporting the roof as well as successive floors. The customary procedure for building a single-story warehouse is to first erect concrete foundations, then erect footings or piers upon which the column members can be fixed, next extend roof joists between the several column members, then extend roof purlins between adjacent roof joists, and then erect a roof structure on the roof purlins.

In conventional warehouse construction wherein the building structure is designed prior to the planning of the storage structure, it is desirous that the columns be spaced apart as far as possible in order to provide large, unobstructed areas for the racks or bins of the storage structure. The fewer columns there are, the less interference there will be between the racks or bins and the columns. However, there is a definite limit as to the spacing between columns; and the farther apart the columns are spaced, the larger the column members must be and the larger the roof joists must be in order to support the roof. Expenses of construction are increased greatly and erection procedures may be complicated when the spacing between columns is lengthened to a considerable extent.

It is well known that a column must resist lateral deflection as well as support a vertical load. The critical length of a column is usually considered to be the distance between the points at which the column is rigidly secured against lateral deflection. In conventional warehouse construction, the length of a column is normally the distance between the point where the column is anchored to a footing, and a point where the column is attached to a roof joist. Usually, there are no intermediate members supporting the column against lateral deflection and each column must resist horizontal forces by itself.

Since the strength of a column is dependent upon its ability to resist structural stresses, the moment of inertia of its cross section is an important factor in the determination of its carrying capacity. In the place of the moment of inertia, however, for the purpose of comparison, it is more convenient to use a term referred to as the radius of gyration. In designing a conventional type of warehouse structure, the size of the column is determined generally, not only by the load imposed upon the column, but almost always, by the unsupported length of the column in ratio to the radius of gyration of the particular column member. The unsupported length of a column in conventional warehouse construction is generally the distance from the floor to the roof. Consequently, it is usually necessary that a large structural member be used for a column. The expense of providing large structural members for columns is great; and in addition, the handling and erection expenses are costly.

Columns having their lower ends fixed are stronger than columns having their ends flat, hinged, or round. The stronger the column member is made in this manner, the smaller the structural member required. Consequently, it is a general practice to employ columns having fixed ends. Therefore, in conventional warehouse structures, all of the column members are fixed, and the structure for supporting the roof is a rigid, nonmovable series of large column members.

In the building of a warehouse, after the conventional structure has been erected, then racks, bins, or various types of shelving structures are installed between the column members. The racks, bins, or shelving structures are normally prefabricated in units but sometimes assembled separately. Whatever type of racks, bins, or shelving structures are employed, generally there are groups of vertical members which support several spaced-apart horizontal members.

In conventional warehouses, the storage structure is entirely independent of the building structure. There is no cooperation between the column members and the storage structures for supporting the roof. The storage structures are erected in place as necessary for suitable operation of the warehouse, and the only association between the storage structure and the columns is that the storage structures must be arranged so that there will be no interference by the columns. Usually the storage structures are arranged in aisles for access, with the storage structures aligned with the columns.

Ordinarily, in conventional warehouse structures, there is no physical connection between the storage structures and the columns, unless it is desired that a temporary connection be made to prevent inadvertent movement of the storage structure. It is desirable that no physical connection be made between the storage structure and the column members because, on occasions, it may be necessary to rearrange the storage structure. Because conventional column members are designed to carry the roof without lateral support, actually there is no need for connecting the column members and the storage structures.

Attempts have been made to support the horizontal members of a storage structure directly on the column members of a warehouse. One arrangement, for example, is shown in Patent No. 2,003,670, issued June 4, 1935, to Robert C. Walker. This patent discloses the use of specially designed column members for supporting the floors and the roof of a library structure. The special column members allow the horizontal members of the

storage structure to be attached to or removed from the column members. This merely eliminates the vertical members employed in conventional storage structures. Generally, however, the building is constructed in the usual manner and employs the conventional type of column members.

Conventional warehouse structures are relatively expensive. Obviously, there is a great need for inexpensive warehouse construction that has all the advantages of conventional warehouses. Although conventional warehouse structures have been entirely suitable in the past, the expense involved in erecting the structure is exceedingly burdensome and in some instances prohibitive. There is a great need and demand for large scale warehouse construction which is less expensive than the conventional type of construction.

The primary object of this invention is to provide a construction for a warehouse and a method of erection which is more economical than conventional construction, and yet which has all of the advantages of conventional warehouse structures.

In general, this object is accomplished by providing warehouse construction wherein the customary columns, or the column and girder type of erection is eliminated. Instead, the roof structure is carried and supported by the storage structure. Rather than have a few extremely heavy and expensive column members which are fixed at both ends for supporting a roof load, this invention provides for a large number of smaller vertical members extending from the floor to the roof and supported against lateral deflections at numerous points throughout their length.

This invention provides for a series of upright or vertical members which have two basic functions, one to support the horizontal members of the storage structure, and the other to support the roof load. The roof, in effect, is divided into numerous small areas, the load of each of which is carried by a single vertical member. The roof load carried by the vertical member is relatively small in comparison with the load carried by a conventional column member. Furthermore, the roof load carried by a single vertical member is small compared with the load usually placed on the vertical member by the horizontal members of the storage structure. Accordingly, in order for the numerous vertical members of the storage structure to support the entire roof load of the warehouse, it usually is not necessary that a significant increase in the size of the vertical members be made over the size of the vertical member in conventional storage structure. Generally, the vertical members of this invention will be the same size which would normally be required to support the horizontal members of conventional storage structures.

In the structure of this invention, the horizontal members of the storage structure support the vertical members against lateral distortion and lateral movement. It is well known, and as explained above, the strength of a column or vertical member is related directly to its unsupported length. In this structure, numerous points of support against lateral movement are provided throughout the vertical member. For example, where a conventional column member may have no points of support between the floor and the roof, in this structure, there will be numerous points of support preventing the lateral distortion of the vertical members. Therefore, the size of the vertical member in this structure can be significantly smaller in cross section than conventional column members.

In addition to eliminating conventional column members, this structure eliminates many undesirable features of conventional construction. Large roof joists normally are supported directly on conventional columns. These are eliminated by this construction and the roof is supported at numerous points throughout its area rather than at a few concentrated points as with conventional column construction. Additionally, because conventional columns

are eliminated, the customary column foundations, including footings and piers, are omitted in this structure. This is accomplished by supporting the roof structure directly on a floor slab at several points through the vertical members.

In general, a suitable large number of vertical members are provided and bear directly on a floor slab through a bearing plate on the bottom thereof. Bearing plates on the tops of the vertical members allow the roof purlins to be supported directly on the vertical members. Horizontal members extend between the numerous vertical members in spaced-apart rows and are securely attached thereto by bolting, welding, or suitable connecting means. Normally, the vertical members and horizontal members would not be moved after being erected in position with the roof of the building supported thereon. Once erected, the horizontal members cooperate with the vertical members to securely and safely support the roof load. Unlike conventional construction, it is possible that the vertical members can be moved even after the building has been erected, and provision may be made for this.

This construction is particularly suitable for single-story construction, although it is adaptable to multi-story buildings by applying the same principles of construction used in a single-story structure. The vertical members in multi-story structures directly support the floor decks and the roof, and the horizontal members of the storage structure cooperate with the vertical members in this respect. Throughout the building, the horizontal members of the storage structure cooperate with the vertical members to provide numerous points of support along the vertical members between the floors for preventing lateral deflection of the vertical members.

In the erection of a warehouse structure, the spacing of the vertical members must of course be co-ordinated with the spacing of the roof support members, the purlins for example. Great latitude of design is available, however, because each of the vertical members employed in the storage structure is not necessarily needed for supporting the roof load. This gives the warehouse great versatility in the arrangement of the storage structure. In this connection, bearing plates are located at the bottom of each vertical member, and a detachable connection may be made at the top of the particular vertical members which actually support the roof. The vertical members need not be fixed permanently in place.

A change of design of the storage arrangement can be effected easily by changing the support of the roof to various ones of the vertical members in accordance with the storage structure arrangement desired. For example, in one storage arrangement, it may be desirous to have wide aisles. This might necessitate the removal of certain portions of the storage structure. If it happens that part of the storage structure which is to be removed contains vertical members which support the roof, then the roof load can be transferred to certain ones of the vertical members which are to remain.

These embodiments of the invention are illustrated in the accompanying drawings, in which:

FIG. 1 is a side elevation view showing a portion of typical warehouse construction;

FIG. 2 is a side elevation view comparable to FIG. 1, and showing the construction of this invention;

FIG. 3 is a side elevation view showing a portion of a warehouse using the construction of this invention for supporting the roof;

FIG. 4 is an end elevation view corresponding with FIG. 3;

FIG. 5 is a side elevation view showing a modification of the roof-supporting structure of this invention;

FIG. 6 is an end elevation view corresponding with FIG. 5;

FIG. 7 is a side elevation view showing a modification of the construction of this invention employed with truss-type structure;

FIG. 8 is an enlarged side or end elevation view showing in detail a connection between a vertical member and a roof purlin;

FIG. 9 is a side or end elevation view showing a modification of the structure of FIG. 8;

FIG. 10 is a side or end elevation view showing another modification of the structure of FIG. 8;

FIG. 11 is an enlarged side or end elevation view showing an extension structure for connecting a vertical member and a roof purlin;

FIG. 12 is a side or end elevation view showing a modification of the structure of FIG. 11;

FIG. 13 is an enlarged side elevation view showing in detail a connection between horizontal and vertical members of the storage structure;

FIG. 14 is an end elevation view corresponding with FIG. 13;

FIG. 15 is a side elevation view showing in detail a modified connection between horizontal and vertical members of the storage structure;

FIG. 16 is an end elevation view corresponding with FIG. 15;

FIGS. 17 and 18 are side elevation views showing in detail other modifications of the connection between horizontal and vertical members of the storage structure;

FIG. 19 is a side elevation view showing a modification of this construction suitable for multi-story construction;

FIG. 20 is an enlarged side elevation view of a detail of the structure shown in FIG. 19;

FIG. 21 is an enlarged side elevation view showing a modification of structure suitable for multi-story construction; and

FIG. 22 is an enlarged side elevation view of still another modification of structure suitable for multi-story construction.

In FIG. 1 there is illustrated a portion of conventional construction commonly used in erecting warehouses. This conventional construction employs a group of columns **10**, only one of which is illustrated. The conventional column **10** may be an H-section member or other suitable structural steel member. Sometimes, in warehouse construction, the column members are made of reinforced concrete.

In the conventional type of construction illustrated in FIG. 1, the column **10** is supported by a suitable reinforced concrete footing **12** and an upright pedestal **14**. The footing **12** illustrated in FIG. 1 is merely shown in diagrammatic form. Usually, such footings are more complex than illustrated.

A concrete floor **16** is cast in place after the footings and pedestals for the columns are erected. In FIG. 1 the pedestal **14** is shown as extending above the floor **16**. In some cases, however, the column **10** will extend downwardly through the floor and have a suitable bearing beneath the floor level.

In conventional warehouse construction, a roof girder or beam **18** extends horizontally for a considerable distance and bears upon two or more of the columns **10**. The size of the roof girder **18** is determined according to many factors such as the spacing between the roof girder, the roof load to be supported, etc. Roof purlins **20** rest upon and extend laterally of the roof girder **18**. These purlins **20** support the roof structure **22**, which for example, may include roof slab units which extend between adjacent purlins **20**.

A warehouse constructed in this conventional manner provides covered floor area for the storage of a variety of commodities. It is customary that a suitable storage structure be installed in the warehouse for supporting the commodity. The type of storage structure employed may be in the form of racks, bins, shelves, drawers, etc. The warehouse structure is entirely independent of the type of storage structure employed. Usually, in designing the warehouse structure itself, little or no consideration is given to the storage structure employed, other than to consider the spacing of the columns.

In FIG. 1 there is illustrated a representative type of storage structure **26**, which may include, for example, vertical members **28** for supporting horizontal members **30**. Additional storage structure may be employed in connection with the structure **26**, for example, partitions between the vertical members **28**, drawers, shelves, etc., might be supplied. The conventional type of storage structure **26** is installed in the warehouse after the warehouse structure has been completed, or nearly completed, but in most cases after the column and roof structures are in place.

The conventional storage structures **26** usually are not tied or fastened to the columns **10** and do not provide lateral support for the columns **10**. The storage structures **26** may be in form of completed units, or they may be prefabricated and installed in sections, or they may be preassembled or assembled in place. They may be of any form suitable for the particular warehouse and the commodity to be handled. Normally, such conventional storage structures **26** can be moved around and placed to form aisles for access to the storage structure as necessary and desired.

In FIG. 2, for purposes of illustration, there is shown generally the construction of this invention. The conventional columns **10** are eliminated, as well as the foundation and pier members, and the conventional roof beams or girder members. This construction includes a combined support and storage structure **36** having vertical members **38** and horizontal members **40**. The vertical members **38** normally are continuous from a floor structure **42** to the roof. The horizontal members **40** are rigidly and securely attached to the vertical members **38** and supply lateral support throughout the length of the vertical members. The roof purlins **20** are located directly over and are supported by the vertical members **38**, and the roof structure **22** is supported on the purlins **20** in the usual manner.

The storage structure **36** rests upon a concrete slab **42**, or other floor construction, which may be suitably strong as necessary to support the roof **22** though the storage structure **36**. In this manner, the roof load is, in effect, divided up into numerous small units, each one of which is supported directly by a vertical member **38** of the storage structure **36**. In turn, the roof load is directed to the concrete slab **42** or other floor construction at numerous points. Conventional roof and purlin structure may be employed, and in addition, a conventional floor slab construction may be used. The vertical members **38** rest on suitable plates **43** in order to distribute the load to a wide area, rather than a concentrated area.

This structure may be employed effectively without the need for heavy vertical columns because the numerous horizontal members **40** of the storage structure **36** provide lateral support for the vertical members **38**. The strength of the vertical members **38** is related directly to their unsupported length. This structure provides for numerous points of support along the vertical members **38** between the floor and the roof. Therefore, the size of the vertical members **38** can be kept at a minimum. Ordinarily, the vertical members **38** of this construction need not be any heavier or larger than the vertical members **28** used in the convention storage structure **26**.

In FIGS. 3 and 4 there is illustrated a section of a warehouse employing the construction of this invention and showing how the storage structure **36** can be arranged into suitable aisles for access and how the vertical members **38** can be employed to support the roof **22**. The storage structures **36** are arranged in rows A and B to provide aisles between adjacent units of vertical members **38** and **39**, and horizontal members **40**, as shown in FIG. 4. The rows of storage structure **36** formed in this manner extend laterally or crosswise of the roof purlins **20**. In rows A vertical members **38** extend from the floor **42**

upwardly far enough to support a roof purlin **20**. Vertical members **39**, opposite the vertical members **38**, extend upwardly to support the horizontal members **40** but are somewhat shorter and do not extend upwardly to the roof. The horizontal members **40** span the distance between vertical members **38** and **39** and support the vertical member **38** against lateral deflection imposed by the roof load and the storage load.

The storage structure **36** in rows B does not employ vertical members **38** which extend all the way upwardly to the roof purlins **20**. This resembles conventional storage structure in that the only function of the vertical members is to support the horizontal members which receive the commodities to be stored in the warehouse.

In FIGS. 5 and 6 there is shown a modified arrangement of the storage structure **36**. The rows C of storage structure **36** formed by vertical members **38** and **39**, and horizontal members **40** are aligned longitudinally with the roof purlins **20**. As shown in FIG. 6, each vertical member **38** in a row laterally of the purlins **20** extends from the floor **42** upwardly far enough to support the roof purlins **20**. As shown in FIG. 5, however, vertical members **38** are arranged in alternate rows with shorter vertical members **39**.

As in the arrangement of the storage structure **36** illustrated in FIGS. 3 and 4, the horizontal members **40** extending between the vertical members **38** and **39** to provide numerous points of support along the vertical members for preventing lateral deflection of the vertical members **38**. In this manner, suitable strength and rigidity is provided for the vertical members **38** in order that these relatively small size vertical members may securely and safely support the roof structure **22** and the storage load.

Only two of the many possible arrangements of the storage structure **36** have been illustrated, in FIGS. 3 and 4, and in FIGS. 5 and 6. This structure **36** can be arranged depending upon the type of commodity to be accommodated in storage. For example, with reference to FIG. 4, the rows B might be eliminated if extremely wide aisles were desired and if deep shelves were needed, the horizontal members **40** could be made considerably longer with respect to those illustrated in FIG. 4.

Unlike the usual type of warehouse, when erecting a warehouse employing this construction, it is necessary in the initial stages of planning that consideration be given to the storage structure members as to their size and resultant strength. This is considerably different from the usual problems encountered in ordinary warehouses. In conventional warehouse construction, the structures employed to form the warehouse are not dependent upon the size of the storage structure members; however, in the structure of this invention, the size and strength of the vertical and horizontal members **38** and **40** of the storage structure **36** are important aspects of the overall warehouse structure.

In FIG. 7 there is illustrated a truss-type roof construction employing an arrangement of storage structure slightly different from that illustrated in FIGS. 3 and 4 and in FIGS. 5 and 6. In this type of truss construction, purlins **20** are not employed, but rather, truss sections **50** are used to support a roof structure **52**. Vertical members **56** of a storage structure, for example, a storage structure of the type illustrated in FIGS. 3 and 4 and in FIGS. 5 and 6, are employed at spaced intervals predetermined according to the length of the truss sections **50**. The tops of the vertical members **56** are supplied with plates **58** upon which bear the ends of adjacent truss sections **50**.

Because the truss sections **50** are not continuous throughout the length or width of the warehouse, it is necessary that the vertical members **56** be fixed or stationary. It is necessary that a vertical member **56** always be located at abutting ends of the truss sections **50** as shown in FIG. 7. However, vertical members **38** are employed between the vertical members **56**, as necessary, to support the horizontal members **40**. These horizontal members **40** in turn are securely attached to and provide the necessary horizontal support for the vertical members **56**.

The vertical members **38**, **39** and **56**, of this construction, may be of any type of suitable cross section configuration. For example, the vertical members in cross section might be channels, angles, hat-sections, pipe or tube sections, C-sections, H-sections, Z-sections, or various built-up or combination sections. Because the vertical members of this construction can be relatively light or small as compared with the columns of conventional warehouse construction, a variety of cross sectional shapes may be employed.

In FIG. 8 there is illustrated a vertical member **64** of tubular cross section for supporting a roof purlin **66**. Suitable bearing between the vertical member **64** and the purlin **66** is achieved by a bearing member **68** having an enlarged section **70** for receiving the vertical member **64** and a horizontally extending plate section **72** upon which the purlin **66** may bear. The vertical member **64** may be threaded into the enlarged portion **70**, for example, or the connection may be a tight fit. While it is generally desirous that the vertical members of the storage structure not be fixed permanently or immovably, it may be predetermined that certain vertical members are not to be moved. In this case, the vertical members **64** can be permanently fixed to the purlins **66** by welding the purlin **66** to the horizontally extending plate portion **72** of the cap member **68**, however, nut and bolt devices could be used, if desired.

In FIG. 9 there is illustrated a vertical member **76** to the top of which there is welded a plate **78** of suitable horizontal dimensions to receive a roof purlin **66**. A connection between the vertical member **76** and the purlin **66** is made by nut and bolt devices **80** extending through holes provided in the plate **78** and the lower flange of the purlin **66**. The nut and bolt devices **80** may be disconnected to allow the vertical member **76** to be moved if desired.

In FIG. 10 there is shown another modification of a connection between a vertical member **84**, for example, a channel member, and the purlin **66**. A pair of angle clips **86** are attached to opposite flanges of the vertical member **84** by nut and bolt devices **88**. The attachment could be made by welding if desired. The outstanding legs of the angle clips **86** provide a horizontal bearing for the purlin **66**. A detachable connection is made between the angle members **86** and the lower flange of the purlin **66** by nut and bolt devices **90**. These nut and bolt devices can be disassembled in order that the vertical member **84** can be moved if desired.

In FIG. 11 there is illustrated a modified structure whereby vertical members **39** can be employed to support the roof purlins **66**. The vertical members **39** might not be long enough to extend from the floor to the roof purlins. A short upright member **94** which may have the same cross sectional configuration as the member **39** is provided with a plate **96** at the top thereof, and the plate is fastened to the roof purlin **66** by nut and bolt devices **98**. The short upright member **94** is positioned directly above the vertical member **39** and is of sufficient length to span the distance between the purlin **66** and the vertical member **39**. After the members **39** and **94** are aligned vertically, a pair of splice bars **100** are securely fastened to each of the members **39** and **94** by nut and bolt devices **102**. This construction allows the short vertical members **39** to be adapted for use in supporting the roof loads. Similarly, as when the long upright vertical members **38** are employed, the horizontal members **40** provide suitable horizontal bracing against lateral deflection of the vertical members **39**. If necessary, suitable bracing can be extended between the uppermost horizontal member **40** and the short upright member **94**. Normally, this will not be

necessary because the upright member **94** will be relatively short.

In FIG. 12 there is illustrated a modified form of structure whereby the short vertical members **39** can be adapted to support the roof loads. A vertical member **108**, which in this instance is a tubular member supported by horizontal members **110**, is located in position beneath the roof purlin **66**. A relatively short block member **112** is attached to the lower flange of the roof purlin **66** directly above the vertical member **108**. A sleeve member **114** having generally the same diameter as the vertical member **108** is extended between the top of the vertical member **108** and the bottom of the roof purlin **66**. The block member **112** is of suitable diameter compared with the inside diameter of the sleeve member **114** so that the sleeve member **114** may easily slide over the block member.

In assembling the structure an insert member **116** of suitable diameter is fitted into the top of the vertical member **108** and into the bottom of the sleeve **114**. These members are held in position, as shown in FIG. 12, by nut and bolt devices **118**. The block member **112** and the insert member **116** may be tubular or may be solid members. This form of construction allows the vertical member **108** to be easily disassembled from its association with the roof purlin **66** and moved to a different location. If needed, suitable bracing can be extended between the sleeve member **114** and the uppermost horizontal member **110** to provide additional support against lateral distortion.

In FIGS. 13 through 18 there are illustrated various forms of structure for connecting the vertical members and the horizontal members of the storage structure. It is necessary that the connections be rigid and secure because the horizontal members support the vertical members against lateral distortion. On the other hand, it is desirable that the connection between the vertical and horizontal members be detachable so that the storage structure may be disassembled.

In FIGS. 13 and 14 there is illustrated one type of connection which is particularly suitable for use with channel-shaped vertical members **122**. A channel-shaped horizontal member **124** has a plate **126** securely attached thereto as by welding. The plate **126** is placed against one of the flanges of the vertical channel member **122**. Similarly, a second channel-shaped member **128** has a plate **130** attached thereto as by welding, and the plate is placed along the opposite flange of the vertical member **122** as illustrated in FIG. 14. The two plates **126** and **130** are held securely to the vertical member **122** by nut and bolt devices **132**.

This connecting structure is duplicated at each location where the horizontally extending members **124** and **128** contact a vertical member **122**. Members **124** and **128** may extend for a considerable distance in a horizontal direction depending on the arrangement of the storage structure. Normally, there will be several rows of the horizontal members **124** and **128** spaced apart vertically to form the storage structure. These horizontal members **124** and **128** are suitably strong in order to provide numerous points of support along the vertical member **122**.

In completing the storage structure, a series of horizontally extending members **136** are mounted between the horizontal members **124**, for example. The members **136** may be hat-shaped sections, as illustrated in FIG. 13, or they may be of any other suitable cross sectional configuration. After the members **136** are assembled between the horizontal members **124**, considerable additional rigidity and strength is added to the vertical members **122**. The members **136** may be attached to the horizontal members **124** by nut and bolt devices or by welding, if desired.

The vertical members **122** together with the horizontal members **124** and **128** and the members **136** form the supporting structure for the roof. In addition, these members form the basic framework for the storage structure. In order to complete the storage structure, additional members may be added as necessary depending on the type of storage structure desired. For example, suitable shelving can be laid upon the members **136**. If desired, closed bins or racks or drawers can be built on the basic framework. The manner in which the storage structure is completed will depend upon the commodity to be stored.

In FIGS. 15 and 16 there is illustrated a modified form of connecting arrangement between the vertical members and horizontal members. A vertical member **140** which, for example, may be a channel member, has a horizontal member **142** attached directly to one of its flanges by nut and bolt devices **144**. The horizontal member **142** usually will extend a considerable distance between various vertical members similar to the member **140**, and there will be a number of horizontal members **142** spaced apart vertically. Additional horizontal members **146** extend between vertical members **140** in a direction perpendicular to the horizontal members **142**. The members **146** are connected directly to the web of the vertical member **140** by nut and bolt devices **144**.

The horizontal members **142** and **146** strengthen the vertical member **140** against lateral distortion at various points throughout the length of the vertical member **140**. The rigidity of this structure may be enhanced by a brace **148** attached between the vertical member **140** and one of the horizontal members, such as the horizontal member **142**, for example. The connection may be made by nut and bolt devices **150** located a suitable distance from the juncture of the vertical member **140** and the horizontal member **142**.

In FIG. 17 there is shown a connector device **154** of cross-shape for connecting vertical members **156** and **158** and horizontal members **164** and **166**. The vertical members **156** and **158** fit into opposed sockets **160** and **162**. Horizontal members **164** and **166** fit into similar opposed sockets **168** and **170**. Additional socket members **172** are provided for horizontal members which extend perpendicular to the horizontal members **164** and **166**. The connections between the various vertical and horizontal members and the cross member may be in the form of threads for easy assembling and disassembling. This type of connector device is particularly suitable for tubular members or rod members.

In FIG. 18 there is illustrated a type of connection which may be employed when it is not necessarily desirable that the vertical and horizontal members be disassembled. In addition, this type of connection can be used advantageously when the vertical members are different in cross sectional configuration from the horizontal members. A vertical member **176**, a tube or a rod for example, has a plate **178** attached thereto as by welding or other suitable means. Horizontal members **180** are in turn attached to the plate **178** as by welding or other suitable means. Additional horizontal members may be attached to the vertical member **176** or the plate **178** and extended perpendicularly to the horizontal members **180**. By using the plate **178**, a variety of different shaped horizontal members, can be connected securely and easily to the vertical member **176** by attaching the horizontal members directly to the plate **178**.

The construction of this invention is not limited to single-story warehouses, but can be adapted very satisfactorily for use in multi-story warehouses by employing generally the same combination support and storage structure. In constructing a multi-story warehouse, of course it is necessary to take into consideration the load which will be placed upon the vertical members by the several floor decks. A suitable number of the vertical members of the storage structure are employed to support each floor deck, and the horizontal members of the storage structure are relied upon to support the vertical members against lateral distortion.

In FIG. 19, vertical members **186**, which are representative of the vertical members of the combination support and storage construction, can be extended in a vertical direction far enough to support the floor joists **188** of consecutive floor decks and to support to roof. The actual length of the vertical members **186** depends upon the height of the warehouse. The spacing between the vertical members **186** depends upon and is related to the length of the floor joists **188**.

In FIG. 20 there is shown a connection between the floor joists **188** and the vertical member **186** whereby the vertical member can extend upwardly to successive floors and to the roof. Angles **192** are fastened as by welding to each end of the floor joists **188**. The free leg of the angles in turn are attached to the vertical members **186** as by welding, or by nut and bolt devices, or by other suitable means. In this manner, the vertical members **186** can be extended upwardly past the floor joists **188** without interference. The floor structure may be completed by laying a concrete floor **194** on the floor joists **188** in a conventional manner.

The horizontal members of the storage construction support the vertical members **186** as described above in connection with the horizontal members **40**, for example. Throughout the entire length of the vertical members **186** there will be numerous points of support against lateral distortion provided by the various horizontal members at each floor level. The vertical member **186** may be a continuous piece or may be made up of several pieces.

In FIG. 21, there is illustrated a modified form of construction for the vertical members used in multi-story warehouses. A vertical member **200**, for example a channel member, has attached thereto as by welding a pair of brackets **202** which have legs extending outwardly from opposite sides. Floor joists **204** have angle members **206** attached to their ends, and the outwardly extending ends of the angle members in turn are attached securely to the vertical member **200**. The floor joists **204** rest upon the angles **202**, which cooperate with the angles **206** to attach the floor joists **204** securely to the vertical members **200**. The vertical member **200** extends a short distance above the floor joists **204**. A smaller but similar vertical member **210** is aligned vertically with the vertical member **200** and attached thereto to extend upwardly above the vertical member **200**. Vertical member **210** can be secured to vertical member **200** as by welding, by bolting or other suitable means. The two vertical members **200** and **210** cooperated to provide a continuous vertical support member for supporting subsequent floor decks and the roof of the warehouse. The floor construction may be completed by adding a concrete floor **212** on the top of the floor joist **204** in the usual manner.

In FIG. 22 there is illustrated another modified form of construction for use in multi-story warehouses. A vertical member **216** of the storage structure has a plate **218** attached at its top on which rests a floor joist **220**. The floor deck **222** is built upon a series of floor joists such as the joist **220**. A vertical member **224** is aligned vertically with the vertical member **216** and has a plate **226** attached at the bottom thereof. The load of the vertical member **226** bears upon the plate **226** and in turn is applied through the flooring **222** and the floor joist **220**. This load is then supported by the vertical member **216**.

Although the vertical member **224** is illustrated as being aligned vertically with the vertical member **216**, these vertical members do not have to be so related. Suitable support is supplied for the load applied to the floor joist **220** and the other floor joists by vertical members similar to the vertical member **216**. The vertical members **224** on the upper floor can be arranged as desired and do not have to be placed directly over the vertical members **212** on the lower floor. The vertical members **224** on the upper floor will be supported against lateral distortion by the horizontal member **228** and other horizontal members which are a part of the storage structure.

The type of construction set forth in this invention is adaptable to various sequences of erection. The normal sequence which could be employed to take full advantage of this contruction is to prepare the sub-grade, pour the concrete floors, build the storage structure or a suitable amount of the structure including the necessary vertical and horizontal members, install the roof joists or purlins by supporting them directly on the vertical members of the storage structure, install the roof deck on the roof joist, and then install roofing material.

The type of construction disclosed in this invention affords many advantages over conventional type of warehouse construction. Considerable economy may be realized because the conventional column members are eliminated; and instead, the vertical columns used in the storage structure are employed to support the roof, as in a single story structure, for example, or the floor decks as well as the roof in multi-story structures. The relatively large and heavy column members normally employed in warehouse construction are relatively expensive compared with the smaller vertical members of this invention. Not only that, erection problems are simplified because the smaller vertical members are easier to handle and can be manipulated readily.

This invention has been explained be describing specific vertical members and horizontal members. It should be recognized however, that the type of storage structure commonly referred to as "frameless" could be employed. This type of storage structure has vertical and horizontal members, but instead of being slender and elongated as those illustrated, they are flat or sheet-like.

By eliminating the conventional fixed columns, more covered area is available for the storage structure and more freedom in the arrangement of the storage structure is allowed. For example, it is not necessary to construct a storage structure taking into account the positions of roof-supporting columns. There is no interference between the storage structure and the columns as in ordinary warehouse construction. The aisles do not have to be laid out in accordance with the position of fixed columns. In this same respect, a vertical member of the storage structure can be moved as necessary. This can be accomplished by employing temporary supports for the roof structure while the vertical members of the storage structure are rearranged. This is not possible when fixed columns are employed.

In addition to the advantages of economy and flexibility in a storage structure arrangement, additional advantages are afforded by this structure. For example, the storage structure can be used as scaffolding in the erection of the roof structure. Additionally, the vertical members of the storage structure actually can be removed so that the storage structure originally installed can be completely replaced with a different kind of storage structure or newer storage structure, as desired. The construction of this invention is adapted for use both with permanent type of structures as well as temporary warehouse structures. A portion of a warehouse could employ conventional fixed column type of construction, for example, and an adjacent portion could employ the construction of this invention.

While the invention has been illustrated and described in certain embodiments, it is recognized that other variations and changes may be made without departing from the invention as set forth in the claims.

I claim:

1. A method of erecting a warehouse comprising erecting a floor structure; assembling a storage structure, including a series of vertical members and horizontal members; resting the storage structure directly on the floor structure; supporting the vertical members of the storage

structure against lateral distortion at various points along the length thereof by using the horizontal members; supporting a floor deck directly on certain of the vertical members after the storage structure is assembled; then assembling additional storage structure, including a series of vertical members and horizontal members, on the deck structure; supporting the additional vertical members of the additional storage structure against lateral distortion at various points along the length thereof by using the additional horizontal members; and supporting a roof structure directly on certain of the additional vertical members after the additional storage structure is assembled.

2. In a warehouse construction, a plurality of independent rack units serving as a vertical load bearing means and also serving as a storage structure, in combination with a floor deck and a roof deck, each independent rack unit comprising a plurality of vertical members spaced-apart in longitudinal rows and extending intermediately of the floor deck and the roof deck, a plurality of horizontal members spaced-apart vertically and extending longitudinally and transversely between the rows of vertical members, said horizontal members rigidly interconnecting the vertical members to support each vertical member against lateral distortion at points intermediate the length thereof and said horizontal members dividing each vertical member into unsupported lengths of less than the distance between the floor deck and the roof deck, said vertical members bearing directly on the surface of the floor deck, and said roof deck bearing directly on certain ones of the vertical members, said vertical members being of lightweight structural design such that without the horizontal members, the vertical members could not support the roof deck, and means for detachably connecting the certain ones of the vertical members to the roof deck, said independent rack units being spaced-apart to provide aisles therebetween.

3. In a warehouse construction, a plurality of independent rack units serving as a vertical load bearing means and also serving as a storage structure, in combination with two floor decks spaced-apart vertically, each independent rack unit comprising a plurality of vertical

members spaced-apart in longitudinal rows and extending intermediately of the floor decks, a plurality of horizontal members spaced-apart vertically and extending longitudinally and transversely between the rows of vertical members, said horizontal members rigidly interconnecting the vertical members to support each vertical member against lateral distortion at points intermediate the length thereof and said horizontal members dividing each vertical member into unsupported lengths of less than the distance between said floor decks, said vertical members bearing on the lower floor deck, and the upper floor deck bearing directly on certain ones of the vertical members, said vertical members being of lightweight structural design such that without the horizontal members, the vertical members could not support the upper floor deck, and means for detachably connecting the certain ones of the vertical members to the upper floor deck, said independent rack units between adjacent floor decks being spaced-apart horizontally to provide aisles therebetween.

4. In a warehouse construction according to claim 3 further comprising more than two floor decks, and independent rack units between adjacent floor decks.

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