United States Patent [19]

Livingston

[11] **3,877,187**

[45] **Apr. 15, 1975**

[54] **DWELLING CONSTRUCTION SYSTEM**

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

[22] Filed: **May 18, 1973**

[21] Appl. No.: **361,821**

Related U.S. Application Data

[60] Division of Ser. No. 230,803, March 1, 1972, Pat. No. 3,800,493, which is a continuation-in-part of Ser. No. 166,545, July 27, 1971, abandoned.

[52] **U.S. Cl.** ..... **52/143;** 296/23 R; 52/223; 105/405

[51] **Int. Cl.** **B60b 3/32**

[58] **Field of Search** ..... 52/143, 79, 602; 105/405, 105/422; 296/31 R

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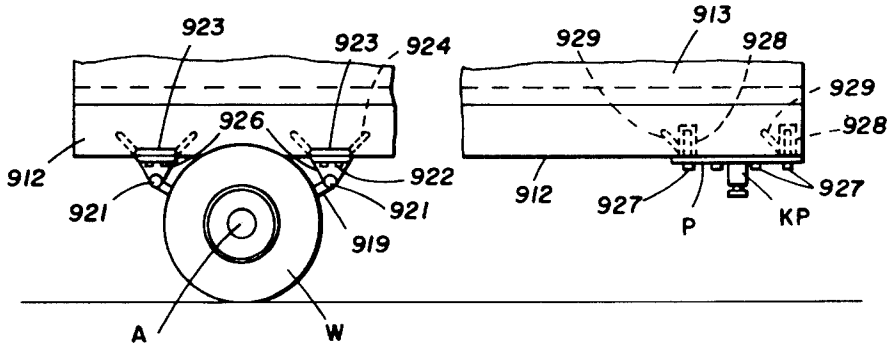
Primary Examiner—John E. Murtagh

Attorney, Agent, or Firm—Hubbard, Thurman, Turner & Tucker

[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.

6 Claims, 21 Drawing Figures



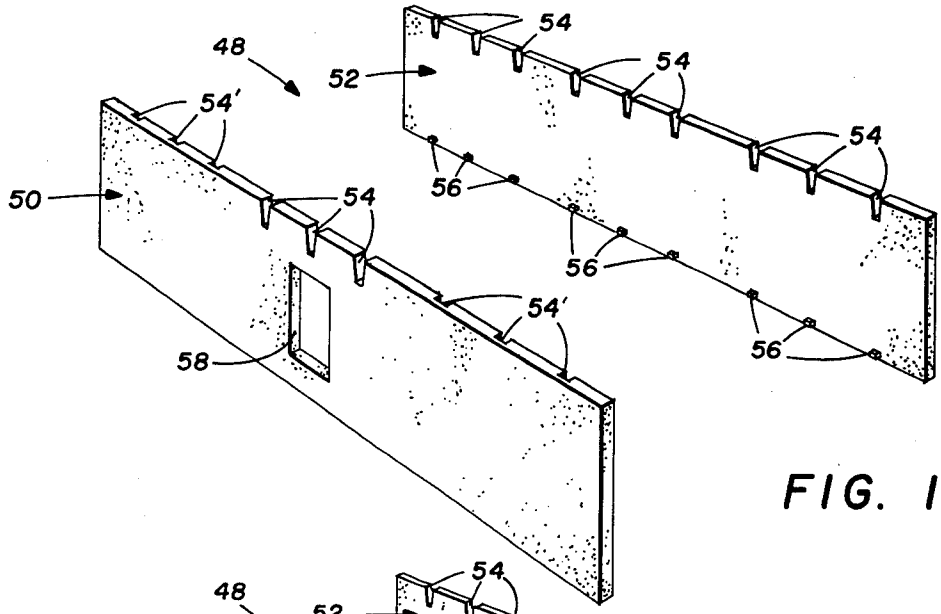


FIG. 1

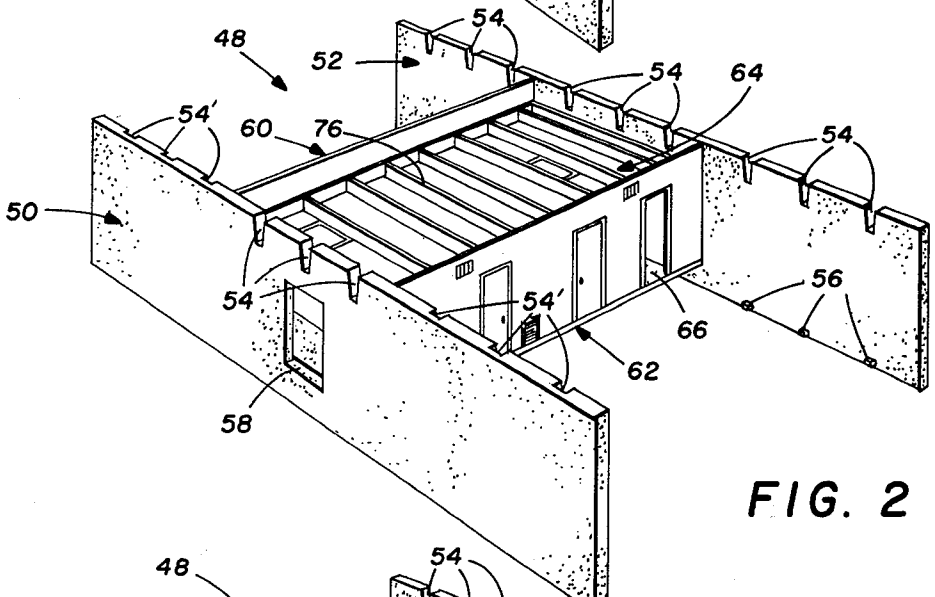


FIG. 2

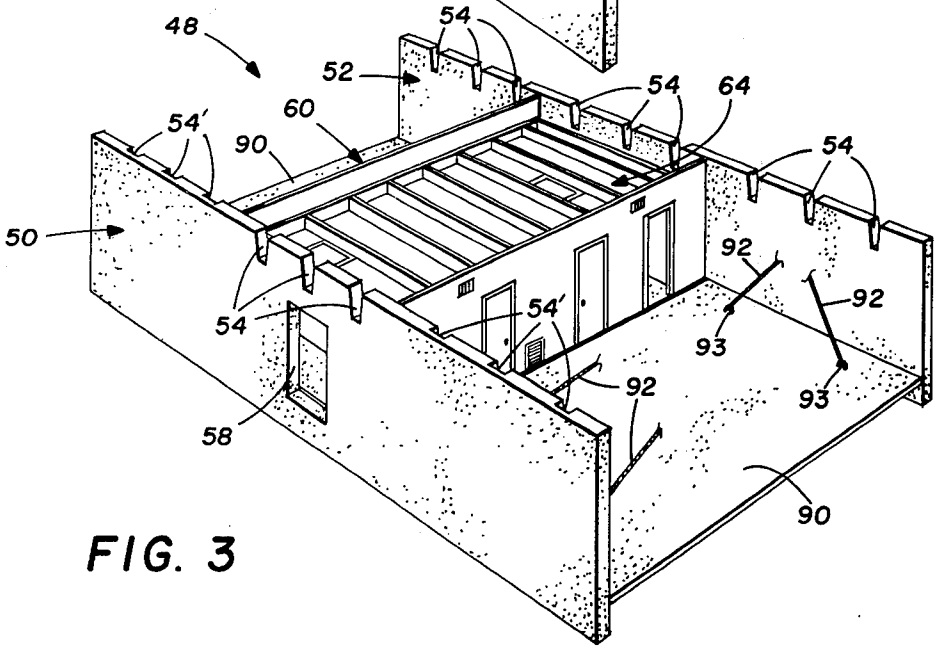


FIG. 3

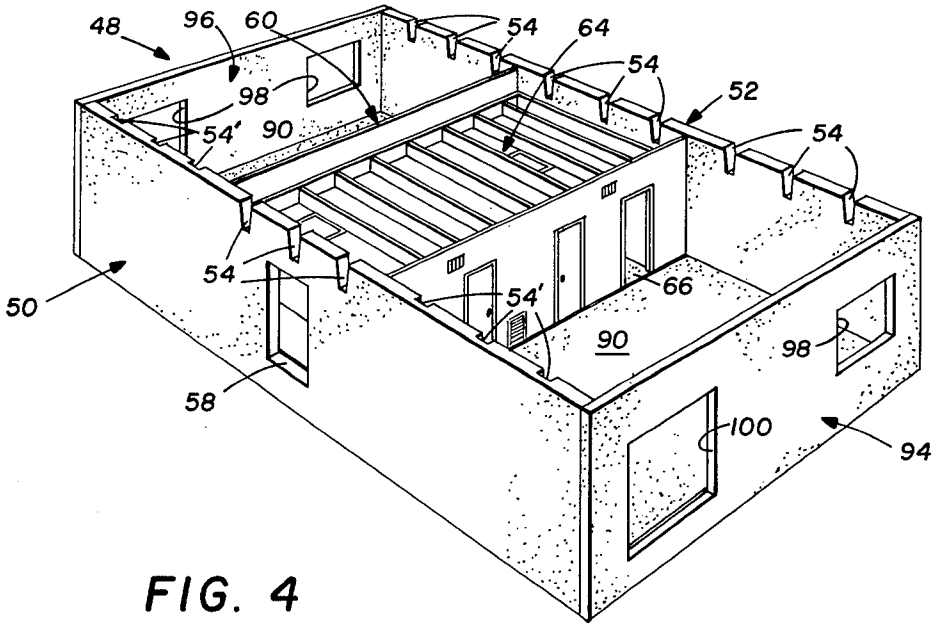

48
96
60
54
64
54
52
98
54'
90
54
54
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54'
66
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58
100
94

FIG. 4

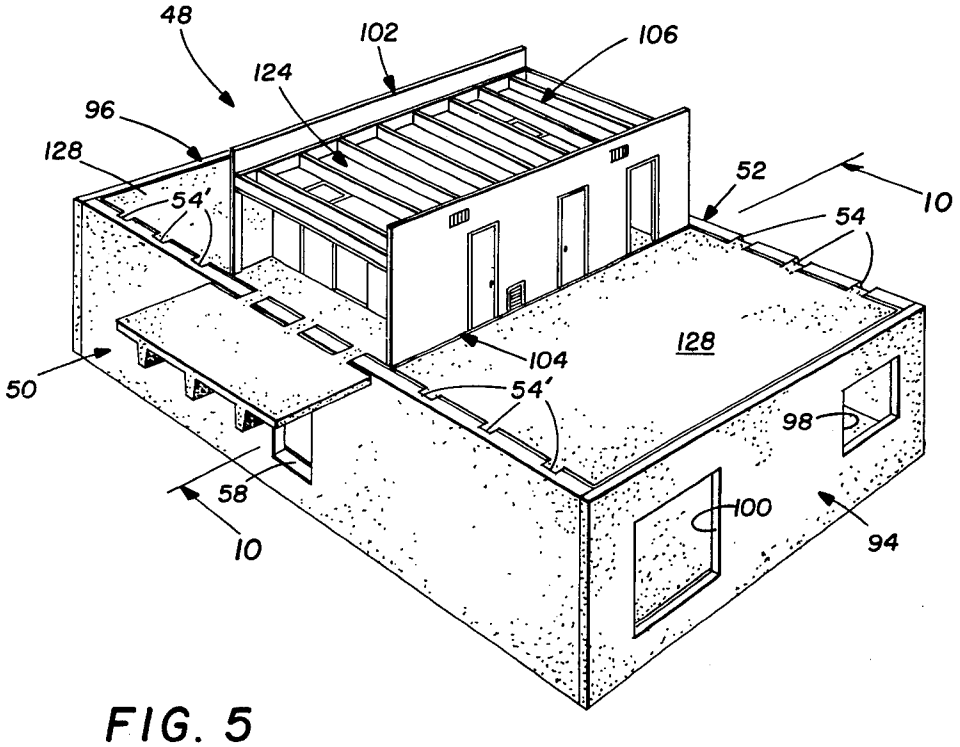

48
102
106
124
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FIG. 5

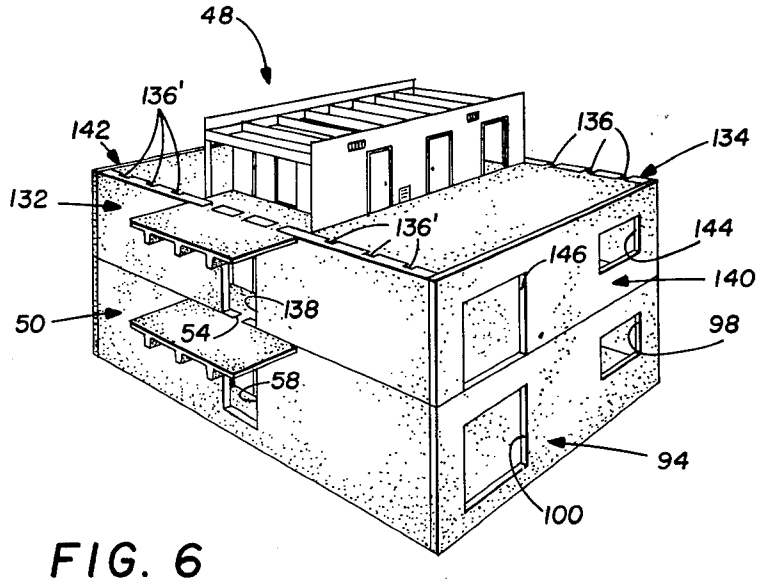

48
136'
142
136
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132
136'
144
146
140
50
138
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FIG. 6

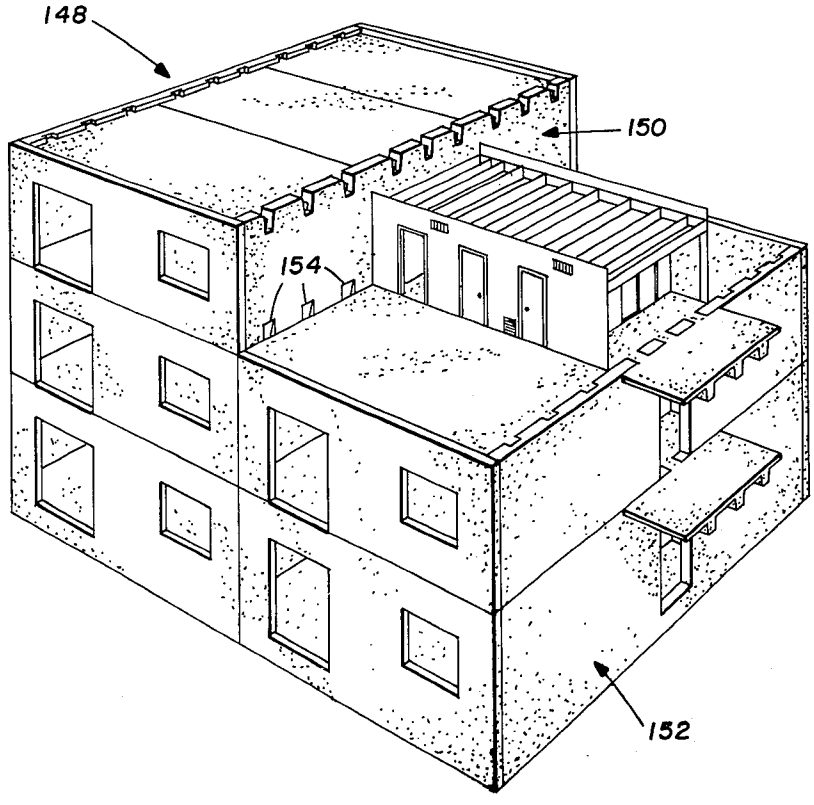

148
150
154
152

FIG. 7

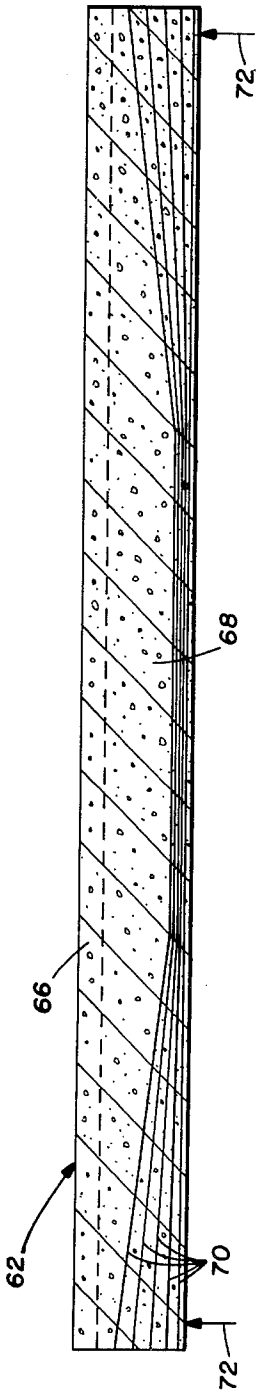


FIG. 8

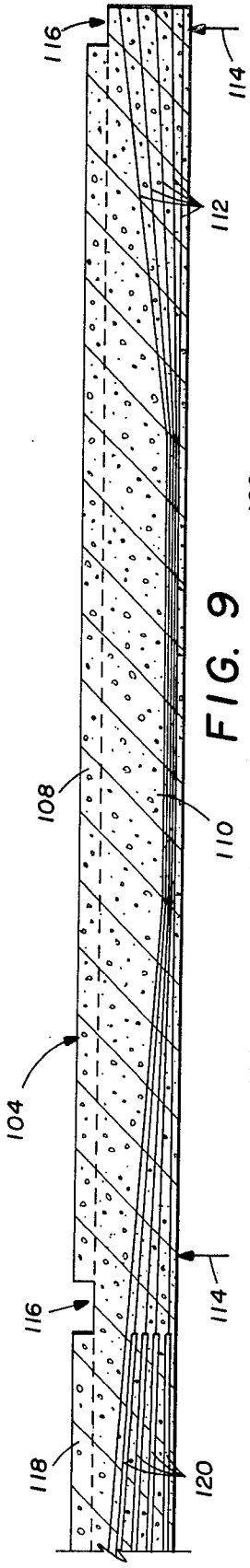


FIG. 9

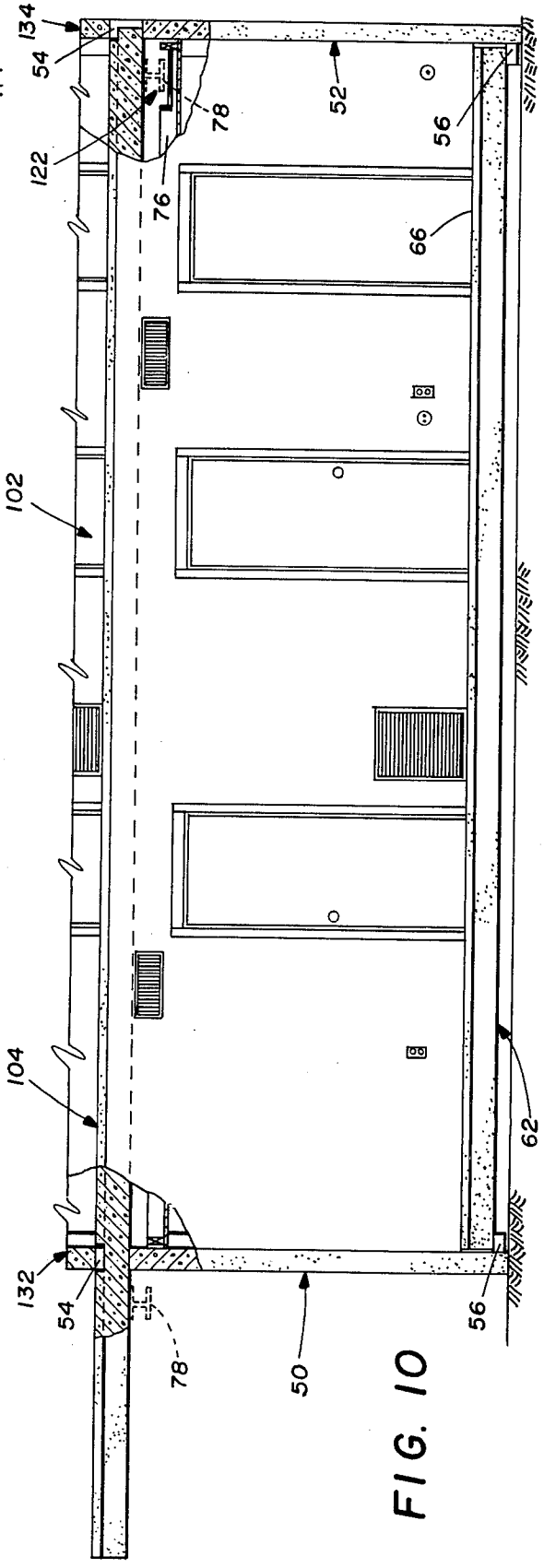
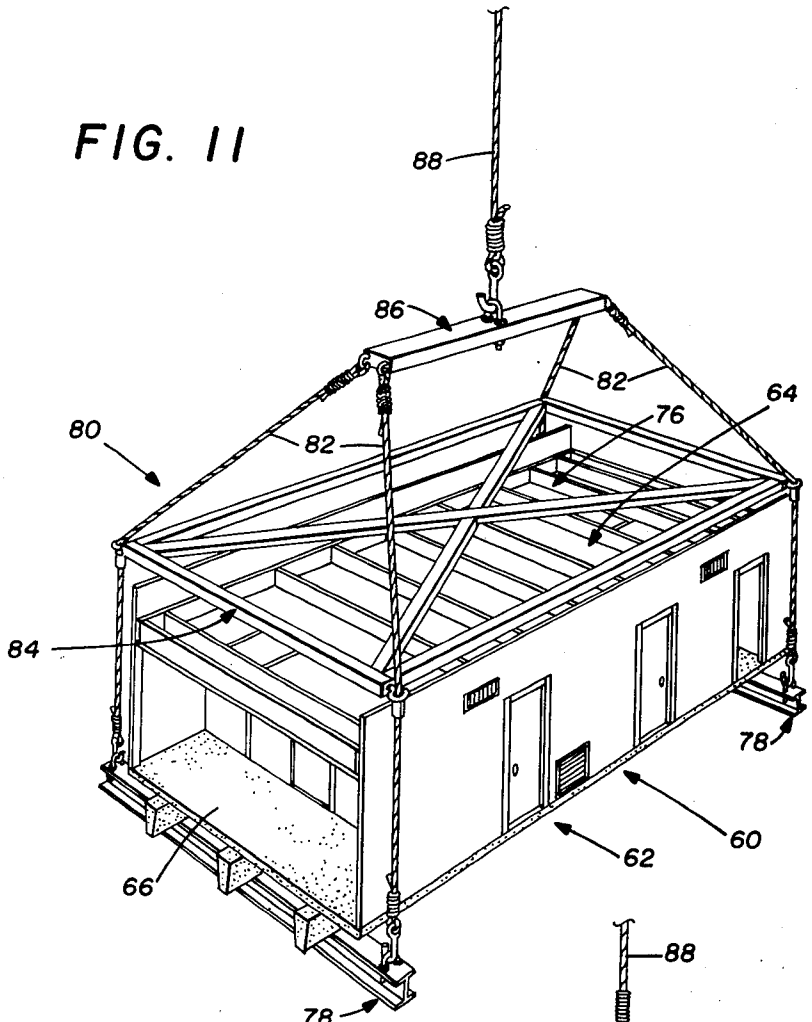


FIG. 10

FIG. 11



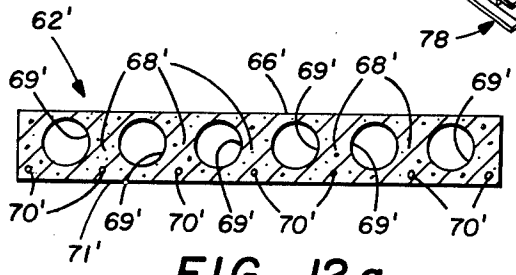


FIG. 12a

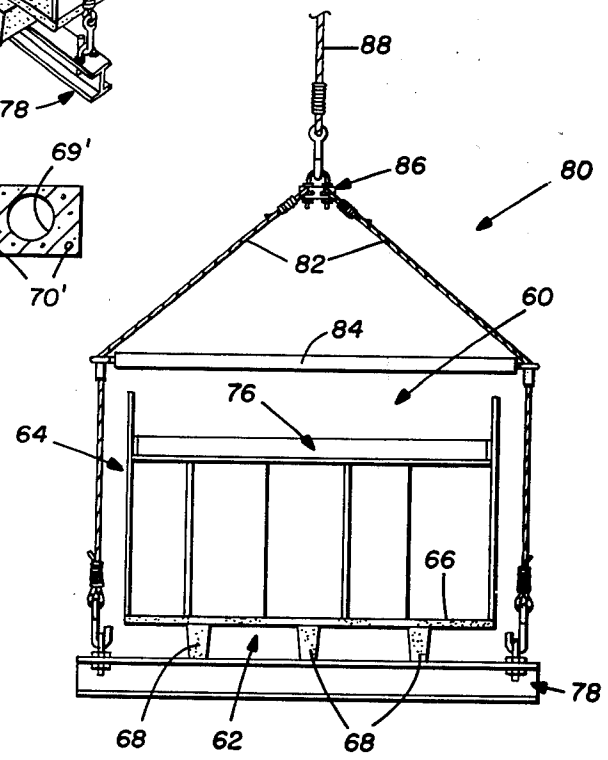


FIG. 12

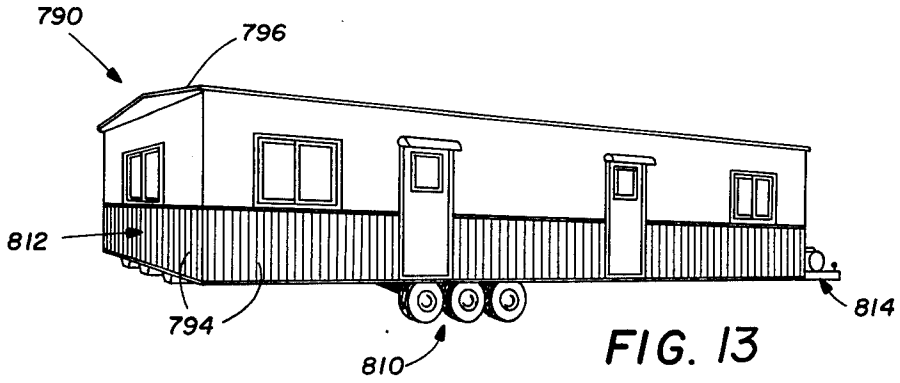

790
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FIG. 13

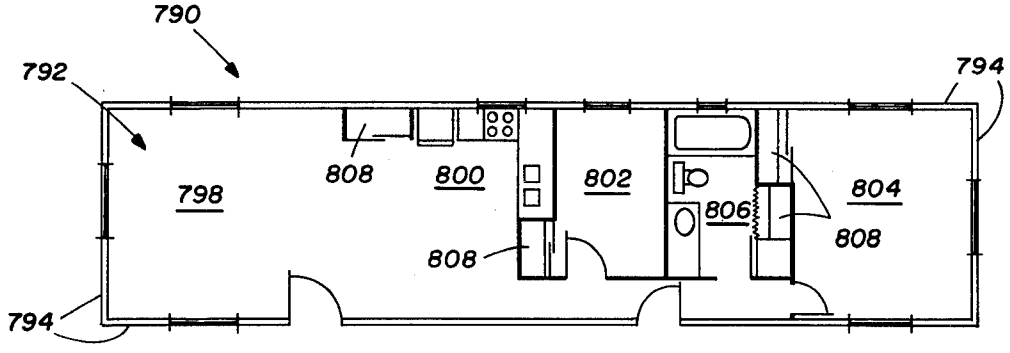

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FIG. 14

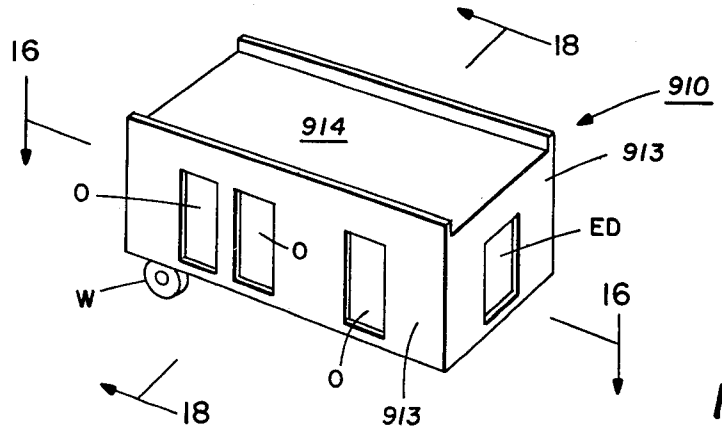

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FIG. 15

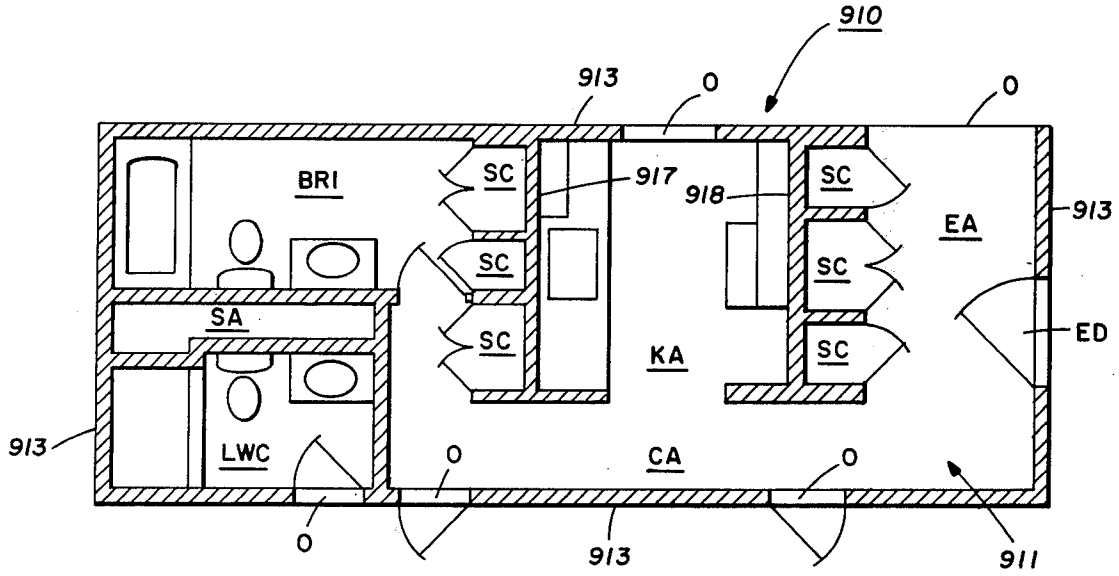

910
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BRI
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EA
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LWC
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911

FIG. 20

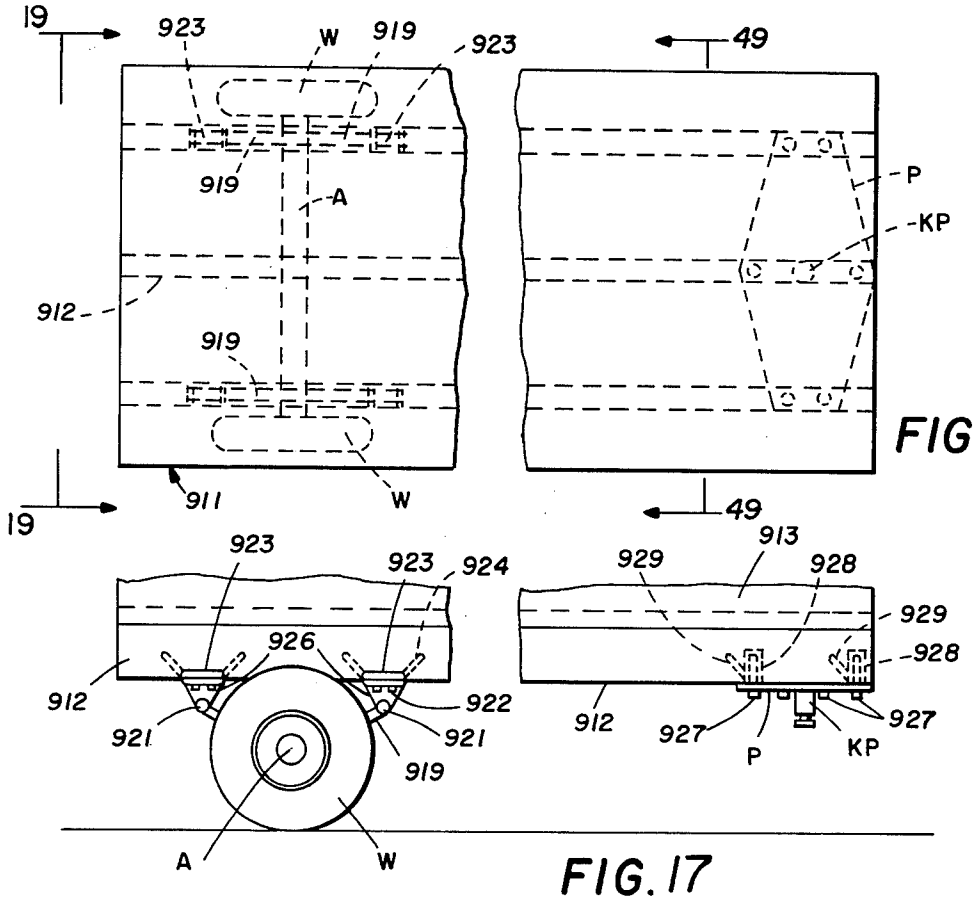


FIG. 16

FIG. 17

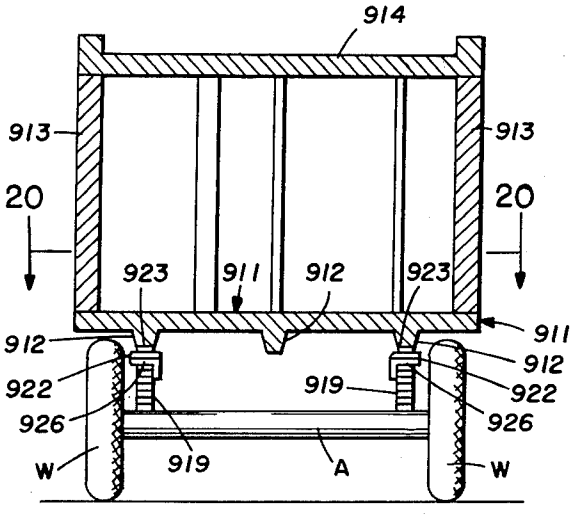


FIG. 18

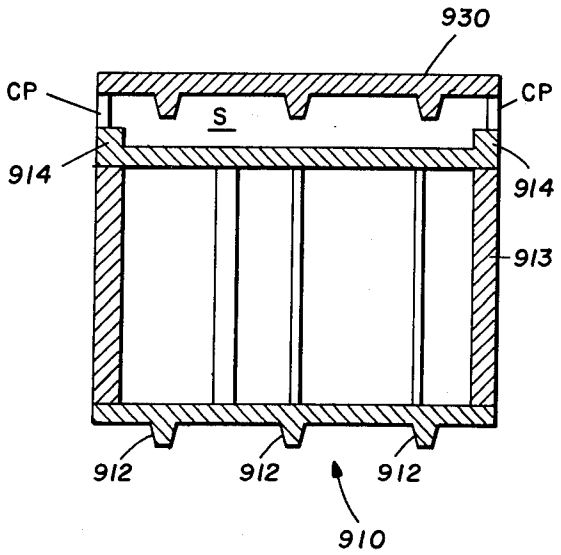


FIG. 19

DWELLING CONSTRUCTION SYSTEM

This is a division of application Ser. No. 230,803, filed Mar. 1, 1972, now U.S. Pat. No. 3,800,493. Application Ser. No. 230,803 is a continuation-in-part of copending application Ser. No. 166,545, filed July 27, 1971, now abandoned.

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 or 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 of 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:

FIG. 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 a perspective view of a trailer house comprising an embodiment of the invention;

FIG. 14 is a plan view of the trailer house shown in FIG. 13;

FIG. 15 is a perspective view of a transportable service module comprising another embodiment of the invention;

FIG. 16 is a view taken generally along the lines 47—47 in FIG. 15 in the direction of the arrows;

FIG. 17 is a side view of the transportable service module shown in FIG. 15;

FIG. 18 is a sectional view taken generally along the lines 49—49 in FIG. 16 in the direction of the arrows;

FIG. 19 is a view taken generally along the lines 50—50 in FIG. 16 in the direction of the arrows and showing the service module following installation; and

FIG. 20 is a sectional view taken generally along the lines 51—51 in FIG. 14 in the direction of the arrows.

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 ad-

vantageous 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 service 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, ect. 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 suitably 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 **108** 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 **120** 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 pallets **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 apartments, 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 eliminate 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.

FIGS. **13** and **14** illustrate a trailer house **790** comprising an embodiment of the invention. The trailer house **790** comprises a single prestressed concrete pallet **792** which supports four walls **794.** The walls **794** in turn support a roof **796.**

The interior of the trailer house **790** comprises a living/dining room **798** including a kitchen area **800,** a small bedroom **802,** a large bedroom **804,** and a bathroom **806.** Various closets **808** are also provided at convenient locations within the trailer house **790.** Of course, as is the case with other dwelling units illustrated in the Drawings, the interior of the trailer house **790** can be arranged in any convenient manner.

Referring specifically to FIG. **13,** the trailer house **790** is supported on a wheel assembly **810.** The prestressed concrete pallet **792** of the trailer house **790** is purposely constructed to provide a rear support point located somewhat forwardly from the extreme rear end of the trailer house. For this reason, the rear portion **812** of the trailer house **790** comprises a cantilever portion of the pallet **792.** The pallet **792** is also designed to provide a forward support point at the extreme front end of the trailer house. This permits the use of a connection assembly **814** which extends forwardly from the front end of the prestressed concrete pallet **792.**

Referring now to FIGS. **15** through **20,** there is shown a transportable service module **910** incorporating yet another embodiment of the present invention. The service module **910** comprises a precast concrete pallet including a deck or slab **911** and a plurality of flanges or beams **912** depending therefrom. A plurality of tension members (not shown) extend through the flanges **912** and serve to prestress the concrete pallet. By this means the pallet is adapted for support at spaced points on the flanges **912** to support a load on the upper surface of the slab **911.**

The transportable service module **910** further comprises a hollow framed structure mounted on the slab **911** of the concrete pallet and defined by a plurality of walls **913.** The walls **913** extend along the four edges of the slab **911** and in turn support an overhead structure **914** which cooperates with the walls **913** to enclose the hollow framed structure of the service module **910.** As is best shown in FIG. **6,** the hollow framed structure further includes a plurality of interior walls **917** and **918** formed on the slab **911** to define subenclosures within the hollow framed structure.

The floor plan of the transportable service module **910** is also illustrated in FIG. **20,** it being understood that any desired floor plan can be utilized in the practice of the invention. In the particular floor plan shown, the walls **913** are provided with a plurality of openings **0** and an entry door ED which extends to an entry area EA. The entry area EA leads to a corridor area CA which in turn leads to a kitchen area KA and a first bathroom BR1. One of the openings O provides access to a lavatory and water closet area LWC. A sanitary area SA is disposed between the areas BR1 and LWC to permit suitable service connections to the facilities therein. The transportable service module **910** further comprises a plurality of storage closets SC formed integrally with the walls **917** and **918.**

Referring now to FIGS. **16** through **18,** the transportable service module **910** is adapted for transportation from a factory, wherein the hollow framed structure is formed and the various facilities of the kitchen area KA, the first bathroom area BR1 and the lavatory and water closet area LWC are installed, to the building site by means of a pair of ground engaging wheels W and an axle A extending therebetween. The axle A is connected by suitable shackles to a pair of leaf springs **919.** Each spring **19** extends to a pair of pins **921** which connect the springs to a pair of shackle plates **922.** Each shackle plate **922** is detachably connected to a shackle member **923** which is secured to the concrete pallet by means of reinforcing rods **924** that are molded into the flanges **912** depending from the slab **911.** The members **923** are positioned at points corresponding to the support points of the flanges **912,** and the shackle plates **922** include flanges **926** which extend directly downwardly from the shackle members **923** to receive the pins **921.** By this means the axle A and the ground engaging wheels W are properly positioned to support one end of the concrete pallet and the hollow framed structure formed thereon for transportation to a construction site.

The opposite end of the transportable service module **910** is adapted for connection to a tractor or other towing vehicle. The kingpin KP depends from a load distributing plate P and is adapted for connection to a conventional semitrailer contact plate of the tractor. The plate P is connected to the flanges **912** of the pallet

by means of a plurality of bolts **927** which are threadedly engaged with internally threaded members **928.** The members **928** are secured in the flanges **912** by means of reinforcing rods **929** moleded therein. The members **928** and the rods **929** are positioned at points corresponding to the support points of the flanges **912** whereby the concrete pallet is properly supported for over-the-road transportation.

Referring now to FIG. **19,** the transportable service module **10** is installed at a construction site by removing the shackle plates **922** to detach the wheels W and the axle A and by removing the bolts **927** to detach the plate P and kingpin KP. The service module **910** is then installed on suitable support by means of a crane or the like. Thereafter a similar service module including a prestressed concrete pallet **930** is installed over the service module **910.** The second module is preferably mounted in spaced relation to the overhead structure **914,** and enclosure panels CP are provided to form a flush outer surface. This forms a service passageway S which may be utilized to provide utility connections between the two service modules.

From the foregoing it will be understood that in accordance with the present invention, dwelling units are formed from prestressed concrete pallets. One of the most important aspects of the invention comprises forming a service core including complete mechanicals for a dwelling unit on a prestressed concrete pallet at a factory by mass production techniques. This substantially reduces the cost of manufacturing a dwelling unit and also substantially reduces the amount of time that is required to finish a dwelling unit following the beginning of construction at the ultimate site of the dwelling. The invention is readily adapted to the construction of the wide variety of dwelling types including garden and low rise apartment buildings, high rise apartment buildings, town house complexes, cluster houses, single family residences, vacation houses, trailer homes, motels, etc.

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. A mobile home comprising:

an elongated prestressed concrete pallet including a substantially planar deck and a plurality of reinforced, longitudinally extending tensioned beams depending from the deck, said beams being adapted for support only at or near one or more longitudinally spaced optimum load support points on said beams,

an enclosure formed on the deck of the pallet including load bearing walls extending a predetermined distance above the deck to support an overhead structure;

at least one pair of ground engaging wheels mounted on the under surface of the beams substantially at one or more of said optimum load support points; and

connecting means for attaching said pallet to a towing vehicle.

2. The mobile home of claim **1** and further comprising means for securing said wheels to said beams, including reaction transmitting means cast integrally with certain of said reinforced beams and positioned at one or more of said spaced support points on the beams, and means connecting said wheels to said reaction transmitting means.

3. The mobile home of claim **1** wherein said pallet is supported by the connecting means and one or more pairs of ground engaging wheels located substantially at one optimum load support point.

4. The mobile home of claim **3** wherein said pallet is cantilevered over said load support point to extend substantially beyond said load support point away from said connecting means.

5. A transportable service module adapted to be towed to a construction site and placed into a total modular housing structure, said module comprising:

a. a precast, prestressed concrete pallet having a deck and a plurality of reinforced longitudinally extending tensioned beams depending from the deck for prestressing said pallet, said beams having spaced support points for supporting a load on the deck;

b. a framed structure including load bearing wall members mounted on said deck;

c. an overhead structure supported on said load bearing wall members and together with said wall members enclosing a portion of the deck;

d. a plurality of subenclosures within said framed structure for enclosing sanitary, electrical and mechanical services for said total modular housing structure;

e. ground engaging wheels for transporting said service module;

f. means for detachably securing said ground engaging wheels to said service module including:

i. reaction transmitting means cast integrally with certain of said reinforced beams and positioned at one or more of said spaced support points on the beams;

ii. means detachably connecting said ground engaging wheels to said reaction transmitting means;

g. draft means including a king pin for connecting said pallet to a fifth wheel of a towing vehicle including:

i. draft reaction transmitting means cast integrally with certain of said reinforced beams;

ii. means detachably connecting said king pin supporting means to said draft transmitting means.

6. A transportable housing module comprising:

a. a precast, prestressed concrete pallet and having a deck and a plurality of depending reinforced longitudinally extending tensioned beams for prestressing said pallet, said beams having spaced support points for supporting a load on the deck;

b. a framed structure secured to said slab and enclosing the area thereof;

c. an overhead structure supported on said framed structure;

d. a plurality of subenclosures within said framed structure including subenclosures for sanitary, electrical and mechanical services;

e. ground engaging wheels for transporting said housing module;

f. means for securing said ground engaging wheels to said module including:

i. reaction transmitting means cast integrally with certain of said reinforced beams and positioned substantially at one or more of said spaced support points on the beams;

ii. means connecting said ground engaging wheels to said reaction transmitting means;

g. draft means including a king pin for connecting said pallet to a fifth wheel of a towing vehicle including:

i. draft reaction trasmitting means cast integrally with certain of said reinforced beams;

ii. means connecting said king pin supporting means to said draft transmitting means.

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