United States Patent [19]

McCrillis et al.

[11] 3,810,335

[45] May 14, 1974

[54] **FIRE BARRIER SYSTEM FOR MULTI-FAMILY DWELLINGS**

[75] Inventors: **Raymond L. McCrillis; Walter T. Fuller,** both of Littleton; **Richard H. Dixon,** Lakewood; **John R. Oldani,** Littleton, all of Colo.

[73] Assignee: **Marcor Housing Systems, Incorporated,** Denver, Colo.

[22] Filed: **May 3, 1973**

[21] Appl. No.: **356,953**

Related U.S. Application Data

[62] Division of Ser. No. 230,825, March 1, 1972, Pat. No. 3,757,477.

[52] **U.S. Cl.** **52/79,** 52/236, 52/238

[51] **Int. Cl.** **E04b 2/74**

[58] **Field of Search** 52/79, 236, 238, 241, 35

[56] **References Cited**

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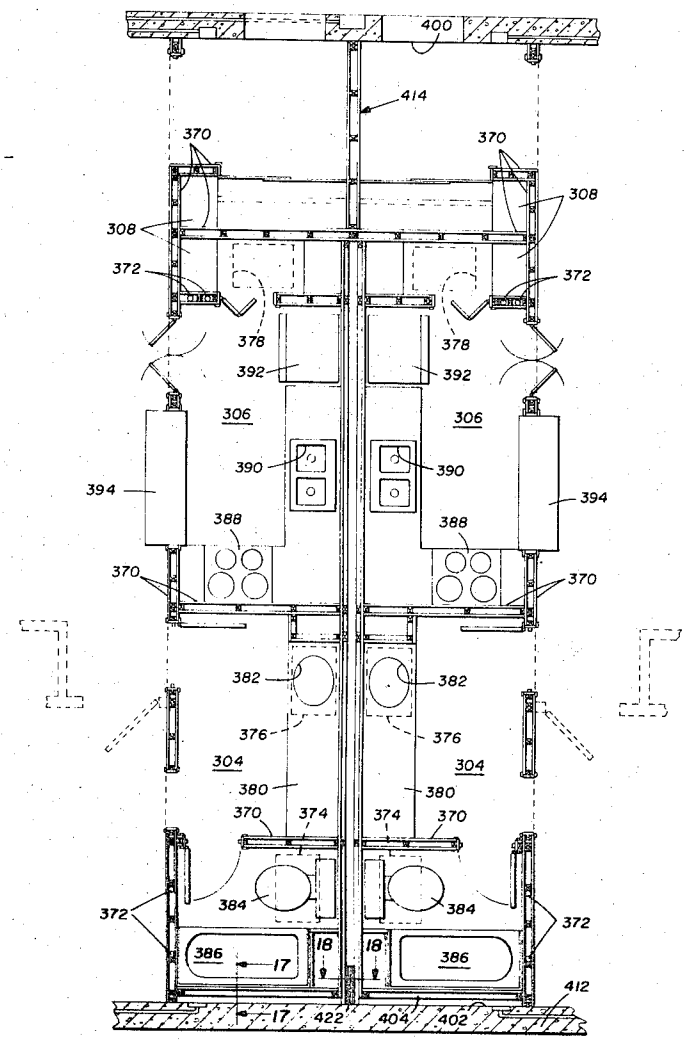
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Primary Examiner—John E. Murtagh

[57] **ABSTRACT**

In a dwelling construction system, a multi-story, multi-family building comprises prestressed concrete pallets which are supported between load bearing walls to form the floors and the ceilings of individual dwellings. Each dwelling includes a service core comprising an enclosure formed on one of the pallets and complete mechanicals for the dwelling. The service cores are fabricated by mass production techniques and are subsequently transported to the building site for installation. In some instances the service core comprises a complete dwelling, in which case the enclosure of the service core may form the exterior walls and the roof of the dwelling.

4 Claims, 28 Drawing Figures



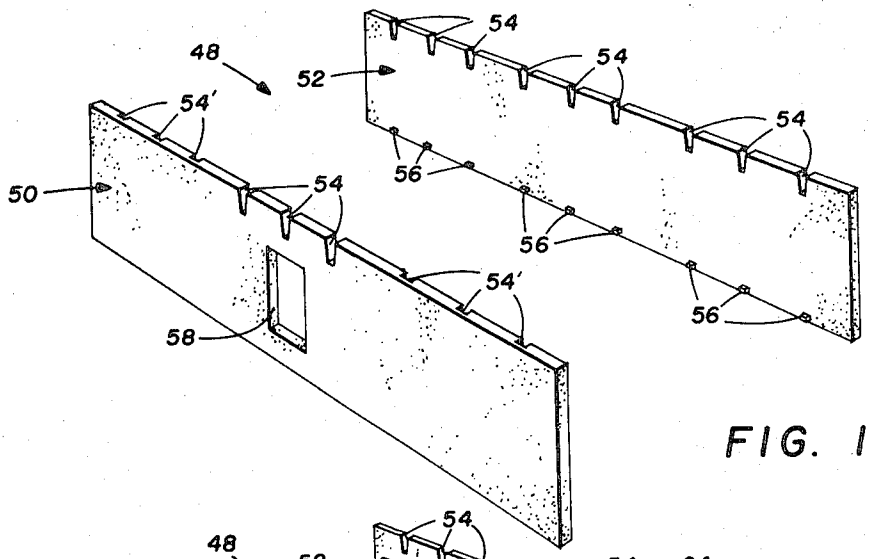


FIG. 1

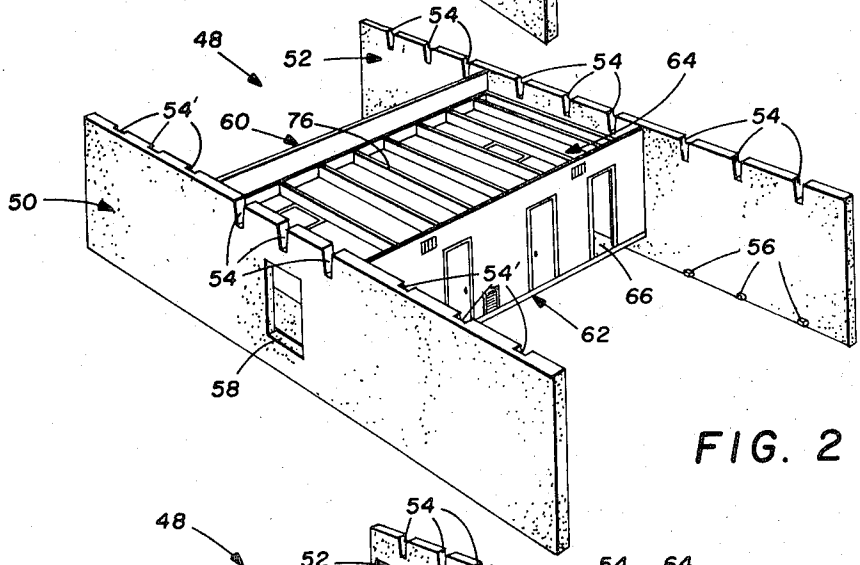


FIG. 2

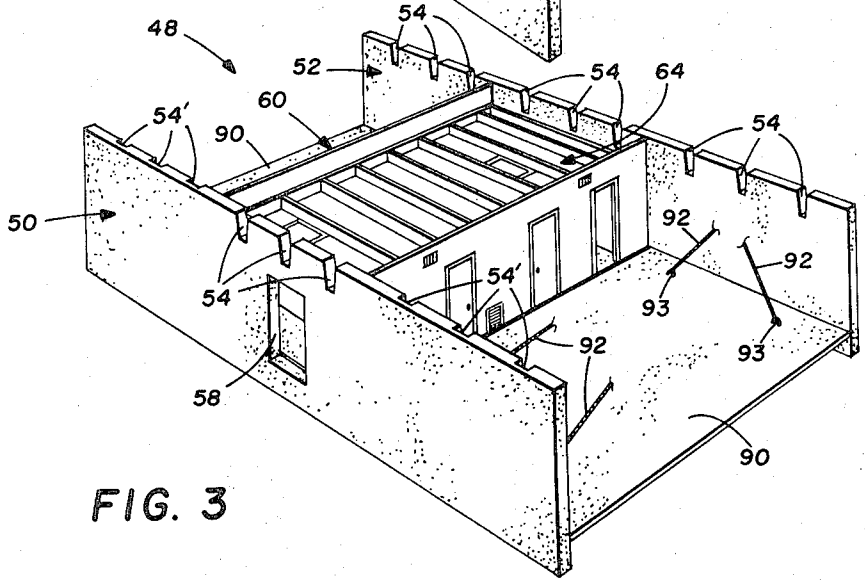


FIG. 3

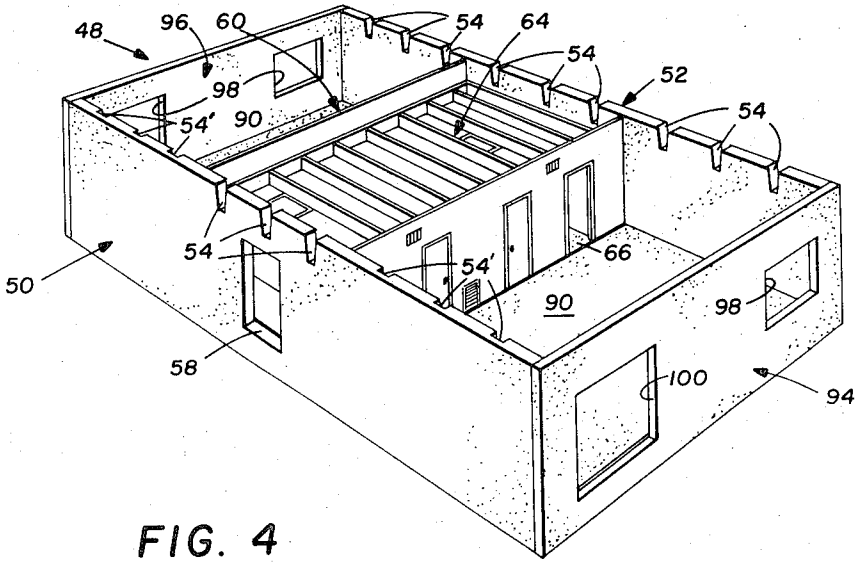

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FIG. 4

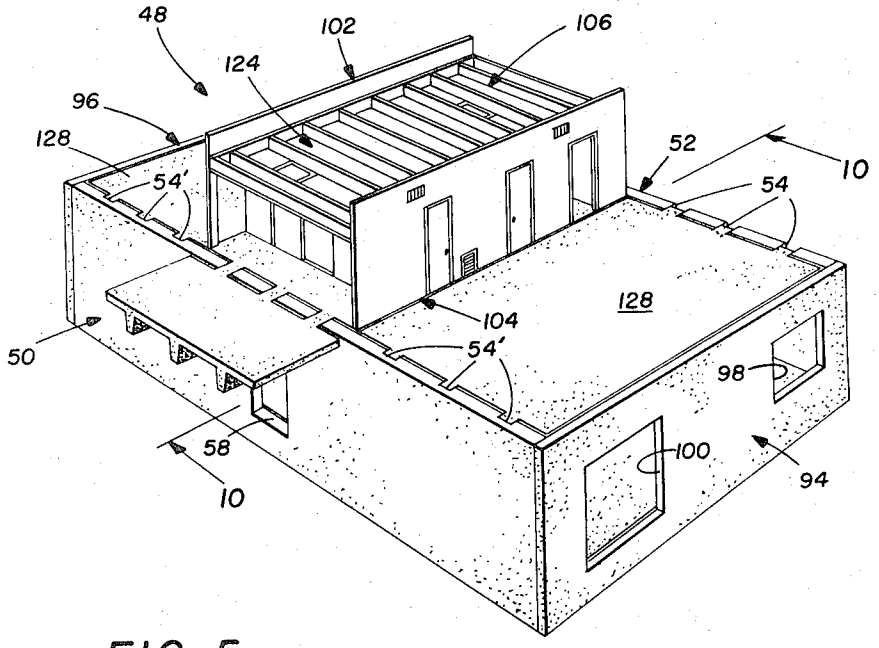

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FIG. 5

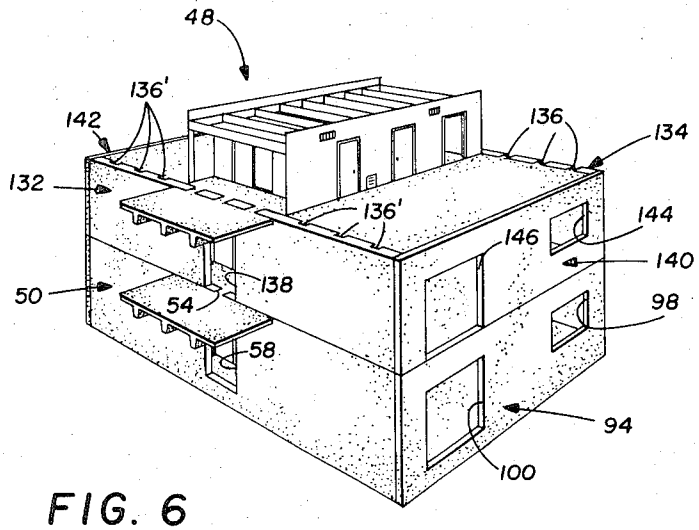

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FIG. 6

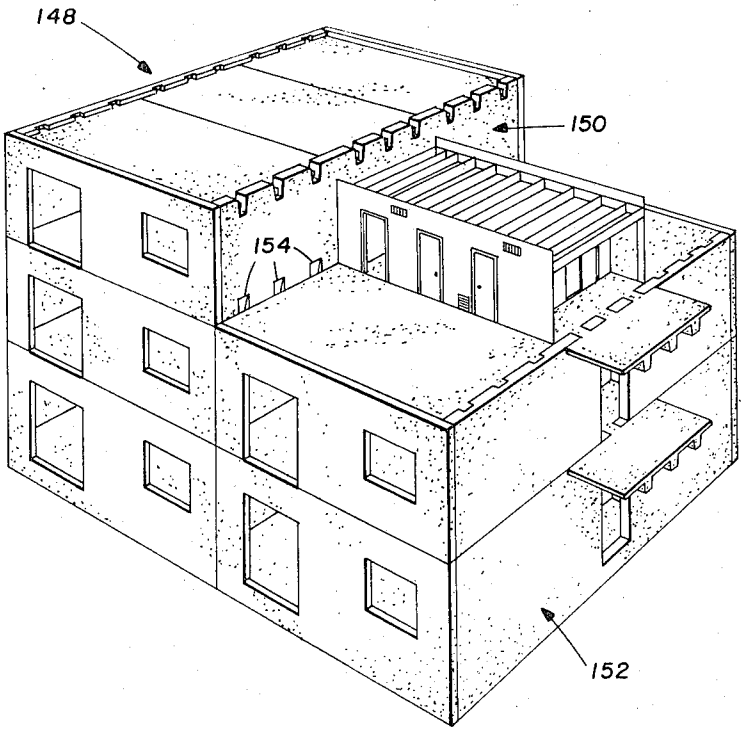

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FIG. 7

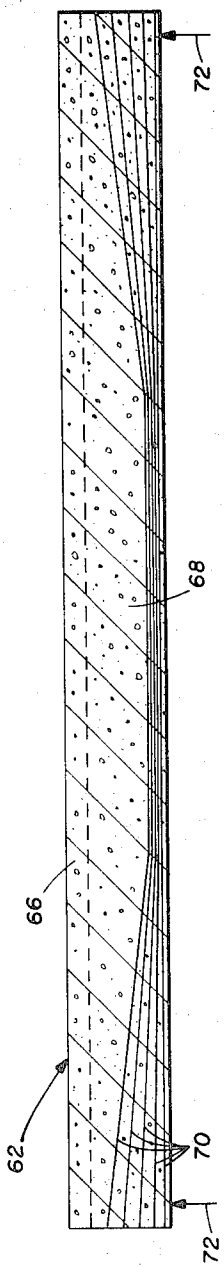


FIG. 8

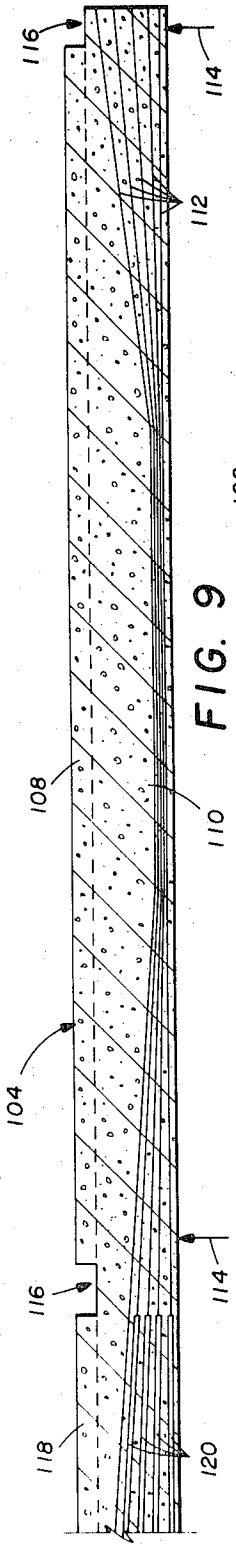


FIG. 9

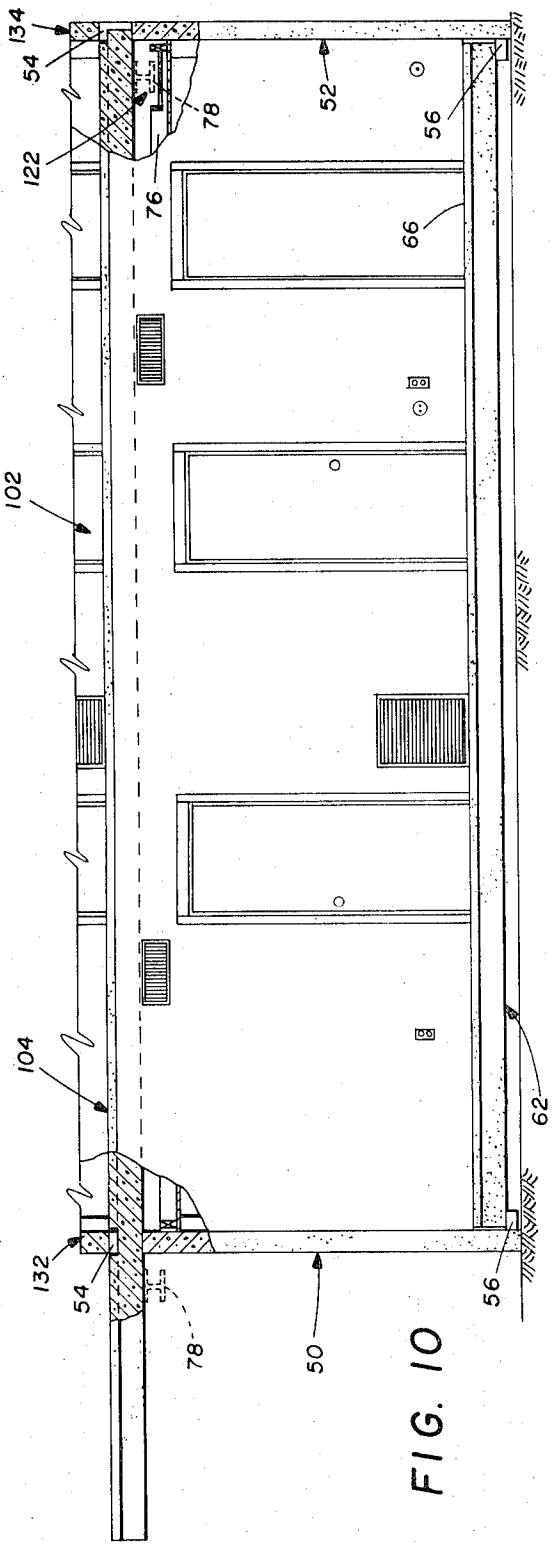
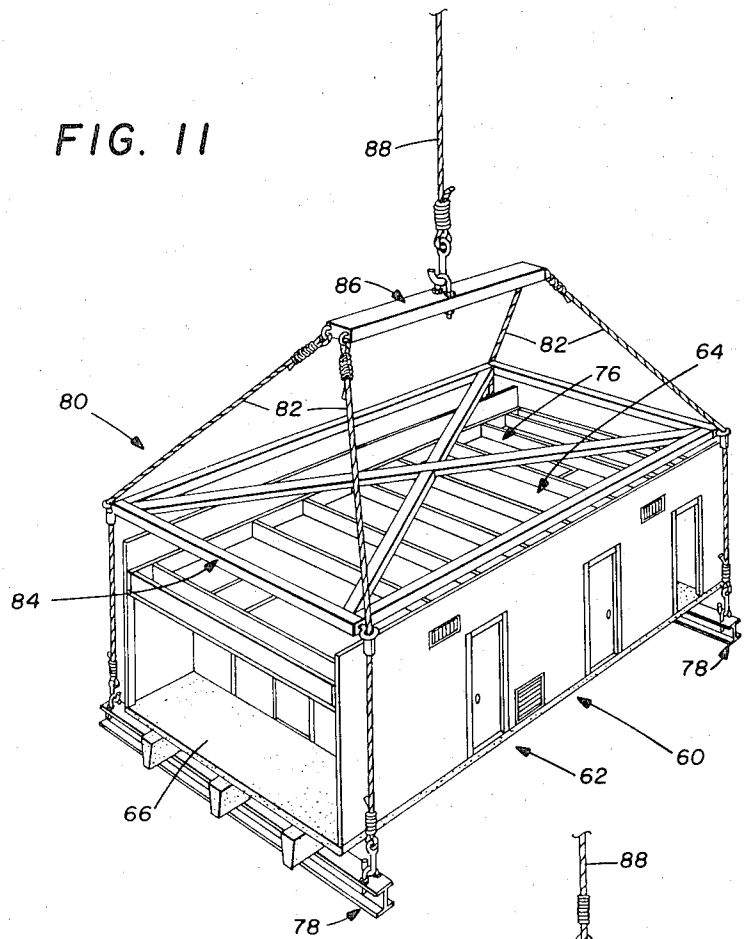


FIG. 10

FIG. 11



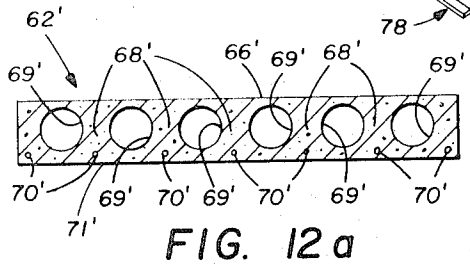


FIG. 12a

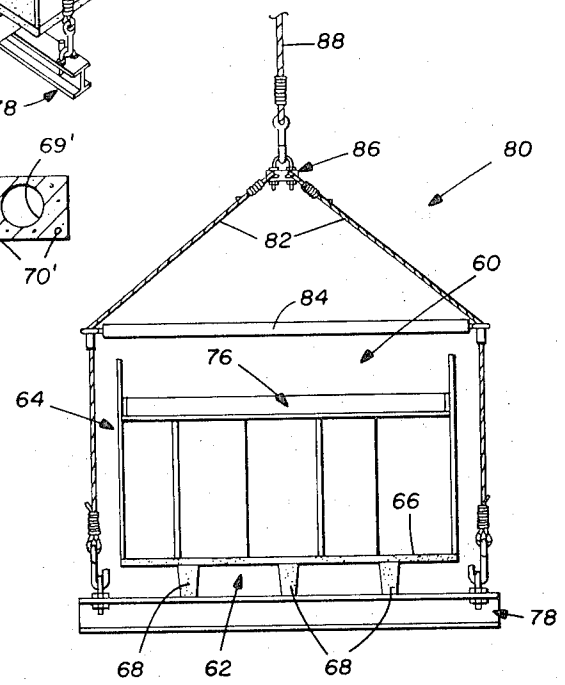


FIG. 12

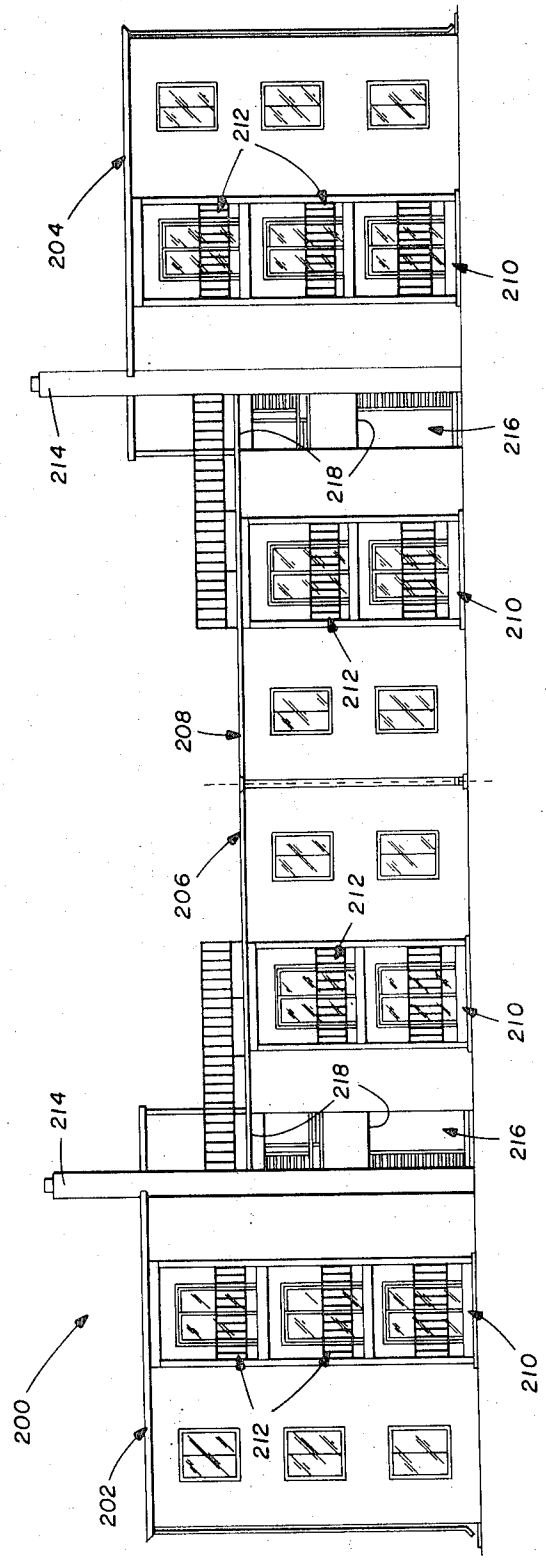


FIG. 13

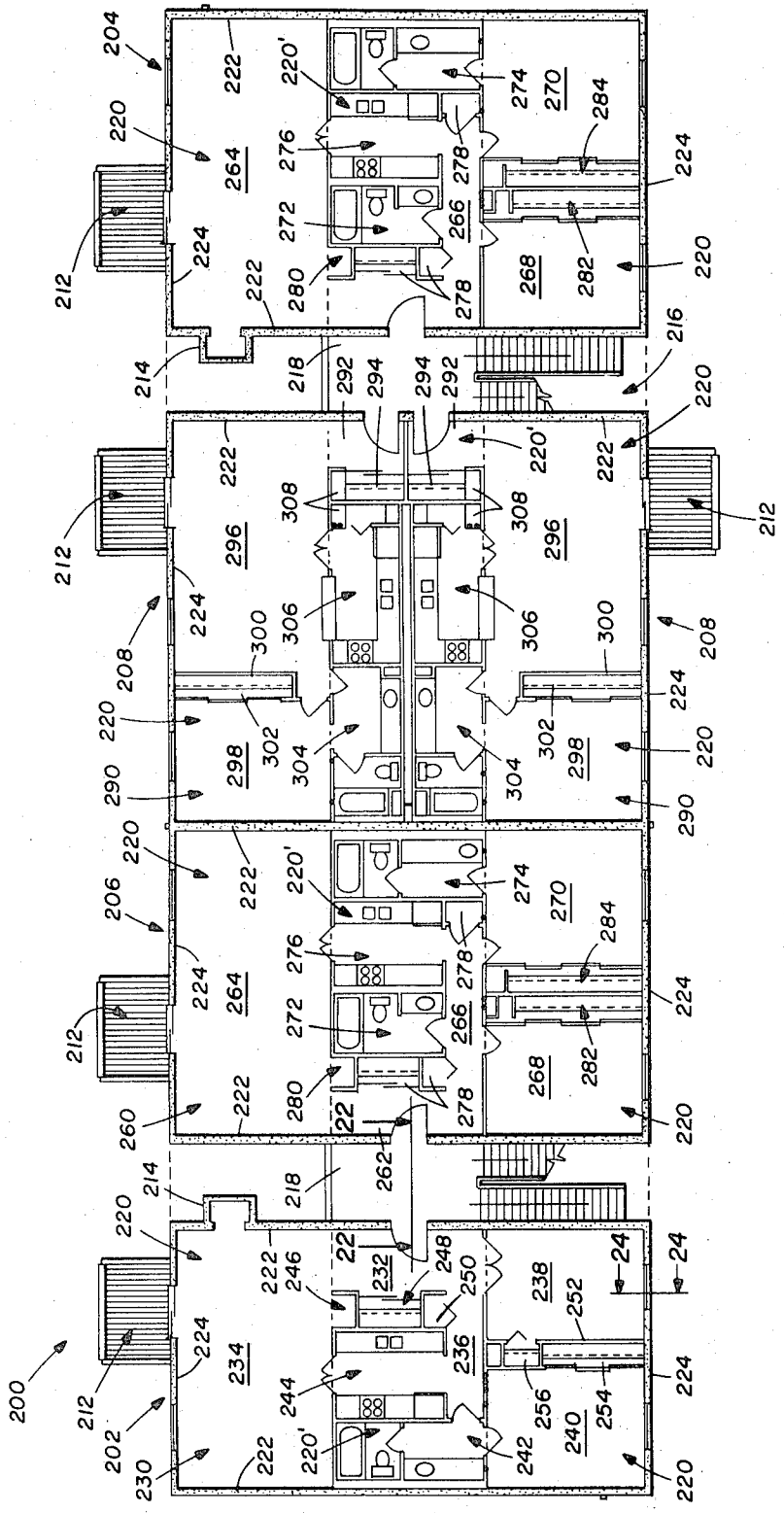

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FIG. 14

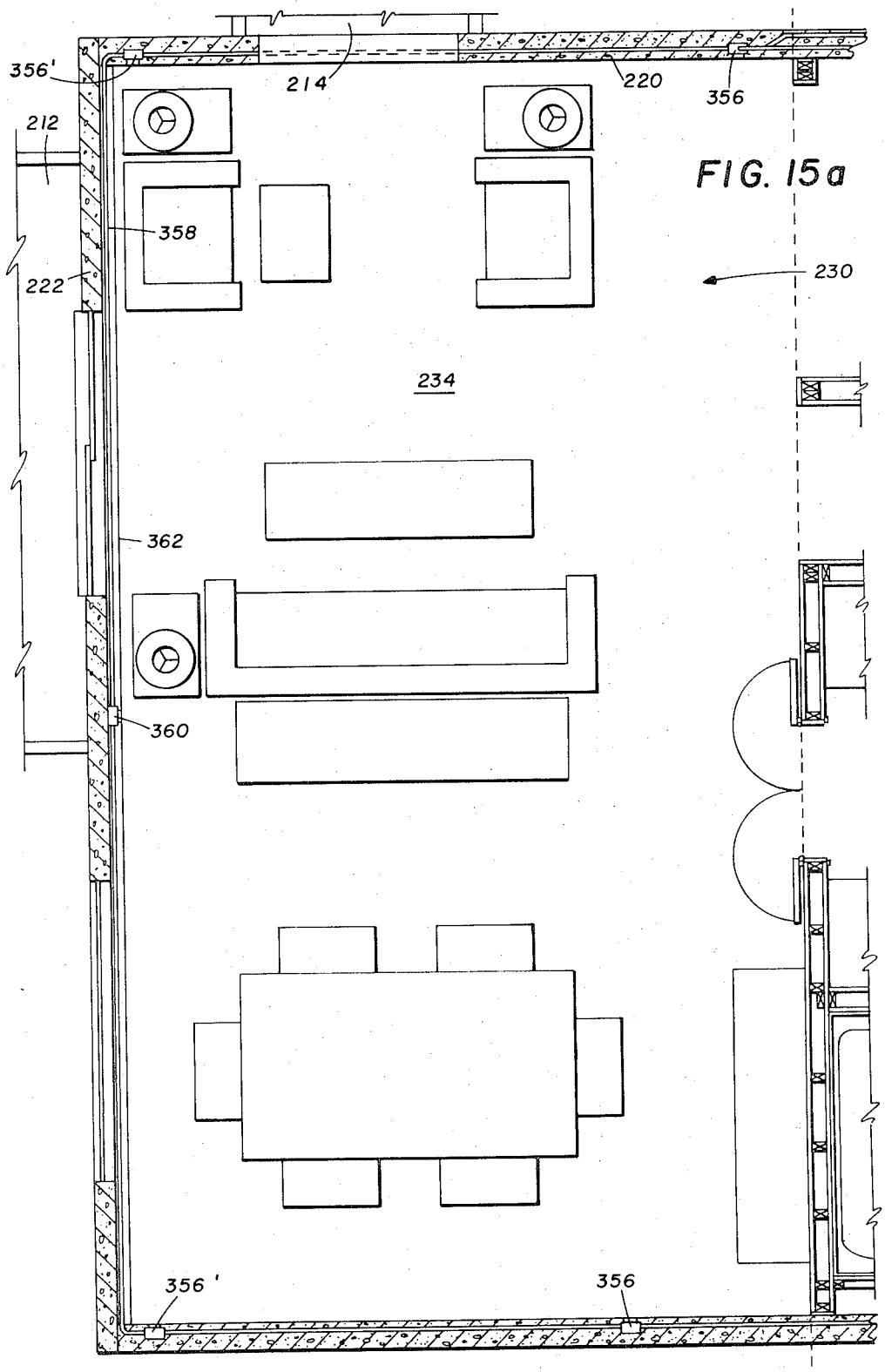


FIG. 15a

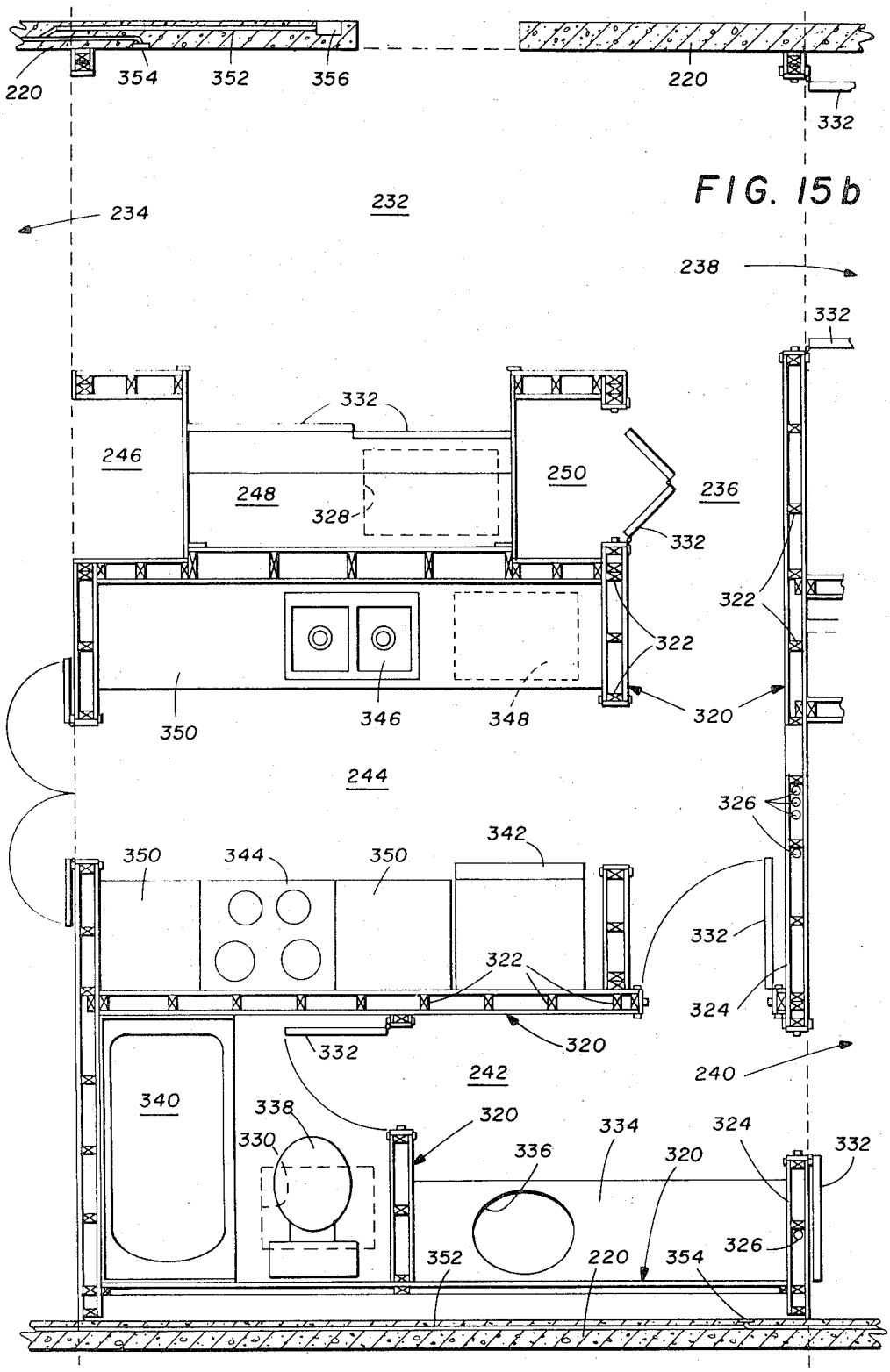

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FIG. 15b

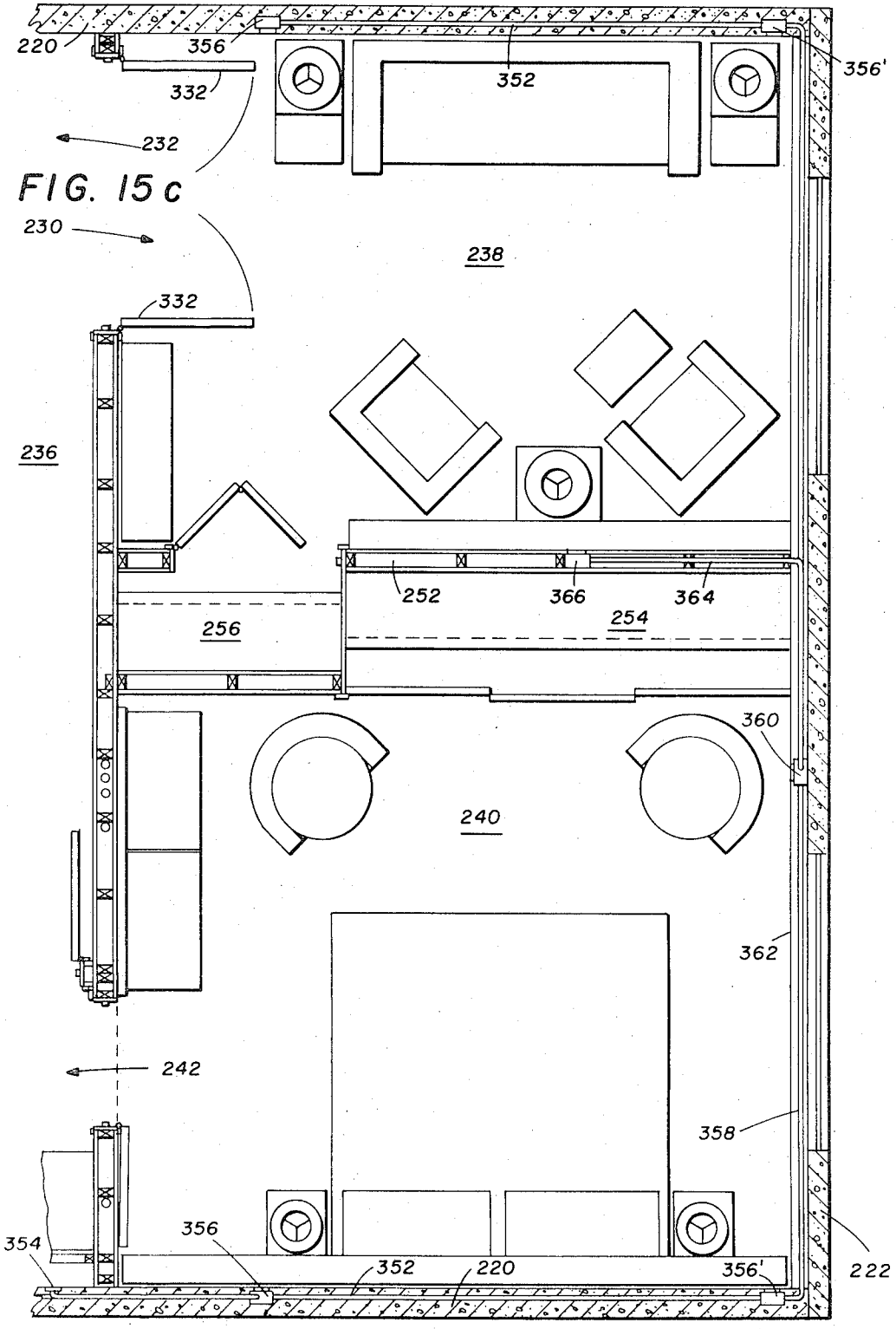
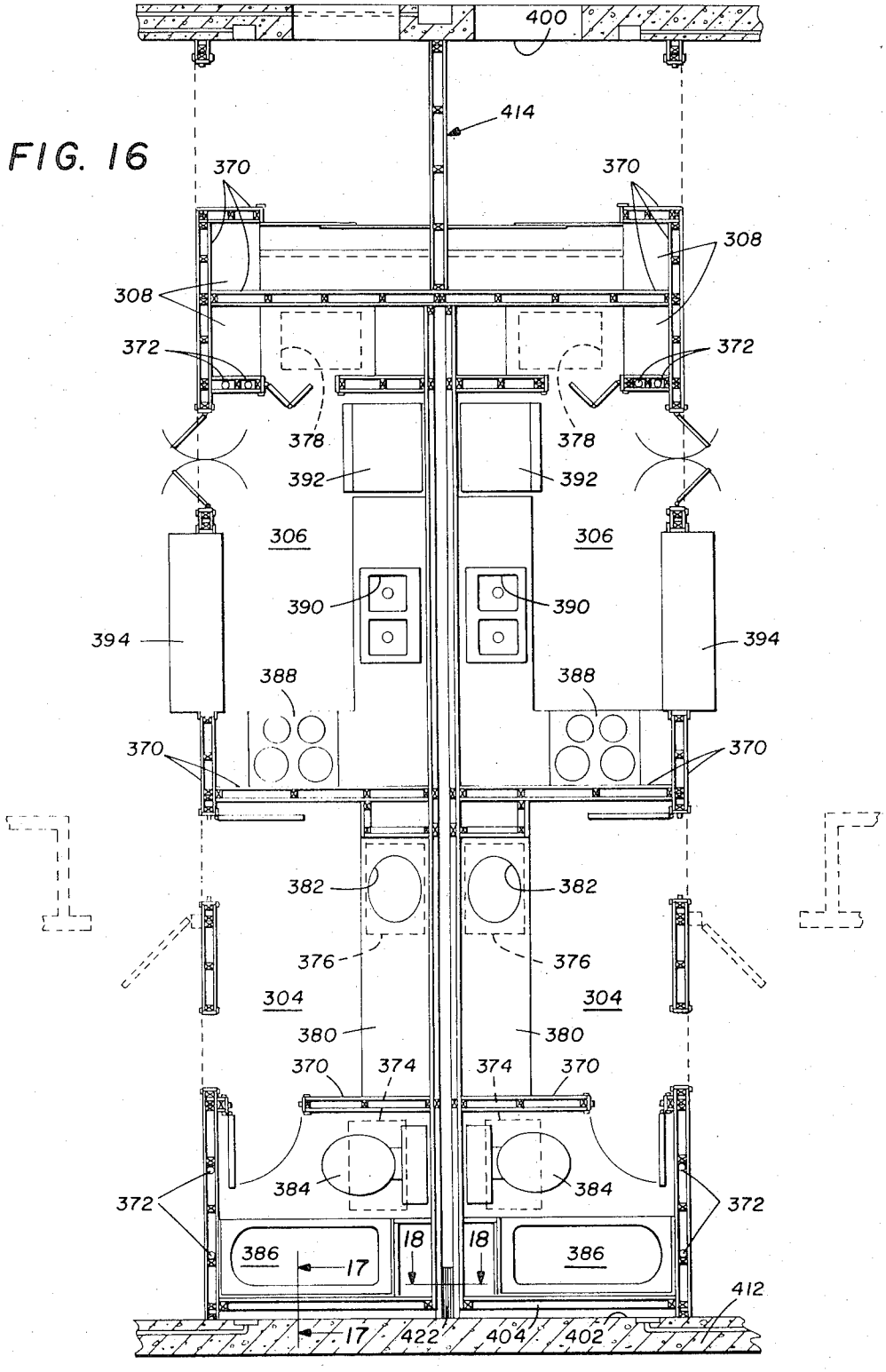

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FIG. 15c

FIG. 16


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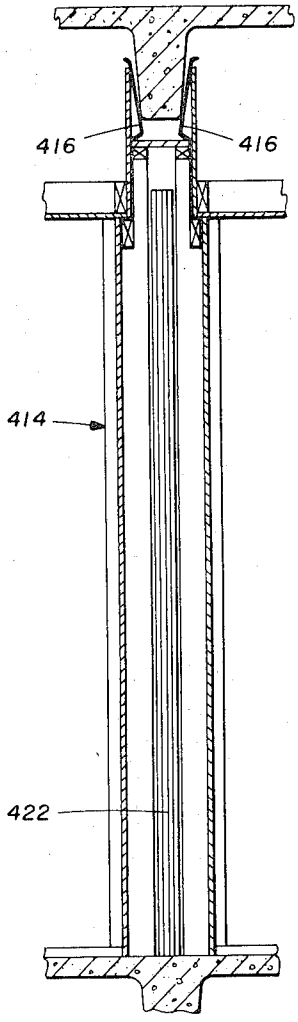


FIG. 18

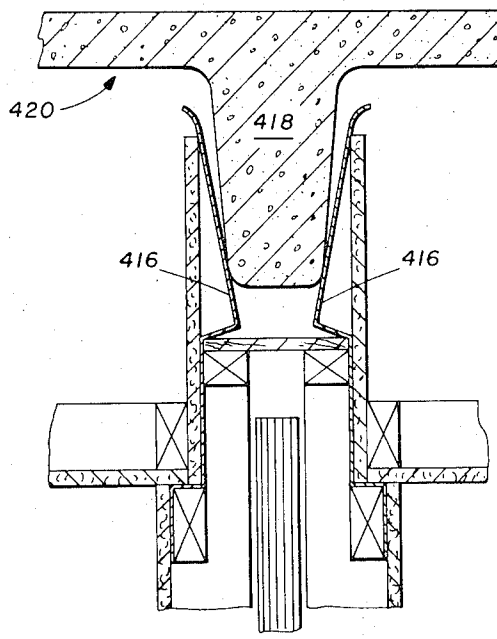


FIG. 19

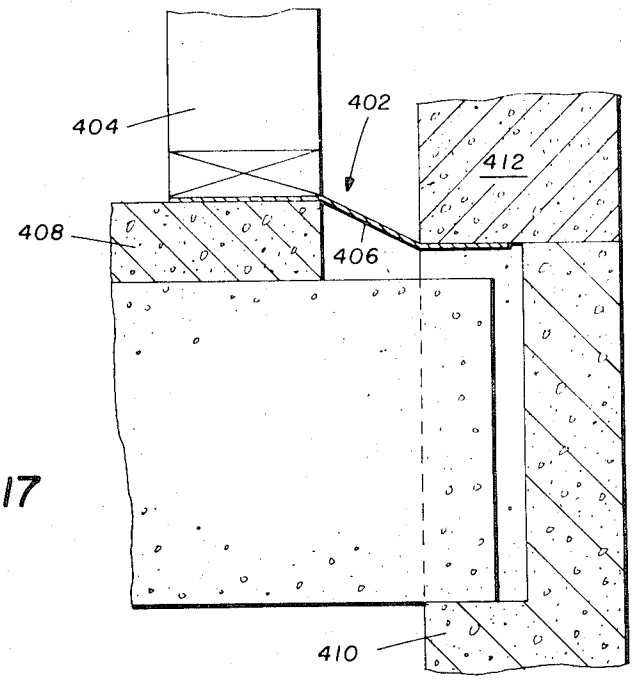


FIG. 17

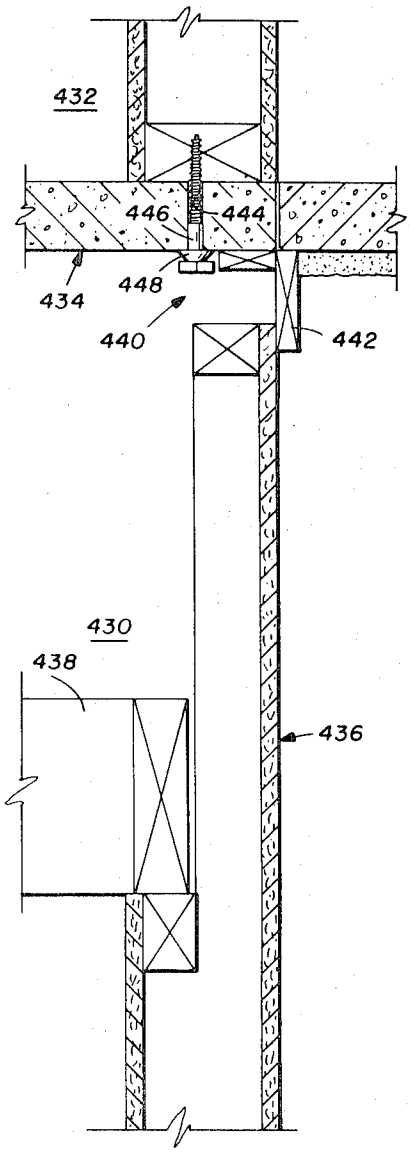


FIG. 20

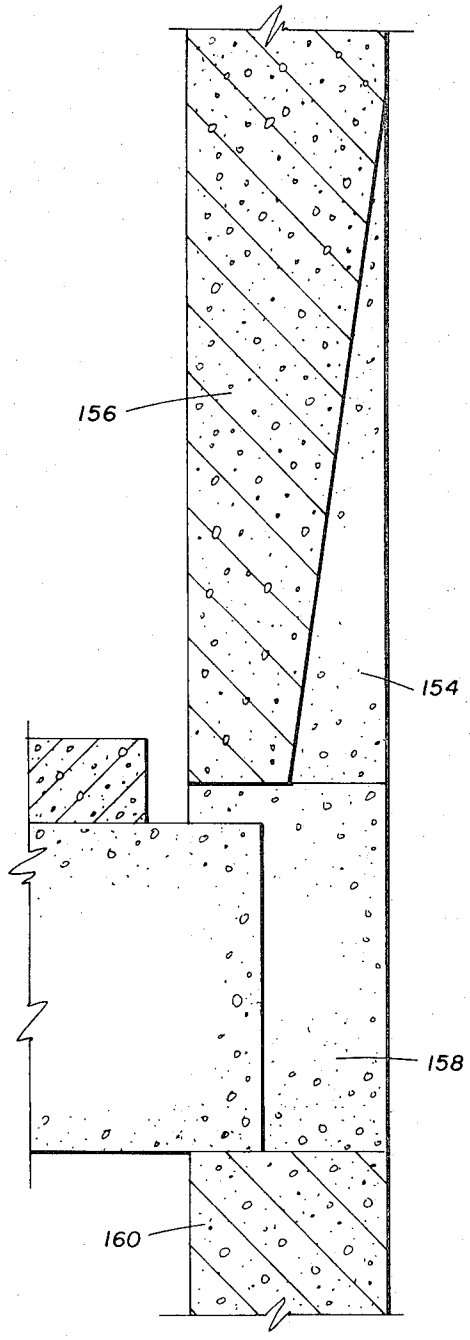


FIG. 21

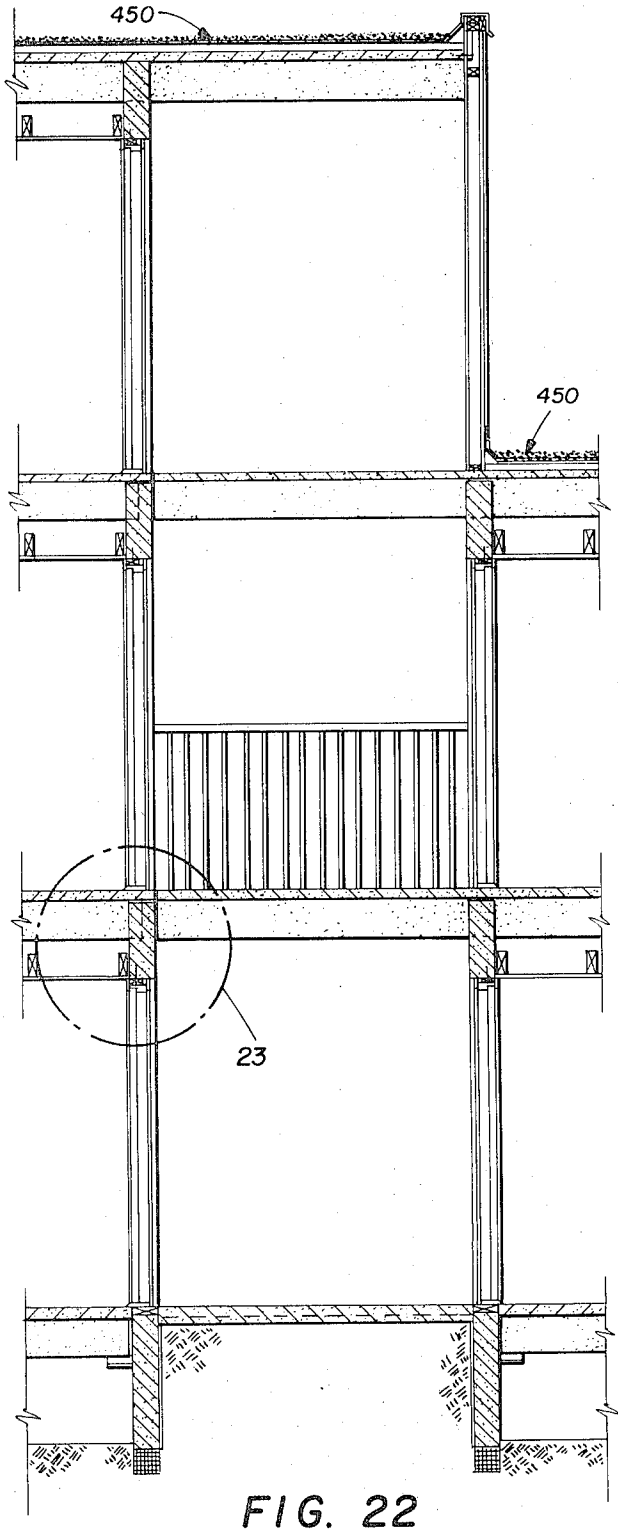


FIG. 22

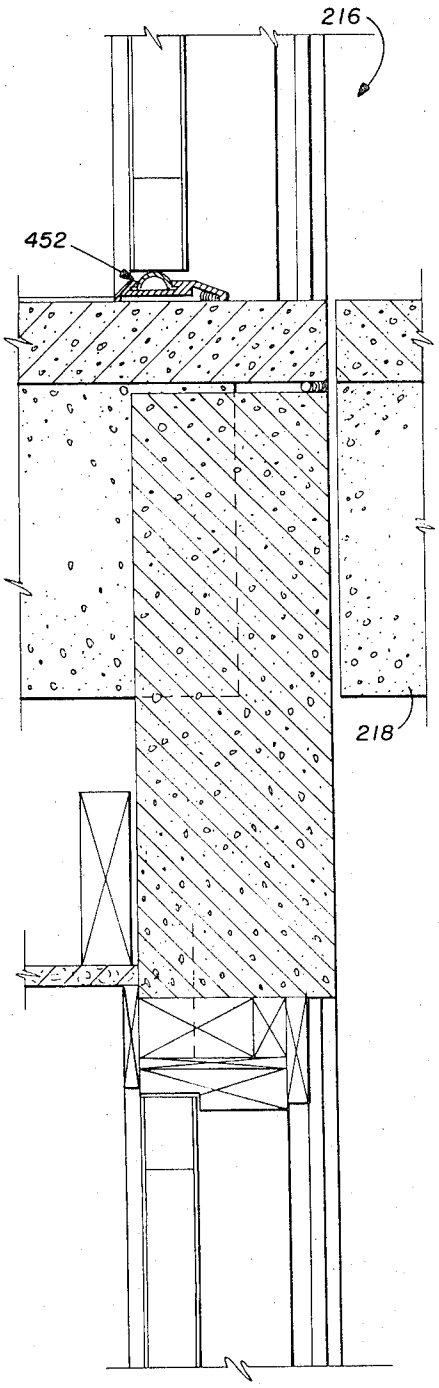


FIG. 23

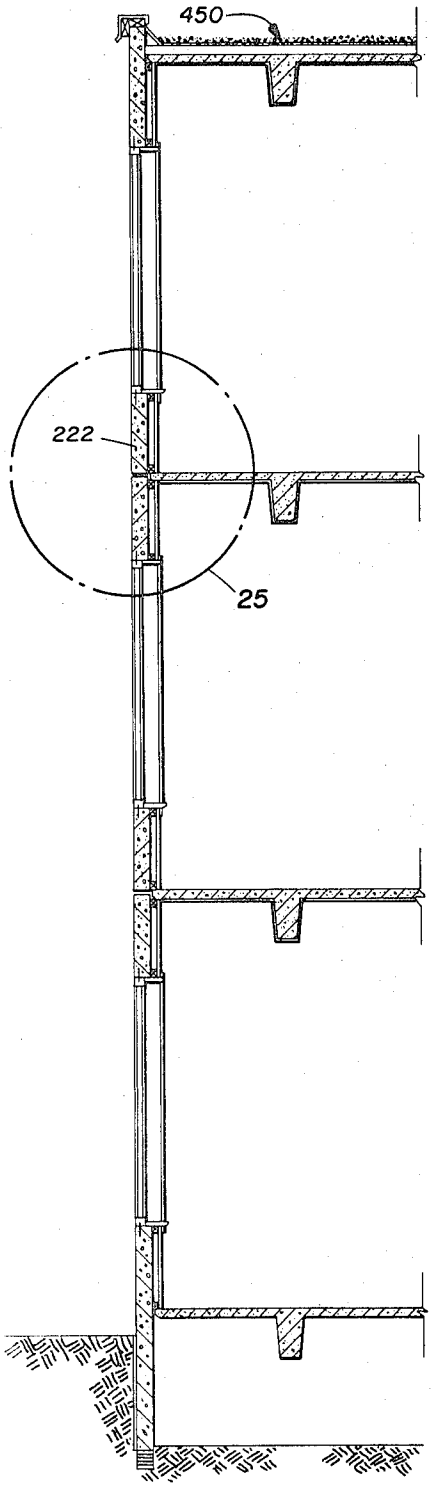


FIG. 24

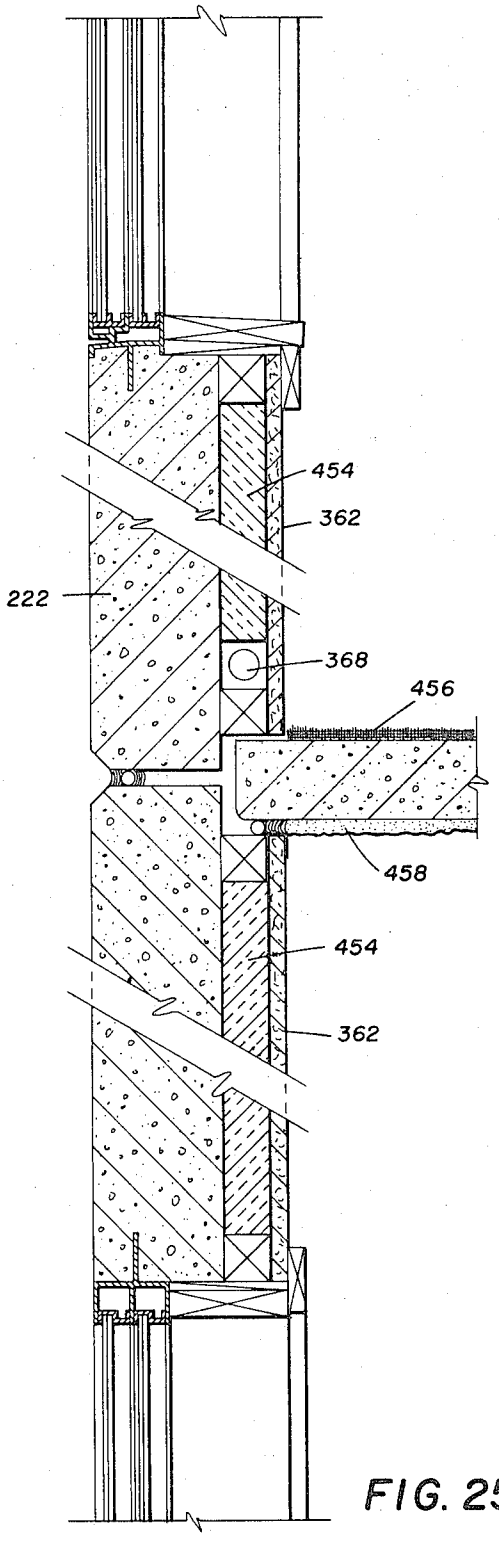


FIG. 25

FIRE BARRIER SYSTEM FOR MULTI-FAMILY DWELLINGS

This is a division of U.S. Pat. application Ser. No. 230,825, filed Mar. 1, 1972, now U.S. Pat. No. 3,757,477.

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to dwelling construction systems, and more particularly relates to a system for fabricating a wide range of dwelling types using production line techniques.

Very substantial sums of money have been expended over the last decade or two to develop building systems which use production line techniques in the construction of both single family and multi-family dwellings. The basic considerations fueling this activity are rapidly increasing labor costs of tradesmen, and the hope that use of production line manufacturing procedures would reduce or eliminate the need for the highly skilled labor of tradesmen as well as provide other cost savings.

This type of construction is particularly promising in the case of dwellings to be erected at remote or relatively inaccessible building sites where labor and materials are not readily accessible.

To date the most successful adaptation of production line techniques to dwelling construction has been in the mobile home industry. As is well known, the fabrication of a trailer house, including the installation of "mechanicals" such as kitchen, bathroom, and temperature control facilities, is typically carried out to completion at a factory. By this means the labor required to install such a dwelling at a particular site is reduced to an absolute minimum.

A different but related method of adapting mass production to dwelling construction comprises sectionalized houses. Typically half or quarter house sections are fabricated at a factory using conventional building materials and techniques and are transported to a construction site by truck. At the site the sections are positioned adjacent one another and are joined to form a completed house.

Multi-family dwelling units have also been constructed using production line techniques. By way of example, one construction system that has been used heretofore involves the fabrication of box-like modules each including a floor, walls and a ceiling which are interconnected to form a structurally integral and transportable unit. The finishing of the modules, including the installation of mechanicals, is completed at a factory. Thereafter the modules are transported to a construction site and are stacked in various configurations to form dwelling units. In this case, the interrelationship of the floor, walls and ceilings of each module cooperates to provide the structural integrity and load bearing capacity necessary to permit the modules to be transported and handled. This type of system has the inherent disadvantage of greatly limiting flexibility of design, and also results in duplicate wall structures.

Although the modular building systems heretofore used have provided some cost reduction, the systems are inherently inflexible and greatly limit the architectural design and livability of the structures. In general, the greater the modularization of the system to achieve reduced costs, the more inflexible the system is to design change, the smaller the rooms, and the more unlivable the dwelling.

Another trend in the construction industry involves the use of prestressed concrete structural components. Thus, structures such as bridges, parking garages, warehouses and the like are presently being fabricated from various prestressed components including load bearing and non-load bearing walls, columns, beams, and floor and roof decks. Heretofore prestressed members have been used solely as structural elements. This practice necessitates the use of labor at the construction site to perform such tasks as erecting interior partitions, installing mechanicals, etc.

The present invention comprises a novel dwelling construction system which incorporates many of the advantages that are characteristic of prior art modular construction systems while eliminating substantially all of the disadvantages that have long been associated with such systems. In accordance with the broader aspects of the invention, a service core is substantially completely fabricated on an assembly line using mass production techniques. The service core is formed on a prestressed concrete pallet which is also fabricated at a plant site using automated equipment for greatest economy. The service core includes a mechanical enclosure which may be fabricated from conventional drywall building materials of the type used in building houses, and similar buildings. The mechanical enclosure may include complete mechanicals for at least one dwelling, i.e., complete kitchen facilities, complete bathroom facilities, complete temperature control equipment, and electrical systems including telephone and television wiring.

Upon completion, each service core is transported to a dwelling site. The concrete pallet provides the only structural integrity required, thus giving total flexibility in the design of the enclosures. In some instances the service core may comprise an entire dwelling. More often, however, each service core is employed in conjunction with additional prestressed concrete pallets to form a relatively large dwelling. In the latter case the pallets extend between and are supported by prestressed concrete load bearing walls to provide a clear span of substantial length. Additional combinations of service cores and pallets may also be supported on the load bearing walls to form garden apartments, high rise apartments, and the like.

In accordance with more specific aspects of the invention, the prestressed concrete pallets used in the service cores and used in conjunction with the service cores to construct dwellings each comprise a relatively thin deck, a plurality of integrally formed beams depending from the deck, and pretensioned members extending through the beams to prestress and maintain the concrete of the beams in compression such that the beams are adapted to span a substantial distance between two spaced load bearing points and still support large static and live loads on the deck. The deck may terminate at the load bearing points, in which case the deck is entirely enclosed by the load bearing walls. On the other hand, the beams may be cantilevered substantially beyond either of the load bearing points to support a deck portion located outside the load bearing walls to provide a balcony, an entry corridor, etc.

In the use of the present invention to construct a multi-family dwelling such as a garden apartment, a pair of load bearing wall panels are initially erected at points

spaced in accordance with the positioning of the support points of the beams of the concrete pallets. After the load bearing wall panels are in place, a service core and then one or more additional pallets are set in place on the load bearing wall panels to form the floor of a first story dwelling. In the case of the first floor dwelling, the beams of the pallets may rest on members projecting inwardly from the load bearing wall panels. Non-load bearing shear wall panels interconnect the load bearing wall panels and serve the dual functions of enclosing the dwelling and maintaining the load bearing wall panels erect.

A service core and then additional pallets which form the ceiling of the first floor dwelling and the floor for a second story dwelling are set in place on the top edges of the load bearing walls of the first floor unit. The beams of the pallets of the second dwelling are preferably received in notches formed in the upper ends of load bearing wall panels that enclose the lowermost dwelling. Also, the decks of the pallets forming the floor of the second dwelling preferably either end at or are interrupted at points corresponding to the positioning of the load bearing wall panels. This permits mounting a second pair of load bearing wall panels directly on the first pair of load bearing wall panels to form the walls for the second floor dwelling.

When the second set of pallets are in place, a second pair of load bearing wall panels and a second pair of shear wall panels are installed. Then a third set of pallets including a service core for a third dwelling are mounted on the second pair of load bearing wall panels to form a ceiling for the second floor dwelling and the floor for a third dwelling. This procedure is repeated until all of the dwellings in the apartment are formed. Then prestressed concrete pallets are mounted on the uppermost load bearing wall panels to form the roof of the uppermost dwelling, and of the stack of dwellings. The interiors of the several dwellings are then grouted, and floor and wall coverings installed, whereupon the structure is ready for occupancy.

As will be appreciated by those skilled in the art, prestressed concrete pallets of the type employed in the practice of the present invention can be supported only at the two design load bearing points. In most instances, the blank pallets are handled by means of eyes cast in the concrete. However, the pallets upon which the service core is formed make this method of handling the pallets impractical. Accordingly, each service core is set in place by means of a pair of picking bars which extend under the support points of the beams of the pallet, a harness including members for connection to the opposite ends of the two picking bars, and a crane which operates through the harness and the picking bars to lift and position the pallet. On the other hand, both for fire prevention purposes and for the sake of appearance, it is highly desirable that the enclosure of each service core extend substantially into engagement with the pallet located next about the service core. To this end the enclosure of each service core is equipped with at least one picking bar slot positioned to permit withdrawal of one of the picking bars that will be used to install the service core or pallet above the service core. The picking bars used in the installation of the pallets weigh approximately 400 pounds. This necessitates reinforcing the picking bar slots to such an extent that the picking bar does not damage the service core as it is withdrawn.

The building codes of the various cities and states typically require a fire barrier having a one hour rating between adjacent dwellings in a multi-family dwelling. In the practice of the present invention this requirement is easily fulfilled with respect to pallets that do not comprise service cores by simply filling the spaces between the decks of the pallets and the load bearing wall panels and the shear wall panels with grouting. On the other hand, the enclosures of the service cores prevent access to these spaces and thereby prevent the filling of the spaces with grouting. For this reason the service cores are preferably installed with one edge of the deck engaged with the adjacent wall panel. At the other end of the deck a strip of sheet metal is secured between the enclosure and the deck. The strip of sheet metal is extended over the upper edge of the load bearing wall panels that supports the deck and is engaged by the load bearing wall panel that is mounted on the supporting panel to provide the necessary fire barrier.

In accordance with a particular embodiment of the invention, double loaded service cores are utilized in the construction of adjacent dwellings. That is, a single prestressed concrete pallet is equipped with two complete but separate sets of mechanicals, one for each of the adjacent dwellings. In such a case it is necessary to form a fire barrier having a one hour rating between the portion of the service core that is individual to one of the dwellings and the portion that is individual to the other dwelling.

The majority of the fire barrier for a double loaded core may comprise a wall including at least one layer of ⅝ inch sheet rock. A pair of diverging sheet metal flanges are provided at the upper end of this wall for engagement with a beam of the pallet that is installed above the double loaded core to form the upper portion of the fire barrier. The fire barrier wall is also provided with a stub wall which is slidably supported at the end of the deck that will be engaged with a load bearing wall. During installation of the double loaded core the stub wall is retracted. Then, after the load bearing wall panels adjacent the double loaded core have been installed, the stub wall is moved outwardly and is engaged with the adjacent load bearing wall panel. By this means the fire barrier between the portions of the double loaded core that are individual to the separate dwellings is extended to the full height and the full width of the core.

In addition to the foregoing, the present invention incorporates numerous features which contribute greatly to its overall practicality. For example, notwithstanding the strength of prestressed concrete pallets, it has been found that a direct connection between a particular pallet and the enclosure of a service core situated beneath the pallet is not workable. Instead a slip joint is employed to provide a pleasing appearance while permitting relative movement between the pallet and the service core as a result of live loads.

Another important feature of the invention involves the manner in which convenience outlets are provided at spaced points around each dwelling. Thus, electrical conduits are formed in the load bearing wall panels when the panels are manufactured. After the panels are installed, electric service lines are directed from the adjacent service cores through the conduits in the load bearing wall panels and along the shear wall panels. The shear wall panels are typically covered with wood panelling or the like, so that the resulting dwelling is

equipped with suitable convenience outlets and yet has no exposed conduit or wiring.

Still another important feature of the invention involves an improved method of forming the enclosures of the service cores. It has been found that a great deal of time is wasted if the enclosures are formed by finishing the walls on one side, installing the walls on the pallet by fastening through the panel frame into the pallet, and then finishing the walls on the other side of the panel. In accordance with the present invention holes are formed in the pallets along the lines that will comprise the walls of the enclosures. This permits the walls to be completely finished and then secured to the pallets by means of lag screws which are inserted through the holes in the pallets from the bottom.

DESCRIPTION OF THE DRAWINGS

A more complete understanding of the invention may be had by referring to the following Detailed Description when taken in conjunction with the accompanying Drawings, wherein:

FIGS. 1–7 are illustrations of progressive steps in a method of fabricating dwelling units incorporating the invention;

FIGS. 8 and 9 are illustrations of presetressed concrete pallets utilized in the practice of the invention;

FIG. 10 is a view taken generally along the line 10—10 in FIG. 5 in the direction of the arrows;

FIGS. 11 and 12 are perspective and end views, respectively, showing a method of and apparatus for installing service cores which is utilized in the practice of the invention;

FIG. 12A is an end view of an alternative type of prestressed concrete pallet that can be utilized in the practice of the invention;

FIG. 13 is an elevational view of an apartment complex constructed in accordance with the invention;

FIG. 14 is a plan view of the apartment complex shown in FIG. 13;

FIGS. 15A–15C are an enlarged plan view of one of the apartments comprising the apartment complex shown in FIG. 13;

FIG. 16 is an enlarged plan view illustrating the service core of one of the apartment buildings shown in FIG. 14;

FIG. 17 is a sectional view taken generally along the line 17—17 in FIG. 16 in the direction of the arrows;

FIG. 18 is a sectional view taken generally along the line 18—18 in FIG. 16 in the direction of the arrows;

FIG. 19 is an enlargement of the upper portion of FIG. 18;

FIG. 20 is a sectional view taken generally along the line 20—20 in FIG. 16 in the direction of the arrows;

FIG. 21 is an illustration of special slots which are utilized in the practice of the invention to facilitate the installation of prestressed concrete pallets on previously erected load bearing walls;

FIG. 22 is a sectional view taken generally along the line 22—22 in FIG. 14 in the direction of the arrows;

FIG. 23 is an enlargement of a portion of FIG. 22;

FIG. 24 is a sectional view taken generally along the line 24—24 in FIG. 14 in the direction of the arrows;

FIG. 25 is an enlargement of a portion of FIG. 24.

DETAILED DESCRIPTION

METHOD OF DWELLING CONSTRUCTION

Referring now to the Drawings, and particularly to FIGS. 1–7 thereof, a method of dwelling construction incorporating the present invention is employed to construct an apartment building 48. As is best shown in FIG. 1, the first step in the method comprises the erection of a pair of load bearing wall panels 50 and 52. The wall panels 50 and 52 are both formed from prestressed concrete and are both nominally six inches thick. The wall panels 50 and 52 are further similar in that they are both provided with a plurality of slots or notches 54 formed in the upper ends and with a plurality of support members 56 which project inwardly from points adjacent their lower ends. The notches 54 are generally U-shaped, but comprise inwardly tapered side walls, and some of the notches 54′ in the wall 50 extend only part way through the wall so as to provide a flush outer surface. The supporting members 56 may comprise any convenient construction, but preferably comprise pipe stubs cast into the panels 50 and 52 and extending inwardly therefrom. One difference between the wall panels 50 and 52 is that the wall panel 50 is provided with a door opening 58.

Referring now to FIG. 2, the next step in the method of dwelling construction comprises the installation of a service core 60. The service core 60 comprises a prestressed concrete pallet 62 and an enclosure 64 formed on the pallet 62. The service core 60 further comprises complete "mechanicals" for a dwelling unit, i.e., complete kitchen facilities, complete bathroom facilities, and complete temperature control facilities.

The prestressed concrete pallet 62 of the service core 60 is shown in FIG. 8. The pallet 62 comprises a deck 66 and three beams 68 which depend from the deck 66. Thus, the pallet 62 is of the type commonly known as a triple T deck. A plurality of tension members 70 extend through each beam 68 of the pallet 62 and serve to prestress the beams, whereby the beams 68 are adapted for support at spaced points indicated by the arrows 72 to support a load on the deck 66. As is well known in the art, a prestressed concrete pallet of the type shown in FIG. 8 is subject to breakage unless it is properly supported.

The cross sectional configuration of the pallet 62 is shown in FIG. 12. Those skilled in the art will appreciate the fact that the invention may also be practiced using either solid core or hollow core prestressed concrete pallets 62′ of the type shown in FIG. 12A. The pallet 62′ comprises a deck 66′ and a plurality of beams 68′ which depend from the deck 66′ between cylindrical passageways 69′. A plurality of tension members 70′ extend through a lower portion 71′. One difference between the pallet 62 and the pallet 62′ is that whereas the beams 68 of the pallet 62 are exposed, the bottom of the pallet 62′ is flat.

Referring again to FIG. 2, the enclosure 64 of the service core 60 is formed on the deck 66 of the prestressed concrete pallet 62. The enclosure 64 is preferably formed from materials of the type used in constructing conventional homes and similar buildings, i.e., two by four and two by six studs, drywall panels, and similar materials. The enclosure 64 includes interior partitions which separate the various mechanicals of the dwelling

unit into kitchens, bathrooms, and the like, and further includes at least one end wall and a dropped or false ceiling **76.**

In accordance with the illustrated embodiment of the invention, the service core **60** is completely fabricated at a factory by means of mass production techniques. The fabrication of the core **60** comprises construction of the walls, partitions, and ceilings in suitable jigs and fixtures, installation of the walls, partitions, and ceilings, installation of all mechanicals, installation of electrical, plumbing, and heating/air conditioning risers for the mechanicals, installation of all doors and cabinetry, installation of floor and wall coverings, and painting. Thus, when the service core **60** is installed between the load bearing wall panels **50** and **52,** it is complete and ready for use. This feature of the invention is highly advantageous in that it not only reduces the cost of a dwelling by applying mass production techniques to the construction of the service core, but also reduces the time that is required to finish a dwelling following the beginning of construction at the dwelling site.

Upon completion of the manufacture of the device core **60** at the factory, it is transported to the site of the building **48** by truck. During such transportation, the service core **60** is supported solely at points corresponding to the support points of the beams. This is accomplished by means of members positioned under the support points of the beams to maintain the remainder of the pallet out of contact with the bed, etc. of the truck.

The service core **60** is installed by means of apparatus of the type shown in FIGS. **11** and **12.** A pair of picking bars **78** are positioned under the beams **68** of the pallet **62** at points corresponding to the support points of the beams. The picking bars **78** are engaged by a harness **80** comprising a plurality of cables **82** and a spreader frame **84** which functions to cause the cables **82** to extend vertically upwardly from the picking bars **78** to points above the enclosure **64** of the service core **60.** The cables **82** are connected to a beam **86** which is in turn supported by a cable **88** extending from a crane (not shown). By this means the crane functions through the harness **80** and the picking bars **78** to lift and position the service core **60.**

Referring again to FIG. **2,** the service core **60** is installed between the load bearing wall panels **50** and **52** with each beam **68** of the pallet **62** engaged with one of the support members **56.** It will be appreciated that due to manufacturing tolerances and in order to facilitate the installation of the core **60** between the wall panels **50** and **52,** the length of the pallet **62** is necessarily somewhat less than the distance between the interior surfaces of the walls. The resulting gap is accommodated by positioning the deck **66** closely in engagement with the wall panel **50,** whereupon a suitable entry in the enclosure **64** is aligned with the door opening **58** in the wall panel **50.** This forms a small gap between the deck **66** and the wall panel **52.** However, an end wall is provided at the end of the enclosure **64** remote from the door opening **58,** whereby the gap is not visible from within the service core **60.**

The next step in the method of dwelling construction comprises the installation of a pair of blank prestressed concrete pallets **90** between the load bearing wall panels **50** and **52.** The pallets **90** are handled by means of cables **92** which are connected to eyes **93** in the pallets. The same procedure could be employed in handling service cores except that the enclosures of the service cores prevent access to the eyes of the pallets. Thus, the service cores must be handled by means of picking bars.

The blank pallets **90** are identical to the pallet **62** of the service core **60** in that they each comprise a deck, three beams depending from the deck, and tension members extending through the beams for prestressing the pallets. The pallets **90** are positioned between the wall panels **50** and **52** with their respective beams engaged with the support members **56** of the walls. The decks of the pallets **90** are therefore aligned with the decks **66** of the pallet **62,** whereby the pallets **90** cooperate with the pallet **62** to form the floor of a dwelling unit.

As is best shown in FIG. **4,** the installation of the pallets **90** is followed by the installation of a pair of shear wall panels **94** and **96.** The wall panels **94** and **96** are formed from prestressed concrete, but differ from the load bearing wall panels **50** and **52** in that they are nominally 4 inches thick. The shear wall panels include window openings **98** and a door opening **100** and serve the dual functions of enclosing the ends of the dwelling unit and maintaining the load bearing walls erect.

The shear wall panels **94** and **96** are preferably connected to the load bearing wall panels **50** and **52** by forming welds between suitable members which either comprise part of or are connected to the reinforcing structure of the wall panels. The load bearing wall panels and the shear wall panels may also be joined by other techniques of the type commonly employed in the construction industry to connect prestressed concrete structural members. The various prestressed concrete pallets which are employed in the practice of the invention may be connected to the load bearing wall panels by similar techniques, however, it has been found that it is often unnecessary to connect the pallets to the load bearing wall panels in any fashion.

Upon the installation of the shear wall panels **94** and **96,** the lowermost apartment of the apartment building **48** is structurally complete. Thereafter, a service core **102** for a second dwelling unit is mounted on the load bearing wall panels **50** and **52.** As is shown in FIG. **5,** the service core **102** comprises a prestressed concrete pallet **104** and an enclosure **106** formed on the pallet **104.** The service core **102** further comprises complete mechanicals for the second apartment.

The pallet **104** of the service core **102** is illustrated in FIG. **9.** The pallet **104** is similar to the pallet **62** in that it comprises a deck **108** and three beams **110** which depend from the deck. A plurality of tension members **112** extend through the beams **110** to prestress the beams and thereby adapt the beams for support at spaced points indicated by the arrows **114** to support a load on the deck **108.**

The pallet **104** also differs from the pallet **62** in several important respects. First, the deck **108** is discontinued at spaced points **116** corresponding to the positioning of the load bearing wall panels **50** and **52.** Second, the deck **108** and the beams **110** extend beyond one of the support points **114** to form a cantilever portion **118** of the pallet **108.** At least some of the tension members **112** extend through plastic tubes **120** or are otherwise disengaged from the material of the beams **110** in the cantilever portion **118.** This is necessary in order that the portion **118** can be supported in cantilever fashion.

The installation of the service core 102 is illustrated in FIG. 10. The picking bars 78 of the lifting and positioning apparatus shown in FIGS. 11 and 12 are engaged with the beams 110 of the pallet 104 at points adjacent the support points 114. At the end of the pallet 104 comprising the cantilever portion 118, a picking bar 78 may be positioned at a point located outside the positioning of the load bearing wall panel 50. Therefore, no problem is encountered in removing the picking bar after the service core 102 is installed. On the other hand, at the opposite end of the core 102, a picking bar 78 must be engaged with the core 102 at a point located within the positioning of the load bearing wall panel 52. To this end the service core 60 is provided with a picking bar slot 122.

The picking bar slot 122 comprises a reinforced portion of the false ceiling 76 of the core 60 which is purposely constructed to have sufficient strength to support the picking bar after it is disengaged from the harness 80. By way of example, picking bars suitable for use in the practice of the present invention typically weigh approximately 400 pounds. In such a case the picking bar slot 122 is preferably formed from two by twelves and two by sixes so as to have sufficient strength to support the picking bar.

Referring again to FIG. 5, the enclosure 106 of the service core 102 is similar to, and may in fact be identical to, the enclosure 64 of the service core 60. The enclosure 106 includes a dropped or false ceiling 124 including a picking bar slot 126 and also includes an end wall which is situated at the end of the enclosure 106 remote from the cantilever portion 118 of the prestressed concrete pallet 104. Like the enclosure 64, the enclosure 106 is preferably completely fabricated by mass production techniques prior to the installation of the service core 102.

The service core 102 is installed on the load bearing wall panels 50 and 52 with each beam 110 of the pallet 104 engaged with one of the notches 54 of the load bearing wall panels. As has been indicated, the deck 108 of the pallet 104 is discontinued at points corresponding to the positioning of the load bearing wall panels. This permits the positioning of the upper surface of the deck 180 of the pallet 104 either in alignment with, above or below the upper surfaces of the load bearing wall panels 50 and 52, as desired.

Those skilled in the art will appreciate the fact that due to the nature of prestressed concrete pallets, the service core must be supported at points corresponding to the positioning of the load bearing wall panels 50 and 52. However, notwithstanding this requirement, it has been found that the service core 60 may be provided with members extending into engagement with the pallet 104 of the service core 102. These members do not support the pallet in the true sense, but merely limit and control deflections of the pallet due to varying live loads thereon.

Following the installation of the service core 102, a pair of blank prestressed concrete pallets 128 are mounted on the load bearing wall panels 50 and 52. The pallets 128 are similar to the pallet 104 of the service core 102 in that they each comprise a deck, three beams depending from the deck, and tension members extending through the beams to prestress the pallet. Also, the decks of the pallets 128 are discontinued at points corresponding to the positioning of the load bearing wall panels. The pallet 128 are mounted on the load bearing wall panels with each beam of the pallet engaged with one of the notches 54 or 54' of the load bearing wall panels.

Referring now to FIG. 6, the next step in the method of dwelling construction comprises the positioning of a second set of load bearing wall panels 132 and 134 on the load bearing wall panels 50 and 52. The wall panels 132 and 134 are similar to the wall panels 50 and 52 in that they are constructed from prestressed concrete and in that they are nominally 6 inches thick. Also, the wall panels 130 and 132 are provided with notches 136 and 136' in their upper edges which are identical to the notches 54 and 54', and the wall panel 132 is provided with a door opening 138 which is similar to the door opening 58 in the load bearing wall panel 50.

Following the installation of the load bearing wall panels 132 and 134, a pair of shear wall panels 140 and 142 are mounted on the shear wall panels 90 and 96, respectively. The wall panels 140 and 142 are formed from prestressed concrete and are nominally 4 inches thick. A plurality of window openings 144 and a door opening 146 are formed in the walls 140 and 142 at points corresponding to the window openings 98 and the door openings 100 of the shear wall panels 94 and 96. The shear wall panels 140 and 142 function to enclose the ends of the second apartment of the apartment building 48 and to maintain the load bearing wall panels 132 and 134 erect.

Upon completion of the foregoing steps, the second apartment of the apartment 48 is structurally completed. Thereafter the steps are repeated to form additional apartments. It will be understood that the additional apartments are positioned directly above the previously formed apartments and thereby function to increase the height of the apartment building 48. When all of the apartments comprising the apartment building 48 have been constructed, prestressed concrete pallets similar to the pallets 90 are positioned on the uppermost load bearing wall panels to form the roof of the apartment building. At this point the apartment building 48 is complete insofar as its structural components are concerned.

After the roof of the apartment building 48 has been installed, the interiors of the various apartments comprising the apartment building are finished. This involves filling the gaps between the wall panels and the pallets and between the wall panels per se with grouting, forming connections between the electrical, plumbing, and heating/air conditioning risers of the service cores of the apartments, constructing interior partitions to define bedrooms, closets, and the like, installing electrical wiring, including telephone and television wiring, installing doors and windows in the door and window openings of the wall panels, and the like. The interiors of the apartments are also finished. This involves installing carpeting, painting the interior surfaces of the load bearing wall panels, installing thermal insulation and paneling on the interior surfaces of the shear wall panels, and spraying the under surfaces of the pallets which do not comprise service cores with an asbestos material. The latter procedure has been found to be highly advantageous in that it provides the interiors of the apartments with a "beamed" ceiling effect which is highly pleasing in appearance, in that it provides sound deadening qualities, and in that it provides increased fire protection for the apartments. Upon completion of the finishing of the interiors of the apart-

ments, the apartment building **48** is ready for occupancy. In actual practice it has been found that when the present invention is utilized, a three story apartment building can be completed and ready for occupancy within a few weeks following the start of construction. This extremely short completion time is made possible because the service cores of the dwelling units of the apartment building are completely fabricated before construction at the dwelling site is commenced.

Referring now to FIG. **7**, there is shown a completed three story apartment building **148** constructed in accordance with the present invention. The building **148** includes a load bearing wall **150** which does not have pallet portions extending cantilever from it. In many building projects utilizing the present invention, such a wall will be a "double loaded" wall in that prestressed concrete pallets will be supported from both sides of the wall.

It is preferable that one apartment building such as the apartment building **148** be completed at least to the extent that the roof is installed prior to starting an adjacent apartment building. This is to facilitate the complete enclosure of the first apartment building and thereby climinate any possibility of damage to the interior of the building due to weather. Then, after the first apartment building has been completed, the construction of the next adjacent apartment building is commenced.

The construction of the adjacent apartment building involves the erection of a load bearing wall **152** in spaced relation to the load bearing wall **150** of the first apartment building and then supporting prestressed concrete pallets between the load bearing walls **150** and **152**. As has been described previously, at least one prestressed concrete pallet of each dwelling unit of the second apartment building will have a service core formed on it. In the typical apartment building, each dwelling unit will also include blank prestressed concrete pallets.

The only substantial difference between the construction of the first apartment building and the construction of the second apartment building is due to the fact that one of the load bearing walls of the second apartment building has previously been completed to its entire height. This causes the positioning of the beams of prestressed concrete pallets in the notches of the double loaded load bearing wall to be somewhat more involved than is the case when the adjacent load bearing wall panels have not been installed prior to the installation of the pallets. To this end, notches **154** are preferably formed at the lower edges of each panel of the double loaded load bearing wall to facilitate the installation of the beams of prestressed concrete pallets in the notches formed in the upper ends of the next adjacent panel of the load bearing wall.

The notches **154** are best shown in FIG. **22**. Each notch **154** comprises an inwardly tapered portion formed in an upper load bearing wall panel **156** at a point aligned with a U-shaped notch **158** formed in a load bearing wall panel **160** positioned just below the panel **156**. The notches **154** are equal in width to the notches **158**, whereby the positioning of the beams of prestressed concrete pallets in the notches **158** is facilitated.

FIRST EMBODIMENT

Referring now to FIG. **13**, a garden apartment complex **200** constructed in accordance with the present invention is shown. The complex **200** comprises a pair of three story garden apartment buildings **202** and **204** and a pair of two story garden apartment buildings **206** and **208**. The lowermost apartments of the apartment buildings comprising the complex **200** are provided with patios **210** and the upper apartments are provided with balconies **212**. The apartments in the three story apartment buildings **202** and **204** are provided with fireplaces **214**. "Double loaded" entry ways **216** are utilized in the complex **200**. These comprise cantilever portions **218** of prestressed concrete pallets utilized in the three story apartment buildings **202** and **204**.

A typical floor of the apartment complex **200** is shown in FIG. **14**, it being understood that the various floor plans illustrated in the Drawings are representative only and that none of the specific floor plans shown comprises part of the present invention. Each floor of each apartment building in the apartment complex **200** comprises three prestressed concrete pallets **220** including a center pallet **220'** having a service core formed on it. The pallets **220** comprising the apartment buildings **202** through **208** are supported on load bearing walls **222** and are enclosed by shear walls **224**. It will be noted that the pallets **220** comprising the apartment buildings **206** and **208** are partially supported by a double loaded load bearing wall **222'**. As has been indicated, the double loaded entry ways **216** comprise cantilever portions **218** which extend inwardly from the service core pallets of the apartment buildings **202** and **204**.

The apartment building **202** comprises apartments **230** each including an entry **232** comprising part of the service core and extending to one of the double loaded entry ways **216**. The entry **232** of each apartment **230** interconnects a living room **234** and a hallway **236** which extends to a den **238** and a bedroom **240**. The service core further includes a bathroom **242** and a kitchen **244**, and is completed by an enclosure **246** for the heating/air conditioning facilities of the apartment, a closet **248** in the entry **232**, and a closet **250** in the hall **236**. A partition **252** extends between the den **238** and the bedroom **240** to define a pair of closets **254** and **256**.

The apartment buildings **204** and **206** comprise apartments **260** which are somewhat larger than the apartments **230** of the building **202**. Each apartment **260** includes an entry **262** which extends to one of the double loaded entry ways **216**. The entry **262** interconnects a living room **264** and a hall **266** which extends to a pair of bedrooms **268** and **270**. The service core of each apartment **260** includes the entry **262**, two bathrooms **272** and **274**, a kitchen **276**, a plurality of closets **278**, and an enclosure **280** which houses the heating/air conditioning apparatus for the dwelling unit **260**. The bedrooms **268** and **270** are separated by a pair of closets **282** and **284**.

Each floor of the apartment building **208** comprises two relatively small apartments **290**. The apartments **290** each comprise an entry **292** which extends to one of the double loaded entry ways **216** and which is provided with a closet **294**. The entry **292** extends to a living room **296** which in turn extends to a bedroom **298**. The living room **296** and the bedroom **298** are sepa-

rated by a partition 300 defining a closet 302. Each apartment 290 of the apartment building 208 is completed by a bathroom 304, a kitchen 306 and enclosures 308 for heating/air conditioning equipment, all of which are mounted on the service core.

The apartment building 208 differs significantly from the buildings 202, 204, and 206 in that each floor of the building 208 comprises a double loaded service core including complete and separate mechanicals for two dwelling units. This comprises a highly important feature of the present invention in that it facilitates the construction of relatively small dwelling units on a very efficient and economical basis. One important aspect of the double loaded service core concept is that since each service core is common to two dwelling units, it is necessary to establish a fire barrier having at least a one hour rating between the portion of the core common to one dwelling unit and the portion of the core common to the other dwelling unit.

The various features of the dwelling units 230 of the apartment building 202 are shown in greater detail in FIGS. 15A, 15B, and 15C. The service core of the dwelling unit 230 comprises wall and partitions 320 which are formed from materials of the type commonly employed in the construction of conventional houses and similar buildings, i.e., two by four and two by six studs 322, dry wall panels 324, and the like. The walls 320 enclose telephone, television, electrical and plumbing risers 326, and additional risers extend through the enclosure 246. Access panels 328 and 330 are provided to permit interconnecting the electrical, plumbing, and heating/air conditioning facilities of adjacent dwelling units 230 in the apartment building 202. The various closets and rooms of the dwelling unit 230 are provided with hollow core doors 332 of the type commonly employed in houses, apartment buildings, and the like.

The bathroom 242 of each apartment comprises a dressing table 334 including a sink 336, a toilet 338, and a bathtub 340. The kitchen 244 is similarly completely equipped in that it comprises a refrigerator 342, a stove 344, a sink 346 and a dishwasher 348. Full cabinet facilities 350 are also provided in the kitchen 244.

One of the most important aspects of the present invention comprises a system for providing electrical outlets at convenient points around the periphery of each of the rooms of an apartment. Each load bearing wall 222 is equipped with electrical conduits 352 which are formed in the wall when it is cast. The conduits 352 comprise inlets 354 formed at points aligned with and positioned above the false ceiling of a service core. The conduits 352 further comprise various outlets 356 including outlets 356'. The outlets 356' of each conduit 352 are positioned at the outer ends of the load bearing wall 252.

When each apartment is finished additional conduits 358 are connected to the conduits 352 at the outlets 356'. The conduits 358 are secured to the inner surfaces of the shear walls 224 and extend to outlets 360 positioned at convenient points along the shear walls. During subsequent finishing the inner surfaces of the shear walls 224 are covered with paneling sections 362 so that both the conduits 352 and 358 are completely hidden from view in the finished dwelling unit. The conduits 358 may include portions 364 extending through the interior partitions of the apartment to suitable outlets 366, if desired.

It will be understood that although the system for providing convenient electrical outlets in apartments constructed according to the present invention has been illustrated in conjunction with an apartment 230 of the apartment building 202, the same system is utilized in the apartments comprising the apartment buildings 204, 206, and 208. Of course, the routing of the various electrical conduits and the positioning of the various outlets will vary in accordance with particular requirements. However, in each instance the load bearing walls are equipped with suitable conduits, including inlets that will ultimately be aligned with a service core during manufacture and the conduits of the load bearing walls are connected to conduits secured to the interior surfaces of the shear walls during finishing.

Referring now to FIG. 16, the double loaded service core which is employed in the apartments of the apartment building 208 is shown in greater detail. The double loaded core comprises walls and partitions 370 formed from wooden studs and drywall panels. The walls 370 enclose electrical and plumbing risers 372. Additional risers extend through the enclosures 308. Access panels 374, 376, and 378 are provided for facilitating the interconnection of the electrical, plumbing, and heating/air conditioning facilities of adjacent apartments.

The bathrooms 304 of the apartments 290 each comprise a dressing table 380 equipped with a sink 382, a toilet 384 and a bathtub 386. The kitchens 306 of the apartments 290 are similarly fully equipped. Thus, each kitchen 306 comprises a stove 388, a sink 390, and a refrigerator 392. Each kitchen 306 is further provided with a pass through 394 which is situated at counter height.

As will be appreciated by those skilled in the art, one problem that is encountered in the construction of multifamily dwelling units comprises fire protection. The building codes of most cities and other jurisdictions require a fire barrier having at least a one hour rating between adjacent dwelling units of a multi-family building. The present invention comprises various systems for providing such a fire barrier while at the same time adapting dwelling unit construction to mass production techniques. Many of these systems are illustrated in conjunction with FIG. 16 and the sectional views taken therefrom.

When a service core for a dwelling unit comprising the present invention is installed, the end of the service core comprising the entry is positioned as close as possible to the adjacent load bearing wall. This results in a very small gap 400 at the entry end of the service core. The gap 400 is easily filled with grouting to provide the necessary fire barrier. On the other hand, the positioning of the entry end of the service core as close as possible to the adjacent load bearing wall results in a relatively large gap 402 at the opposite end of the service core. Since the end of the core remote from the entry is normally equipped with an end wall 404, access to the relatively large gap 402 is not readily available.

Referring now to FIG. 17, a system for providing a fire barrier having at least a one hour rating in the gap 402 is shown. A sheet metal lip 406 is secured between the end wall 404 and its supporting deck 408. When the service core including the deck 408 and the wall 404

is installed, the lip **406** is extended over the upper edge of the load bearing wall section **410** which supports the service core. Thereafter, when the next load bearing wall section **412** is mounted on the load bearing wall section **410,** the lip **406** is trapped between the bottom of the wall section **412** and the top of wall section **410.** By this means the lip **406** forms a fire barrier across the gap **402.**

Since each service core of the apartment building **208** serves two dwelling units, it is necessary to form a fire barrier between the portions of each service core individual to one dwelling unit and the portion of each core individual to the other dwelling unit. As is best shown in FIG. **16,** each service core of the apartment building **208** comprises a wall **414** comprising at least two layers of ⅝ inch drywall sheets. The wall **414** extends the entire length of the service core and forms the majority of the fire barrier between the opposed portions of the service core.

Referring now to FIGS. **18** and **19,** the upper end of the wall **414** comprises a pair of opposed flanges **416** formed from sheet metal. The flanges **416** are positioned to receive a beam **418** comprising a portion of a prestressed concrete pallet **420** which is installed above the service core. By this means the flange **416** and the beam **418** cooperate to complete the upper portion of the fire barrier between the opposed portions of the service core.

As has been indicated, the service cores of dwelling units comprising the present invention are installed with the entry end positioned as close as possible to the adjacent load bearing wall. In the case of double loaded cores, this practice results in a gap between the end of the wall **414** remote from the entry and the load bearing wall adjacent thereto. To this end, the wall **414** is equipped with a stub wall **422** which is formed from sheets of ⅝ inch drywall or some other fire retardant material.

The stub wall **442** is slidably supported in the wall **414** and is retracted during the installation of the service core. Following installation of the service core and the adjacent load bearing walls, the stub wall **422** is moved outwardly and into engagement with the adjacent load bearing wall. By this means the fire barrier provided by the wall **414** is extended across the entire distance between the load bearing walls which enclose the service core.

It will be appreciated that notwithstanding the use of the flanges **416** and the stub wall **422,** it is possible that small gaps may remain in the fire barrier between the opposed portions of the service core following the installation of the adjacent load bearing walls, the positioning of the stub wall **422** and the mounting of a prestressed concrete pallet above the service core. In such a case, pieces of ⅝ inch drywall are employed to close any such gaps. Access to such gaps for use in installing the drywall pieces is gained through the access panels **374, 376,** and **378** of the service core.

Referring now to FIG. **20,** several important features of the present invention are shown. As will be appreciated from the foregoing, the prestressed concrete pallets which are utilized in the practice of the invention are supported entirely by prestressed concrete load bearing walls. That is, the enclosures of the service cores which are utilized in the practice of the invention to house the mechanicals of one or more dwelling units are not used in any way as structural or supporting members. This fact is clearly illustrated in FIG. **20** wherein portions of a lower service **430** and an upper service core **432** which is supported on a prestressed concrete pallet **434** are shown. The service core **430** includes an outer wall **436** which extends above a false ceiling **438.** The wall **436** does not, however, engage the pallet **434.** Quite to the contrary, a gap **440** is purposely maintained between the upper end of the wall **436** and the pallet **434.**

Notwithstanding the high strength of prestressed concrete pallets, it has been found that such pallets exhibit certain flexibility. This is especially noticeable when a large number of persons is supported on a particular pallet. As has been indicated it has been determined that members may be extended between pallets to limit this flexure. However, it cannot be completely eliminated. The gap **440** is therefore provided in order to permit the prestressed concrete pallet **434** to flex downwardly without damaging the wall **436.**

It will be appreciated that the gap **440** would be objectionable if it could be observed from within the dwelling unit incorporating the service core **430.** To this end a strip **442** is secured to the underside of the pallet **434** and extends downwardly beyond the upper end of the wall **436.** The strip **442** thus cooperates with the wall **436** to form a slip joint between the underside of the pallet **434** and the upper end of the enclosure of the service core **430.** Such a slip joint hides the gap **440** and yet permits movement of the pallet **434** relative to the core **430.**

In the practice of the present invention the various walls and partitions of the service cores are assembled in suitable jigs and fixtures. It has been determined that considerable time and expense can be saved if the walls and partitions are completely finished on both sides while they are in the jigs and fixtures. However, such practice would appear to be negated since it would then be impossible to secure the walls and partitions to the deck of a prestressed concrete pallet.

This difficulty can be overcome by boring holes **444** through the deck of a prestressed concrete pallet along lines that will comprise the walls and partitions of a service core. The walls and partitions are then completed on both sides in suitable jigs and fixtures. The completed walls and partitions are positioned at their proper places on the pallet and are secured to the pallet by lag screws **446** which are inserted through the holes **444** and threadedly engaged with the walls and partitions. This technique has been found to be highly satisfactory in that it permits complete finishing of the walls and partitions on both sides and yet provides means for rigidly securing the completed walls and partitions to the decks of prestressed concrete pallets.

As has been indicated, the pallets that are utilized in the practice of the present invention are apt to flex subjected to varying live loads. On the other hand, the walls and partitions of the enclosures of the service cores are relatively inflexible, at least insofar as bending with the pallets is concerned. To this end the connections between the pallets and the walls are preferably rendered somewhat resilient, for example by mounting springs, such as the Belleville washers **448** shown in FIG. **20,** at suitable locations to accommodate relative flexure between the walls and the pallets.

Various additional details of the apartment complex **200** are illustrated in FIGS. **22–25.** Referring first to FIG. **22,** the various apartment buildings comprising

the complex **200** are provided with roofs **450** which are formed on prestressed concrete pallets, but which are otherwise finished by conventional techniques to prevent moisture from entering the apartments of the complex. As is best shown in FIG. **23**, the cantilever portions **218** comprising the double loaded entry ways **216** extend adjacent to but do not engage the load bearing walls comprising the next adjacent apartment buildings. As has been indicated, the decks of the prestressed concrete pallets are normally discontinued at points corresponding to the positioning of the load bearing walls. The decks, may, however, be extended at points corresponding to the door openings to provide a suitable door sill **452**.

Referring now to FIGS. **24** and **25**, the structural details of the dwelling units at the shear walls **224** are shown. Sections of thermal insulation **454** are mounted on the inner surfaces of the shear walls **224** and are covered by the paneling sections **362**. As has been indicated, the conduits **368** also extend behind the paneling sections **362** and are therefore fully hidden from view. FIG. **25** further illustrates the use of carpeting **456** and a sprayed asbestos coating **458** on the upper and lower surfaces of blank prestressed concrete pallets.

Although preferred embodiments of the invention have been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it will be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements, modifications, and substitutions of parts and elements without departing from the spirit of the invention.

What is claimed is:

1. The multi-family dwelling unit comprising:

a pair of spaced, substantially vertically extending load bearing wall means;

a first prestressed concrete pallet supported on the load bearing wall means and comprising a substantially planar deck and a plurality of beams depending from the deck;

two sets of mechanicals mounted on the first pallet and each comprising complete kitchen, bathroom and temperature control facilities for a dwelling unit;

a second prestressed concrete pallet supported on the load bearing wall means above the first pallet and comprising a substantially planar deck and a plurality of beams depending from the deck; and

a fire barrier wall mounted on the first pallet between the two sets of mechanicals and extending continuously between the load bearing wall means and between the deck of the first pallet and the second pallet.

2. The multi-family dwelling unit according to claim **1** wherein the fire barrier wall further comprises means for receiving one of the beams of the second pallet to complete the upper portion of the fire barrier wall.

3. The multi-family dwelling unit according to claim **2** wherein the fire barrier wall further includes a member supported for sliding movement into engagement with one of the load bearing wall means to complete one end of the fire barrier wall.

4. A method of forming a dwelling unit comprising:

forming an enclosure including a fire barrier wall comprising a pair of beam receiving flanges at the upper end and a retracted stub wall at one side on a first prestressed concrete pallet;

positioning a pair of prestressed concrete load bearing walls at the opposite ends of the first prestressed concrete pallet;

sliding the stub wall outwardly and into engagement with one of the load bearing walls to extend the fire barrier wall the entire width of the enclosure; and

positioning a second prestressed concrete pallet on the spaced load bearing walls with a beam of the second pallet received in the flanges of the fire barrier to extend the fire barrier wall to the entire height of the enclosure.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,810,335 Dated May 14, 1974

Inventor(s) Raymond L. McCrillis; Walter T. Fuller; Richard H. Dixon; John R. Oldani

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 7, line 22, delete "device" and substitute therefor --service--;

Column 9, line 44, delete "180" and substitute therefor --108--;

Column 11, line 26, delete "climinate" and substitute therefor --eliminate--.

Signed and sealed this 24th day of September 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents