METHOD AND APPARATUS FOR ERECTING MODULAR HIGH-RISE BUILDING

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ABSTRACT

A method and apparatus for erecting a high-rise building comprising a plurality of stacked modules. A wheeled delivery platform transports each module from a truck or the like on rails which extend parallel to a wall of the building and at right angles to the ultimate direction of module insertion in the building. The module is supported on a plurality of wheeled dollies each supported on rails carried by the platform, and these rails extend across the platform at right angles to the direction of movement of the platform. The platform, when properly positioned, has its rails aligned with corresponding rails carried by supporting means in the building structure so that the module can be rolled on said dollies off the delivery platform and into its predetermined position in the building. Alternate vertical columns of modules are provided with jacking means to permit the raising of the entire building by the height of one module plus suitable clearance space to permit the insertion of additional modules which will then comprise the next lower floor of the building. Auxiliary jacking means provides for the raising of each module once it has been placed in its desired position by the amount of the predetermined clearance space to permit it to be secured to the module above it in the stack, and wedges maintain each such module in the elevated position after the auxiliary jacks are removed, thereby eliminating the necessity of at any time lowering the building structure to take up the clearance space.

3 Claims, 18 Drawing Figures
**FIG. 1A.**

**FIG. 1B.**

**FIG. 1C.**

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BACKGROUND OF THE INVENTION

In recent years, a considerable amount of effort has been expended on developing new methods of housing construction which take advantage of the mass production technology that has evolved in most other industries. As a consequence, it is now known that housing structures such as individual homes, so-called "town-houses," and other structures of modest height can more economically be built in factories according to the modular concept, i.e., a concept whereby a portion of such structure is built as a unit or module at the factory, transported to the site, and then assembled together, with the modular units being placed alongside each other and/or above each other in a predetermined configuration.

The available technology has, however, quite generally been limited to the construction of buildings of relatively low height. Thus, the practice generally has been first to place the modules for the ground level in place, and then to stack on top of these the modules for the second floor, and so on. Finally, the top unit with its roof is placed in position. However, it will be readily apparent that this method of construction severely limits the height of such a structure because of the considerable difficulty of lifting a module, weighing a number of tons, from the ground level to any appreciable height.

In order to make more efficient use of available land space, it has become important to develop methods and apparatus which will permit the construction of high-rise buildings of many floors, using factory-built modules. In our copending application Ser. No. 5281, filed Jan. 23, 1970, we have disclosed a modular unit which is particularly adapted for use in the construction of a high-rise building. In our copending application Ser. No. 5296, also filed Jan. 23, 1970, and our copending application Ser. No. 5296, also filed Jan. 23, 1970, and now issued U.S. Pat. No. 3,631,648, issued Jan. 4, 1972, we have disclosed a method for the erection of high-rise building structures formed of modular units. According to the latter application, the method of high-rise building construction disclosed there is quite generally the reverse of that normally employed in that the top floor is constructed first of a plurality of modules and then raised by an amount substantially equal to the height of a module. The second-topmost floor is then constructed by inserting the modules which are to comprise such floor, and fastening them to the modules of the floor above, and the two top floors are then raised another level so as to permit insertion into the building of the modules which make up the third floor from the top. This procedure is repeated until the building is completed.

The construction method of our copending application Ser. No. 5296 referred to above employs modules which are formed in part of reinforced concrete and in part of structural steel members which are readily capable of absorbing both the dead load and the live load ultimately to be imposed upon the structure. The modules are placed upon a series of supporting structures which are permanently fixed in place and form the supports for the building when it is completed. To either side of such permanent supporting structures is positioned a second type of supporting structure which may be temporarily placed and removed when the building is completed and is provided, moreover, with a jacking means which is capable of raising a substantial load.

After the supporting structures are all in place, i.e., both the permanent supports and the temporary supports having the jacking means, a row of modules is placed on the supports and secured to each other as by bolting. When this is done, the temporary supporting structures have their jacking means operated so as to raise the entire top story of the building by substantially the height of a single story. When this is accomplished, the spaces now appearing immediately above the permanent supporting structures are filled by inserting a module in each such position, and when all of these open spaces have thus been filled with modules, the jacking means associated with the temporary supporting structures are all lowered, thereby providing additional spaces in which further modules can be placed. There is then provided a second row of modules which will eventually comprise the second-topmost story of the building. The modules of this row are now all secured together by suitable bolts passing through the structural supporting members. Following this step, the jacking means is again raised to thereby raise the two top stories of the building by substantially the height of a single module, and it will be readily apparent that this again provides empty spaces, one above each of the permanent supporting means into which the additional modules can now be inserted. The above-described procedure is carried out repeatedly until the desired building height is achieved.

In our copending application Ser. No. 32,060, filed Apr. 27, 1970, and now U.S. Pat. No. 3,632,088, issued Jan. 4, 1972, for "Means for Raising Building of Modular Construction," we have shown apparatus which is particularly adapted for erecting a modular high-rise building according to the method of the aforementioned application Ser. No. 5296 and embodying modules of the type disclosed in the aforementioned application Ser. No. 5281. This application Ser. No. 32,060 particularly is directed to the jacking apparatus used for raising the modules by the height of at least a single story of the building, and we have also disclosed in such application apparatus for transporting modules, from a vehicle such as a truck which delivers them to the building site, to the predetermined position for each such module in the building structure. The apparatus disclosed therein provides a plurality of rails over which each module may be rolled and with the rails being so positioned and oriented relative to the building structure that each module is movable in a straight-line path from the transport vehicle and directly into position in the building structure, atop either one of the permanent supporting structures or one of the jacking means.

The apparatus of the present invention comprises an improvement in the module delivery system over what is disclosed in the aforesaid copending application Ser. No. 32,060. Thus, with respect to the apparatus of the earlier application, it was necessary to provide either a set of rails for each module included in a single story in the building so that modules could be delivered from a transport vehicle to any desired position on the ground.
story or floor of the building, or it was necessary to provide a single pair of rails and then move such rails from one position to another for each subsequent module to be positioned within the building. By means of the improved apparatus of the present invention, a pair of rails is provided exteriorly of the building at right angles to the direction of final movement of each module as it is inserted into the building structure, and the rails support a wheeled delivery platform which can be rolled back and forth along the rails to any desired module position. The delivery platform, in turn, supports a plurality of rails which run at right angles to the first-mentioned rails, and each pair of additional rails supports a wheeled dolly upon which the module itself may be placed. Consequently, when the delivery platform is moved to the desired module position, the module then supported upon the latter-mentioned dollies may be rolled off the delivery platform and into place within the building structure.

Of course, in order that a module can be inserted into place when one or more floors of the building have already been erected, it is necessary that the next-higher floor have been raised sufficiently above the supporting structure upon which the module is to be placed to provide adequate clearance for insertion of the module and also the wheeled dollies upon which it rides. A clearance space of about one and one half inches is ordinarily adequate.

Once any module has been inserted into position above its respective supporting structure it is, of course, possible to interconnect such module with those positioned thereabove in the next-higher floor by merely lowering the jacking means so that the entire building is then lowered by the amount of the predetermined clearance space so as to rest upon the newly inserted modules, whereupon all these can then be secured to the modules above. This, however, is not a desired or preferred mode of operation since it necessarily involves a lowering of the entire building structure for each additional floor that is added, and this is not desired because it increases the likelihood that difficulty will be encountered in keeping the building structure entirely level. For this reason, the wheeled dollies on which the module is supported and upon which it rolls into the building structure, are each provided with an auxiliary jacking means which permits raising the module relative to the dollies by the amount of the clearance space so that the module can then be coupled to the modules above. Once this has been accomplished, the wheeled dollies can be removed from the confines of the building structure and used for the emplacement of a further module.

Of course, in the use of the method of building erection described in the aforementioned application Ser. No. 5296, it is contemplated that the final module insertion step to complete the row of modules in a floor of the building will occur only after all of the jacking means which are spaced throughout the building have been lowered, with the building then resting upon the spaced modules which have already been inserted atop the fixed supporting structures. Here again, it is desired that the building not be lowered from the position to which it has already been raised, and for this reason the improved method of the present invention contemplates that suitable shims or wedges will be provided underneath each of the already positioned modules of the bottom row so as to support each of these above its respective fixed supporting structures by the necessary amount of clearance as required to permit insertion of the remaining modules above the respective jacking means. When these remaining modules are all inserted in place, then they too are raised by the auxiliary jacking means associated with their respective wheeled dollies so that each of these can in a similar manner be secured to the module directly above, thereby completing an interconnected row of modules constituting a further floor of the building. Thereafter, the entire building is once again raised by the height of one floor of the building so that the process can again be repeated. As mentioned above, it is a characteristic therefore of the use of the apparatus of this invention that it permits an improvement in the method of building construction in that at no time is the portion of the building which has already been raised required to be lowered and yet adequate tolerance is provided between the then-existing second floor of the building and the permanent supporting structures and also each jacking means to permit the easy insertion of modules with the desired clearance space as required.

It is therefore an object of this invention to provide apparatus which makes possible the rapid erection of a modular, high-rise building by facilitating the positioning and placement of modules in the building structure. It is another object of this invention to provide an apparatus and method for the erection of a modular high-rise building which permits the raising of the building, a floor at a time, without requiring that the portions raised at any time be lowered.

BRIEF DESCRIPTION OF THE DRAWINGS

In describing this invention, reference will be made to the accompanying drawings in which:

FIGS. 1A–1F diagrammatically illustrate the method of building erection of this invention;
FIG. 2 is a perspective drawing of a module such as is used in the construction of a high-rise building according to the present invention and also the means for transporting such module to facilitate its easy insertion into the building structure;
FIG. 3 is a plan view of the apparatus of the present invention for placing and supporting and jacking the high-rise modules of this invention;
FIG. 4 is an end view of the high-rise building of this invention during construction, showing particularly the arrangement of the jacking means and fixed supporting structures and the end towers which support the end modules;
FIG. 5 is a side view of the apparatus of FIG. 4 illustrating the manner in which the module conveying apparatus situated exteriorly of the building cooperates with the supporting means or jacking means positioned within the building structure;
FIG. 6 is an end view of a module and the delivery platform which rides upon the track rails;
FIG. 7 is a detailed end view of the supporting structure of the type shown in FIG. 4;
FIG. 8 is a view taken along the section line 8–8 of FIG. 7;
FIG. 9 is a plan view of the module delivery platform of this invention;
FIG. 10 is an end view of the delivery platform of FIG. 9 taken along the section line 10—10; FIG. 11 is a side view of a portion of a wheeled dolly which provides for the supporting and rolling of the module into position in the building structure; FIG. 12 is a detailed view taken along the section line 12—12 of FIG. 11; and FIG. 13 illustrates the manner in which the various temporary supporting structures and associated jacking means may be removed.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. 1A–1F illustrate the manner in which a multi-story building may be erected quickly and inexpensively, according to the invention, using modules of the type shown, for example, in perspective view in FIG. 2. The modules are framed in, part, of an outer framework which comprises a plurality of structural members, preferably of steel to provide the desired strength. Preferably, I-beams and channel beams of adequate dimension to support the predetermined load are provided for this outer framework.

The framework for the module comprises along the short ends 5 of the module 9, two vertically disposed I-beams 6 and 7 whose height is at least equal to the overall height of the module. Although the opposite end of the module is not shown in FIG. 2, it is to be understood that the module is symmetrically constructed and that therefore two additional I-beams 6', 7' corresponding to the beams 6 and 7 are provided exteriorly of the module at the remote end as well. Secured to the bottom ends of the two I-beams 6 and 7 is a channel-shaped structural member 8 which is preferably secured to the I-beams 6 and 7 by bolts (not shown). A similar channel member 17 is secured to the colinear I-beams 6', 7' at the remote end of the module. Interconnecting the I-beams 6 and 7 and channel beam 8 with the corresponding parts at the remote end of the module are a pair of I-beams 15'(of which only one is shown in FIG. 2) which extend along the bottom of the module, and each such I-beam is secured to the respective colinear I-beams 6 or 7 and to channel beam 8 by angle plates (not shown) and bolts (not shown).

Secured to the top surfaces of the channel beams 8 and 17 and to the transversely extending I-beams 15' is a floor 25 which is preferably formed of steel-reinforced concrete. When one module is stacked atop the other, the vertical colinear I-beams 6 and 7 of the stacked modules are vertically aligned with each other. Since each colinear I-beam 6 or 7 has a length at least equal to the overall height of the module, and is preferably equal in length to the height of the module, the beams 6 and 7 of the respectively stacked modules abut each other so that the weight of each unit or module is supported by the aligned I-beams 6 and 7 of the stacked modules through the successive modules. The ceiling of each module may comprise sheetrock material or the like 18 and need not be designed to support any portion of the load of the module stacked above since all of the floor load of the higher module is borne by the transversely extending I-beams 15' and carried thereby to the I-beams 6 and 7 at each end of the module.

Referring to FIGS 1A–1F, in FIG. 1A, the foundation for the building is shown at 15, and it will be apparent to one skilled in the art that such foundation may be below grade level although of course it is entirely possible to construct the building with a foundation 15 at grade level. In any event, a first step in the method of erecting a building is to place on the foundation a plurality of structural supporting units 10 each having associated therewith a module jacking means 12. These units 10, 12 are spaced so as to underlie alternate ones of the modules to be coupled together to form the top floor of the building; in some instances such units 10, 12 will be used in connection with adjoining modules rather than alternately spaced modules as will be discussed hereinafter. The supporting structures 10, which are shown only diagrammatically in FIGS. 1A–1F, are formed of structural steel members which, it will be understood are suitably cross-braced and supported so that they will each be capable of supporting a number of modules equal to twice the number of floors to be included in the completed building or structure.

Each supporting structure 10 is provided with a jacking means diagrammatically illustrated as 12 in FIG. 1B and having the capability of selectively raising a load vertically by an amount at least equal to the overall height of the module. The detailed structural arrangements of such a jacking means are illustrated in our aforesaid application Ser. No. 32,060. Although only two vertical lifting columns are shown in FIG. 1B for each of the jacking means 12, it should be understood that the means 10, 12 is preferably constructed in the form of a rectangular parallelepiped having vertical supporting members at each corner and also a jacking means at each corner.

Generally, there is provided a permanent supporting structure 11 between each pair of the temporary supporting structures 10, each including a jacking means 12. Each said supporting structure 11 is rigidly secured to the foundation to form a permanent part of the building when completed. Each supporting structure 11 is also suitably cross-braced and of sufficient strength to be able to support a dead load corresponding to the weight of a number of modules equal to twice the number of stories in the completed building, and also whatever live load may be placed on the floor of the module, wind loading, etc.

When all of the supporting structures 10 and 11 are in place as shown in FIG. 1A, the next step is to position on top of each of the supporting structures a series of modules 13 and 14. Although these modules may all be substantially identical in exterior configuration and structural details, although possibly differing in interior partition arrangement, plumbing, wiring, etc., they have been designated in FIGS. 1A–1F by different reference characters 13 and 14 dependent only upon whether the module is supported upon a jacking-supporting structure 10, 12 or upon a fixed supporting structure 11.

Once the various modules 13, 14 are in place on the jacking-supporting structures 10, 12 and fixed supporting structures 11 as in FIG. 1A, the modules are all coupled together by suitable bolts (not shown) passing through adjoining structural supporting members. When this has been completed, each jacking means 12 is raised, and the operation of the various jacking
means 12 is suitably synchronized, as is more particularly shown in the aforesaid copending application Ser. No. 32,060, to ensure that the row of modules is raised uniformly and in a level fashion by an amount substanti- tally equal to the overall height of a single module, with the result that the structure under assembly then has the general appearance shown in FIG. 1B.

In raising the row of modules which is to comprise the topmost floor from the position shown in FIG. 1A to that shown in FIG. 1B, it is desired to raise the row by a height which is slightly in excess of the overall height of any module. This is necessary in order to pro- vide adequate clearance for the insertion of additional modules in the blank spaces which extend above each of the permanent supporting structures 11. The insertion of such additional alternately spaced modules is shown in FIG. 1C, and it will be readily apparent that in order for such modules to be put in place, the spaces provided therefor by the raising operation shown by FIGS. 1A and 1B must provide adequate clearance which may, for example, be in the order of one and one-half inches or thereabout.

As each module is inserted in a respective one of the alternate spaces shown in FIG. 1C, the module is raised by an auxiliary jacking means associated with the wheeled dollies upon which the module is rolled into position in the building, and the distance that each module is raised corresponds to the above-mentioned clearance space. When this is done, each raised module may then be secured to the module directly above. Thereafter, a wedge is placed under each corner of a module 14 to maintain it and the modules stacked above it elevated above the respective supporting structure 10 by the amount of the previously men- tioned clearance. The various jacking means 12 then are all lowered (FIG. 1D), the topmost row of intercon- nected modules 13, 14 now being all supported on the supporting structures 11 through the intervening modules 14. The two overhanging modules 13 at each end of the building are at this time temporarily sup- ported by towers 59, each of which is provided with a movable projecting support member 59' which acts to support the endmost modules.

It will be apparent that the arrangement now existing, and as diagrammatically illustrated in FIG. 1D, provides additional gaps which permit the insertion of modules 13 to fill these gaps so that finally a row of ad- joining modules 13, 14, is provided which comprises all of the modules required for the second-from-the-top floor of the building which will then have the general appearance shown in FIG. 1E. Adequate clearance space is now available for the easy insertion of these alternately spaced modules 13; thus, each module 14 in the bottommost row is now raised above its respective supporting structure 11 by its associated wedges (not shown in FIGS. 1A-1F), and therefore each module 13 of the top floor is necessarily also spaced above a supporting structure 11 by a distance equal to the height of a module plus the predetermined clearance space.

The next step is to operatively couple together all of the modules of this second-from-the-top story of the building so that raising of the plurality of jacking means 12 associated with the temporary supporting structures 10 will permit raising of the two top stories as an in- tegral unit, thereby again providing voids alternately spaced and respectively positioned above the permanent supporting structures 11 into which additional modules may be inserted for the third-from-the-top story of the building. The above-described procedure is repeated as many times as is required until the building is of the desired height. When this is accomplished, the temporary supporting structures 10 and their as- sociated jacking means may all be removed from the building to permit their re-use in the erection of another building.

Once all the floors of the building, except the first, have been raised to their elevated positions, the building reaches a condition as shown in FIG. 13 where all of the floors of the building above the first or ground floor have been raised to their intended final height, and the building is now resting upon the alternately spaced modules 14, each supported upon a fixed supporting structure 11. It is now desired that the various temporary supporting means with associated jacking means 10 be removed from the building so that these devices can subsequently be used in the erection of another building. This may be accomplished by loosening the fastening means such as bolts (not shown) which anchor the base of each temporary supporting means 10 to the foundation of the building. The head of each jack is secured to the underside of the module supported thereon. Thereafter, the jacks are retracted, raising the lifting device to the underside of the module 13. When this is done, each movable truss then retains its position adjacent to an elevated module 13.

The jacking means together with the associated tem- porary supporting means is, of course, a very large and cumbersome structure and also very heavy, and it is therefore desirable to provide a means for removing this device to a position outside the confines of the building so that it may be loaded upon a truck or the like and moved away from the building site. This function may readily be accomplished by positioning on the rails 56 and 70 positioned on the respectively opposite sides of the temporary supporting means 10, in FIG. 13, one of the wheeled dollies 80 such as is shown in FIG. 11. Two or more spaced transverse steel beams 90 may then be placed across such pair of dollies lying to either side of the temporary supporting structure to be removed and then temporarily secured to the upstanding structural elements of the temporary supporting means by, for example, bolts 91, so that such temporary suppor- ting means and its associated jacking means may then be rolled out along the dollies 80 and along the rails 56 and 70 to a position exteriorly of the building.

It can be seen that the overall height of one of the temporary supporting means 10 and associated jacking means is higher than the overall height of any one module, and this is of course required if any one of these jacking means is to be capable of lifting a substan- tial load by a distance which is in excess of the overall height of any one module. As a result, when any jacking means is retracted so as to be raised off the floor of the building, it is evident that the bottom portion of such jacking means and temporary supporting means will ex- tend below the bottom surface of any module 14 posi- tioned on the ground floor of the building and will, in fact, even extend below the level of the rails 56 and 70 upon which the supporting means and jacking means
10 is to be conveyed outside of the building structure. This is, of course, of no particular consequence since the transverse members 90 lying across the dollies 80 can readily pass through the supporting and jacking means 10 and still be bolted or otherwise secured to its upright members to permit such apparatus to be removed outside of the building. It is required, of course, that the height of the exterior wall of the building be sufficiently low to provide adequate clearance for the removal of such jacking and supporting means. Thus, as a practical matter, it is required that the distance D3 which represents the distance from the bottom of the modules for the second floor of the building above the floor surface of the building foundation be slightly greater in height than the overall height of any jacking and supporting means when retracted (represented by D4), plus the height of the peripheral building wall (D5). If this condition is met, it will be apparent that a retracted jacking means together with its associated temporary supporting means 10 can be rolled outside of the building and yet have its bottom-most portion clear the top of the building wall as shown in FIG. 13.

FIGS. 2 and 3 illustrate a portion of the module delivery system of the invention. Referring first to FIG. 3, a portion of the building foundation is shown at 30, and it can be seen that the depth of the building, i.e., from left to right, corresponds to the length of two modules and moreover that the portion of the building's width which is shown corresponds to the width of four modules. Of course, it will be understood that the building can be of greater depth than that shown or it can be only one module deep and that the width of the building can be of any desired amount, but it is believed adequate for the purpose of illustrating the principles of the present invention to show an arrangement of the type illustrated in FIG. 3.

It will be assumed, in FIG. 3, that the left-hand edge of the building is the front of the building, and the backwardly recessed position of the portion of the building indicated by the set-back of the foundation at 30 represents a set-back such as is often found, for example, in high-rise apartment buildings where the central core of the building housing the lobby, elevators, etc., may be set back from the rest of the building by a predetermined amount. Of course, it will be understood that it is by no means necessary that the building be provided with such a set-back and such feature is illustrated here only to make it clear that the principles of the invention are equally applicable whether there is a set-back or not.

FIG. 3 shows that a plurality of temporary supporting structures 10 and also permanent supporting structures 11 is positioned within the building foundation and shows additionally the preferred arrangement of such structures. Thus, the endmost modules which are to form the right-hand end of the building are adapted to be supported upon a temporary supporting structure 10, for the front module and 10r for the rear module. Adjacent to these are positioned two permanent supporting structures 11r and 11s, and these are adapted to support a similar pair of modules. Preferably, the centrally located modules, i.e., those located in the area of the set-back, are both supported on a temporary supporting structure, each having an associated jacking means, and these are respectively indicated as 10a, 10r, 10t, and 10s. Beyond the central core portion, the next row of modules (not shown) are supported by permanent supporting structures (not shown) and the next row after that by temporary supporting means and so on, for the successive rows of modules in the building. The modules in the endmost row are again preferably supported by temporary supporting means 10 and respective jacking means 12.

It is seen to be understood this combination of temporary supporting means 10 and jacking means 12 comprises on each side thereof, a pair of fixed trusses 31 and a movable truss 32 which is vertically slidable between the fixed trusses, as more particularly disclosed in our aforesaid copending U.S. Pat. application Ser. No. 32,060, and a plurality of jacking cylinder means, preferably hydraulic, is provided to enable each movable truss to be raised relative to the associated fixed trusses.

Extending parallel to the front of the building, i.e., vertically along the left-hand edge of FIG. 3, are four track rails 33 mounted upon supports 34, and providing a trackway for rolling support of a wheeled delivery platform 35. The wheels of the platform are shown at 36, and FIG. 3 also shows that the platform 35 supports on its upper surface a plurality of rails 37, 37a. The platform further comprises various structural support members such as those indicated at 38 and 39, and diagonal bracing members 40, as shown in greater detail in FIGS. 9 and 10.

To place a module in the desired position within the building, the module is moved, as by a crane, from a truck or other transport vehicle and is placed in position on the delivery platform 35. The platform 35 may then be moved along the track rails 33 to its desired position. Such movement may be effected, for example, by a power-driven winch 41 which winds a steel cable or the like 42 over a drum 411 on winch 41. One end of cable 42 is attached to the platform 35 at 42a and the other end is attached thereto at 42b. The cable passes over a pulley (not shown), and after passing over the pulley, the cable 42 is returned to the drum of the winch and wound thereon in the opposite direction to the first-mentioned position. As a result, rotation of the winch 41 in one direction of rotation causes the platform 35 to roll in one direction along rails 33, whereas rotation of winch 41 in the opposite direction will similarly move the platform 35 in the opposite direction along rails 33.

FIG. 4 illustrates an end elevational view of the building arrangement shown in plan view in FIG. 3. Thus, the three temporary supporting structures of FIG. 3, i.e., 10, 10r and 10t, each having an associated jacking means, are all shown and also the intervening permanent supporting structure 11, and an additional such unit 11s which does not appear in FIG. 3. Each permanent supporting structure such as the structure 11r comprises vertical supporting members 45 which are interconnected by lateral bracing members 46 and diagonal bracing members 47. As shown in greater detail in FIG. 7, laterally extending I-beam sections 48 are each respectively secured to one of the upstanding structural support members 45 and each is, in turn, supported by a bracing member 49 which may be welded or bolted at one end to member 48 and at the
other end to the vertical support member 45. Secured to the top surface of each of the laterally extending support members 48 are a pair of rails 50 along which the module-supporting dolly can ride as hereinafter described.

It will be noted that the upper level of these rails 50 is substantially below the surface of the topmost module-supporting members comprising the longitudinally extending I-beams 51 and the transverse beam 52, and the reason for this is to provide space below the level of the module for the two individual module-supporting dollys riding upon rails 50 to thereby permit these to be removed once the module has been inserted in place and lifted off the dollys.

FIG. 5 shows in side elevational view one of the temporary supporting structure 10 and its associated jacking means 12. As more particularly disclosed in the aforementioned pending application Ser. No. 32,060, such supporting and jacking means comprises fixed trusses 53 which provide for a sliding support for movable trusses 54, the latter being capable of being raised by hydraulic jacking means under the control of a hydraulic fluid system.

FIG. 5 also shows the laterally extending supporting members 55 which support longitudinally extending members 55', each of the latter supporting, in turn, a rail 56. Referring to FIG. 4, the means 55 may comprise a transversely extending I-beam member which is welded or otherwise secured to an adjacent supporting and jacking means 10 and provides a support thereon for a pair of rails 56. Such a means is used between a pair of adjacent supporting and jacking means such as the means 10a and 10b shown in FIG. 4 and may be bolted to the fixed trusses of the supporting means. In the intervening space between a temporary supporting means and a permanent supporting means such as, for example, the space between the supporting means 10a and the supporting means 11, the rails therebetween are secured to the transversely extending members 48, forming a part of supporting means 11, as shown in FIG. 7 and already described.

In connection with the supporting and jacking 10, at the right-hand end of the building, it will be noted that a transversely extending member 57 is secured to such means 10, and provides support thereon for a pair of rails 58. In connection with this end unit, it will be noted that a plurality of supporting towers 59 (these are shown in FIG. 3) is provided and the function of these towers, as previously described, is to provide support for the overhanging modules 60 at the end of the building during such times that the associated jacking means 12 is lowered, thereby providing no lifting support directly underneath these end modules 60. The required support is provided by an extendable support arm 59' which is normally retracted within tower 59 but can be extended during the time that the overhanging modules 60 require additional support.

Because of the necessary proximity of the towers 59 to the end supporting means 10a, 10b, it is desired that the rails 58 associated therewith be positioned more closely to the supporting means 10, than is the case, for example, with the supporting means 10a. This relationship can be noted by observing that the rails 58 are closer to the center line of the supporting and jacking means 10, in FIG. 4 than are, for example, the rails 56 relative to the center lines of either the supporting and jacking means 10a or 10b.

As shown in FIG. 5, the transverse rails 37 on the delivery platform 35 are vertically aligned so as to be at the height of the rails 56 supported on either cross-member 55, cross-member 48, or cross-member 57, as the case may be (see FIG. 4). FIG. 5 further shows that the rails 33 are supported on a framework of structural support members 65 and that the support member for each pair of rails is positioned and mounted upon a pylon 66 which may be formed of concrete and supported on or embedded in the ground. FIG. 5 further shows that the winch 41 may, if desired, be mounted on the delivery platform 35.

It will be noted, from FIG. 9, and also FIG. 10, that the delivery platform 35 is provided with a single pair of rails 37a and 37b on one side thereof and four such rails 37a - 37d on the other side. The reason for having two more rails on one side than on the other is to accommodate such delivery platform to the transfer of a module onto a supporting structure of either standard spacing or less-than-standard spacing of the associated rails. Thus, it will be recalled, in connection with FIGS. 3 and 4, that the pair of rails 56 shown in FIG. 4, for example, are spaced a predetermined amount from the center line of the supporting means 10a and the same distance from the center line of the supporting means 10b. Similarly, the pair of rails 50 provided for the supporting means 11, is spaced from its center by the same predetermined amount. However, the pair of rails 58 associated with the endmost supporting means 10, are more closely spaced to the center of such supporting means 10b, and the reason for this is to move such rails inwardly to provide clearance for the tower 59 which, it will be remembered, must be positioned quite closely in toward the supporting means 10a in order that suitable support can be provided for the overhanging module 60.

Referring now to FIG. 3, when the delivery platform 35 is appropriately lined up for the insertion of a module into the prescribed space on the supporting means 10a or 10b, the two rails 37a and 37b are line up, respectively, with the rails 71 and 72 on the right-hand side of the supporting means 10a. When this is done, the two additional rails 37a and 37d on the platform 35 line up with the two rails 73 at the left-hand side of the supporting means 10b. In other words, the spacing D1 shown at the right-hand side of FIG. 9 corresponds to the spacing between respective pairs of rails for any of the module positions other than those on the right and left-hand ends of the building.

To accommodate to the lesser rail spacing D2 which prevails at each end of the building, one positions the platform again so that the rails 37a and 37d are longitudinally aligned with the pair of right-hand rails 74, 75 on the supporting means 10, and under those circumstances the appropriate spacing is provided for the remaining rails on the platform 35 so that the rails 37a and 37d are then longitudinally aligned with the left-hand pair of rails 76, 77 positioned intermediate supporting means 10a and 11a.

FIG. 11 illustrates the manner in which each wheeled dolly 80 supports and raises the associated module. Thus, the dolly comprises a longitudinally extending beam 81 which may be of I-beam type and supporting
an axle thereon at 82 and a wheel 83 in such manner that the bottom of the wheel extends only very slightly below the bottom surface of beam 81 so that the minimum amount of clearance is required for each wheeled dolly underneath a module. At the end of each beam 81 is a bracket 84 upon which rests a hydraulic jack 85. Such jack may be of the type which is capable of hand operation, and the piston of the jack is arranged to bear against the web of channel beam 8 which, as previously described in connection with FIG. 2, constitutes one of the end structural support members for the module.

When the module is moved into position on an appropriate supporting means, with the wheels 83 rolling, for example, from the rails 37 of delivery platform 35 onto, for example, the rails 56 shown in FIG. 4, it will be readily apparent that such module can enter into the space provided therefor only if such space provides adequate clearance for the movement of the module, and it has been found that an appropriate clearance space is in the order of one to one and one-half inches. Once the module has been placed in position, it is then necessary that be connected to the modules in the next floor of the building above. Of course, this could be accomplished by lowering the entire building by the amount of the predetermined clearance so that the lowest modules can then be suitably secured, as by bolting, to the module positioned thereabove. However, as previously mentioned, it is desired to avoid having to lower the building at any time and therefore it is provided by this invention that such building lowering step shall be entirely avoided and this can be accomplished by raising each newly inserted module by extending the jacks 85 so as to raise the module from the dolly 80.

Once the module has been raised by the amount of the predetermined clearance space so that it then abuts the next higher module above in the stack, the two dollies 80 can then be rolled out from under such module and be available for use in the placement of another module. By providing that the rails upon which such dollies ride are positioned below the lowest extremity of the module-supporting surfaces by an amount at least equal to the overall height of such dolly, it is assured that any such dolly can readily be removed from below the associated module once the module has been lifted therefrom by the jacks 80 and subsequently connected to the module thereabove so that the weight of such module is then removed from the dolly. Thus, all that then needs to be done is to lower the various jacks 85 to remove all force exerted by the module on the carriage and permit its easy withdrawal.

Eventually, as shown in FIG. 1D, when all of the alternately spaced modules 14 of the then existing ground floor of the building are in place, and each secured to the module thereabove and with the various dollies all removed, it then becomes possible to proceed to the next step which is the lowering of the various jacks 12 to reach the conditions of FIG. 1D. It must be remembered, however, that each of the modules 14 interspersed between the raised jacks 12 of FIG. 1C is at this time suspended from the module directly thereabove and consequently, if the jacks 12 were all now lowered, this would result in the lowering of the entire building which has already been raised. The amount by which the building would then be lowered would equal the clearance space now existing at the bottom of each such interspersed module 14. To prevent this, a wedge is placed under each module to prevent the lowering of any of the interspersed modules 14 and also to prevent lowering of any story of the building thereabove. This is shown in FIG. 8 where the columnar I-beam 7 of the module is supported by a wedge 90 which is driven between the bottom of I-beam 7 and the top of vertical member 91 constituting a portion of the module supporting means. By placing a plurality of such wedges, one for each corner of each module, the lowering of the building is prevented while, at the same time, providing the required and predetermined clearance space so that, upon the lowering of the various jacks 12, adequate space is provided above such lowered jacks and the module suspended thereabove to permit the insertion of additional alternately-spaced modules to finally arrive at the condition disclosed in FIG. 1E.

What we claim is:

1. Apparatus for the erection of a building formed of modular units at least two of which are horizontally interconnected to form a row comprising a single floor of the building and having at least two such rows stacked one above the other and vertically interconnected, the improvement which comprises:

a. a plurality of supporting structures positioned below the level of the first intended floor of the building and each adapted to support the weight of a plurality of modules,

b. at least some of said supporting structures including a module jacking means for raising the modules on the respective supporting structures by at least the height of a single module,

c. each supporting structure having associated therewith a plurality of laterally spaced rails extending from the building edge inwardly in the direction of intended module insertion into said building,

d. track rails extending alongside said building in a direction generally transverse to the direction of said laterally spaced rails,

e. a delivery platform having supporting wheels for rolling along said track rails and also supporting a second set of rails extending parallel to said laterally spaced rails,

f. at least one wheeled dolly adapted to roll on said delivery platform while supported on said second set of rails and supporting a module thereon, whereby each module may be rolled while on said dolly to a predetermined position aligned with its intended position in the building and then rolled on said dolly off said platform and onto a respective one of said supporting structures,

g. and auxiliary jacking means for raising each module relative to said wheeled dolly to permit removal of said dolly from underneath the module supported thereon and the attachment of the raised module to any module thereabove.

2. The apparatus of claim 1 in which two said rails extend alongside each said supporting structure and each module is supported by two said dollies each independent of the other and each having two pairs of laterally spaced wheels adapted to roll along said rails.
3. The apparatus of claim 1 in which each said rail has its upper surface lying below the module-supporting surfaces of the associated supporting structure by at least the overall height of said dolly.