United States Patent

Vanderklaauw

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[45] Sept. 19, 1972

[54] APPARATUS FOR FORMING AND LIFTING MULTI-STORY COLUMNS IN ONE STORY INCREMENTS

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[52] **U.S. Cl.**.....**425/63,** 264/34

[51] **Int. Cl.**.....**E04g 13/02**

[58] **Field of Search** 425/65, 63; 264/33, 34; 254/45

[56] **References Cited**

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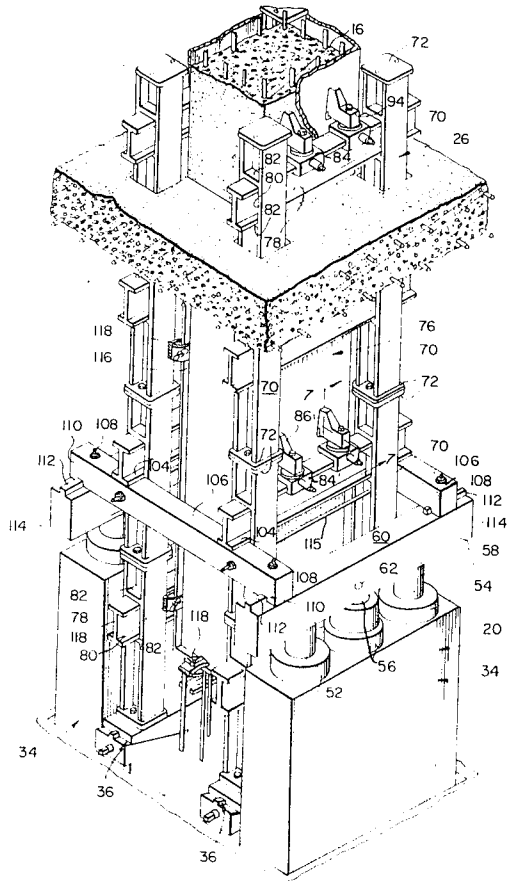
Primary Examiner—Robert D. Baldwin

Attorney—Stowell & Stowell

[57] **ABSTRACT**

The basic supporting framework of reinforced concrete slabs and columns for a multi-story building is formed in a roof down fashion and erected in a continuous lifting process from the foundation level. Auxiliary column sections, which retain molding formworks for the columns and are supportingly tied to the formed concrete columns, support the load of the building, until the concrete at the bottom hardens, by bearing on adjustable bearing platforms at the foundation. Lifting devices at the foundation cooperate with the supporting auxiliary column sections to push the building up after each floor is built. The lifting devices raise the auxiliary columns off the cooperating adjustable bearing platforms to permit the insertion under and attachment to the auxiliary column assemblies of a further auxiliary column section with the lifting devices operating in step-by-step alternation with support of the auxiliary column assembly on the bearing platforms until the building is raised to the desired height for a new floor at which time a reinforcement cage for a new permanent concrete column to be poured is fixedly inserted in the newly created space within the auxiliary column and attached to the preceding column.

7 Claims, 9 Drawing Figures

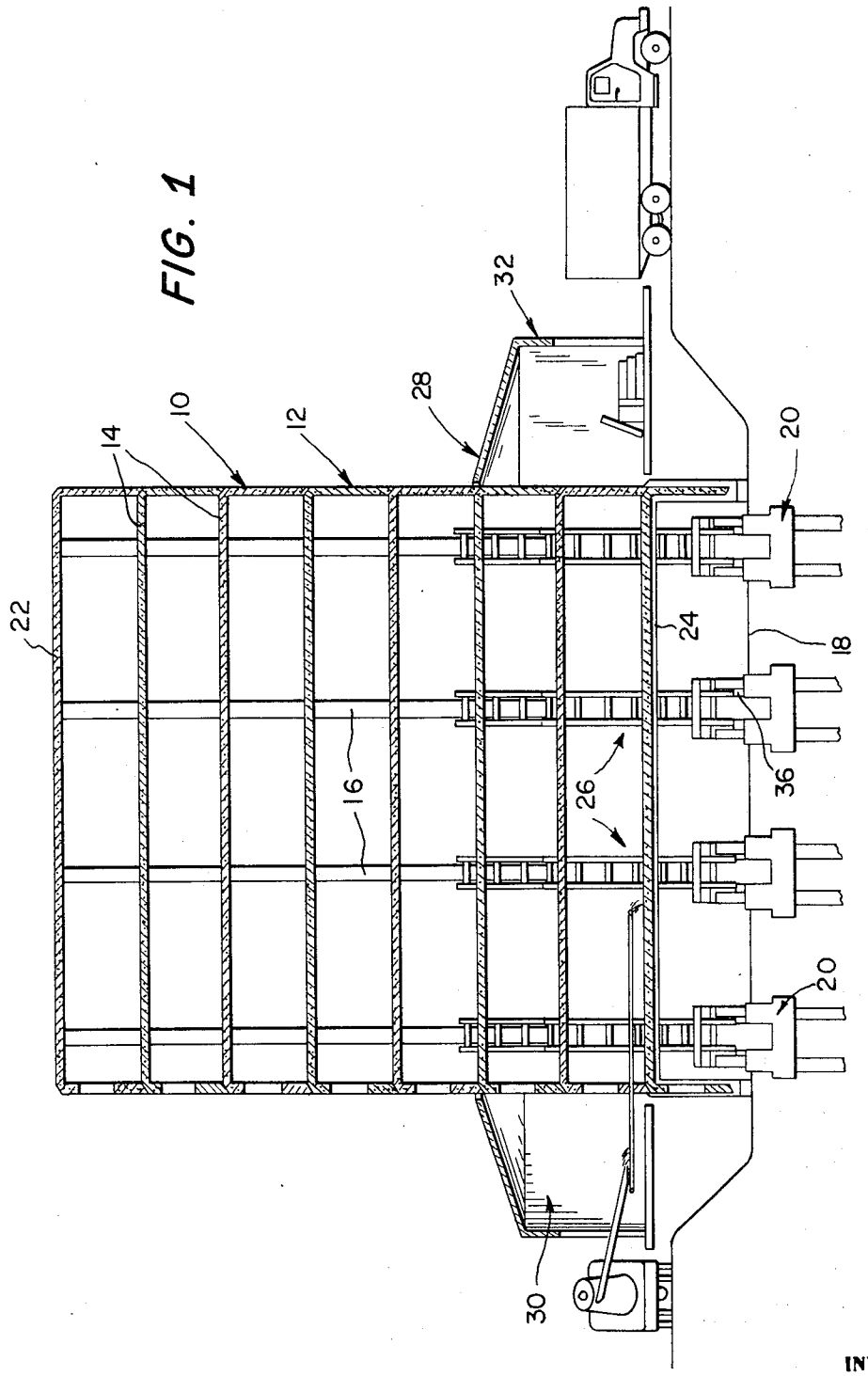


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SHEET 1 OF 6

FIG. 1



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ATTORNEYS

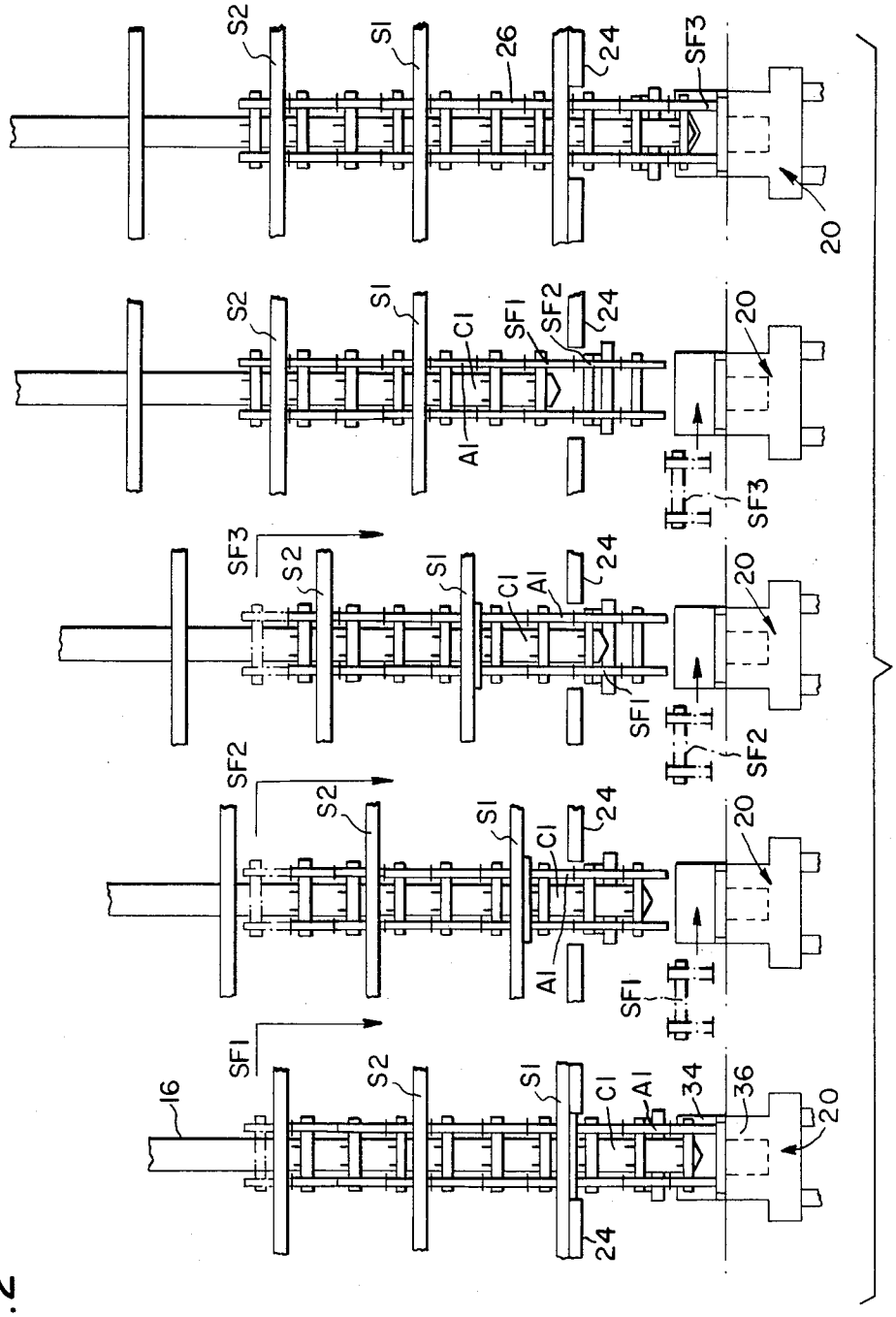


FIG. 2

FIG. 3

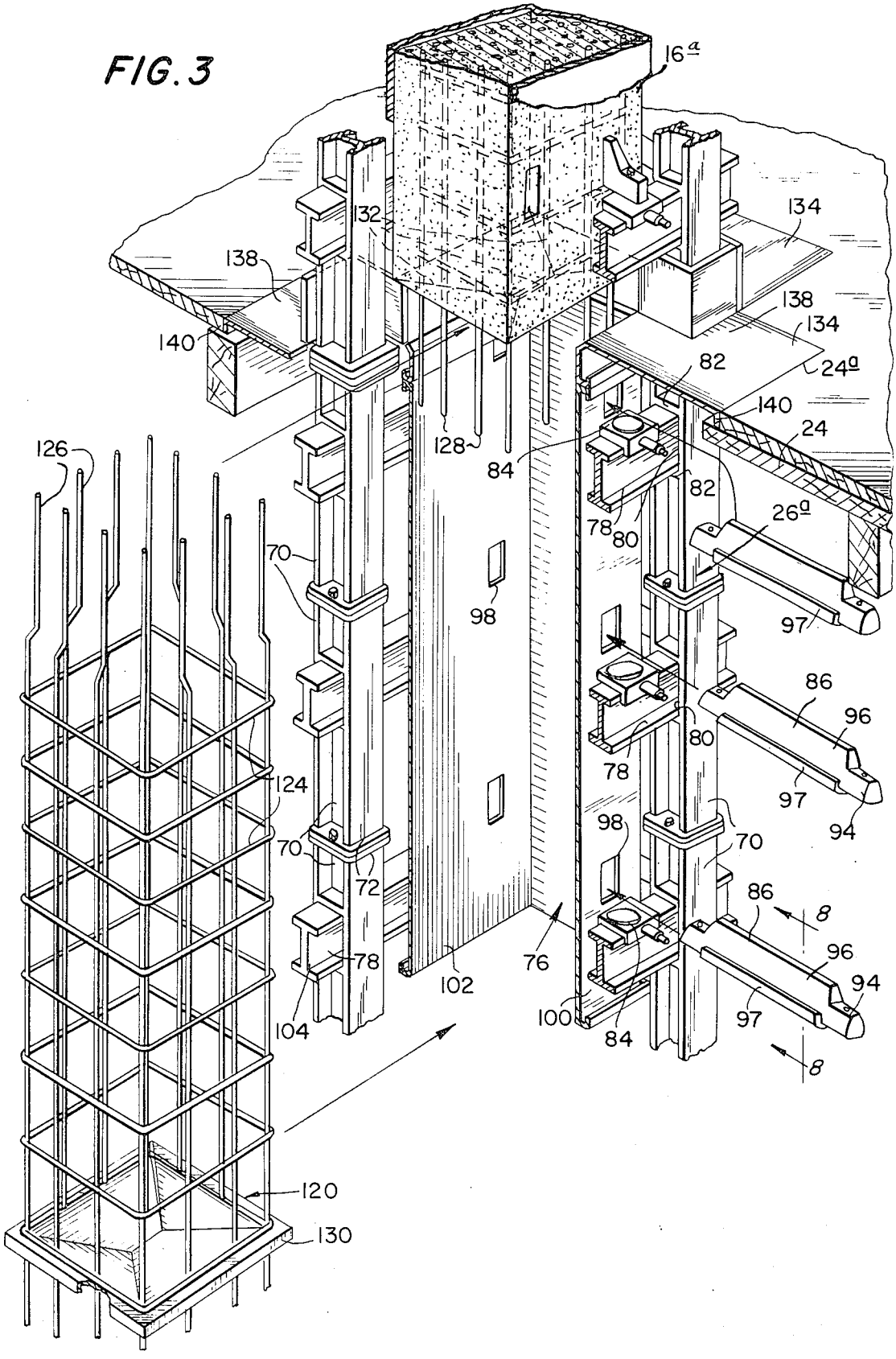

16a
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FIG. 4

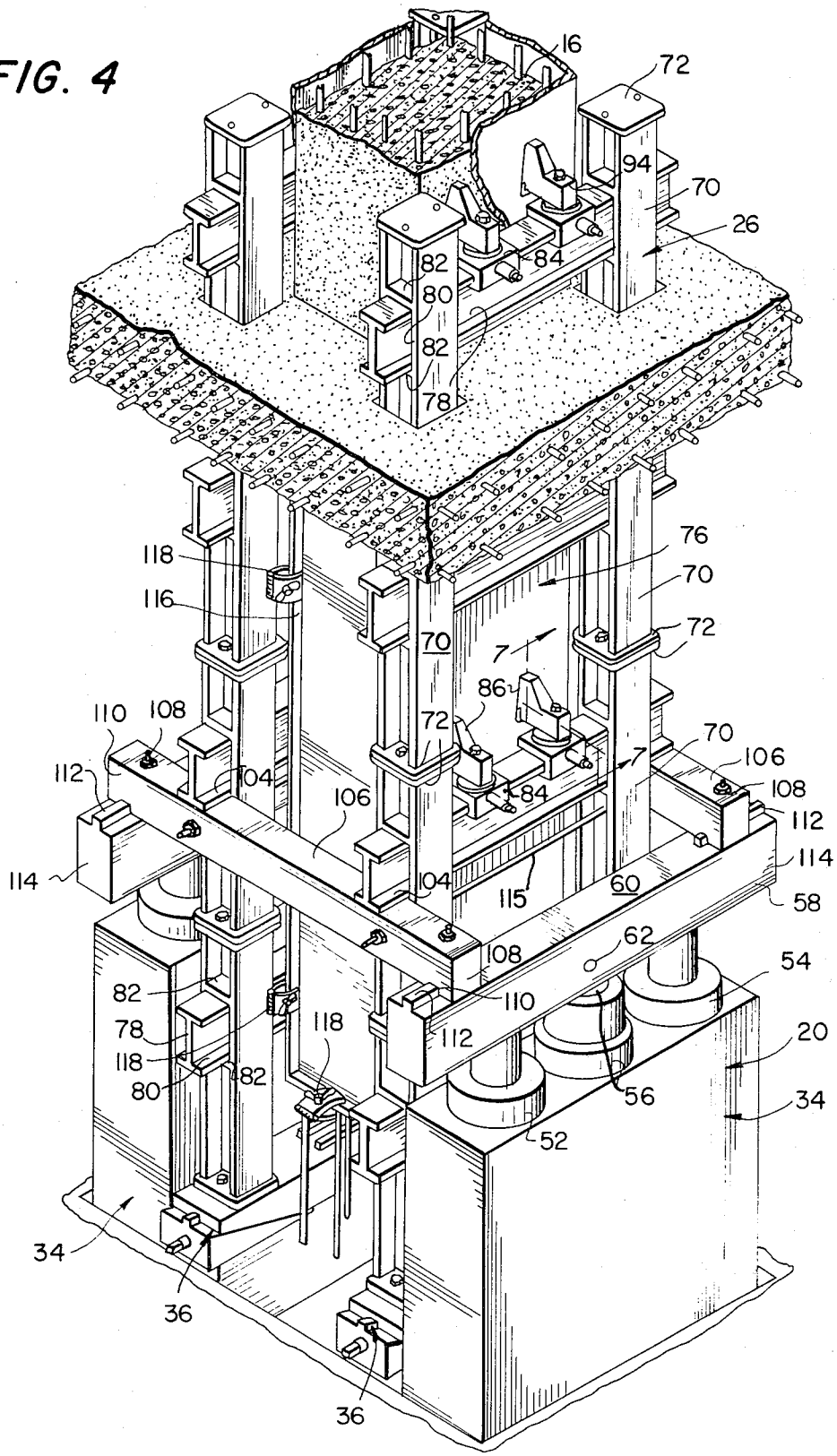

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FIG. 5

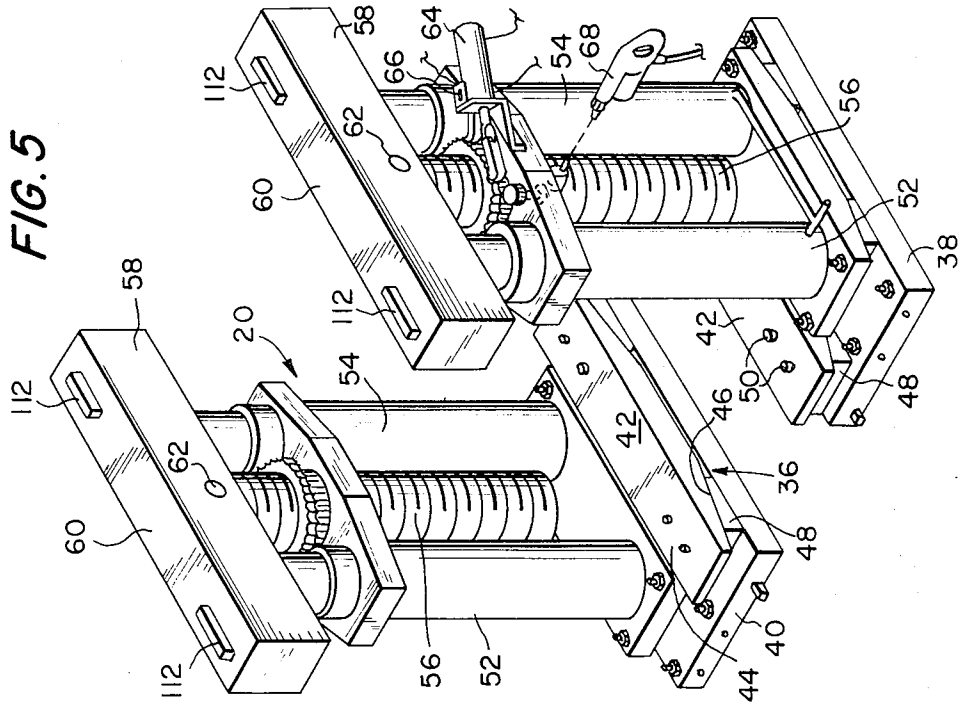


FIG. 8

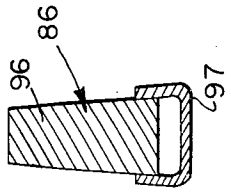


FIG. 6

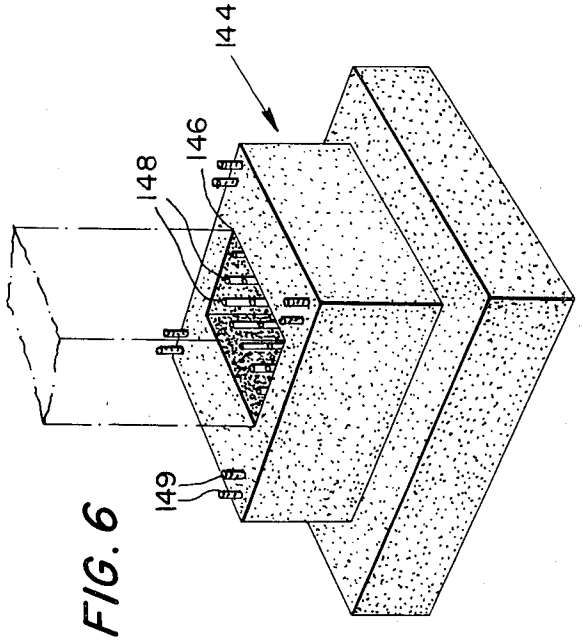


FIG. 7

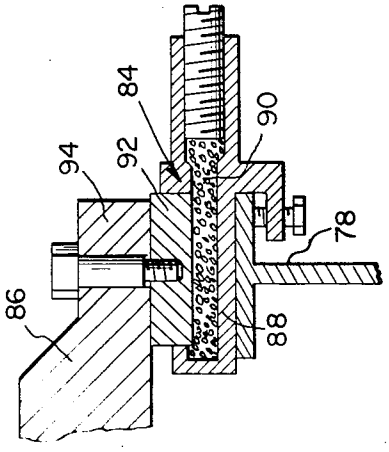
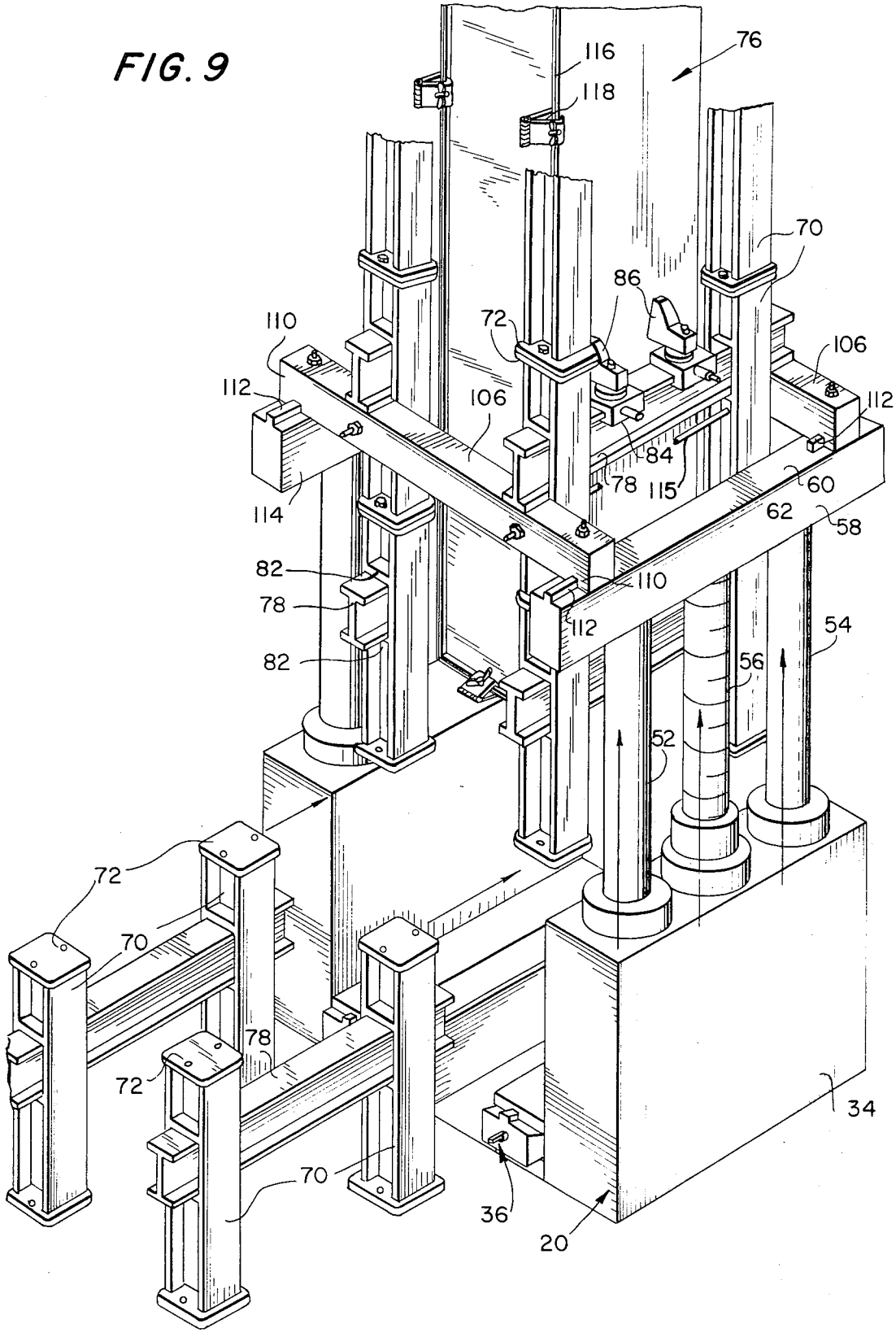


FIG. 9


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APPARATUS FOR FORMING AND LIFTING MULTI-STORY COLUMNS IN ONE STORY INCREMENTS

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention generally appertains to improvements in the manner of and means for constructing multi-story buildings and other similar structures and more particularly relates to a new and novel method of an apparatus for forming the concrete framework of slabs and columns of an upper floor at the foundation level and elevating such substantially completed upper floor from the foundation level so that the framework of the next lower floor may be similarly formed and thereafter raised, with the building being erected in a continuous lifting process from the foundation level.

2. Description of the Prior Art:

The construction of high-rise or multi-story concrete structures from the roof downward and involving the jacking or lifting of the framework as it is completed in floor by floor fashion at or below the ground level is well known in the art. Such construction involves a sequence of operations wherein the roof is cast on a fixed form at ground level, the roof is pushed up and the floor below is cast on the same form; then the roof and floor are pushed up and the next floor is constructed. The formation and lifting steps are repeated depending upon the number of floors.

When the building goes up, material for finishing each space between floors is brought in at ground level and processed on the way up. Exterior walls are built and completed at ground level so that the building is enclosed and protected from weather during construction. The installation of partition walls and mechanical, electrical and plumbing facilities is carried out at low elevations with such work being effected on the completed floors as soon as the concrete framework will accommodate such.

There are many salutary and economic advantages attendant with such construction technique. For example, since all of the production is done in a confined factory-like area at a convenient ground level, considerable savings of time is realized, lower construction costs in relation to an increase in building height are achieved and minimization of the danger of accidents occasioned by working at unprotected heights is attained.

There are a number of prior United States patents, in particular, that disclose in various ways and fashions the general method outlined in the preceding but the most exemplary patent is U.S. Pat. No. 3,201,502, issued Aug. 17, 1965. In such patent there is disclosed a construction method of the floor by floor ground level framework formation and elevation type to which the present invention relates.

Specifically, in accordance with the method of such patent, upright support members having a height of at least two floors or stories are fixed on the foundation and circumscribe a columnar area in temporarily retaining form boards for columns to be formed. Beneath the space between the support members and located below the foundation level is a lifting jack which acts directly upon the formed and set columns within the support members to elevate the columns.

The formed columns are pushed upwardly by the underlying jacks and slide in the sheath-like support afforded the columns by their support members. Locking wedges cooperate with the columns, including their framework and forms, and cross bars of the upstanding support members to lock the columns in raised positions when the jacks are lowered within the lowermost columnar space afforded by the support members at the foundation level and which space is created for the formation of a succeeding lower column.

While the general concept and overall manner of such patented method has considerable merit, the particular manner of supporting the columns and of raising the formed columns and the design of the lifting arrangement has serious drawbacks, especially with regard to the lack of restraint of lateral loads during construction and the absence of proper and necessary foundation support for the lower part of the building while newly placed concrete is hardening.

SUMMARY OF THE INVENTION

In accordance with the present invention, auxiliary or super columns are provided to give support to the lower portion of the structure while newly placed concrete is hardening and to provide attachment means of a dependable and composite force thrust nature between the hardened columns and lifting devices for lifting the formed columns and slabs.

The auxiliary columns are in the form of supporting auxiliary columns that are composed of vertical members located around the columnar area and, in particular with polygonal columns, located at the corners of the columnar area. The vertical members are composed of sections joined together in end to end relation to make a rigid structure and the vertical members are connected in side by side pairs by interconnected cross ties which serve to support collapsible bearing pads on which yoke members are removably mounted. The yoke members serve to transfer the load of the permanent concrete columns to the auxiliary columns and have suitable dimensions for stress purposes in that the yoke members pass through the columnar area and through reinforcement cages therein and remain in such area during the pouring and setting of the concrete in the columnar area for the production of the permanent concrete columns.

The vertical members of the auxiliary columns penetrate the floor slabs away from the critical shear area of the floor-to-column connection, thus permitting continuity in the reinforcing and in the concrete. The lowermost sections of the auxiliary columns have their lower ends bearing on adjustable bearing platforms which are mounted on the foundation independent of the lifting devices. The bearing platforms can be raised and lowered for adjustment by screw operated wedges and serve to ensure firm bearing support of the formed columns and slabs and the forming or setting columns. The bearing platforms act in alternate conjunction with the lifting devices and support the building between lifting cycles.

The sections of the auxiliary columns are provided with interlocked cross beams that transmit the lift force of the lifting devices to the auxiliary columns which are tied to the concrete columns by the cross ties and yoke members. Two lifting devices are provided for each

auxiliary column and they are mounted directly on the foundation independent of the auxiliary columns and the bearing platforms.

It is obviously important that all columns be lifted at the same rate and, therefore, a control system is provided to synchronize the lifting devices and make adjustments where necessary.

In carrying out the method of the invention with the auxiliary columns supported by the bearing platforms and the cross beams thereof engaged by the lifting devices, an alternating supporting and lifting cycle is undertaken. Thus, assuming the presence of a formed concrete column between the foundation level and the fixed slab form that is vertically spaced above the foundation a distance substantially equal to the height of a story of the structure, it can be appreciated that such formed concrete column will be encased by formboards retained by the supporting sections of the auxiliary column. The lower end of the lowermost section of the auxiliary column will be resting on the bearing platforms on the foundation and the cross beams will be potentialed above the lifting devices. The auxiliary column will be tied to the concrete column by the yoke members extended through the formed column and resting on the bearing pads carried by the cross ties of the auxiliary column sections.

The lift cycle will proceed in relation with the supporting platforms on a cyclic basis related to the length of the vertical sections of the auxiliary column sections and in relation to the height of the story or floor of the building. Any number of auxiliary column sections can be used per story. Assuming each vertical section of the auxiliary column to be of a length of approximately 3 and the building story height to be about nine feet, it can be realized that there will be a three cycle lift. The lifting devices will lift the preceding slabs and the formed columns upwardly in increments of approximately 3 feet to permit the insertion and attachment of a further auxiliary column section at the lower end of the lowermost preceding auxiliary column. The opening between the lowermost column and the bearing platforms will be made larger, if necessary to permit a new column section to be inserted, by lowering the bearing platforms. The lifting devices function to jack the building to a height approximating the one/third floor to floor distance. After the inserted column section is in place, the bearing platform is raised and the building is then supported on the bearing platform supports and the lifting devices are lowered for a further bearing point in relation to the relocated cross beams on the auxiliary column. Another lifting cycle then begins to enable a further auxiliary column section to be inserted under and attached to the previously placed and attached section. Such alternating supporting and lifting continues until an auxiliary column of three sections or 9 in fixed length is established under previously installed sections with such column resting on the supporting platforms and bearing the entire load of the building at the foundation.

Thus, when three jacking or lifting cycles are completed, that is, one floor height, the building is supported on the auxiliary columns. At this stage, the cross beams on the auxiliary column and spanning from one lifting device to the other lifting device for each column assembly can be removed and one side of the auxiliary column is opened. A steel bar reinforcement cage is inserted within the auxiliary column and the upper wire ends thereof are attached to the bar stubs projecting down from the previously formed concrete column. The reinforcement cage carries a closure pan at its lower end to block off the lower end of the auxiliary column. The yoke members are passed through the cage from their outer ends supported by the pads on the cross ties of the auxiliary column and the side of the column is closed.

Concrete is poured over the fixed floor slab form and flows down over a block-out form at the open upper end of the auxiliary column to fill up the columnar space defined by the formboards within the auxiliary column.

In consideration of the foregoing it can be appreciated that a primary object of the present invention is to provide an alternating cyclic foundation supporting and lifting method for supporting the building by transfering the load to the foundation while the building is being raised and while it is still as the permanent columns are reaching adequate strength.

Another important object of the present invention is to provide auxiliary or super columns which transfer the load to the foundations while the building is being raised and the permanent columns achieve sufficient strength.

Another important object of the present invention is to provide independent foundation supported bearing platforms and lifting devices that supportingly and liftingly act on the auxiliary columns which envelop and support the permanent columns while the concrete hardens.

A still further important object of this invention is to provide an improved and efficient concrete structure erection system that has decided technical merit and applicability in the present and projected economic market.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic vertical cross-sectional illustration of a multi-story building under construction in accordance with the method and apparatus of the present invention.

FIG. 2 is a detailed schematic illustration of the lowermost part of a permanent column supported by an auxiliary column showing in a continuous sequence from left to right the three cycle lift.

FIG. 3 is a detailed exploded perspective view of the lowermost part of an auxiliary column with the same open to receive the reinforcement cage preparatory to the forming of a new concrete column and after the completion of the jacking cycles.

FIG. 4 is a detailed perspective view of the lowermost end of the auxiliary column and showing in detail the bearing platforms and lifting devices associated therewith.

FIG. 5 is a perspective view of the lifting devices for each column.

FIG. 6 is a detailed perspective view of a footing for the permanent concrete column.

FIG. 7 is a detailed vertical cross-sectional view of one of the collapsible bearing pads for the yoke members and is taken substantially on line 7—7 of FIG. 4.

FIG. 8 is a detailed vertical cross-sectional view of one of the yoke members and is taken substantially on line 8—8 of FIG. 3.

FIG. 9 is a detailed perspective view of the lifting devices and supporting platforms in relation to the lowermost section of the auxiliary columns and showing the lifting devices in their uppermost strokes with the auxiliary column raised off from the supporting platforms.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now more particularly to the accompanying drawings and initially to FIGS. 1 and 2 for a general understanding of the system, method and apparatus of the present invention, the reference numeral **10** generally designates a multi-story or high-rise building or similar structure which has a basic supporting framework **12** of concrete slabs **14** and columns **16**. Below the building **10** is a foundation level **18** in the form of a dug out pit or basement wherein supporting and lifting plants **20** for the building are installed with one plant being provided for and underlying each column.

In the initial stage of construction, the roof **22** of the building and its associated underhanging outer walls are formed on the slab form **24** which has vertical openings to accommodate auxiliary or super columns **26** which support and lift the building and whereby the permanent concrete columns **16** are formed with the poured concrete on the upper surface of the slab form **24** flowing down into formworks retained by the auxiliary columns, as will be more particularly described.

As part of the initial erection stage a shed arrangement **28** may be provided over the foundation pit or basement and built to overhang the sides of the building as the erection proceeds so as to provide weather protection for workmen and also provide sheltered areas for concrete delivery, as at **30**, and for materials delivery and storage, as at **32**.

In the sequence of building operations, the roof **22** is cast on the fixed form **24** at ground level, the roof is pushed up by the lifting plants **20** and the building supported at the foundation by auxiliary columns **26** on the supporting plants **20** while the floor below the roof is cast on the same form **24**; then the roof and floor are pushed up, the next floor cast and the operation continues in sequential operations of lift, support and casting.

While the building goes up, materials for finishing are brought in at ground level into the shelter area **32** and processed on the way up. Exterior walls are built and completed at ground level, for example, by being poured simultaneously with the pouring of the floor slabs and the columns or other method, so that the building is enclosed and protected from the weather during construction.

The lifting is done by lifting jacks or devices **34** which form a part of the plants **20** and which operate in a cyclic lift fashion, as shown more clearly in FIG. 2 and as will be described in connection therewith. The jacks **34** are synchronized and controlled to ensure equal lift throughout the building.

The supporting plants are composed of adjustable bearing platforms **36** that are mounted on the foundation independent of the lifting jacks but which are disposed adjacent to and in cooperation with the lifting jacks. Both the lifting jacks and the supporting platforms act on the auxiliary columns **26** which are composed of metal or steel sections, as will be more particularly described, which envelop and support the permanent columns while the concrete hardens. As the building is being jacked up, the auxiliary column sections at the top of the columns **16** are removed and added to the bottom.

As shown in greater detail in FIG. **5**, each of the plants **20**, which serve to support and to lift the auxiliary columns **26** and permanent columns **16** and thereby and therethrough the whole building, is composed of two independent, spaced apart and parallel base plates **38** and **40** that are suitably anchored to the foundation level. Each base plate carries a lifting jack **34** and a supporting platform with the jack and platform on one base plate cooperating with the jack and platform on the companion base plate in the supporting and lifting of one of the column assemblies, which includes the auxiliary and the permanent column. The supporting platform **36** on each base plate is disposed inwardly of the lifting jack **34** thereon.

Each supporting platform **36** has a flat upper bearing surface **42** and opposing end portions **44** which have tapered undersurfaces **46** that accommodate screw actuated adjusting wedges **48**. The vertical cylindrical stubs **50** serve to allign the newly inserted column section. The bearing platforms support the lower ends of the lowermost stack frame section of the auxiliary column or stack frame. The adjustability of the platforms enables them to tighten a new stack frame section into place before a new lifting cycle is initiated. The bearing platforms can be adjusted by the screw actuated wedges and serve to ensure firm bearing support for the column assemblies between the lifting cycles.

Each of the lifting jacks **34** is supported directly by the base plates independent of the associated bearing platform and includes upstanding, spaced apart hydraulic rams **52** and **54**, which supply the lifting force, and a vertically interposed regulating screw **56** which regulates the amount of lift. The upper ends of the rams are connected by a cross-head having an upper bearing surface **60** with the cross-head **58** being connected by pin **62** to the upper end of the regulating screw **56**.

Operating fluid in the ram cylinders is maintained at a pressure necessary to ensure that no load is imposed on the companion regulating screw **56** but, nevertheless, the screws **56** are designed to support the entire column load for reasons of safety.

Each of the jack units has a drive unit **64** with a counting device **66**. The drive units for all the jack units are connected in series with a central control board so that extremely accurate horizontal level control is obtained by automatically activating all the jack units from a central control station. The drive unit **64** for each jack unit cannot be started unless all of the counting devices **66** for the jacks throughout the building register the same number. A hand drill **68** may be employed to return the cross-heads **58** to the starting position.

As shown in greater detail in FIGS. **3** and **4**, each of the column assemblies is composed of the permanent

concrete column **16** and the auxiliary or super column **26** which is in the nature of a stack frame composed of steel frame sections **70**. The stack frame sections are channel-shaped and are approximately 3 feet in length, as illustrated or other lengths, and have opposing flat bearing feet **22** which are apertured to receive connecting bolt assemblies **74** that join the sections in end to end relation. In the illustrated instance, the columns are of rectangular cross-sectional shape and the auxiliary column sections are provided at the corners of the columns and the columnar area that the mold boards **76**, which are retained by the auxiliary column sections, define. The auxiliary column sections are joined in end to end relation to form opposing pairs of frames with the opposing pairs being joined by transverse cross ties **78** which are I-beams, as illustrated, or rectangular bars having their opposing end portions fitted in pockets **80** defined by vertically spaced webs **82** formed in the auxiliary column sections adjacent the upper ends thereof.

The flat upper surfaces of the cross ties **78** support bearing pads **84** that carry the ends of yoke members **86**. The bearing pads are clamped to the cross ties and have internal pockets **88** within which a plurality of spherical ball elements **90** are solidly packed. The adjustable mounting foot **92** for the end portions of the yoke members seat on the ball elements, as shown in detail in FIG. 7.

Each of the yoke members **86**, as shown in FIGS. **3** and **8**, has a small width and a large vertical dimension. Each yoke member has opposing end portions **94** carrying the mounting feet **92** and a slender intermediate portion **96** that is tapered upwardly very slightly and has a flat top portion and a flat base. The flat, larger base is fitted with an encompassing sheet metal channel member **97** that is spaced from the base surface and functions to facilitate the removal of the yoke members from the hardened concrete of the permanent columns **16**. In this regard, the yoke members pass through the poured and setting concrete of the permanent columns and are inserted through suitable openings **98** provided in the opposing walls **100** and **102** of the mold form **76**. The yoke members transfer the load of the permanent concrete columns **16** to the auxiliary or super columns **26**.

The cross ties **78** have outstanding or projecting end portions **104** which extend beyond the columnar area and beyond the vertical auxiliary column sections at the corners of such area. Such end portions have flat undersurfaces which cooperate with the cross heads **58** of the jacks **34**, as shown in FIGS. **4** and **9**, through the intermediary of cross beams or bars **106**. The cross beams **106** span the adjoining end portions **104** of the cross ties and bear against the flat undersides thereof. The cross beams have extending end portions **108** which are provided on their undersides with transverse slots or keyways **110** that lockingly receive the keys **112** formed longitudinally on the upper surfaces of the end portions **114** of the jack cross heads **58**. The ends are also bolted together. The end portions of the opposing cross beams **106** are tied together by tie rods **115**.

The mold form **76** has its walls provided at their joining vertical edges with complemental flanges **116** that receive clamps **118** whereby the walls are held together in rectangular columnar forming relation. As shown in FIG. **3**, after the preceding concrete column **16*a*** is jacked up one floor height, the building is supported by the supporting platforms **36**, as shown in FIG. **4**, and, at this stage, the cross beams **106** are removed and one side wall of the mold form is removed so that one side of the auxiliary column **26*a*** is open. A bar reinforcement cage **120**, as shown in FIG. **3**, is inserted into the open auxiliary column **26*a***.

The reinforcement cage **120** is composed of vertical reinforcing rods or wires **122** held in rectangular formation by encircling bands or stirrups **124**. The upper end of the reinforcement cage **120** has its bars offset so that the upper end is of less cross-sectional dimension than the lower end and the main body of the cage. The upper ends **126** of the bars are joined to the depending stubs or dowels **128** of the bar reinforcement cage for the preceding pour, that is, the cage embedded in the concrete column **16*a***. The lower end of the cage **120** carries a closure pan of pyramidal shape. The pan **130** serves to close off the lower end of the auxiliary column **26*a*** during the pouring of the concrete and the shape thereof results in the formation of the concrete column, for example the column **16*a***, with a lower end that has upwardly sloped walls **132** serving to ensure good contact with the new concrete during the pouring of the floor and the columns, which pouring is simultaneously effected, using a block-out form **134**.

The block-out form **134**, as shown in FIG. **3**, is composed of four identical angular plate sections which are held in assembled rectangular formation on the slab form **24** at the opening **24*a*** therein for each column assembly. The form plate **138** of each form section **136** has a downturned flange **140** on its outer end that spaces the form plate at floor level above the slab form **24** while the inner end of the form plate has a longer downturned flange **142** that cooperates with the flanged upper ends of the walls of the column mold form **76** and is clamped thereto. The form plate of each section **136** has cooperating angular vertical corners which encompass the vertical stack frame sections and protect them during the pouring of the concrete.

The block-out form **134** cooperates with the slab form **24** and the lower end of the preceding concrete column **16*a*** permitting concrete to flow from the floor slab into and down the auxiliary column within the form therein.

As found necessary in the establishment and support of the stack frames, shim plates may be interposed between the bearing feet **72** of adjoining stack frame sections **70** to compensate for lag caused by uneven loading between columns.

After the building has been erected and jacked to its final height, for example, 20 stories, the lowermost column is fitted and anchored in a column footing **144**, as shown by way of example in FIG. **6**. Such footing is performed and has a cavity **146** with upstanding dowels **148** for the final joint between the lowermost concrete column and the footing that firmly rests on the ground surface. The footing also supports anchor bolts **149**.

The operation and the essential steps of the method can best be appreciated from a consideration of FIG. **2** wherein three lifting cycles are shown. At the left of FIG. **2**, the formed concrete column C1 has hardened sufficiently in the auxiliary column A1 which is resting on the supporting platforms **36** of the lifting plant **20**. In

sequence, the columns C1 and A1 are jacked up by the jacking device 34. In the next to the left showing, it can be seen that the column assembly is lifted about 3 feet so that new auxiliary column section SF1, which had been removed from the top, may be inserted under and attached to the column A1. The column is supported and then lifted again to permit new auxiliary column section SF2 to be inserted under and attached. The column is supported and then lifted to permit a new stack frame section SF3 to be inserted and attached. At this point, the new auxiliary column A2 is complete and, as shown in the extreme right showing, is resting on the supporting platforms 36 ready for the formation of a new concrete column. As can be seen from FIG. 2, the column sections are rotated from the top and inserted and attached at the bottom. As also can be seen from FIG. 2, when the columns are raised the first floor S1 is lifted off from the slab form at the same rate as the preceding floor S2 with the floors being lifted at the same rate and in increments as the column assemblies are lifted.

It is not believed that further description of the operation is necessary and it is believed that the system, method and apparatus will be clear to those skilled in the art. Of course, while a specific structure and method have been illustrated in the accompanying drawings and described herein, as, for example, in the Abstract, it is to be understood that such is merely exemplary for those skilled in the art and the invention is only limited by the scope and spirit of the appended claims.

What is claimed is:

1. Apparatus for the formation of a multi-story concrete framework for a concrete building having superposed floor slabs spacedly supported by load-bearing columns comprising:

a. adjustable bearing platforms mounted at a foundation level;

b. lifting devices mounted adjacent to but independent from the platforms;

c. auxiliary column means adapted to be erected on the platforms and supported thereby and adapted to be raised at least one story in height by said lifting devices;

d. a concrete molding formwork for columns carried by the auxiliary column means;

e. means carried by the auxiliary column means for operatively connecting the lifting devices to the auxiliary column means;

f. and means for attaching the auxiliary column means temporarily to concrete columns formed within the molding formwork to provide vertical support during elevation to said level.

2. The invention of claim 1 wherein said auxiliary column means are formed from vertical sections to a height equal to one story of the building, said vertical sections being substantially less in height than such building story height and a plurality of such sections being joined together to equal such building story height.

3. The invention of claim 2 wherein said vertical sections in their joined relation define a plurality of stack frames disposed vertically in a columnar array with means transversely joining said stack frames together.

4. The invention of claim 3 wherein said transversely joining means includes cross ties and said attaching means removably mounted on the cross ties for spanning the columnar space defined by the array of stack frames and adapted to be encased in the poured concrete columns and connect the concrete columns to the auxiliary column means.

5. The invention of claim 4 wherein said last means includes yoke members.

6. The invention of claim 5 wherein collapsible bearing pads mount the yoke members on the cross ties.

7. The invention of claim 1 wherein said bearing platforms are vertically adjustable and have upper bearing surfaces that support the lower ends of the lowermost auxiliary column means.

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