United States Patent [19]

McNamara, Jr.

[11] **3,710,534**

[45] **Jan. 16, 1973**

[54] **METHOD OF FORMING BUILDING UNITS AND ASSEMBLING SAME WITH LATERAL DISPLACEMENT**

[76] Inventor: **John Owen McNamara, Jr.**, 5 Taylor Street, Fort Screven, Ga. 31311

[22] Filed: **March 16, 1970**

[21] Appl. No.: **20,084**

Related U.S. Application Data

[63] Continuation of Ser. No. 720,925, April 12, 1968, abandoned.

[52] **U.S. Cl.** **52/745,** 52/126, 52/236, 264/33, 425/63

[51] **Int. Cl.**.....**E04g 21/14**

[58] **Field of Search** .....52/745, 126, 236; 25/118 S, 25/131 Z; 249/4; 264/33, 34, 31; 425/63

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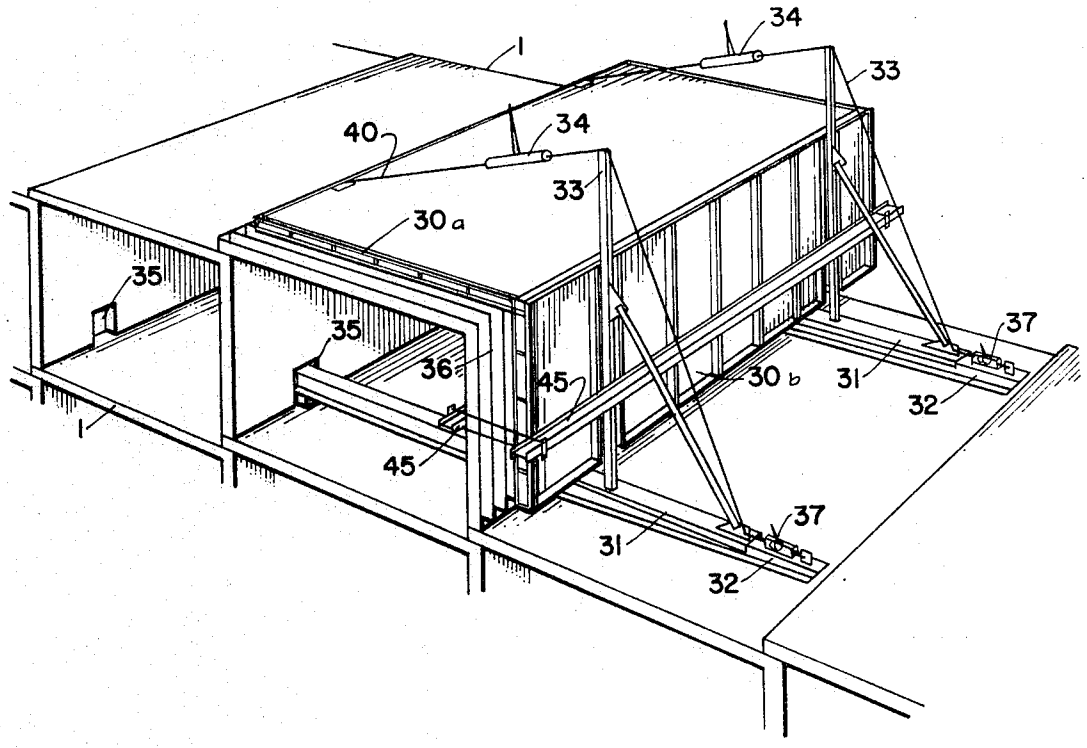
Primary Examiner—Alfred C. Perham
Attorney—Wynne & Finken

[57] **ABSTRACT**

A method of manufacture and assembly of preformed building units is provided wherein a stack of right angle units is cast with the upper layers of the stack being moved as a group horizontally, leaving the bottom unit in place.

4 Claims, 27 Drawing Figures



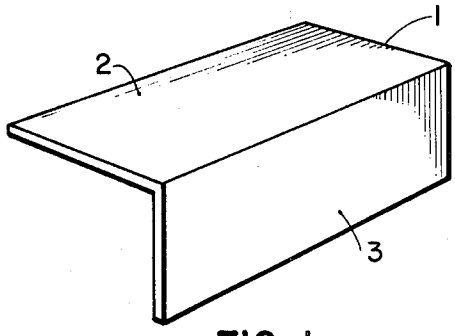


FIG. 1

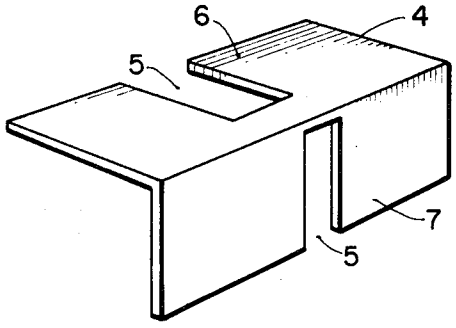


FIG. 2

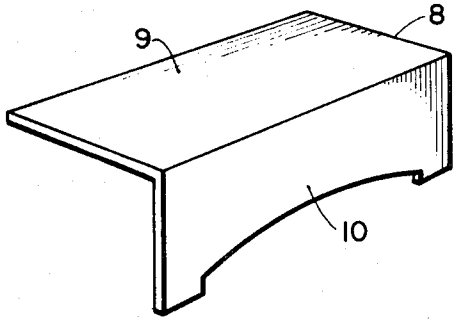


FIG. 3

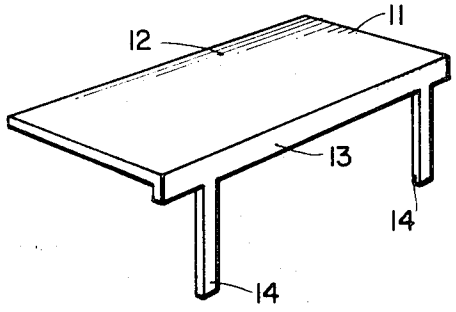


FIG. 4

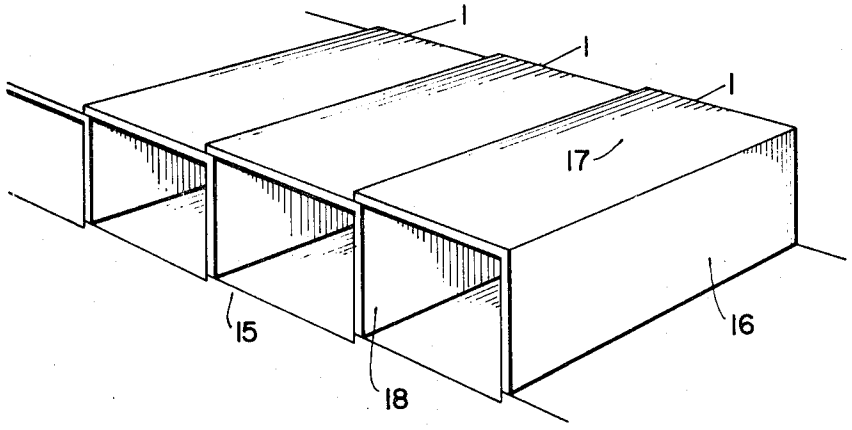


FIG. 5

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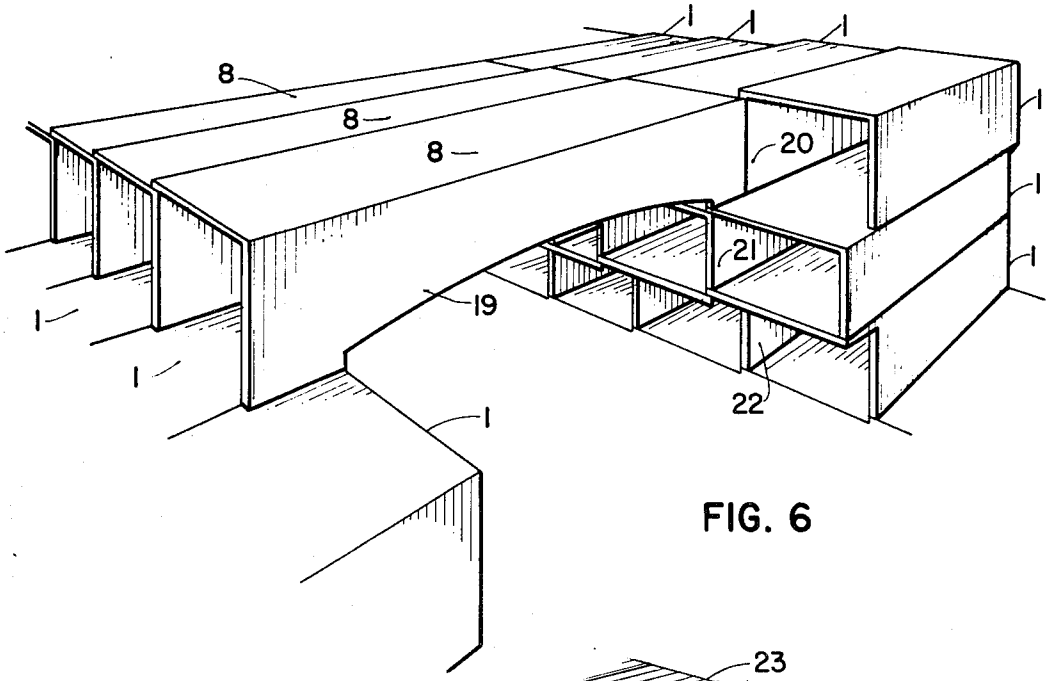

FIG. 6

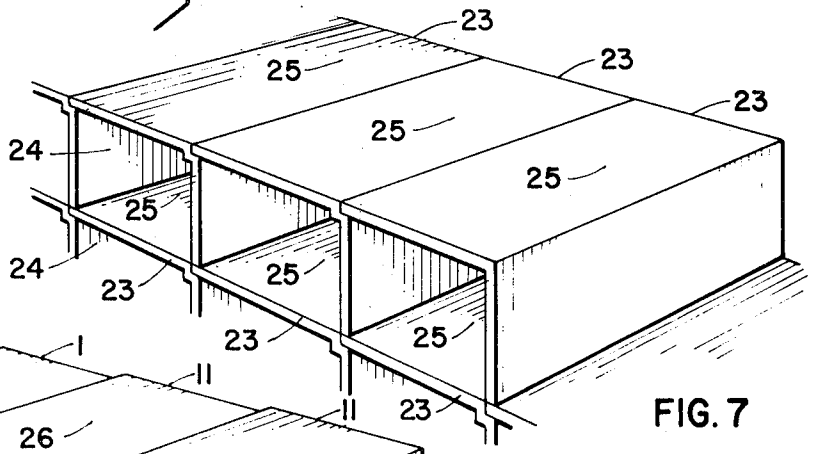

FIG. 7

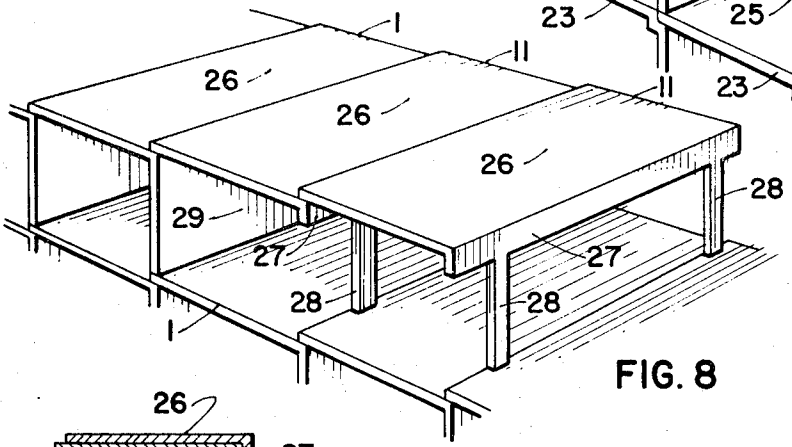

FIG. 8

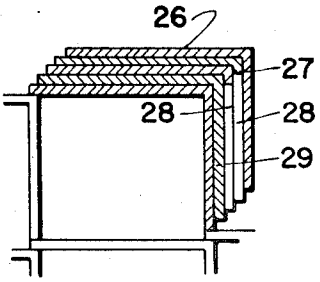

FIG. 9

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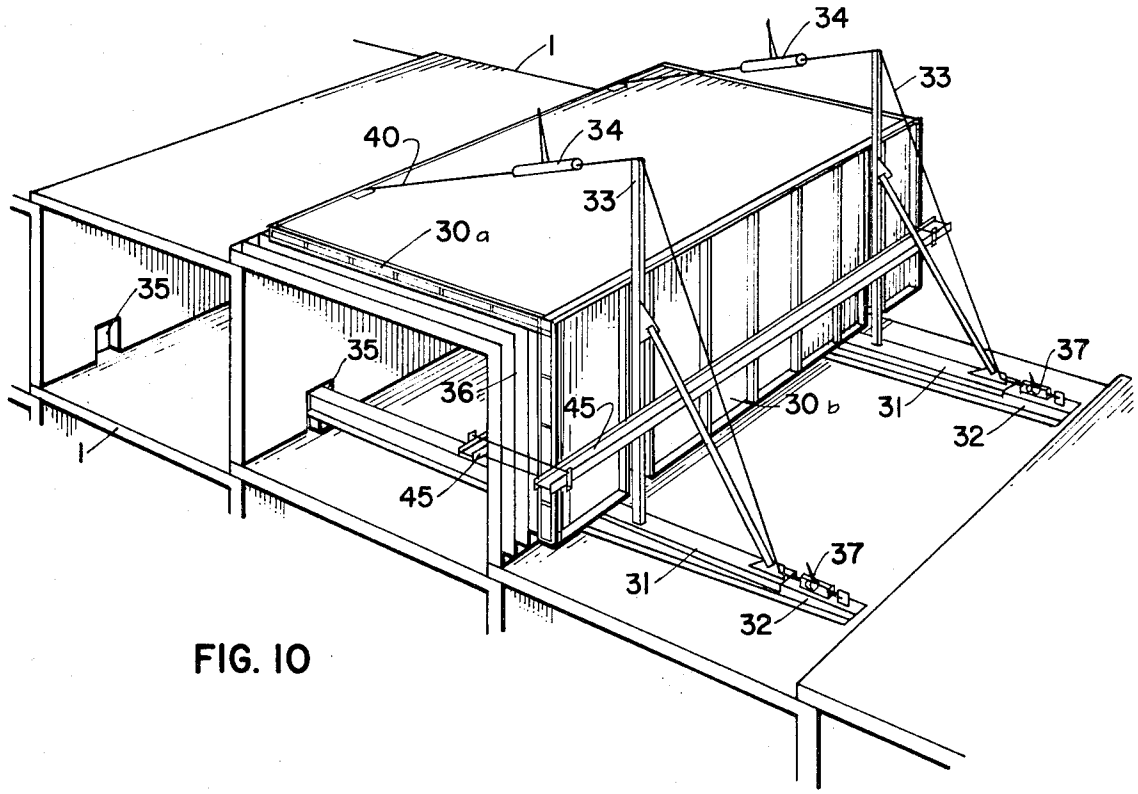

FIG. 10

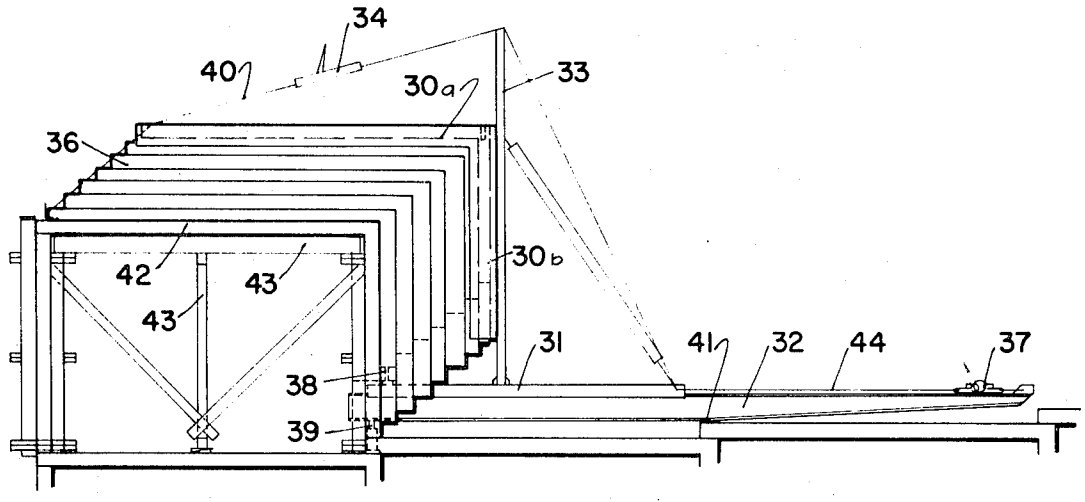

FIG. 11

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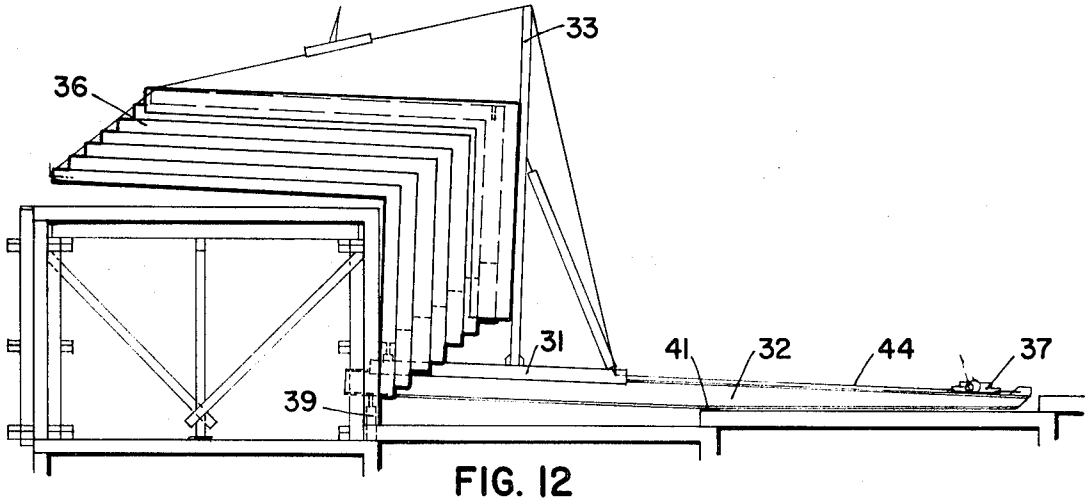

FIG. 12

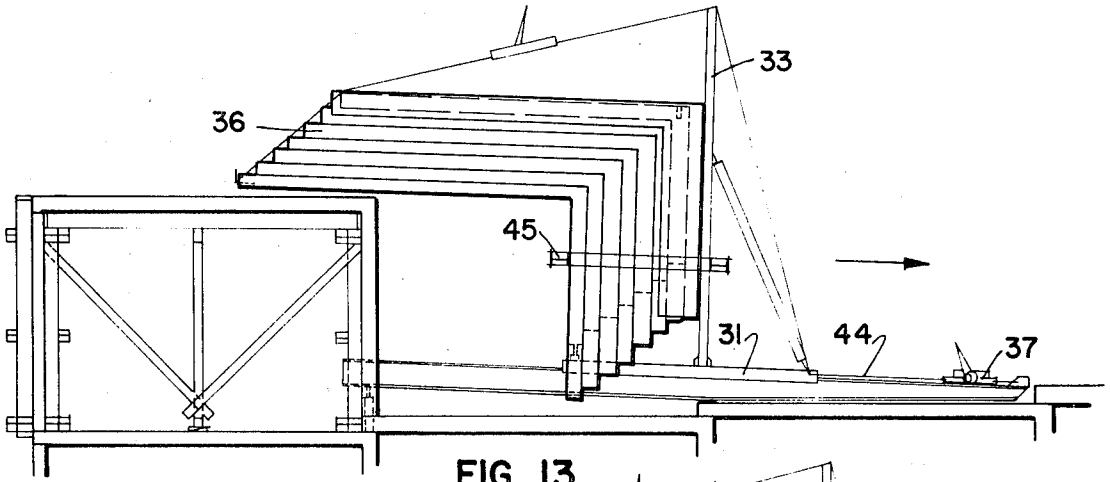

FIG. 13

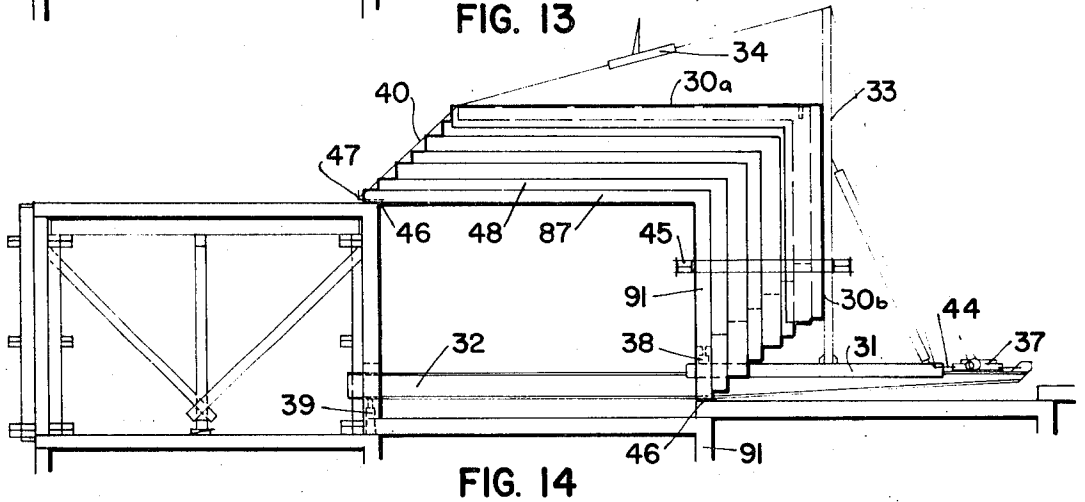

FIG. 14

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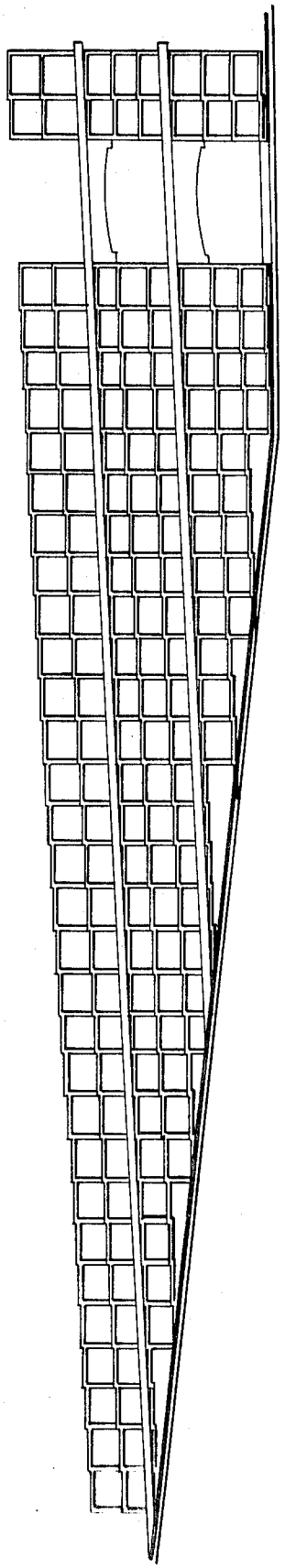

FIG. 15

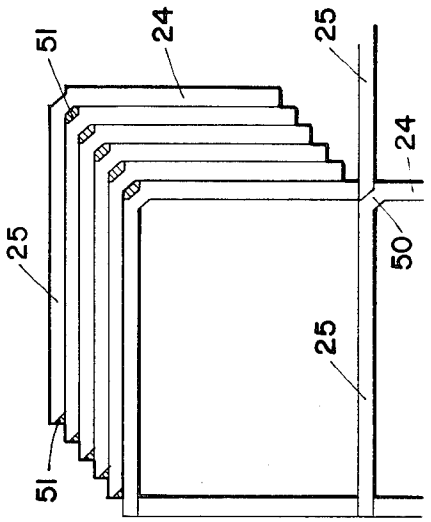

FIG. 17

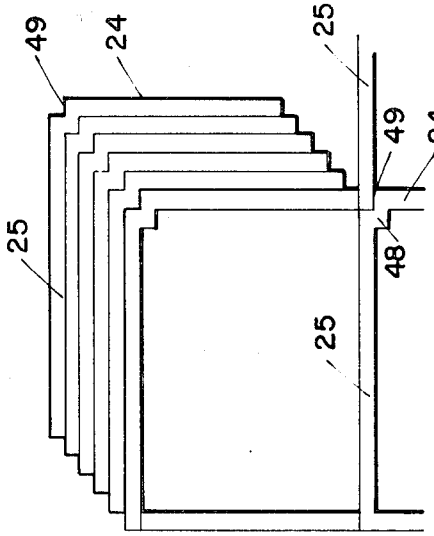

FIG. 16

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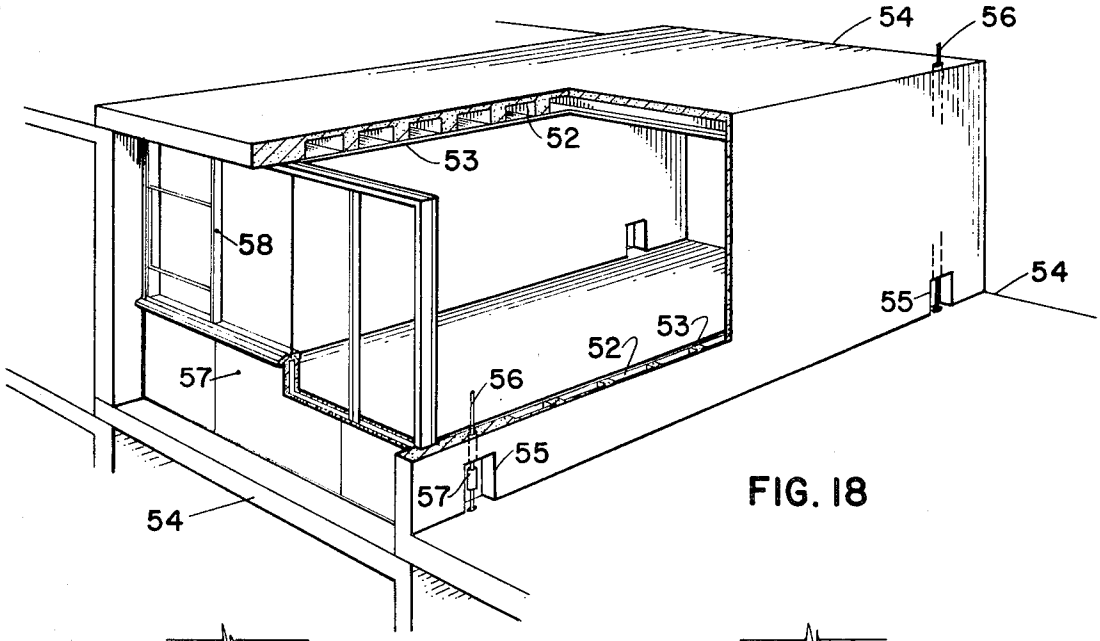

FIG. 18

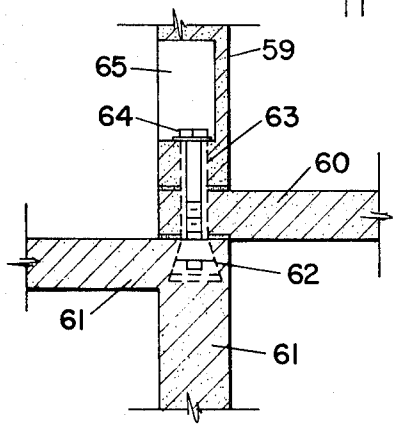

FIG. 19

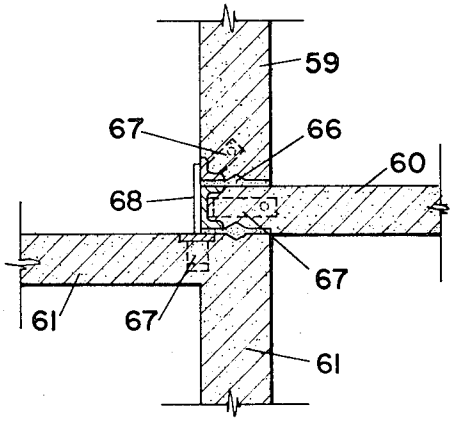

FIG. 20

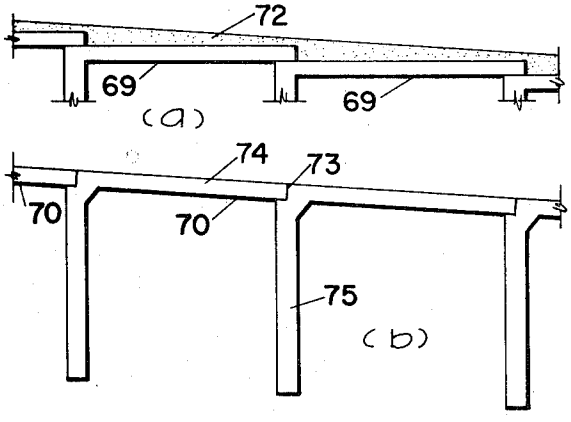

FIG. 21

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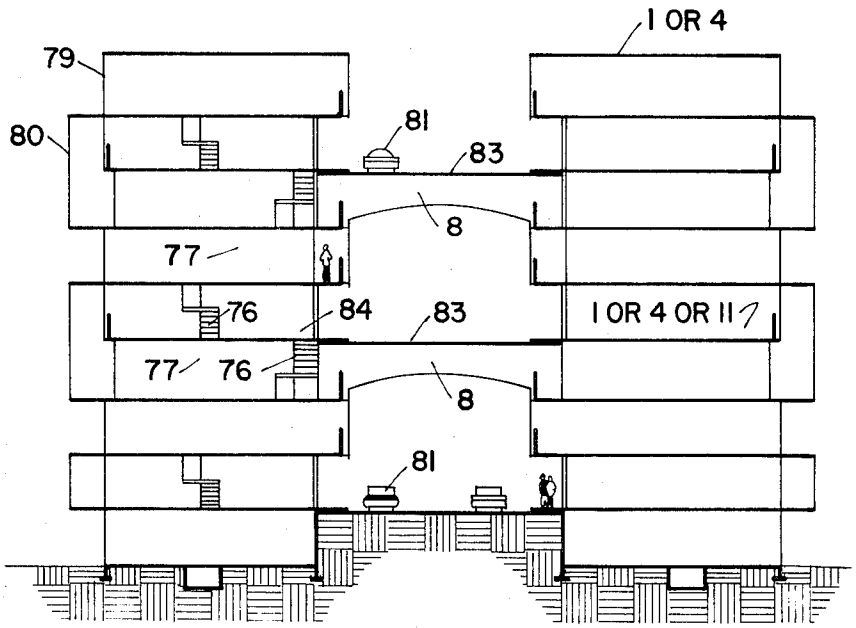

FIG. 22

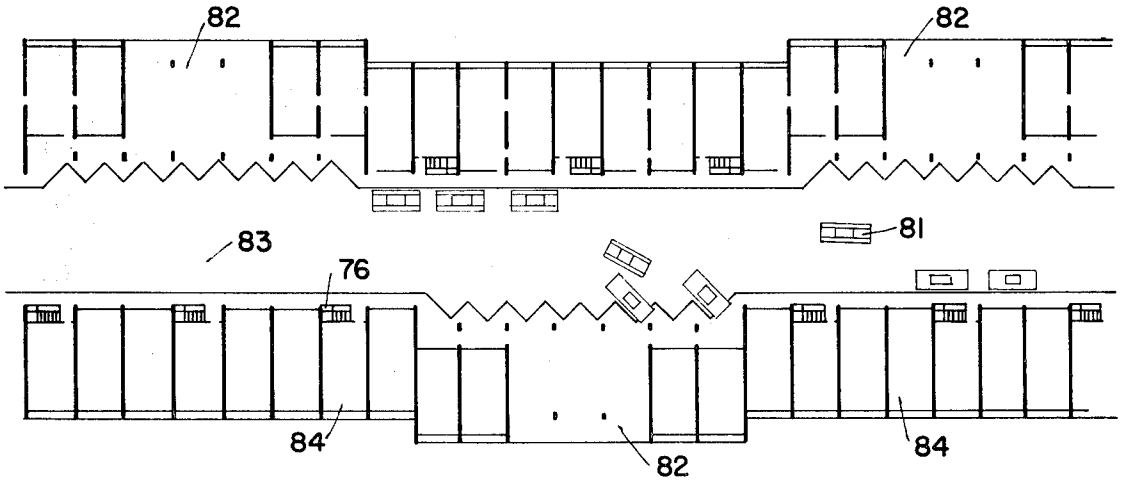

FIG. 23

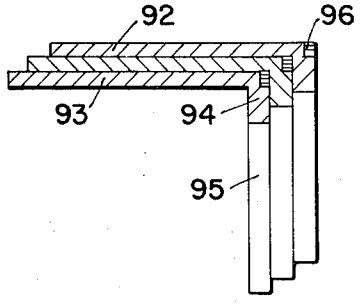

FIG. 27

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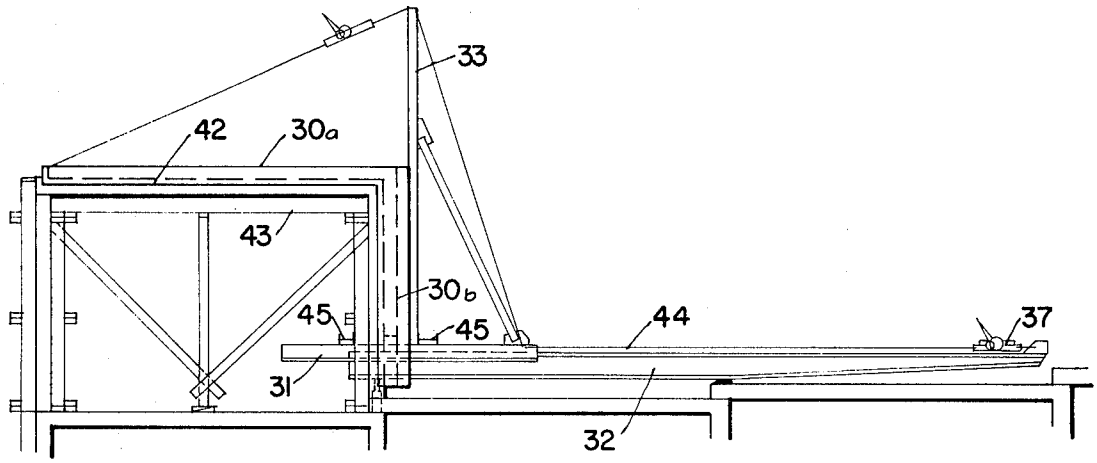

FIG. 24

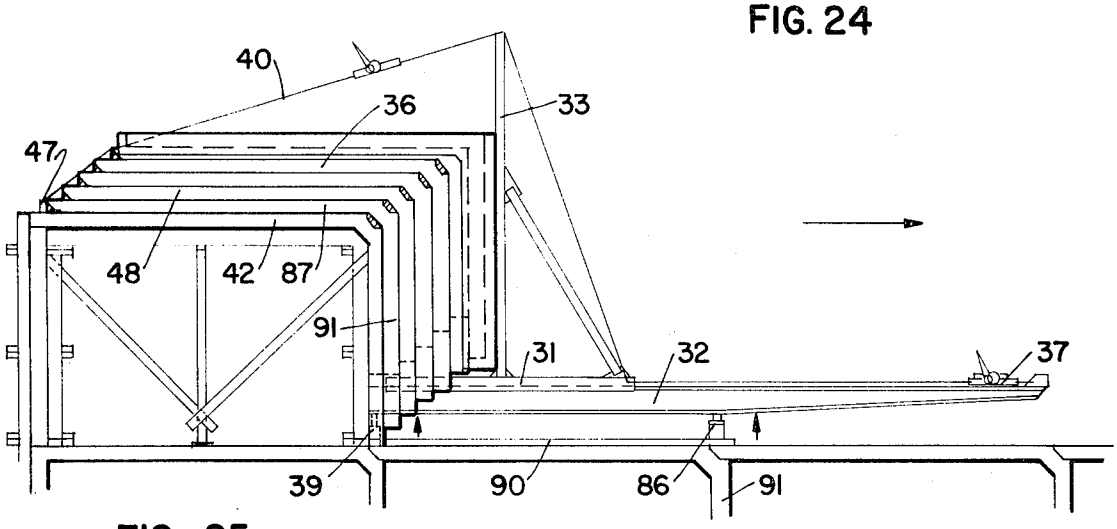

FIG. 25

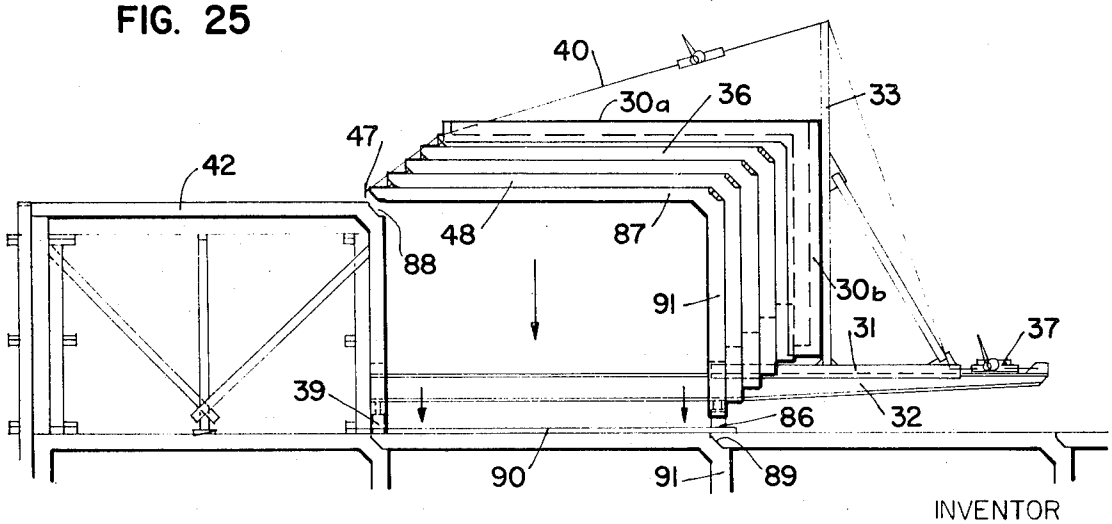

FIG. 26

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METHOD OF FORMING BUILDING UNITS AND ASSEMBLING SAME WITH LATERAL DISPLACEMENT

This is a continuation of application Ser. No. 720,925 filed Apr. 12, 1968 and now abandoned.

This invention relates to the building art and more particularly to the use of units comprising a horizontal or sloping member and an essentially vertical member cast integrally and of concrete or other moldable material. These units are assemblable in a variety of combinations to form buildings or structures of various shapes and sizes and of one or more stories.

One object of the invention is to provide a single type unit for mass production, whose horizontal or inclined element may serve as floor, roof or ramp and whose essentially vertical element serves as girder, beam, wall or columns.

Another object is to provide units that may be nest-cast to reduce the forming required.

Another object is to provide units that are stable against lateral and vertical load when assembled, without the requirement of moment-resisting connections or additional shear walls or bracing members. Such units may have openings provided for horizontal or vertical access through the units when they are assembled. When the units are assembled they can be secured permanently to each other.

A further object is to provide a unit which may be erected or placed in position without the need for lifting or transporting the completed unit for significant distances, thus avoiding the need for handling devices such as cranes or derricks. It also permits the placing of larger and heavier units in taller assemblies without the reach and load capacity limitations of currently available lifting equipment.

The invention furthermore relates to a method of manufacturing the units to be assembled as a building or a structure. In this method the units are so cast, in nest fashion, that the external surface of previously cast unit provides the forming surface for the internal surface of the next cast unit. Vertical and horizontal forming surfaces are provided and spaced to establish those surfaces not defined by the previously cast unit. The configuration of the units comprising both horizontal and vertical elements is such, and the manner of nesting is such, that the units may be translated laterally without its being necessary to lift the units vertically off of the stacks. The units are cast in an orientation that allows lateral translation of the units in the direction that assembly of the structure is established to proceed. The object of this configuration and procedure is to allow necessary handling to be accomplished with horizontal forces which are but a small fraction of the weight of the units being handled.

The invention relates furthermore to a method for erecting or handling and assembling the units. In accordance with the invention the units are raised as a group sufficiently to break bond and suction and translated laterally on slides and skid beams into position where the first cast slab in the stack is deposited in position. One object of the method according to the invention is to allow erection or placing of the longest cured (first cast) unit without disturbing the subsequently cast members in the stack. This method allows a uniform curing period for each unit and accelerates the building process. The usual nest-casting technique

requires that the lower units in the stack remain in position until the top most unit has cured a sufficient time to attain adequate strength to be moved into place. Another object of the method according to the invention is a means for allowing a continuous casting and curing operation to proceed on the stack while simultaneously placing the lower cured units, thereby accelerating the building process.

The invention relates furthermore to a device for carrying out the method according to the invention. Such device comprises a plurality of skid beams on which a stack of cast units and their form is slid laterally by a manual or powered means. Attached to the slide which travels on the skid beams is a bracing system to provide support for the form and the stack of cast units. A lifting and lowering device is employed to elevate one end of the skid beams providing a gradient. A lifting and lowering device is provided between the stack and the slide as a means of transfering the support of the stack to the slide on the skid beams, as a means of lowering the stack to deposit a unit and as a means of separating the stack from the deposited unit.

Another aspect of the invention is the assemblage of a plurality of units in a stepped or sloping configuration comprising rows and tiers of units separated by suspended vehicle ramps. The object of such an arrangement is the provision of direct vehicular access to the habitable and useable spaces created by the units.

For a better understanding of the invention, reference is made to the accompanying drawings which show some embodiments of the invention.

FIG. **1** is a perspective view of a typical building unit for use as slab and bearing wall.

FIG. **2** is a perspective view of a typical building unit showing a manner in shish openings may be provided for horizontal or vertical access through the units.

FIG. **3** is a perspective view of typical unit suitable for use as slab and deep girder.

FIG. **4** is a perspective view of a typical unit modified for use as slab, beam and columns.

FIG. **5** shows a perspective view of a manner of assembly of typical wall and slab units in a stepped arrangement.

FIG. **6** is a perspective view showing typical units stacked vertically and assembled in stepped fashion to enclose habitable spaces. Units serving as girders and slabs have been assembled with the wall and slab units to demonstrate their use to span and enclose larger spaces.

FIG. **7** is a perspective view of an assembly of units fabricated with a haunch at the juncture of slab and wall. This manner of assembly provides level floor or roof surfaces.

FIG. **8** is a perspective view of wall and slab units assembled together with beam, column and slab units.

FIG. **9** is a vertical sectional view of a stack of wall and slab units nested together with beam, slab and column units.

FIG. **10** is a perspective view of a device by means of which a given method of manufacturing and assembling the units according to the invention can be accomplished.

FIG. **11** is a side elevation of the device shown in FIG. **10** together with a stack of nest-cast units.

FIG. 12 is a side elevation of the stack with the end of the skid beams elevated and the first-cast unit left in place.

FIG. 13 is a side elevation of the stack from FIG. 12 while being displaced laterally on the slide.

FIG. 14 shows the skid beam ends lowered and the stack in position to allow lowering of another unit in place.

FIG. 15 is a side elevation of structure comprising a plurality of the units stacked and assembled as a building ramped for access to all spaces by vehicle.

FIG. 16 and FIG. 17 show variations of the haunch at the juncture of the horizontal and vertical elements comprising a typical unit.

FIG. 18 indicates a manner for defining the spaces within the units with the addition of end closure panel walls.

FIG. 19 illustrates a manner of joining units with bolts and inserts cast in members while FIG. 20 indicates a connection of units by field welding of contiguous metal inserts.

FIG. 21 shows the stepped configuration of assembled units transformed into a smooth ramp by the addition of fill and paving.

FIG. 22 is a vertical section taken through the building shown in side elevation in FIG. 15.

FIG. 23 is a possible plan arrangement of rows and tiers of units separated by the vehicle ramps shown in FIG. 22.

FIG. 24 is side view of the device used in the manufacture of the units. This figure shows the positioning of the forms when casting the first unit in the moveable stack.

FIG. 25 is a side elevation of a device for forming and placing units when they are to be assembled with floors or roofs in a common plane.

FIG. 26 shows the units of FIG. 25 laterally transferred and in position to be lowered.

FIG. 27 is a side elevation of a stack of units having bearing recesses.

The following is a detailed description of the units, their assembly, their manufacture and a method for placing of the units.

FIG. 1 indicates a unit 1 comprising a horizontal or sloping floor or roof slab 2 integrally cast with, and rigidly joined with, an essentially vertical wall member 3.

FIG. 2 illustrates a unit 4 as described in FIG. 1 with openings 5 provided to accomodate the inclusion of doors or windows in the wall member 7, and/or stairs or elevators in the floor or roof member 6.

FIG. 3 shows a unit 8 comprising a horizontal or sloping floor or roof slab 9 cast integrally with, and rigidly joined with, an essentially vertical element 10 which may serve as a girder capable of large spans.

FIG. 4 is a perspective view of a unit 11 comprising a horizontal or sloping floor or roof slab 12 cast integrally with, and rigidly joined with, a beam 13 and a plurality of columns 14.

FIG. 5 is a perspective view of an assembly of units 1 supported on a foundation 15.

The units 1 may be connected at their points of mutual contact by bolts cast in the units or by the welding together of metal inserts cast in adjacent units at their points of contiguity. When connected at these points the units 1 when assembled as shown are stable against components of lateral load applied in a direction perpendicular to the plane of the vertical element 16. This stability results from the co-action of the connections outlined above and the rigid joint at the juncture of the wall 16 and the slab 17. The assembly of walls 16 and 18 together with the slab 17 function as a three hinged arch. When wall panels and slabs are assembled separately as is the usual case, lateral stability is achieved by relatively costly and difficult moment resisting connections or with the incorporation of shear walls parallel to the direction of the applied loads. The assembly of the units 1 in the configuration shown defines stable and useful sheltered spaces.

The assembly illustrated in FIG. 6 shows a manner of vertically stacking tiers of units 1 with their vertical elements 20, 21 and 22 superimposed one over the other. FIG. 6 also illustrates a manner in which a plurality of units 8 may be assembled with other units to span and enclose large spaces. The vertical elements 19 of units 8 bear on and align with vertical elements 21 of units 1.

FIG. 16 and FIG. 17 indicate variations in the conformation of the joints between the vertical elements 24 and the horizontal element 25. These joint conformations permit assembly of the units 23 in the manner illustrated in FIG. 7, thereby comprising structures with the horizontal elements 25 aligned in a common plane to form level rather than stepped floors or roofs. Vertical elements 24 are aligned in common planes. These joint conformations are such that nest-casting may be employed as illustrated in FIG. 16 and FIG. 17.

The units 11 comprised of slab 26, beam 27 and columns 28 may be assembled together with units 1 comprised of slabs 26 and walls 29 as illustrated in FIG. 8 and also may be nest-cast together as illustrated in FIG. 9.

A device for forming and placing the cast units is pictured in FIG. 10. The essentials of this device are slab edge form 30*a*, wall or girder side form 30*b*, slide 31, skid beam 32, mast and bracing 33 for form and stack of units, stack support cable 40, cable take-up device 34, opening for skid beam 35, stack of nest-cast units 36, manual or powered winch (or other pulling device) 37, stack lifting jack 38, skid beam elevating jack 39, rocker or swivel bearing 41. (See FIG. 11 for 38, 39 and 41).

In FIG. 24 a starting unit 42 has been cast on conventional forming 43. The edge form 30*a* and the wall form 30*b* are in position for casting the first unit of a nested stack. The edge form and wall form may be partly or wholly connected to, and supported by, the mast and bracing 33 in a manner that will allow only upward movement of the form relative to the mast. The mast, in turn, is supported on the slide 31. The slide 31 is slidably supported on the skid beams 32. The pressure of the freshly cast material between the form 30*b* and the unit 42 is resisted by the strongbacks 45 and the mast 33. A plastic film, sheet finish material, chemical or other type bond preventive is applied to that surface of unit 43 which forms the under surfaces of the unit to be next cast. When the cast material in the newly-cast unit has sufficiently hardened to allow form removal and work loads that follow, the wall form 30*b* is disconnected from the edge form 30*a* and the slides together with the masts 33 and wall forms 30*b* are slid laterally

on the stationary skid beams 32. This translation may be accomplished through the cables or rods 44 and the pulling device 37. After the sheet finish or bond preventive is placed on the casting surfaces of the last cast unit and after the metal reinforcing has been placed, the wall form 30*b* and edge form 30*a* is repositioned vertically upward on the mast 33 a distance equal to the thickness of the cast horizontal element 42. The forms 30*b* and 30*a* are repositioned horizontally an amount equal to the thickness of the cast vertical element 42. The strongbacks 45 are repositioned to accomodate the new dimensions and the next unit in the stack is cast. This proceedure is repeated until a stack of nested units of the desired number is cast as shown in FIG. 11. The number of units in the stack 36 will be a function of the required curing period, the time required for casting the units and the time required for placing and ability of the equipment to safely sustain the placing loads as described hereafter.

When the first-cast unit (not the last-cast, as is the conventional way) has cured long enough to attain the strength to resist handling stresses the stack 36 and the device will be essentially as illustrated in FIG. 11 and the process of placing units may begin as follows:

Elevate the stack slightly by extending the lifting devices 38 between the stack 36 and the slide 31. This will break the bond and suction between the in-place unit 42 and the stack 36, and will provide clearance over the mortar setting bed when the unit arrives at its intended location. Simultaneously with this elevation of the stack, slack is removed in the stack support cables 40 with the take-up devices 34 (when the horizontal slab is not designed to cantilever its full width).

The lifting devices 39 at the end of the skid beams 32 are then extended to establish a gradient (if required) so gravity may assist the pulling devices 37 in translating the stack 36 laterally in the direction of intended placing. Jacking the ends of the skid beams 32 rotates the entire stack and device about an axis through the rocker or swivel bearings 41 as shown in FIG. 12.

The stack 36 and slide assembly 33 and 31 are then displaced laterally by the pulling devices 37 as shown in FIG. 13. During this travelling period another unit may be cast, thereby making the casting and placing operations concurrent and speeding the building process.

When the stack is in position with the vertical elements 91 of the units aligned (FIG. 14) the lifting devices 39 under the skid beams 32 are activated to lower the beams and stack to their original inclination with the horizontal. The lifting device 38 and the take-up device 34 are operated simultaneously to lower the bottom unit 87 into the intended position seating the contact areas in mortar beds 46 as illustrated in FIG. 14. With load and contact removed from the lifting devices 38 and 39, the skid beams 32 are pulled ahead to the next position using the cable 44 and the pulling device 37 or by some other means. Disconnect the stack support cable 40 at its connection 47 to unit 87 and reconnect the cable 40 to support the end of unit 48. The rocker bearings 41 and lifting devices 38 and 39 are then relocated in the relationship to the stack 36 and to each other that existed before the placing of unit 87, before repeating the placing cycle. When additional units are to be added to the stack the slide and form assembly 31, 33, 30*a* and 30*b* are repositioned as described above for casting subsequent units before the placing cycle is commenced. It is anticipated that the vacumn process will be employed to consolidate and accelerate the hardening of concrete, when it is the casting material, thereby reducing the time for each cycle.

FIG. 15 illustrates an assembly of one of many possible combinations of the units described in FIG. 1 thru FIG. 4. The manner of arrangement of the units would be influenced by the topography of a particular site. Buildings comprising assemblages of the units described herein are particularly adaptable to the natural slopes of hilly terrain. They may be erected normal to the land contours as illustrated in FIG. 15 or they may be assembled with level floors and roofs parallel to the contours in the configuration shown by FIG. 7.

FIG. 16 illustrates a manner of rigidly casting horizontal elements 25 with vertical elements 24 in nest fashion such that when placed in their assembled relationship a joint 48 is made with a seat 49 that provides bearing for the end of adjacent horizontal member 25. The assembled horizontal members 25 then lie in a common plane.

FIG. 17 illustrates a manner of accomplishing the same end described above but with a joint configuration 50 that allows more simple detailing of the internal metal reinforcing connecting horizontal members 25 and vertical members 24. The joint is formed by the insertion of a removable filler material 51 to exclude the casting material when the unit is cast.

FIG. 18 shows by cut-away section how the units may be lightened, when necessary or expedient, by casting the units on void or rib-producing elements 52 of cardboard, plastic, or other material. The voids created may be used as duct, wiring, piping or conduit chases or as a means of establishing a more efficient structural form of reduced weight. These void or rib forms and the finish material 53 would also serve to prevent bonding of the several units when placed between individual units during the casting process.

Also shown in FIG. 18 is one means of connecting the individual units 54 after assembly. Openings 55 provided in the units provide access for connecting rods 56 which may be cast in units or inserted thru cast chases and connected by welded or threaded sleeves 57 or by welded splice bars. Concrete or similar moldable material may be used to close the openings and effect a connection of the rods by bonding through the castable material.

FIG. 18 illustrates closure of the open ends of assembled units 54 by prefabricated or built-in-place panels 57 of conventional building materials. Panels may be fabricated with or without windows 58 or doors.

An alternate method of connecting units by bolting is shown in FIG. 19 where threaded inserts 62 are cast in lower units 61 and bolts 64 inserted thru sleeves 63 formed in edge of horizontal element 60 and vertical element 59 in which an access opening 65 has been provided.

Another alternate means of joining units at their contiguity is by welding as detailed in FIG. 20. Metal inserts 67 are cast in the units in such a manner that they occur in close proximity when the elements 59, 60 and 61 are assembled. The adjacent inserts 67 can be welded through a connecting bar 68.

FIG. 21 represents alternate means of providing a smooth ramp comprised of nest cast units 69, 70. FIG. 21*a* shows units 69 assembled in a manner similar to that of units 8 in FIG. 6, but with a fill and paving material 72 superimposed thereon to provide a smooth surface. The same effect may be accomplished as shown in FIG. 21*b* by providing a joint 73 comprising a recessed shelf in vertical member 75 for the support of the end of element 70 which is inclined with the horizontal to create a ramp gradient, the whole configuration being nest-castable similar to the units of FIG. 26.

FIG. 22 is a vertical section through a structure comprising units 1 (FIG. 1), units 4 (FIG. 2), units 8 (FIG. 3), units 11 (FIG. 4), assembled as shown in FIG. 6. A side elevation of the structure illustrated in FIG. 22 would be similar in part to that in FIG. 15 when stacked in step fashion rather than with level floors as described in FIG. 7. The units 8 may form ramps or streets 83 to provide vehicle 81 and pedestrian access directly to useable spaces, such as 84, which connect to other spaces and levels 77 by way of stairs 76. Units 79 may be placed offset from other units 80 as desired to create porches and balconies. The various levels at the ramps 83 may be taken together as multi-story neighborhoods, a typical partial plan of which might be as shown in FIG. 23, comprising play or public areas 82, streets 83, useful or habitable spaces at a plurality of levels interconnected by stairs 76.

FIG. 25 shows a modification of the device described in FIG. 10 thru FIG. 15 and in FIG. 24. Except as described hereafter, the casting and forming of units are similar to that shown in FIG. 24 and described hereinbefore. One object of this modification is to facilitate the placing of units so that their essentially horizontal elements are in a common plane. Referring to FIG. 25, when the first-cast unit 87 (not the last-cast, as is the conventional way) has cured long enough to attain the strength to resist handling stresses the stack 36 and the device will be essentially as illustrated in FIG. 25 and the process of placing units may begin as follows:

Elevate the skid beams 32 by extending the lifting devices 39 and 86. The amount of this elevation should be sufficient to break the bond and suction between the stack 36 and the in-place unit 42 and to provide clearance over the mortar setting bed when the unit 87 arrives at its intended location. The lifting device 39 may be extended an additional amount lifting one end of the skid beam and the stack assembly to establish a gradient in order that gravity may assist the pulling devices 37 (if desired) in translating the stack laterally in the direction of placing. The stack 36 and slide assembly 31 and 33 are then displaced laterally by the pulling devices 37 until the stack is in position with the vertical elements 91 of the units aligned in a vertical plane (as shown in FIG. 26). The lifting devices 39 and 86 under the skid beams are then lowered, allowing the unit 87 to settle in position on mortar setting beds 88 and 89. The skid beams 32 and the lifting devices 39 and 86 are then relocated in relationship to the stack 36, and to each other, that existed before the placing of unit 87. Detach the attachment 47 connecting the stack support cables 40 to the unit 87 and reconnect to equivalent location on unit 48 (FIG. 26). The placing cycle may then be repeated. During the time of moving the stack 36 another unit may be cast. When additional units are to be added to the stack the slide and form assembly 31, 33, 30*a* and 30*b* are repositioned as described before for casting subsequent units. It is anticipated that the vacumm process will be employed to consolidate and accelerate the hardening of concrete when it is the casting material, thereby reducing the time for each cycle.

The device pictured in FIG. 25 and its operation, as described hereinbefore, may also be used to place the stepped arrangement of units shown in FIG. 11.

FIG. 27 illustrates a means of nesting units 92, comprising slabs 93, beams 94 and columns 95 with bearing recesses 96 to permit assembling with the slabs in common plane.

I claim as my invention:

1. A method of manufacture and assembly of preformed building units, each unit being cast integrally and having a top element and a side element forming a substantially right angle unit comprising the steps of:

providing a form on a previously cast first unit for receiving flowable material to produce a superimposed second unit thereon with the previously cast first unit providing the bottom for the new top element and one side form for the new side element,

pouring flowable material into said form and allowing it to set,

providing a form on said second unit for receiving flowable material to produce a superimposed third unit with the previously cast second unit providing the bottom for the new top element and one side form for the new side element,

pouring flowable material into the third unit form and allowing it to set,

raising said second unit to break bond and suction with the first unit, and moving said second unit horizontally to place the second unit in a predetermined position, and

lowering said second unit producing a supporting relationship of the second unit top element with the first unit top element, and continuing with said raising, moving, and lowering steps to produce a supporting relationship of the third unit top element with the second unit top element.

2. A method as defined in claim 1 and including supporting the end of the second unit top element when said second unit is raised and moved.

3. A method as defined in claim 1 and wherein said third unit is cast during the moving of the second unit horizontally.

4. A method as defined in claim 1 and wherein added units are formed prior to lowering said second unit.

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