United States Patent

[11] 3,594,965

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[54] **PRECAST BUILDING CONSTRUCTION**
21 Claims, 24 Drawing Figs.

[52] **U.S. Cl.** **52/126,** 52/263, 52/745, 254/89
[51] **Int. Cl.** **E04b 1/34,** E04g 21/00
[50] **Field of Search** ..... 52/122, 126, 745, 263, 292, 293, 295, 294; 254/89, 89 H, 92, 109, 106

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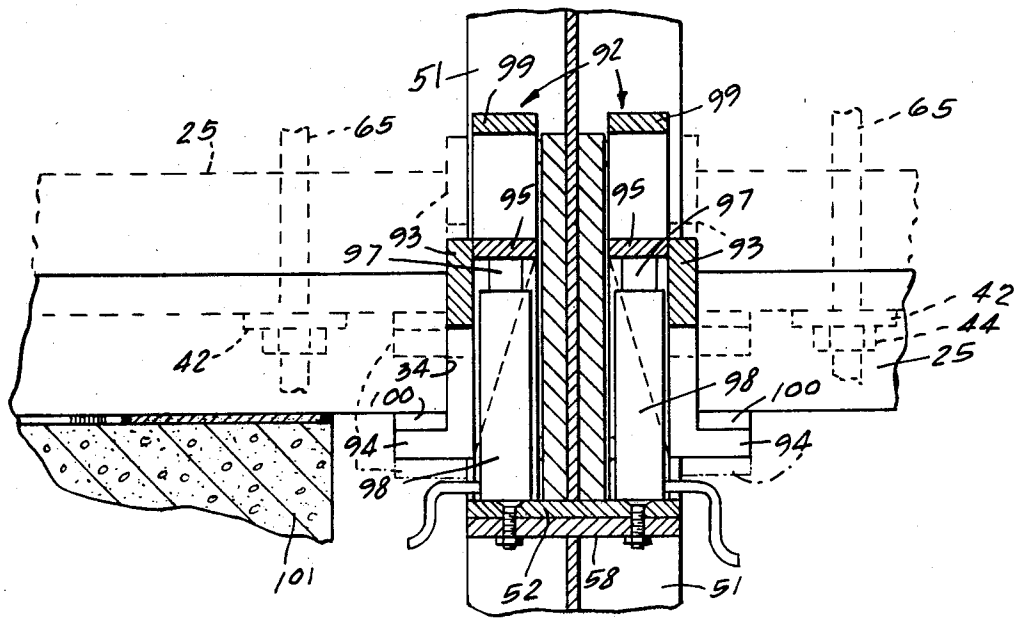
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Primary Examiner—John E. Murtagh
Attorney—Hill, Sherman, Meroni, Gross & Simpson

ABSTRACT: Floor slabs are precast in situ one upon another, temporary steel lifting columns are mounted through aligned clearance holes in the stack of slabs, a holding carriage and a lifting carriage are operatively disposed about each of the columns, threaded tension rods are coupled to removable tension rod sections properly located and coupled to the slabs, lifting jacks mounted on the lifting carriage actuate the tension rods to lift the entire stack of slabs to a height adjacently above the final elevation of the lowermost of the slabs in the stack, the pack of slabs is held by the holding carriage until the lifting carriage is raised to a further lifting height, the lowermost slab in the stack is temporarily supported at its highest elevation and is released from the lifting tension rods so that the remaining slabs can be raised and the successive lowermost slabs dropped off at their predetermined elevated positions, while angular wall columns are mounted in position to provide the ultimate support for the lowermost slab which is then lowered onto such columns and released from the temporary holding means. After all of the slabs have been erected, the lifting equipment is removed for reuse. To facilitate handling and placement of the wall columns one or more cranes may be mounted on and ride up with the topmost slab.



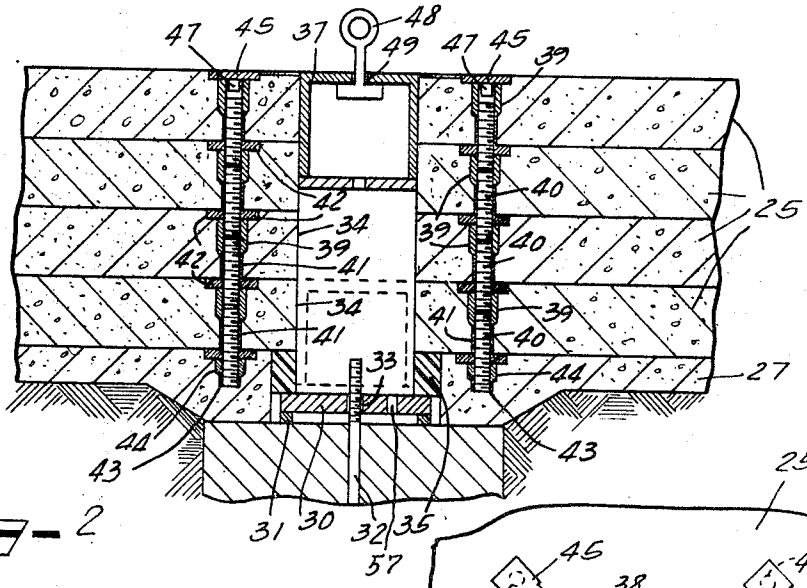


Fig. 2

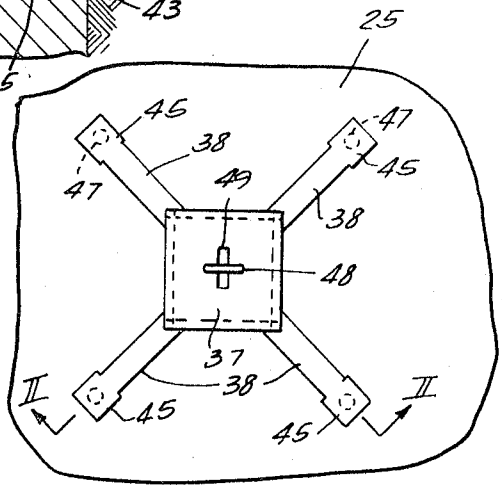


Fig. 1

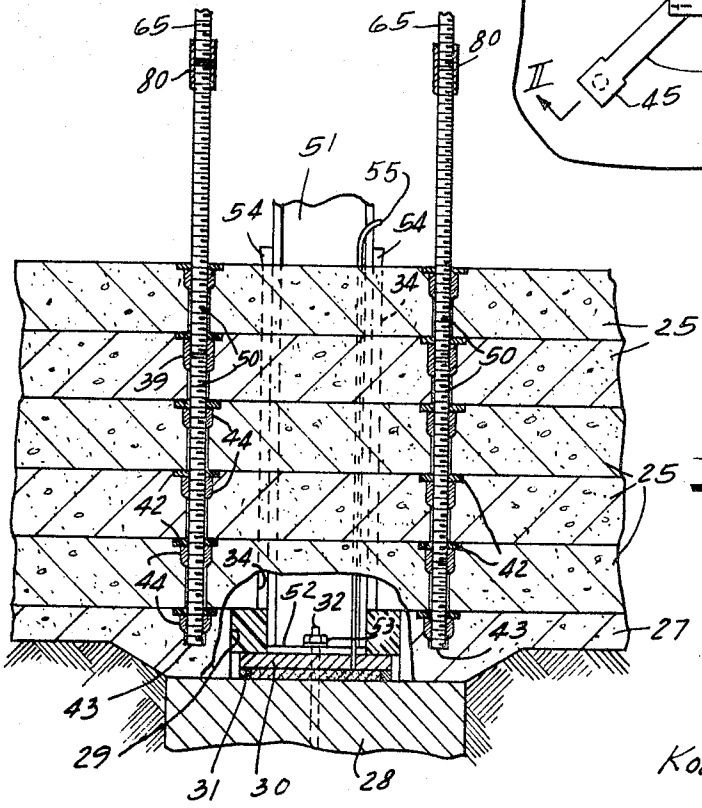


Fig. 3

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Fig. 4

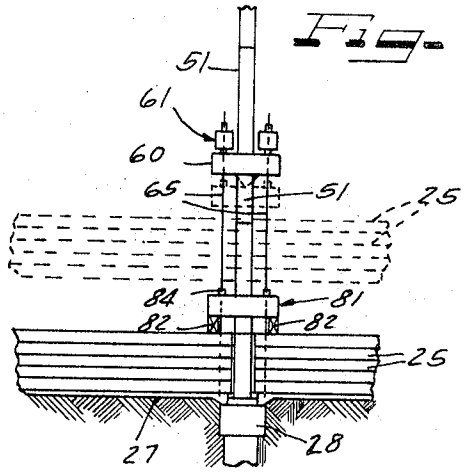


Fig. 5

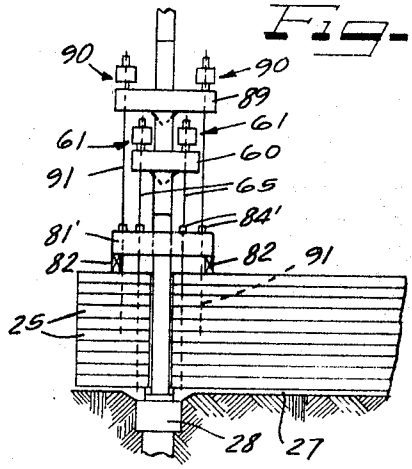
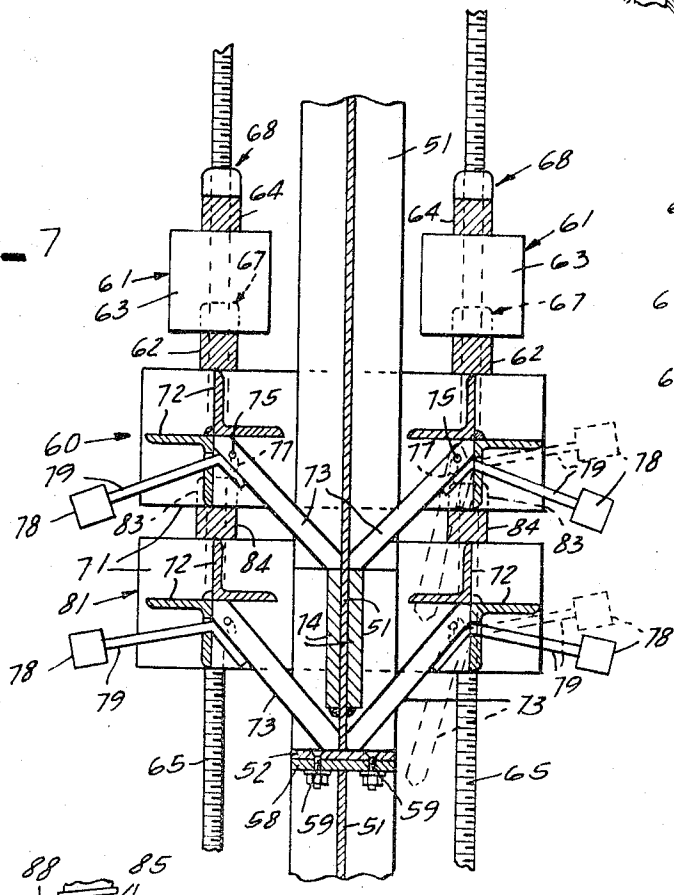


Fig. 7



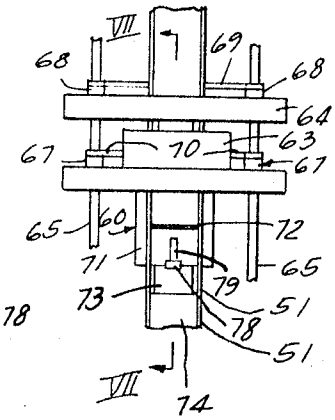


Fig. 6

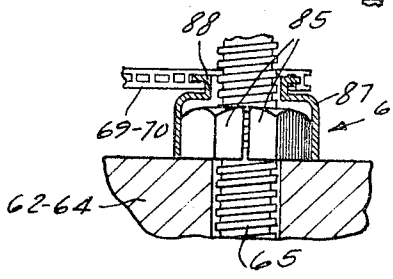
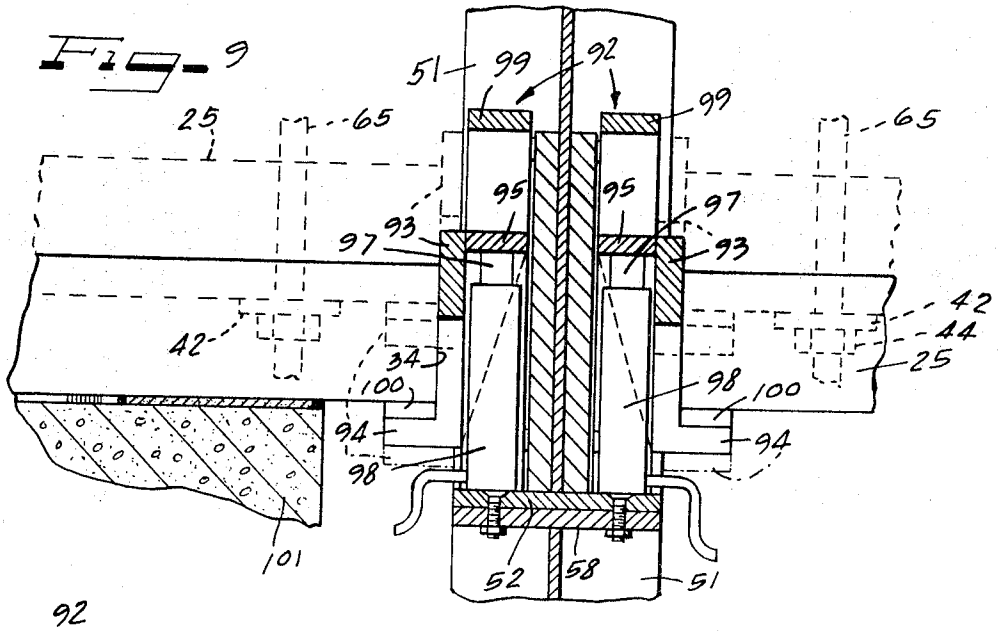


Fig. 8

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Fig. 9



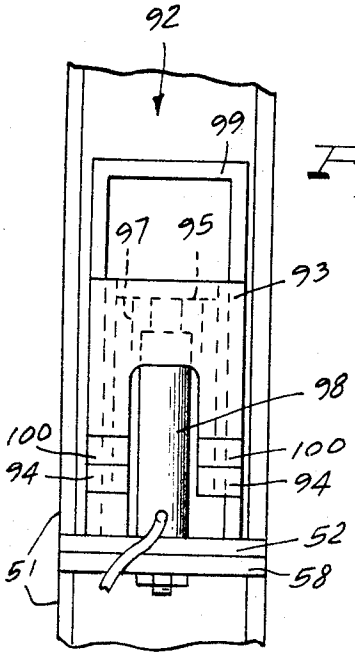
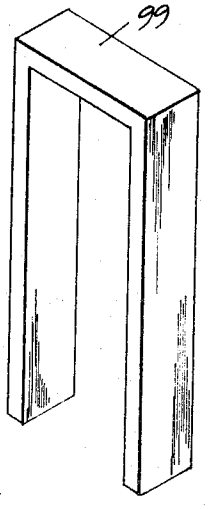


Fig. 10

Fig. 11



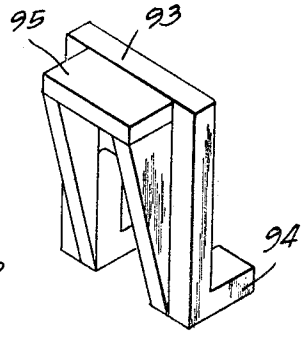
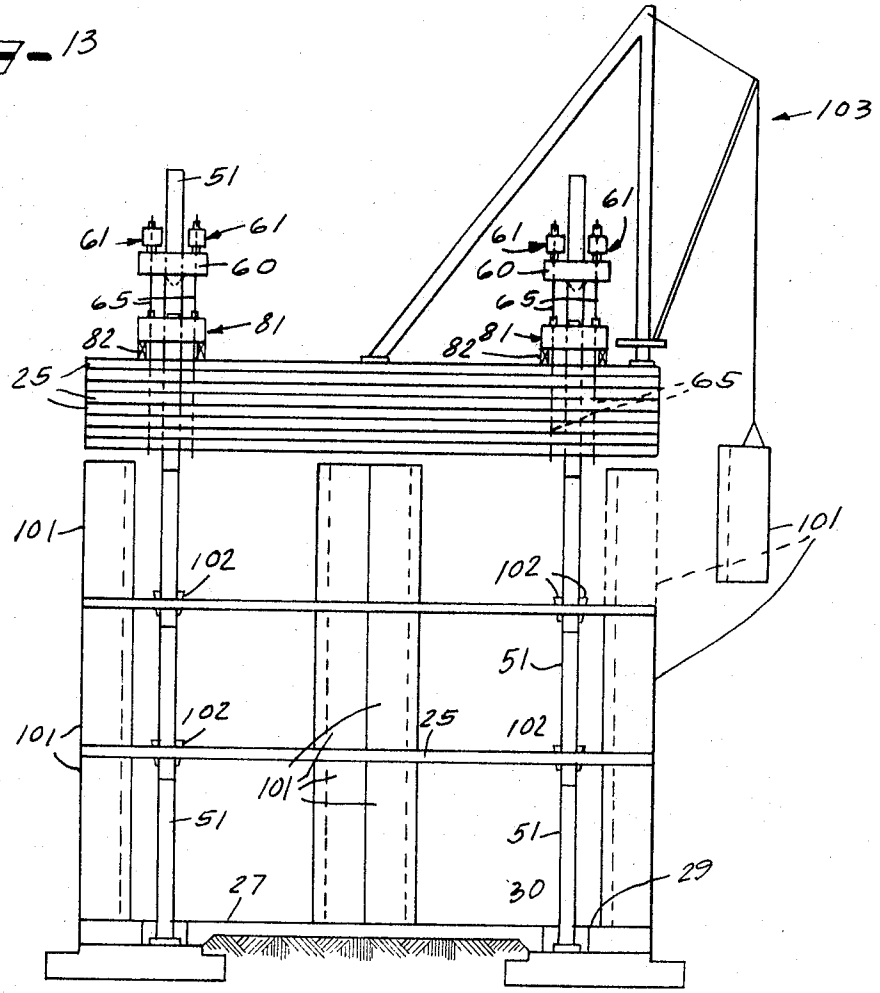


Fig. 12

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Fig. 13



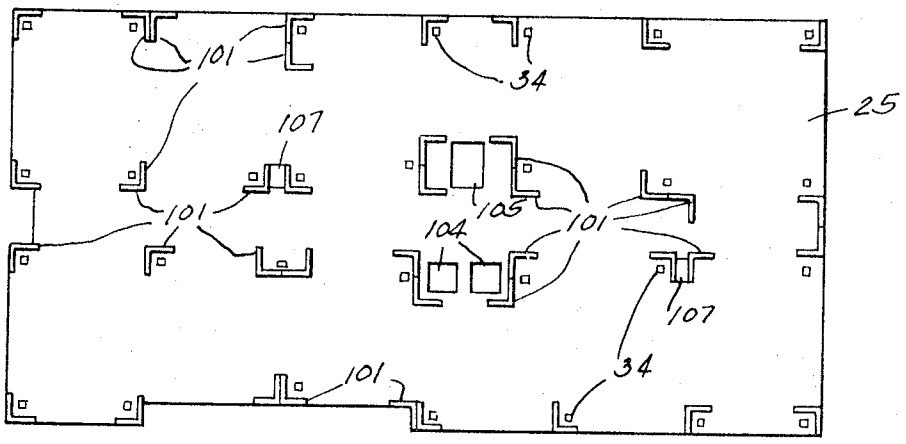


Fig. 14

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Fig. 15

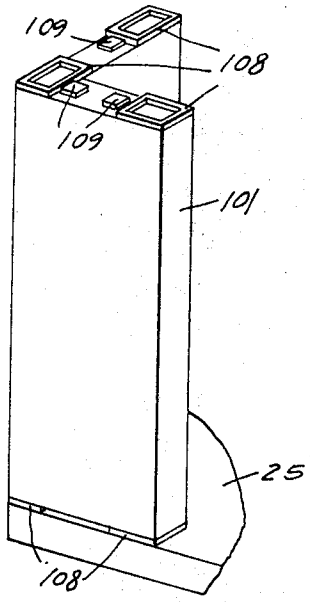


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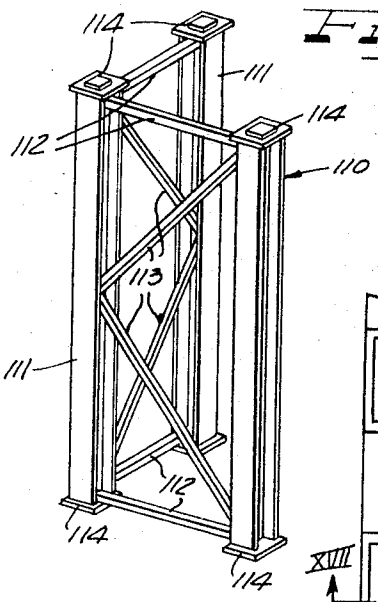
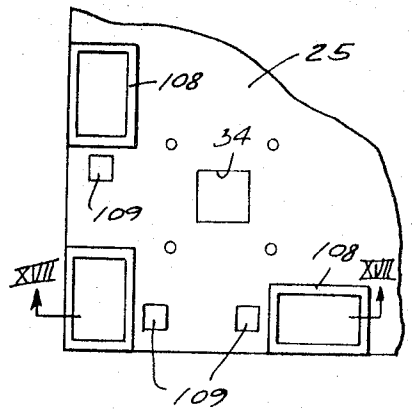


Fig. 16



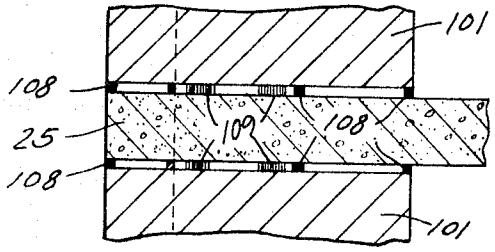
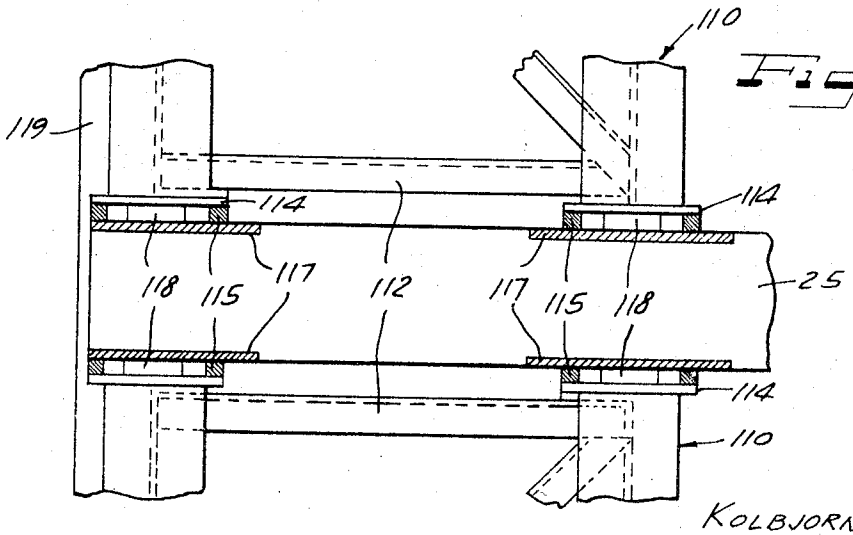


Fig. 17

Fig. 19



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Fig. 20

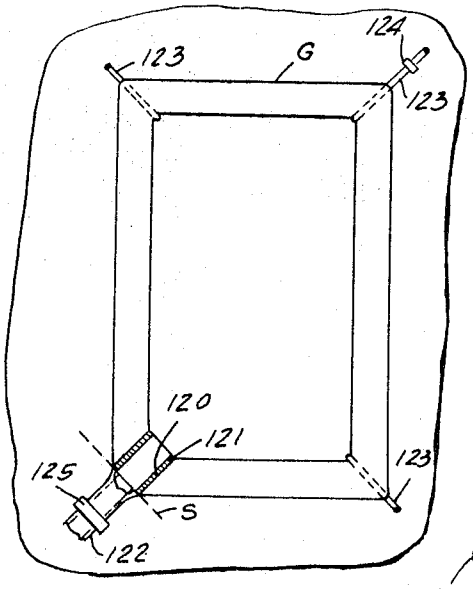
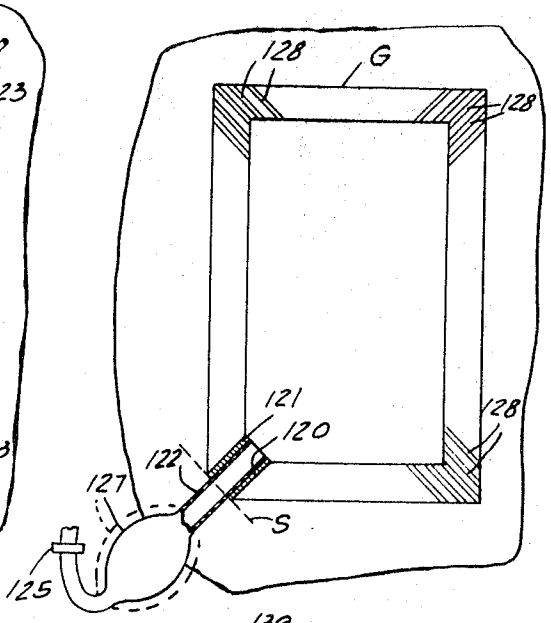


Fig. 21



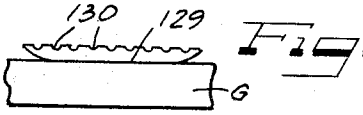


Fig. 22

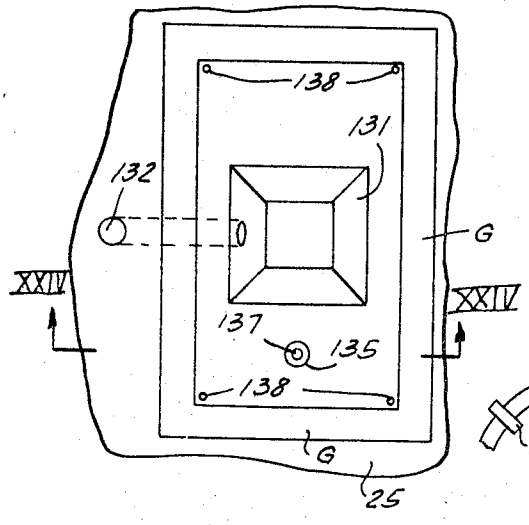


Fig. 23

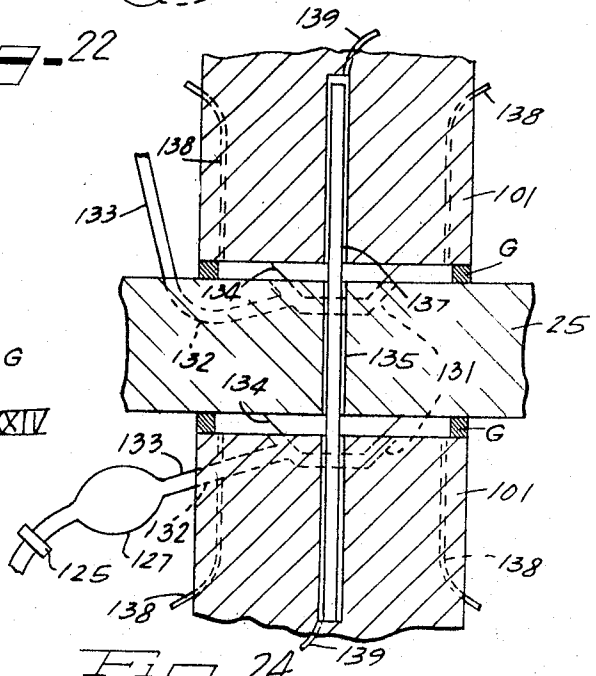


Fig. 24

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PRECAST BUILDING CONSTRUCTION

This invention relates to precast building construction involving the in situ casting of concrete slabs one upon another in the total number required and then elevating the slabs to and mounting them permanently in their intended positions in the building.

Building construction utilizing reinforced or post-tensioned concrete deck or floor slabs is now a reasonably well-developed art as represented in Phillip N. Youtz, U.S. Pat. Nos. 2,686,420 entitled "SLAB LIFTING APPARATUS" and 2,720,017 entitled "METHOD OF ERECTING BUILDINGS."According to those patents permanent steel supporting columns are erected for the intended building, concrete slabs are poured in situ one upon another about and between the columns with attachment collars fixed in the slabs and engaged about the respective columns. Slab-lifting jacks are mounted on the tops of the columns with threaded tension rods depending therefrom and attached to successive batches of two or three slabs which are successively raised by temporarily supporting the uppermost batches of slabs while the lower batches are raised to respective positions and the successive lowermost slabs are permanently attached to the columns by securing their collars in place. The collars serve as guides for the slabs along the columns as well as ultimate means through which the slabs are secured to the columns.

The slab-lifting jacks have an arrangement of respective hydraulic jacks mounted between a holding yoke and a lifting yoke, the jacks raising their lifting yokes by predetermined increments such as in a ½-inch stroke by hydraulic power, thereby correspondingly raising the lifting rods through the holding yoke. Holding nuts are run down the threaded rods onto the holding yoke while the lifting yoke is lowered and takeup nuts run down the upper extensions of the rods onto the lifting yoke, and the cycle repeated. In this manner the heavy loads of the slabs are inched upwardly. At least to the extent of details of the slab-lifting jacks and their mechanical and hydraulic operation, the disclosures of the aforesaid patents are incorporated herein by reference as is also U.S. Pat. No. 2,758,467.

One of the disadvantages of prior constructions has resided in the necessity for erection of supporting columns before pouring or casting the concrete slabs, wherein the columns are obviously obstructions preventing the use of fully automated equipment, but requiring a great deal of manual labor. Further, because the slabs are mounted on the columns, attachment collars must be secured in the slabs about the respective columns requiring tie-in with the reinforcement, and placing limitations upon location of the reinforcement within the slabs.

The prior construction has also placed definite limitations architecturally, being quite restrictive on the architectural layouts due to the need for efficient location of the supporting columns. The best location for the columns is somewhere inside the edge of the slab and away from the slab corners. This results in great architechtural conflicts because of the permanent location of such columns. In addition, fireproofing codes require that the steel columns be fireproofed.

In the permanent column arrangement mounting of the lifting jacks directly on top of the columns creates certain problems. The tall unbraced towerlike columns presented certain lateral instability hazards and thus severe limitation upon the weight and thus the number of slabs that could be lifted. Then, it has been necessary where column extensions are employed to remove the lift jacks from the top of the lower column, and lift the same to the top of the extension column after the latter has been secured in place on top of the lower column.

All of the foregoing and other deficiencies and shortcomings of the prior construction are overcome by the method, structures and apparatus of the present invention whereby floor slabs are precast in situ one upon another, temporary steel lifting columns are mounted through aligned clearance holes in the stack of slabs, a holding carriage and a lifting carriage are operatively disposed about each of the columns, threaded tension rods are coupled to removable tension rod sections properly located and coupled to the slabs, lifting jacks mounted on the lifting carriage actuate the tension rods to lift the entire stack of slabs to a height adjacently above the final elevation of the lowermost of the slabs in the stack, the pack of slabs is held by the holding carriage until the lifting carriage is raised to a further lifting height, the lowermost slab in the stack is temporarily supported at its highest elevation and is released from the lifting tension rods so that the remaining slabs can be raised and the successive lowermost slabs dropped off at their predetermined elevated positions, while angular wall columns are mounted in position to provide the ultimate support for the lowermost slab which is then lowered onto such columns and released from the temporary holding means. After all of the slabs have been erected, the lifting equipment is removed for reuse. To facilitate handling and placement of the wall columns one or more cranes may be mounted on and ride up with the topmost slab.

An important object of the present invention is to provide a novel precast building construction wherein elevation of the slabs to their functioning position is effected along temporary columns.

Another object of the invention is to provide a new and improved method of constructing precast concrete buildings in which roof and floor deck slabs are precast in situ one upon another and are all lifted in a one-shot manner wherein each successive lower slab is dropped off as erection progresses.

A further object of the invention is to provide a new and improved method of constructing precast buildings by lifting a stack of precast slabs and successively mounting the lowermost slabs in load-supporting relation on substructure erected under the raised slabs.

Still another object of the invention is to provide a new and improved precast building construction in which precast deck slabs are lifted up and mounted directly onto preformed wall-column members.

Yet another object of the invention is to provide novel apparatus for erecting precast building structures.

A still further object of the invention is to provide a new method of and means for mounting columns in full load-bearing relation to supporting and supported structures.

Other objects, features and advantages of the present invention will be readily apparent from the following detailed description of certain preferred embodiments, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a fragmentary top plan view of a stack of precast building deck slabs depicted during the slab pouring or casting operation;

FIG. 2 is a sectional detail view taken substantially along the line II–II of FIG. 1;

FIG. 3 is a sectional detail view similar to FIG. 2 but showing a slight modification in the slab making technique and depicting certain additional details;

FIG. 4 is a schematic elevational view depicting the assembly preparatory to lifting a stack of horizontal floor and roof deck slabs;

FIG. 5 is a similar sectional view depicting an arrangement for doubling the lifting capacity as compared to the arrangement in FIG. 4;

FIG. 6 is an enlarged side elevational view looking toward the left in FIG. 4;

FIG. 7 is a vertical sectional detail view taken substantially along the line VII–VII in FIG. 6;

FIG. 8 is an enlarged sectional elevational detail view of one of the takeup nuts employed in the lifting apparatus;

FIG. 9 is a vertical sectional detail view depicting the manner in which a horizontal slab is maneuvered in placing it on its supports after it has been raised and released from the bottom of the stack;

FIG. 10 is a side elevational view looking toward either the left or right in FIG. 9;

FIG. 11 is an isometric view of a bearing yoke member employed in the slab maneuvering device of FIGS. 9 and 10;

FIG. 12 is an isometric view of a supporting bracket used in the slab handling device of FIGS. 9 and 10;

FIG. 13 is a schematic illustration depicting various features and steps employed in the erection of a building pursuant to the invention;

FIG. 14 is a schematic top plan view depicting the layout of a typical floor slab and angular wall columns;

FIG. 15 is an isometric view showing a precast angular wall column in course of erection;

FIG. 16 is a fragmentary top plan view illustrating placement of grouting gaskets and shims for a wall column;

FIG. 17 is a fragmentary vertical sectional detail view taken substantially along the line XVII–XVII of FIG. 16;

FIG. 18 is an isometric view of a steel structure angular wall column,

FIG. 19 is a fragmentary vertical elevational view, partially in section depicting the erected relationship of steel frame wall columns to a floor slab;

FIG. 20 is an enlarged top plan view of one form of grouting gasket;

FIG. 21 is a similar top plan view of a modified form of the grouting gasket;

FIG. 22 is a fragmentary side elevational view of a grouting gasket with an air bleed plate assembled therewith;

FIG. 23 is a top plan view of another grouting gasket arrangement; and

FIG. 24 is a fragmentary vertical sectional detail view of a building assembly employing the grouting gasket arrangement of FIG. 23 taken substantially on the line XXIV–XXIV of FIG. 23.

According to the present invention horizontal floor and roof deck slabs are poured in situ one upon the other in an area entirely free from columns so that the slabs can be poured and finished by means of mechanical equipment on the order of that utilized for paving and precasting of sectional and like concrete slabs which are then transported to the building position. This is accomplished by the elimination of building load supporting columns in the building area. To this end, a stack of concrete slabs 25 (FIGS. 1 and 2) is successively poured in situ upon a base slab 27 of at least the same total area and which may be a basement slab or a ground level slab as preferred. Suitable footings 28 are provided under the slab 27 and desirably in suitable locations to afford base support for temporary lifting columns to be hereinafter described. Over the footings, the slab 27 is provided at the locations desired with respective wells 29 of adequate dimensions to receive therein respective heavy steel foundation plates 30 each of which rests upon a suitable elastomeric grouting gasket 31. Column anchor bolts 32 extend up from the footing and through respective clearance holes 33 in the plate 30 for receiving the foot of a column.

As each of the slabs 25 is successively poured provisions are made for accommodating slab lifting equipment. Before the first slab 25 is laid upon the base slab 27, a parting agent is coated upon the top surface of the slab 27, and such a parting agent is coated upon the top surface of each succeeding slab so that all of the slabs 25 will be separable. It will be understood that suitable edge forms are also employed.

Since according to this invention the slabs 25 are not mounted on common vertical columns, the need for attachment and lifting collars in the slabs as in conventional construction is entirely eliminated. Instead, each of the slabs 25 is provided with a simple temporary lifting column clearance opening 34 aligned with the column base well 29 and with each of the openings in the other slabs of the stack. This greatly simplifies structurally efficient placement of reinforcement (not shown) in the slabs.

Where, as shown, the opening 34 is of smaller horizontal cross-sectional dimensions than the well 29, suitable removable filler, such as rigid foam plastic commercially available as Styrofoam, pieces 35 may be applied over the foundation plate 30 in the overhanging area of the lowermost slab 25 to maintain the slab thickness and to maintain the well accessible for subsequent removal of the baseplate 30 whereafter the well may be grouted closed or utilized for another purpose if desired.

To form the openings 34 during the pouring and finishing of each of the slabs 25, a removable, flattop box core form 37 is desirably employed which is mounted, for each of the slabs 25, at an elevation flush with the intended top surface plane of the slab to be poured so that it may also serve as a thickness gauge. Such placement of the form 37 is desirably effected by mounting it through respective radially extending spiderarms 38 upon the upper ends of respective internally threaded coupling sleeves 39 which are screwed onto the upper end portions of respective threaded stub rods 40 resting upon respective spacer sleeves 41 which in turn rest upon respective lifting plates 42 lying flush within the top surface of the underlying slab and mounted to the associated stub rod 40. Under the lowermost of the slabs 25, the lifting plate 42 is recessed within the top surface of the base slab 27 which has respective recesses 43 accommodating the lower end portion of the adjacent stub rod 40 and an attachment nut 44 by which the adjacent plate 42 is secured in place on its stub rod. Preparatory to pouring each of the slabs 25, a core plate 45 on the outer end of each of the spiderarms 38 is aligned with a respective coupling 39 of one of the four upwardly projecting stub rods 40, with a downwardly projecting alignment boss 47 fitting into the socket provided by the upper portion of the coupling sleeve. Leveling of the forming spider is easily effected by rotary threaded manipulation of the respective couplings 39. Each of the forming or core plates 45 is of the same dimensions as the lifting plates 42 so that after each slab has set and the core forming spider is removed as by lifting it through a device 48 attached through a slot 49 in the top of the mold body 37, a recess will be provided in the top surface of each of the slabs 25 to receive the lifting plates 42.

Where instead pouring and finishing the slabs with equipment of the generally road paver type, the so-called conveyor bridge type of equipment is to be used, longer tension rod sections 50 (FIG. 3) may replace the single slab length sections 40 thus reducing the number of pieces of equipment that need be handled. For example, the sections 50 may be of a length to accommodate four slab thicknesses. Where the longer sections 50 are used, the coupling sleeves 39 need be only at the splice joints, while the nuts 44 may be used at all other of the lifting plates 42. An approximately 3 -foot maximum upward extension of the rod sections 50 is tolerable for conveyor bridge slab pouring. Where the rod extensions 50 are employed, the coring mold former 37 may have openings through the forming plates 45 thereof to receive the extensions therethrough, instead of the locating bosses 47 previously described.

After all of the slabs 25 for a particular building structure have been completed and are ready to be erected, namely, after the topmost slab of the stack has been sufficiently cured, temporary steel lifting columns 51 of preferably H-beam section are inserted through the aligned clearance holes 34. Respective foot plates 52 rigid on the lower ends of the columns 51 are secured to the tops of the respective baseplates 30 by means of the bolts 32 onto which are driven retaining nuts 53. These nuts are placed by any suitable means such as magnetic extension wrenches and tightened lightly. The abutting surfaces of the baseplate 30 and the foot plate 52 are desirably milled to make thorough bearing contact. Since the baseplate 30 is floatingly supported by the elastomeric gasket 31 thereunder, the full bearing contact is assured between the plates when the column 51 is perfectly vertically adjusted and maintained in such adjustment as by means of suitable wedges 54 inserted between the column 51 and the edge defining the uppermost clearance hole 34 which is enabled because the clearance holes are of sufficiently larger size than the beam section to provide complete clearance about the column. After the column has been thus fixed in its vertical orientation, grout is driven into the space under the

baseplate **30** within the gasket **31** and supports the column in full load bearing relation upon its footing **28**. Introduction of the grout may be through a grout tube **55** delivering through a suitable hole **57** in the margin of the baseplate **30**.

After the grout under the columns **51** has set to load bearing strength, lifting of the stack of slabs **25** as a unit may be effected upwardly along the columns, and the arrangement is such that the lifting is expedited to the full height of the building by suitable floor-by-floor increments with utmost efficiency, avoiding unduly tall and laterally unsupported columns, without any necessity for dropping lifting rods downwardly to reach for packs of slabs underneath previously raised slabs, and without requiring dismounting of lifting jacks from the tops of columns in order to mount column extensions. To this end, the columns **51** are constructed in substantially one floor sections, being typically of about 8feet 8 inches in length and constructed to be bolted in alignment. Each column section **51** has on its upper end a cap plate **58** (FIGS. 6 and 7) upon which is received the foot plate **52** of a superposed aligned column section in full bearing relation with countersunk flatheaded bolts **59** securing the plates fixedly together. It will be understood, of course, that there are as many of the sectional columns as required for efficiently handling the slab span to be lifted.

Initially there is supported on the lower end portion of the second column section a lifting carriage **60** upon which are mounted in balanced lifting relation a pair of hydraulic lifting jacks **61** illustrated schematically in FIGS. **4**, **6** and **7** and for details of structure and operation reference may be had to the aforesaid U.S. Pat. No. 2,758,467. Suffice it to say that each of the jack assemblies comprises a holding yoke **62** on which is mounted a hydraulically operating jack unit **63** supporting a lifting yoke **64**. Depending freely through the aligned outer end portions of the yokes **62** and **64** are threaded lifting rods **65** secured to the slabs to be lifted and about which are threadedly engaged holding nut assemblies **67** over the yoke **62** and lifting nut assemblies **68** over the yoke **64**. Operation of the jack unit **63** causes the lifting yoke **64** to be raised incrementally such as about one-half inch in a typical instance such that the lifting nuts **68** which have theretofore been run down onto the yoke **64** as by means of an operating chain **69**, effect similar lifting of the lifting rods **65**. Thereupon the holding nuts **67** are run down onto the holding yoke **62** as by means of a chain drive **70**. This lifting cycle is repeated until the lifting rods **65** have raised the slabs the desired distance.

For supporting the jack assemblies **61** in a manner to have the supporting column assume the lifting load in an efficient, balanced relation, the carriage **60** comprises a rugged steel frame having respective opposite coextensive parallel sideplates extending to a substantial length beyond the associated column **51** and slidably engaging the side flanges of the column. Extending between and secured to the opposite end portions of the sideplates **71** are respective angle bar cross-frame members **72** which provide respective right angular inwardly and downwardly facing reentrant seats into which thrust complementary upper ends of respective supporting brace bars **73** which have their lower ends shaped complementary to an upwardly and outwardly facing seat or shoulder provided by the web of the column **51** and the upper end of a respective shoulder plate **74** fixedly secured to the web.

To enable ready shifting of the carriage **60** from the column section to column section, the brace bars **73** are generally hingedly mounted on the carriage. Hinging is effected in a manner to enable full thrusting seating of the upper end of the brace bars in their load-carrying function while nevertheless permitting relatively free swinging of the bars into and out of the loading engagement with the respective carriage and column seats when moving the carriage along the column. For this purpose, each of the brace bars **73** has adjacent to its upper end aligned pintles **75** projecting sidewardly and received in respective arcuate clearance slots **77** in the carriage sideplates **71** dimensioned to enable swinging of the brace bars downwardly and outwardly as indicated in dash outline in FIG. **7**, into clearance relation to the associated column. To facilitate return to and maintenance in the column shoulder seat engaging position, the brace bars are desirably provided with biasing means normally urging them to swing inwardly, herein comprising a respective counterweight **78** mounted on a rigid lever arm **79** extending outwardly from the upper end portion of the bar.

In the operation of the carriage **60**, it is mounted on the column assembly, initially supported on the seating shoulders of the second column section in the assembly. All four of the lifting rods **65** are coupled at their lower ends as by means of internally threaded coupling sleeves **80** (FIG. 3) to the upper ends of the stub rod chains mounted in lifting relation to the slabs **25**. Then, with the holding nuts backed off from the holding yoke **62**, and the lifting nuts **68** run down firmly against the lifting yoke **64**, the jack unit **63** is actuated in unison with all of the other lifting jacks which are similarly operatively disposed in respect to the slab stack until the stack has been raised to the maximum height permitted by the initial setting of the carriage **60**. Schematically FIG. **4** shows the initial phase of lifting the stack of slabs, on comparison of the full outline and dash outline positions.

In order to enable the lifting carriage **60** to be raised to the next higher position on the column assembly and free from the stack of slabs, the stack is held immobile for an interim while the lifting carriages are raised to their next position. For this purpose, holding means are provided at each of the columns, desirably comprising respective holding carriages **81** which in all essential respects are identical and interchangeable with the lifting carriages **60**. Inasmuch as the lifting and holding carriages are depicted herein as identical, the same reference numerals are applied to the elements of the carriage **81** in FIG. **7** as applied to the carriage **60** and it will be understood that the description of the structure and function of the elements is identical. Since the holding carriages **81** need function only to hold the slab stack in the interim while the lifting carriages are elevated to new positions, the holding carriages are permitted to ride freely on the stack until the respective interim holding positions are reached. As shown in FIG. **4**, the holding carriage **81** is disposed in position about the column **51** but rests upon the slab stack, being desirably supported on suitable blocks **82** to afford clearance for the downwardly extending brace bars **73**. As the slab stack is lifted, the brace bars **73** of the holding carriage **81** may be permitted to idle freely along the web of the adjacent column **51**. When the slab stack has been raised as far as practicable by the lifting carriage **60** without resetting the same, the holding carriage **81** will have been brought into substantial alignment with the upwardly facing shoulder provided by the foot plate **52** of the next upper column section. To avoid any necessity for overlifting and then dropping the stack and lifting carriage **81** down into holding position, the holding carriage may be otherwise, such as manually, lifted upwardly relative to the lifting rods **65** until the brace bars **73** automatically snap into seating relation to the foot plate shoulder under their counterweight bias. Then with the carriage **81** supported in holding position on the column assembly, respective holding nuts **83** are run down on the lifting bars **65** firmly against respective holding yokes **84** carried by the holding carriage. Thereby the slab stack load is assumed by the holding carriages **81**. This frees the lifting carriages **60** for repositioning upwardly along the column and relative to the upwardly projecting portions of the lifting rods **65** which have been raised to a sufficient height to be reengaged at the next higher setting of the lifting carriage.

In order to facilitate freeing the lifting carriage in each instance, from the lifting rods, the holding nuts **67** and the lifting nuts **68** are preferably constructed to be freed from the rods so as to avoid having to turn them threadedly up the rods, although that may be done if preferred. In a convenient construction, all of the nuts embody the construction best shown in FIG. **8**, namely each may comprise a pair of complementary split nut sections **85**, such as a standard hexagonal nut cut in half. In operation, a complementary steel shield **87** encom-

passes the nut sections and holds them in threaded engagement with the associated lifting rod. On the upper end of the shield is a sprocket-toothed collar **88** which is drivingly engaged by the associated drive chain. When the carriage **60** is to be repositioned, the respective nut shields **87** are lifted off of the associated nuts and the nut sections **85** are removed from the associated rods **65**. After the carriage **60** has been repositioned, the nut assemblies are reassembled for further operation. Since the split nut structure also facilitates mounting and demounting of the nuts relative to the lifting rods, the holding nuts **83** associated with the holding carriages **81** may embody the same structure if desired.

After the lifting carriages **60** have been repositioned at the next operating level resumption of the lifting cycles of the lifting jacks may be resumed and the lowermost slab **25** in the stack is lifted into a position to be dropped off for its chosen building level. For this purpose the lowermost slab is raised with the stack to an overlifted position wherein its lower face is sufficiently high to afford clearance therebelow and above footings or the next lower slab, as the case may be, to enable erection of load-bearing wall columns upon the lower slab, whereafter the overlifted slab is lowered into supported relation upon the load-bearing substructure which has been erected thereunder while the slab has been held in the overlifted position for headroom.

While the use of two lifting jack assemblies **61** at each column enables lifting double the load of the customary single jack on each column, means may be provided for again doubling the load of slabs to be raised by the present one-shot lift method. For this purpose, the arrangement shown in FIG. **5** may be employed wherein in addition to the lifting carriage **60** and the two jack assemblies **61** carried thereby and operating four lifting rods **65**, a second and in this instance longer lifting carriage **89** is provided to operate in tandem with the carriage **60**. A pair of lifting jack assemblies **90** mounted on the carriage **89** have lifting rods **91** depending therefrom and attached in lifting relation to the upper portion of a stack of precast slabs **25**, which may be of the same number as the slabs in the lower portion of the stack to which the jack assemblies **61** are attached through their lifting rods **65**. In this arrangement the holding carriage **81** may be of substantially the same length as the lifting carriage **89**, and supplied with four holding yokes **84'** and associated holding nuts, to accommodate all of the lifting rods **65** and **91**.

For supporting each successive slab **25** when it reaches its drop-off position, reusable apparatus is provided desirably at each of the columns **51** to afford substantially stress-free support of the slab. In a desirable construction this apparatus comprises a three part separable assembly **92** (FIGS. **9—12**) arranged to mounted on the shoulder provided by the foot flange plate **52** of the adjacent column section joint and within the vertical channel space between the side flanges of the column. To this end, the apparatus **92** includes a generally inverted U-shaped supporting yoke bracket **93** having lower outwardly extending supporting lugs **94** and a head **95** extending inwardly on its upper end portion and engageable in thrusting relation from below by a ram **97** of a hydraulic jack **98** arranged to be seated on the supporting shoulder of the foot flange bearing plate **52**. A slidable bearing guide is provided by filler member **99** of inverted U-shape seated at the lower ends of its vertical legs on the foot plate shoulder and receiving the bracket **93** slidably thereagainst and with ample clearance above the head **95** to enable a full range of operational vertical movement of the supporting bracket **93** under the control of the jack **98**.

The construction and arrangement of the apparatus **92** is such that it can be readily installed from below the slab **25** which has been raised to the overlift position shown in dash outline in FIG. **9**. For this purpose, the filler bearing member **99** is first inserted upwardly into position. The supporting bracket **93** is then inserted upwardly into position within and against the bearing member **99** and held there while the associated jack **98** is placed upwardly into operating position with its ram **97** supportingly under the bracket head **95**. Cushions **100** which may be of elastomeric material are desirably interposed between the supporting lugs **94** and engage the undersurface of the slab **25**. It will be observed that for maximum stability and stress-free operation, two sets of the slab-handling apparatus **92** are associated with each column. Suitable hydraulic control means are provided for operating the jacks **98** and may comprise manual pumping and release means for each pair of jacks or the jacks on all columns may be connected for operation in unison. Initially the jacks **98** are operated to effect a lifting thrust on the engaged slab **25** sufficient to enable releasing the slab from the lifting rods **65** or **91**, as the case may be, by detaching the lifting plates **42** from beneath the slab which is now supported by the brackets **93**. Thereupon the remainder of the stack of slabs **25** above the released slab can be lifted on toward dropping off of the next succeeding lower slab. In the meantime, supporting substructure is erected under the stationarily held slab **25** while the remaining slabs may continue their upward travel.

By virtue of the lifting of the total stack of floor and roof slabs, and the freedom under the lowermost slab for building erection activity as soon as it has reached its headroom overlifted position, on the order of 6 inches above final position in the building, work on the floor area under such lowermost slab can proceed immediately and without interruption while the temporary supporting apparatus **92** is placed on the columns, the slab is released from the bottom of the stack and lifting of the remainder of the stack continues. This lends itself exceptionally well to rapid placement of prefabricated load-bearing wall columns **101** on the floor deck or footings, as the case may be, below the overlifted slab, whereafter such slab is lowered into supported relation on the wall columns **101** by retraction of the jack rams **97**, to the full line position shown in FIG. **9**. With the slab load thus transferred from the holding jacks **98** to the load-bearing substructure, the assemblies **92** can be removed for reuse. Such removal is easily effected by removing the filler bearing members **99** upwardly, swinging the brackets **93** from the lower unloaded position shown in dot-dash outline in FIG. **9** to clear the supporting lugs **94** into the vertical channel of the column and pass the slab while the bracket is withdrawn upwardly. Thereafter the jack **98** may also be withdrawn upwardly for reuse. After each floor slab has been mounted and the temporary or interim handling apparatus **92** has been removed, stabilizing wedges **102** (FIG. **13**) which may be hardwood, may be driven into engagement between the lifting columns **51** and the erected horizontal slab **25** to provide lateral stability for the columns taking advantage of the great lateral stability inherent in the building structure of which the slab is now a part.

To assist in the erection of the preformed load-bearing wall columns **101**, a ground-supported crane may be used, but because of the highly stable, large load capacity means for lifting the stack of slabs **25** herein, a crane **103** is adapted to be mounted on the uppermost or roof slab **25**, as by bolting the same thereto. Thereby the ground area around the building is left relatively free for other purposes, and the top mounted crane is constantly available for lifting materials including the wall columns **101** to each floor space as it becomes available. On the floor on which the wall columns **101** are to be mounted, forklift truck means or dollies may be utilized for moving the wall columns into position.

By having the preformed load-bearing wall columns **101** of angular shape (FIG. **14**) they may set into place to be both stable and plumb without any type of temporary bracing. After they are grouted-in between the slabs below and above, they furnish shear walls in two directions and make the building immediately laterally stable, up to the level of the slab above the wall. These angular wall columns furnish moment stiff connection at all slab supports even in the exterior slab corners. This moment connection is provided with very little reduction in the vertical carrying capacity of the wall column. This result accrues from the fact that there is no bending over a weak axis

in any of the wall column units. The moment stiff connection along exterior walls enables great savings in slab design and greatly reduces damaging deflections in the slab and slab edges as compared to conventional column supported slabs.

Where the horizontal slabs are supported on columns extending therethrough as has been conventional practice, the slabs are subjected to large peak moments at the columns and these moments largely control the selection of the required slab thickness and the amount of reinforcing steel therein. In post-tensioned slabs, these conditions are even more pronounced because of the need to carry the same steel tendon through negative and positive bending zones from one edge of the slab to the opposite edge. By using the angular preformed wall columns of the present invention negative peak moments are greatly reduced and large savings in material and labor are permitted. Another decided advantage of the angular load-supporting wall columns is that fireproofing is substantially facilitated and enhanced, especially where such columns are of precast concrete as compared with conventional steel columns. Typical arrangements of the angular wall columns **101** are schematically depicted in FIG. **14** on a large area floor slab **25** and demonstrate the great versatility of this mode of construction. The great architectural design latitude as to floor plan and wall treatment is readily apparent. Exterior walls, partitions, enclosures and reinforcement about elevator shafts **104**, stairwells **105**, utility openings **107**, and the like in the floor slab are readily accommodated. Location of the temporary column clearance openings **34** in the slab can be readily related to the predetermined positions desired for the wall columns **101** to avoid interference with placement of the columns and yet provide for substantially strain-free lifting and handling of the slab in the manner already described.

In order to secure full and uniformly distributed load bearing by and onto the angular wall column **101** in each instance, a three-point post assembly injected grouting arrangement is provided for, utilizing the same general method and arrangement hereinbefore described in respect to providing a thorough supporting base for the temporary lifting columns **51**. To this end, as shown in FIGS. **15**, **16** and **17**, grout-retaining elastomeric gaskets **108** are positioned between the ends of the wall column and the confronting slabs **25** at preferably three areas, namely adjacent the respective opposite ends of the end edge areas and adjacent the convergence of the end edge areas. Lead-gauging shims **109** are desirably placed between the column edges and the slabs adjacent to but outside the quadrangular grout gaskets **108**. Such shims are of a thickness sufficiently less than the thickness of the gaskets **108** to permit adequate sealing compression of the gaskets, but avoiding collapse of the gaskets beyond useful grout-receptive thickness. Grout is then filled into the areas within the gasket under pressure to afford a desirable density and load-bearing capacity of the set grout. Any remaining gaps between the ends of the wall columns **101** and the slabs may be grouted or calked.

Instead of precast reinforced concrete construction for the wall columns, a prefabricated metal angular wall column **110** (FIG. **19**) may be employed. In a typical construction, the wall column **110** substantially identical vertical posts which may be of H-beam configuration rigidly connected together coextensively in the preferred spaced relatively angular column outline by horizontal bars **112** and diagonal brace bars **113**. On the respective opposite ends of the posts **111** are rigidly affixed coplanar bearing pad flange plates **114**. In mounting the metal frame wall columns **110**, elastomeric grout-retaining ring gaskets **115** are interposed between the bearing pads **114** and respective metal bearing plates **117** mounted in the confronting faces of the floor slab **25**. Respective spacers **118** are preferably disposed between the column units **110**, and within the areas confined by the gaskets **115** if desired, and the slab **25** or other load-engaged surfaced in order to maintain a desired depth of grout space within the gaskets **115**. After erection of the floor slabs and metal frame wall columns has been effected, any desirable wall covering **119** may be applied onto and over the columns and over the exposed edges of the slab **25**, as preferred

In loading grout into any of the gasket-enclosed areas under the column base, and between wall columns and the slab surfaces, not only are means for injecting the grout required but also means for venting air and water to prevent formation of pockets or voids. In one arrangement as depicted in FIG. **20**, the elastomeric gasket G in angular ring form in order to present a quadrangular enclosure for maximum efficiency in the generally quadrangular bearing areas of the respective load-bearing members, may be provided through one corner thereof with a charging hole **120** provided with a semirigid, but resilient reinforcing liner **121** to prevent collapse under pressure and through which discharges a loading hose **122** attached to the gasket and connected with a suitable low-pressure grout pump or injector. Extending from within at least the remaining corners of the gasket to the exterior are vent means comprising small diameter bleed tubes **123**. After the assembly has been completed and the gasket placed under limited compression between the parts to be grouted, grout is injected through the hose **122** until fluid constituents thereof bleed from each of the bleed tubes **123** which may be successively pinched off as the bleedout is observed, as by means of a suitable respective clamp **124**. After the gasket-enclosed area has been filled with grout, the charging tube **122** may be pinched off as by means of a clamp **125** to avoid regression of fluent grout. After-the grout has set, the tube **122** may be cut off close to the gasket G, as indicated at S.

In another arrangement, as shown in FIG. **21**, the gasket loading tube **122** may be fixed within the reinforcing lines **121** and provided with a pressure bulb **127**. As the gasket area is loaded with grout and back pressure develops the bulb **127** expands as shown in dash outline and, being of elastomeric material, the resiliency maintains the grout under pressure while it is setting up and after the tube has been pinched off as by means of the clamp **125** applied to the loading tube outwardly beyond the pressure bulb **127**. Alternatively, bleed tubes, the gasket G may be provided with bleed grooves **128** extending across the corner areas on at least one side of the gasket from the inside to the outside and of such shallowness that although air and water will be permitted to escape, when grout material enters the grooves they will be sealed off so that a self-sealing relationship is attained after air and water has been ejected from the grout area.

Where it is desired to maintain positive bleed passage groove openings even though the gasket may be liable to substantial pressures which might prematurely close off bleed grooves in the actual surface of the gasket, the structure shown in FIG. **22** may be employed comprising a bleed groove plate **129** which may be made from rigid or semirigid plastic or metal and has on its exposed surface bleed grooves **130** while the opposite surface is engaged against and may be compressed into the confronting surface of the gasket. If desired the bleed plate **129** may be adhesively or otherwise secured to the gasket. At its sides, the plate **129** may be chamfered as shown to avoid cutting into the gasket under pressure.

Where it is desired to effect not only bearing uniformity by means of the grout, but also to provide moment continuity, means may be provided for distributing the grout in keying relation to the grouted structural members. Such an arrangement is shown in FIGS. **23** and **24** wherein the gasket encompasses an area within which one of the members has a keying recess **131** to which leads a grouting passage **132** from the outside receptive of a grout delivery hose **133**. From the other of the members there extends into the recess **131** a key projection **134** which remains in spaced relation to the surfaces defining the recess **131** such that when grout is injected into the space around the key and into the gasket enclosed area the key will be set and interlock the members against lateral displacement pressures or stresses. Additional keying may be effected by providing the members with sleeves or aligned core bores **135** within which a dowel **137** of smaller diameter is placed and the grout fills into the bores and about the dowel so

that a thoroughly keyed structure results. Bleed off may be effected in a preferred manner such as by means of bleed ducts **138** bleeding through one or more of the building members to the outside and which ducts are self-sealing due to their length and the relative clogging nature of the grout material in respect to small openings. Similar bleed ducts **139** may lead from the dead ends of the keying bores **135**. If desired, either or both of the grout delivery tubes **133** may be provided with the expansible pressure bulb **127**. Further, either or both of the delivery may be pinched off as by means of the clamp **125** if desired to prevent regression of the grout load.

The gaskets G may be made from any suitable elastomeric material such as neoprene. In order to facilitate placement and retention of the grout gaskets during handling of the building parts and placement thereof, the gaskets may be adhesively secured to the surface on which first mounted. For example, where the gaskets are mounted on a slab surface, they may be adhesively secured thereto in the desired position. Where they are mounted on wall columns, they may be adhesively secured thereto. As delivered to the building site, the gaskets may be provided on one surface with a pressure sensitive adhesive and with a suitable protective cover thereon which is stripped off before the gaskets are applied, according to known practice in the use of such pressure sensitive adhesively coated members.

After all of the precast slabs have been lifted to their final locations and set upon their supporting substructures, all of the stabilizing wedges and hardware employed in the lifting operation, including the lifting jacks, lifting and holding carriages, lifting rods, stub rod chains, couplings, lifting plates, lifting nuts, intermediate holding and handling apparatus, sectional lifting columns and their baseplates are removed from the building for reuse at another building site.

It will be understood that variations and modifications may be effected without departing from the spirit and scope of the novel concepts of this invention.

I claim as my invention:

1, Apparatus for handling building floor and roof slabs formed in situ and provided with column openings through which ground supported lifting columns are mounted and on which columns are supported lifting devices by which a stack of the slabs is adapted to be lifted to raise each successive lowermost slab to a desired elevation wherein that slab is released from the lifting means while the remaining slabs are further lifted, comprising:

interim holding assemblies separably mountable on the respective columns after the respective lowermost slabs have been lifted to substantially their desired elevations;

means on said assemblies for engaging and supporting the lowermost slab with which associated for transference of the slab load to the columns; and

jacking means in each assembly operative for lowering and releasing said engaging means after supporting substructure has been erected under the lowermost slab.

2. Apparatus according to claim **1**, each said assembly comprising a lifting bracket having said slab-engaging means, and a lifting jack comprising said jacking means supporting said bracket.

3. Apparatus according to claim **2**, in which each said assembly includes a removable backup bearing member for said bracket and serving as a filler behind the bracket enabling removal of the bracket from the column and the slab upon removal of the bearing member.

4. Apparatus according to claim **1**, in which said columns have upwardly facing shoulders accessible through said openings, and said interim holding assemblies are mountable on and removable from said shoulders through said openings.

5. A method of constructing a multistory building, comprising:

preforming on a ground-supported base a stack of horizontal slabs one upon the other and of a length and width to cover a substantial building area;

providing in each of said slabs a plurality of lifting column openings vertically aligned in the stack;

erecting in said openings ground-supported lifting columns;

mounting lifting apparatus on said columns;

operating said apparatus to lift said stack of slabs along said columns until the lowest slab in the stack has reached an elevation above said base higher than its intended erected position;

supporting said lowest slab at said higher elevation on said columns and detaching it from the stack and said lifting apparatus;

further operating said lifting apparatus on said columns to lift the remainder of the stack from said column-supported lowest slab while it is held at said higher elevation;

while said remainder of the stack is undergoing further lifting by said apparatus, erecting building substructure independent of said columns under said lowest slab to provide ultimate support for it;

lowering said lowest slab onto said substructure for full support by said substructure and releasing such slab from said columns;

repeating the foregoing procedure with each succeeding lowest slab; and

finally removing said apparatus and columns.

6. A method according to claim **5**, comprising preforming said substructure into a plurality of wall columns each of which as a plurality of integral angularly related wall panel portions providing a self-stable unit, and placing said wall columns into efficient load-bearing respective positions under the lowest slab they are to support before lowering the slab thereonto.

7. A method according to claim **5**, comprising mounting said columns in said aligned openings on baseplates having grout space thereunder, holding said columns in vertical orientation with the baseplates normal to the vertical axes of the respective columns, filling grout under the baseplates through tubes extending through said plates into said spaces, and then setting the grout to assure balanced vertical load distribution in respect to said columns

8. A method of constructing a multistory building, comprising:

preforming on a ground-supported base a stack of horizontal slabs one upon the other and of a length and width to cover a substantial building area;

providing in each of said slabs a plurality of column openings vertically aligned in the stack;

erecting ground-supported columns to project upwardly through said openings to a height at least near the elevation to which the lowest slab in the stack is to be raised;

mounting lifting apparatus on said columns at a height which is sufficient to enable lifting the entire stack to adjacent said elevation;

connecting lifting rods to the slabs in the stack and attaching the lifting rods operatively to said lifting apparatus;

actuating the lifting apparatus to raise the rods and thereby lift the stack to adjacent said elevation but with a clearance space between said lifting apparatus and said stack;

mounting on the columns respective holding carriages within said space and connecting said carriages to said rods in load-supporting holding relation to thereby support the stack from said carriages;

disconnecting said lifting apparatus from said rods and relocating the apparatus on the columns at a second height near the elevation to which the next succeeding lowest slab is to be raised;

then reconnecting the lifting apparatus to said rods for operation to continue lifting of the stack and disconnecting said holding carriages;

continuing lifting of the stack until the lowest slab has reached said elevation therefor;

supporting said lowest slab on said columns;

releasing said lowest slab from the stack; and

operating said apparatus to raise the stack from said lowest slab to adjacent the elevation to which the next succeeding lowest slab is to be raised.

9. A method according to claim 8, comprising supporting said carriages on top of the stack to ride upwardly therewith adjacent to said columns when the carriages are not mounted on the columns or attached supportingly to said rods.

10. Apparatus according to claim 4, said means for lowering and releasing the engaging means comprising hydraulic jacks seated on said shoulders, said means for engaging and supporting the lowermost slab comprising respective brackets supported by said jacks for raising and lowering of the brackets.

11. Apparatus for lifting into position floor and roof slabs which have been formed in situ, comprising:

columns along which the slabs are to be lifted and which columns are in one-story building height sections;

means for securing said column sections vertically end to end;

means on lower portions of said sections providing seats including upwardly facing shoulders;

a respective carriage movable vertically along each column in a manner to leave the top of the associated column free for mounting thereon of another section as a column extension is needed;

lifting means supported by each of the carriages and having means detachably connectable to the slabs for lifting the slabs upon operation of the lifting means; and

means on said carriage separably engaging said seats in load-bearing relation.

12. Apparatus according to claim 11, said last-mentioned means comprising respective brace bars having lower ends engageable with said seats and upper ends, and load transfer structure on the respective carriages engaging said upper ends and thereby transferring the load to said brace bars by which the load is transferred to the associated column seat.

13. Apparatus according to claim 12, each of said bars being pivotally and relatively movably mounted with respect to said structure to enable passage of said brace bars along said shoulders during movement of the carriages upwardly along the columns.

14. Apparatus according to claim 12, in which said structure in each instance provides a reentrant seat, and the upper end of the associated brace bar is of complementary shape to thrust efficiently into engagement with such seat.

15. Apparatus according to claim 11, in which said seats comprise foot flanges on said column sections.

16. Apparatus according to claim 11, in which said column sections have vertical webs, and respective shoulder plates fixedly secured to said webs and providing said seats.

17. Apparatus according to claim 11, comprising second upwardly facing seat shoulders on said lower portions of the column sections at a different elevation from the first-mentioned seats enabling the lifting means carriages and holding carriages both equipped with means for separably engaging the seats to be supported simultaneously in adjacent relation on the column sections.

18. A method of constructing buildings comprising:

forming a stack of reinforced separate concrete building floor and roof slabs successively one on top of the other;

during the forming of each slab forming respective column receiving holes therein aligned with the similar holes in the other slabs;

adjacent to each of said holes removably mounting in the slabs a plurality of vertical slab-connecting lifting rod extension elements having their upper ends above the topmost slab for coupling thereto of lifting rods of lifting apparatus to be carried by columns mounted through said aligned holes;

removably securing lifting plates on said lifting rod extension elements under each of the slabs;

whereby all of the slabs can be lifted in unison and then each lower slab can be released successively from the bottom of the lifted stack; and

supporting for each slab to be formed a hole core and lifting plate socket-forming spider as a thickness gauge on said extension elements above the surface upon which the slab is to be formed.

19. A method according to claim 18, comprising coupling rod sections together in a train to form said extension elements and with the sections in the topmost slab extending thereabove for coupling thereto of the lifting rods of the lifting apparatus, and securing removable retaining means to said rod sections under said lifting plates.

20. A method of constructing a multistory building, comprising:

preforming on a ground-supported base a stack of horizontal slabs one upon the other and of a length and width to cover a substantial building area;

providing in each of said slabs a plurality of lifting column openings vertically aligned in the stack;

erecting in said openings ground-supported lifting columns;

mounting lifting apparatus on said columns;

operating said apparatus to lift said stack of slabs along said columns until the lowest slab in the stack has reached an elevation above said base higher than its intended erected position;

supporting said lowest slab at said higher elevation on said columns and detaching it from the stack and said lifting apparatus;

further operating said lifting apparatus on said columns to lift the remainder of the stack from said column-supported lowest slab;

preforming substructure in a plurality of load-supporting column units having opposite end upper and lower respective bearing faces;

erecting said column units as building substructure independent of said columns and locating said units at desirable locations and supporting the units on their lower bearing faces whereby to provide ultimate support under said lowest slab,

placing grout retaining generally ring-shaped gaskets onto the upper bearing faces of the units to surround the major areas of such faces;

placing load-bearing shims which are slightly thinner than said gaskets between said upper faces and said lowest slab whereby to prevent collapse of said gaskets from the weight of the slab but permitting sealing compression of the gaskets by said weight;

lowering said lowest slab onto the gaskets and thereby enclosing grout spaces within said gaskets;

filling said spaces with grout to assure stable and efficient full support load distribution from the lowest slab onto the units;

releasing said lowest slab from said columns;

repeating the foregoing procedure with each succeeding lowest slab; and

finally removing said apparatus and columns.

21 In a method of constructing a building wherein a preformed slab is lifted along columns mounted in openings in the slab;

mounting said columns on baseplates;

mounting said baseplates on grout-retaining gaskets;

holding said columns in vertical orientation with the baseplates normal to the vertical axes of the respective columns;

filling grout under the baseplates into areas enclosed by said gaskets;

setting the grout to assure balanced vertical load distribution through said columns;

said gaskets comprising elastomeric material;

floatingly supporting said baseplates and effecting said vertical orientation aided by said floating mounting of the baseplates;

said baseplates having respective holes therethrough to the space within the gaskets; and

filling the grout through said holes.