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Jagoda

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[54] **MODULAR BUILDING SYSTEM**

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[51] **Int. Cl.** **E04b 1/348,** E04h 1/04

[58] **Field of Search** 52/79, 185, 236, 262, 264

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Primary Examiner—Price C. Faw, Jr.

[57] **ABSTRACT**

A system for the construction of a multi-story building structure is described in which the structural framework comprises at least two spaced series of contiguous building sections, those sections comprising a plurality of vertically stacked building units defined by horizontal support members, the horizontal support members of adjacent building sections being offset from one another. The horizontal supports of selected building sections in each series are connected by planks to form continuous floors on the same level, those continuous floors defining the main levels of the building. Those planks are connected within the space between the two series of building sections by means of a narrow planar connecting member, stairwells being provided at each side of each connecting member adjacent the non-selected building sections of each series.

Stairway elements provided in those stairwells are effective to connect the main levels of the building with the offset intermediate levels of the non-selected building sections therebetween, whereby a large proportion of split level occupancy units may be provided and public corridors need not be provided on every main level of the building. In addition, the framework allows for occupancy units to extend completely across the building on main levels between public corridors, thereby to provide for occupancy units having double exposure.

The framework is preferably built up from a plurality of precast reinforced structural elements, the basic element having an H cross section. A plurality of H elements are stacked in vertical alignment to form a building section, two such building sections being operatively connected by a third section defined by planks connected at opposite ends to the points between consecutive vertically stacked H elements. The structural framework herein provided affords maximum flexibility of design both with regard to the interior and exterior of the building, and provides a substantially monolithic structural framework with increased structural integrity.

11 Claims, 14 Drawing Figures

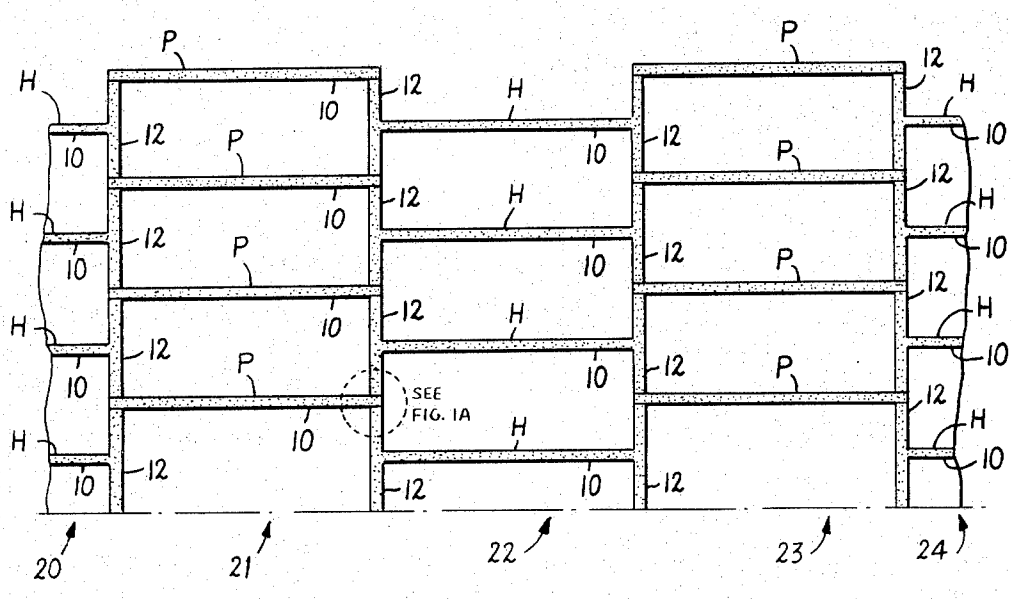
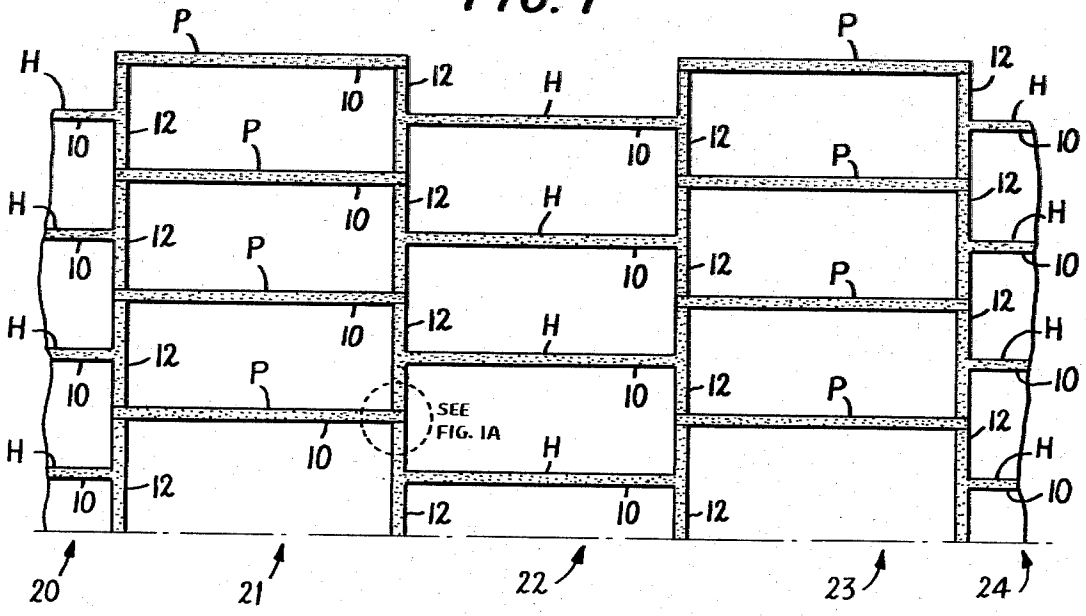


FIG. 1



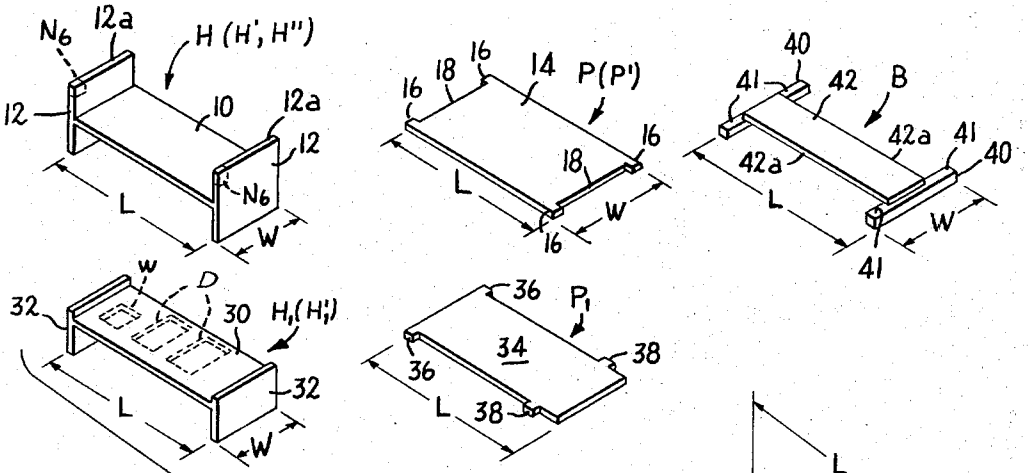


FIG. 3

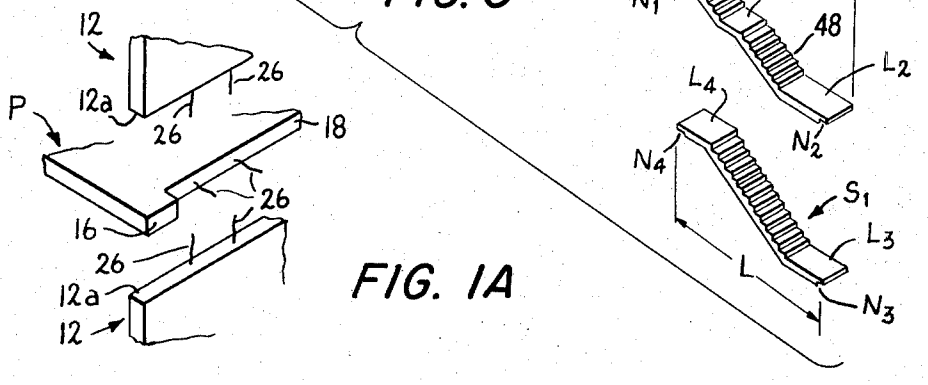


FIG. 1A

FIG. 2

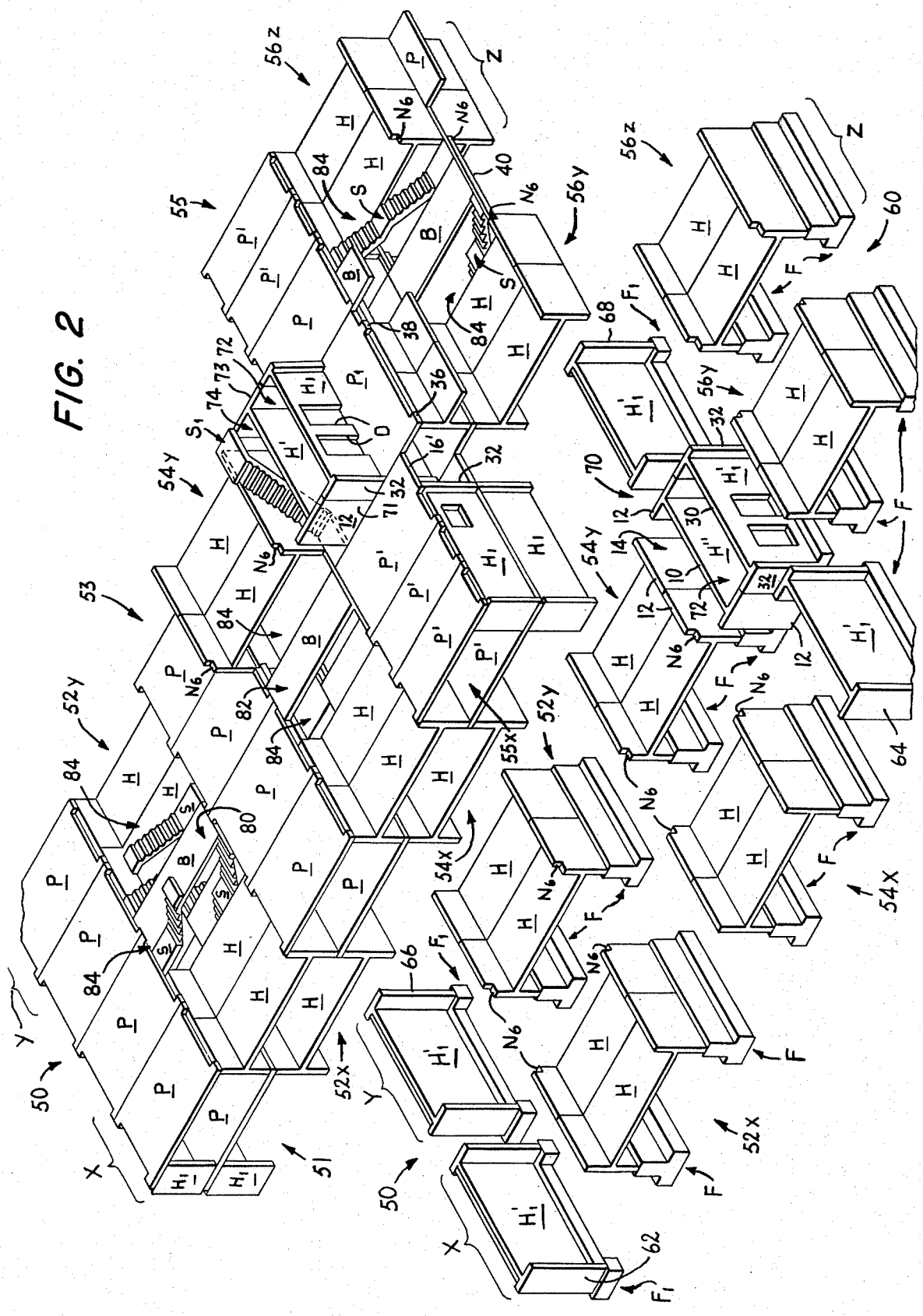

56z
Z
55
56y
60
68
F1
54y
53
52y
70
14
12
10
72
32
30
H''
H'1
H1
P
P'
N6
F
84
S
B
38
36
40
16'
71
73
74
S1
D
66
62
64
54x
55x
52x
50
51
X
Y

FIG. 4

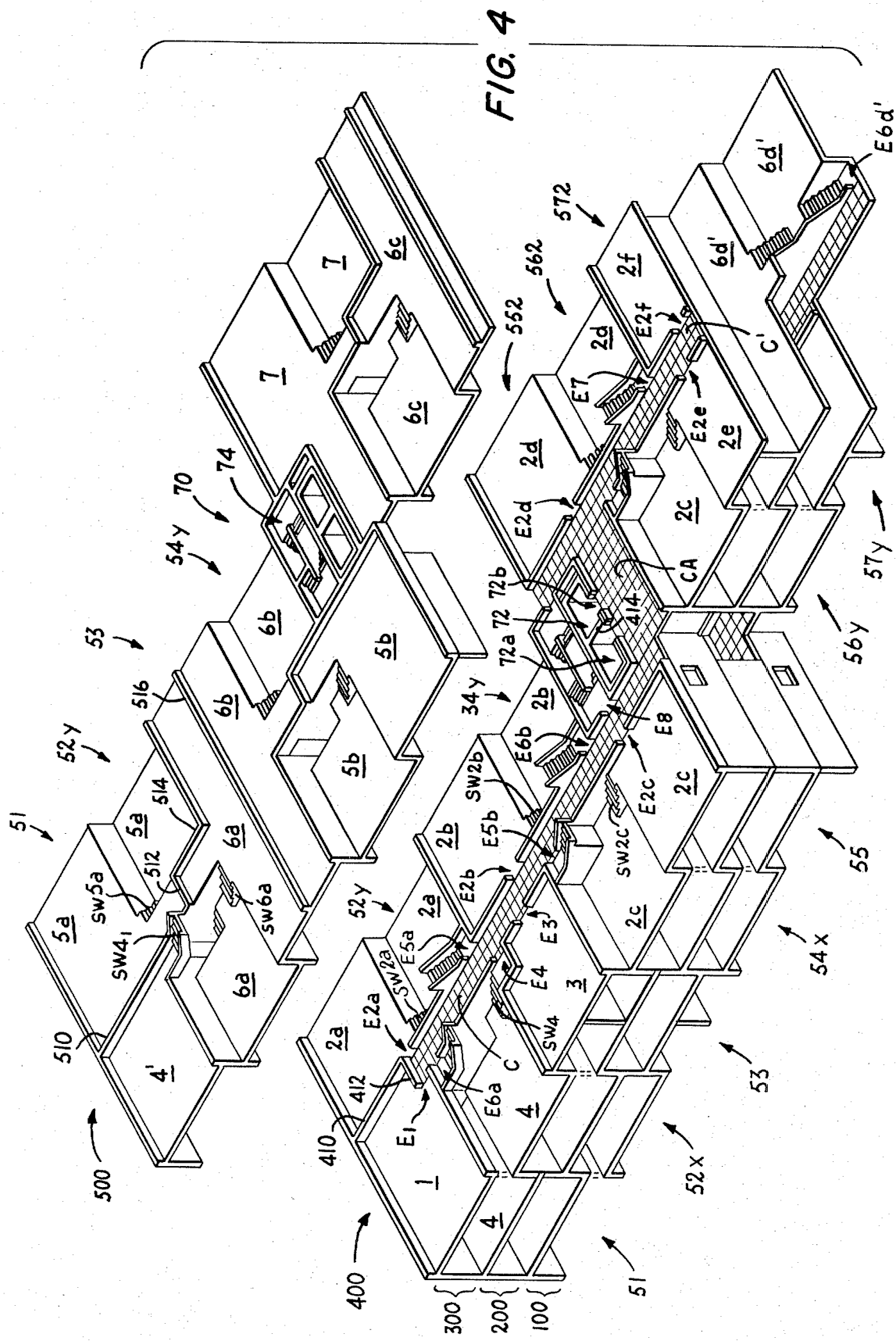

500
51
52y
53
54y
70
74
516
514
512
510
5a
6a
6b
5b
7
6c
4'
sw5a
sw6a
SW4
400
410
412
E1
E6a
C
E5a
SW2a
E2a
E4
E3
SW4
E5b
SW2b
E2b
E6b
E8
E2c
SW2c
E7
E2d
E2f
E2e
C'
CA
72
72a
72b
414
34y
562
552
572
6d'
E6d'
57y
56y
55
54x
52x
53
300
200
100

FIG. 5A

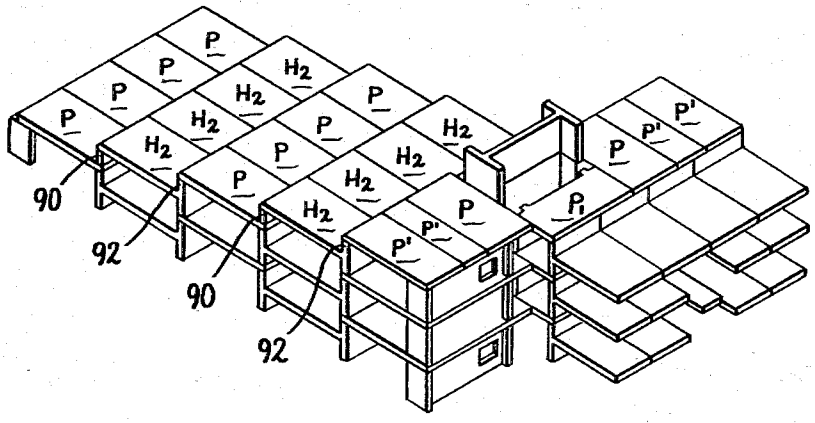


FIG. 5B

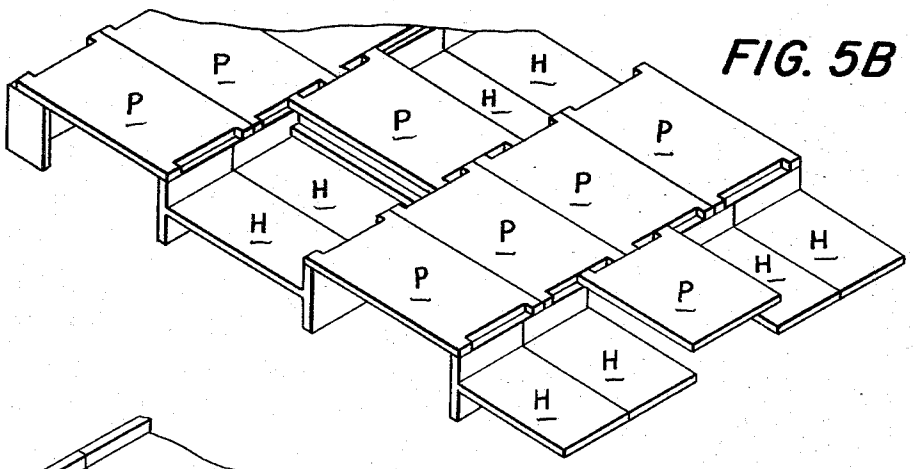
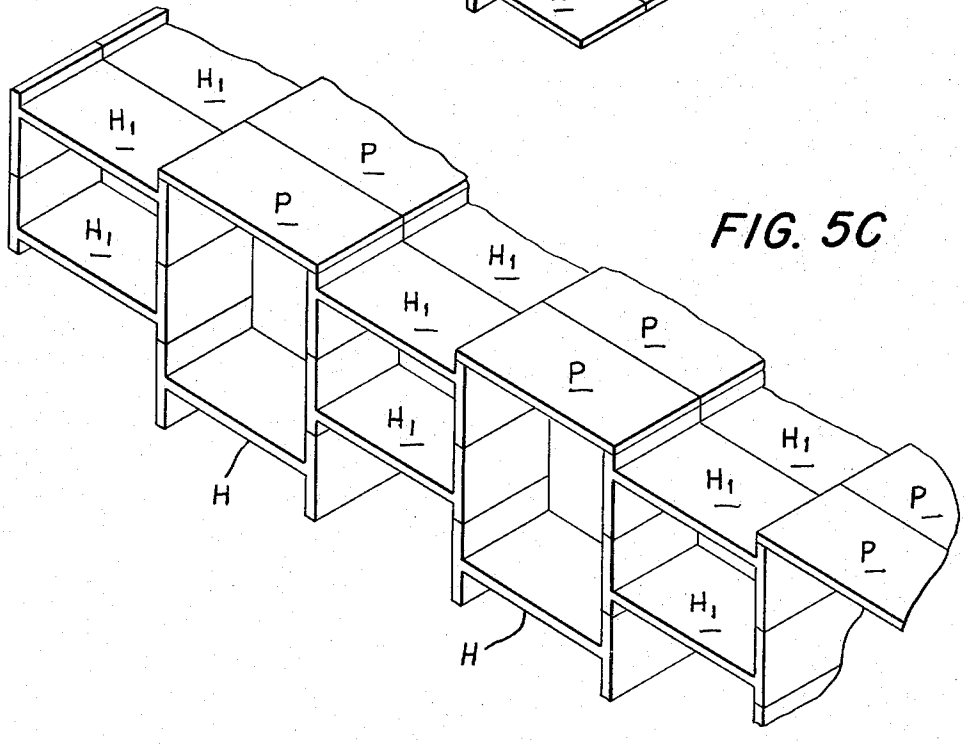


FIG. 5C



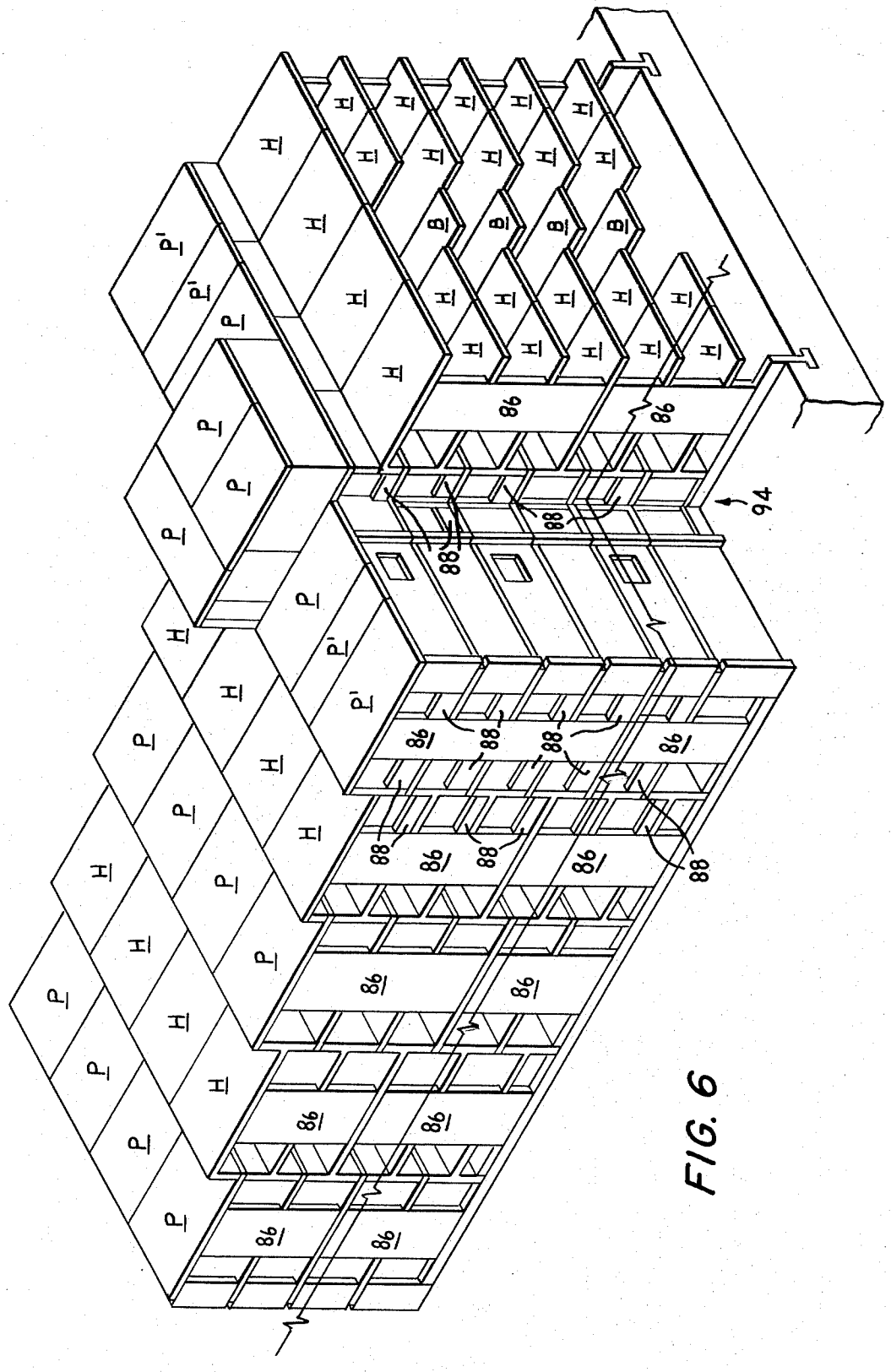


FIG. 6

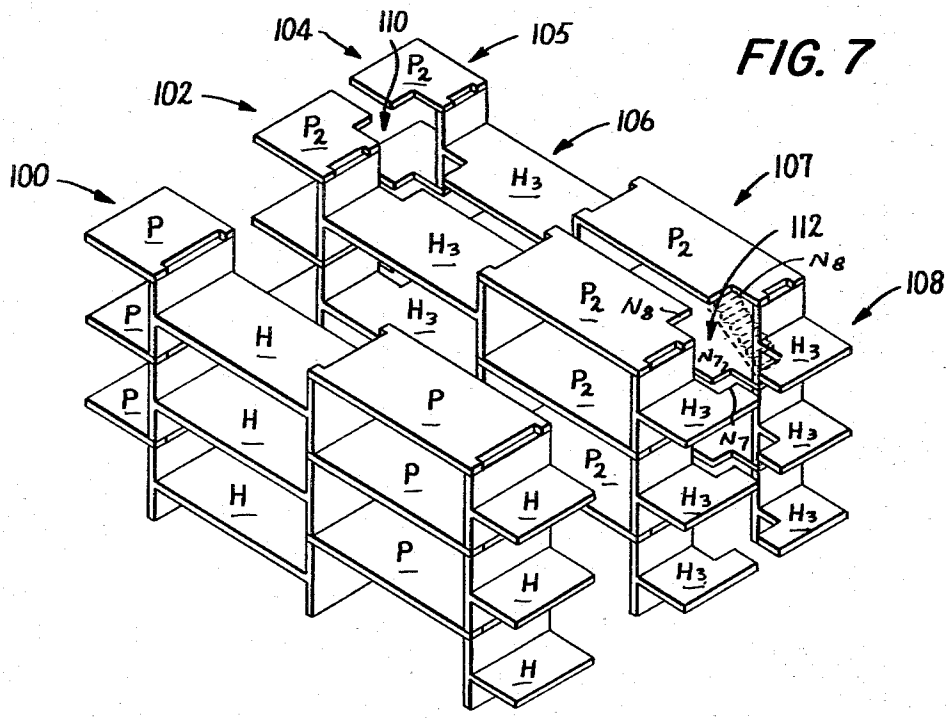

104
110
105
102
106
100
107
112
108
P
P2
H3
H
N7
N8

FIG. 7

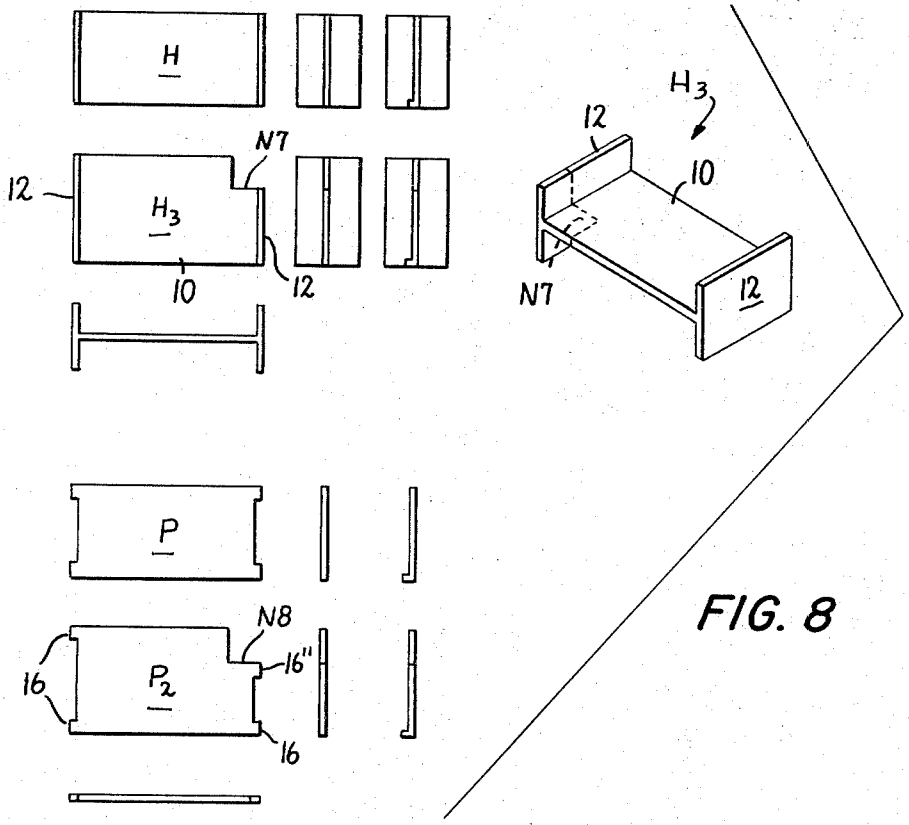

H
N7
12
H3
10
P
N8
16
P2
16"

FIG. 8

FIG. 9

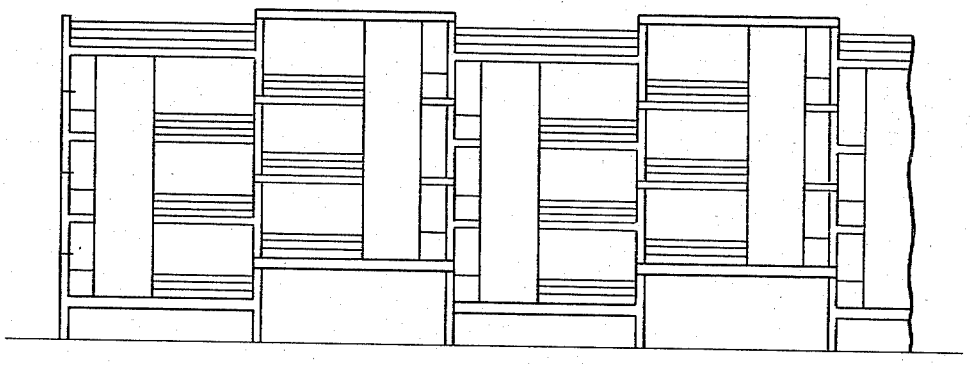
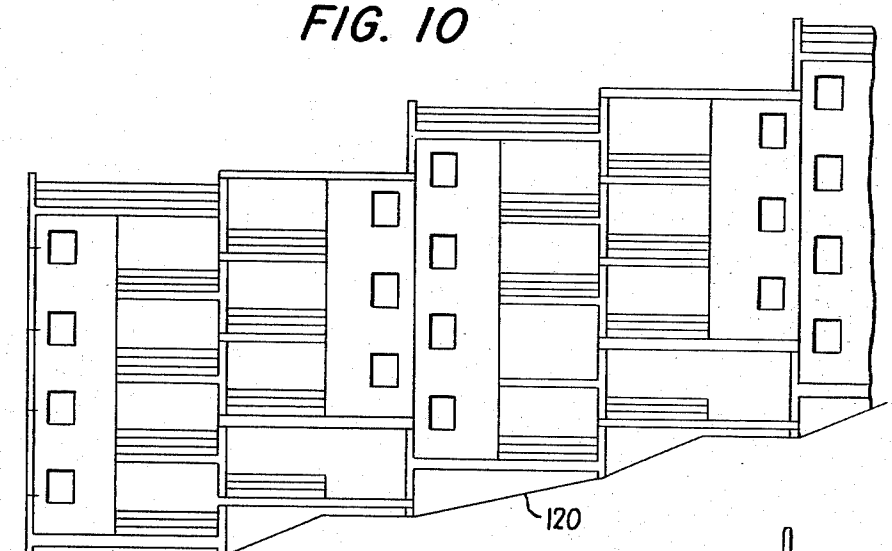


FIG. 10



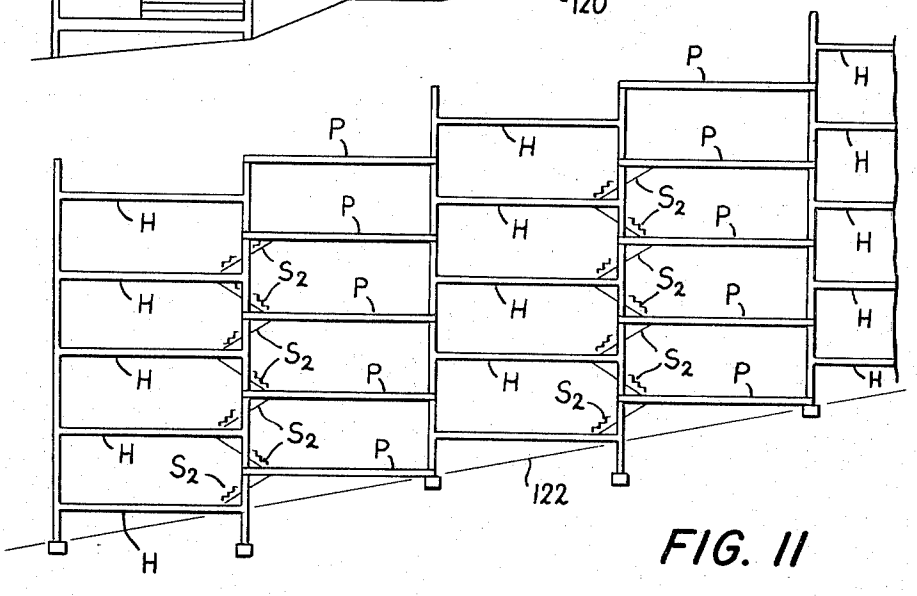


FIG. 11

MODULAR BUILDING SYSTEM

This invention relates to building structures, and more particularly, to an improved structural arrangement for the construction of a variety of multi-story buildings.

Conventional structures of the multi-story type are constructed using a variety of materials and techniques. These standard construction techniques all require on-site fabrication of the primary structural components such as foundation, floors and load bearing vertical walls or other vertical support structures. For example, in a typical construction technique, successive stories are built up by providing horizontal framework between spaced vertical load bearing structure, pouring concrete to form permanent floors extending between such vertical support structure and then building up another story of vertical load bearing supports suitably trussed, whereupon successive vertical supports and the adjacent floor sections mounted therebetween are permanently joined by pouring concrete. This process is repeated for each story of a multi-story building.

The time, labor and materials involved in on-site fabrication of all structural components including the unavoidable delays after each pouring of concrete have long been recognized as the primary cause of soaring construction costs. Moreover, construction of this type can and often is delayed substantially by such variable factors as inclement weather and shortages in both skilled labor and materials.

In addition, traditional building techniques provide little flexibility in design with regard to both the interior and exterior of the structure. Thus, in accordance with traditional design one occupancy unit (an apartment or office or the like) is limited to a single floor, and except for units at the end of a corridor is limited to single exposure. Variations from this basic pattern, while possible, require a rather extensive and time consuming modification of the basic construction technique, since traditionally each story is separated from the succeeding story by structural concrete, except for centrally located stairwells and elevator shafts. Split level units vertically offset by less than one story are extremely difficult to provide with standard building techniques.

Likewise the external appearance of structures constructed by such standard methods is rather limited — the roof is usually flat and the facade must be consistent with the continuous floor construction characteristics of such structures.

Further difficulties are encountered in laying the foundation. Indeed, it will be apparent that uneven terrain presents somewhat of a problem for standard building construction methods and typically the terrain itself must be flattened at considerable expense to accommodate the standard structure. Accordingly, either some units are below ground level or substantial space must be wasted. While it is possible to construct traditional buildings "on a hill," this again requires a substantial variation in the standard techniques and considerable additional expense.

Finally, from a purely structural viewpoint, standard construction techniques as described above leave much to be desired. For example, it is well known that the load bearing capability of a vertical support member is a function of its effective length (the length between lateral support connections). As a result, in standard

multi-story structures the load bearing capabilities of the vertical supports are limited by the required distance of at least one story between supports. While those supports may be laterally trussed, the trusses further limit the interior design of the building.

In recent years attempts have been made to eliminate many of the foregoing problems by modular building techniques using prefabricated units or modules. Many of the so-called modular construction methods are directed only to the prefabrication of non-structural (non-load bearing) elements. While these techniques considerably reduce the cost of the interior work, they do not at all solve the aforementioned problems associated with the standard construction methods. Moreover, attempts at a true modular construction techniques using modular load bearing members have met with little success primarily as a result of the inherent limitations of the structural modules (such as boxes) thus far proposed.

It is a primary object of the present invention to provide an improved modular construction system for use in the construction of a wide variety of multi-story structures which is adapted to drastically reduce the costs of construction, improve structural integrity, maximize design flexibility, and greatly increase the possible speed of erection.

More particularly, it is an object of the present invention to provide a multi-story building technique adapted to substantially eliminate the costs and time involved in onsite fabrication while at the same time increasing design flexibility.

It is yet another object of the present invention to design new and improved precast structural members which may be readily arranged in stacked relationship to form a multi-story structure having improved structural integrity and design flexibility.

It is still another object of the present invention to design a structural arrangement for a multi-story building which provides for maximum dwelling or office use of available floor space.

It is yet another object of the present invention to provide a multi-story structure, the structural framework of which may be erected with a minimum amount of on-site time and labor.

It is still another object of the present invention to design an essentially monolithic multi-story structures using a minimum of standard structural components which may be prefabricated and rapidly arranged and joined to provide a wide variety of external shapes and sizes.

It is another object of the present invention to design a structural member for multi-story buildings which may be arranged to form split level building sections having a flexibility in interior design heretofore unattainable.

It is yet another object of the present invention to provide a multi-story structure readily adapted to be erected on sites of varying terrain with no increase in cost or loss in above-ground floor space.

The present invention comprises a system for the construction of multi-story buildings which broadly stated provides precast monolithic structural members which may be arranged in stacked relationship to form the structural framework of a building, adjacent sections being arranged in split level relationship, a single corridor means providing independent access to at least two vertically aligned occupancy units. As a result

public corridors need not be provided for every full story of the building, the floor space of those stories not including corridors being substantially fully utilized by dwelling or office units (hereinafter called occupancy units). In a preferred design a substantial number of occupancy units embrace two or more adjacent staggered building sections. Accordingly, those units which include floor levels spaced at least one story from the public corridors may be designed with double exposure, the occupany unit extending fully across the structure between successive public corridors.

One such modular building system is disclosed in the copending Jagoda et al, application Ser. No. 170,812 filed Aug. 11, 1971, and now abandoned. That system utilizes a basic structural unit made of precast reinforced concrete in the form of a U-shaped channel having a horizontal base and a pair of vertical legs. The legs of that channel are one half a story in height. Accordingly, when vertically stacked in staggered relationship they define adjacent building sections vertically offset by one half of one story. Corridors are provided on alternate stories of the building to provide increased usable floor space and increased flexibility in interior design including a number of occupany units with double exposure. In addition, the time and expense involved in on-site fabrication is substantially reduced thereby reducing the cost and increasing the speed of construction. Moreover, the use of such precast integral structural members provides significant structural advantages notable among which are the increased load bearing capacity of the system as a result of the reduced height of the vertical support structure and the elimination of the need for expansion joints.

While the specific structural arrangement disclosed in that copending application solves many of the problems of the prior art and provides significant design advantages, it also exhibits major drawbacks. For example, while the need for on-site pouring of each story of the building is eliminated, the use of precast U-shaped members of only one half story in height requires the pouring of concrete to join those members for each half story in the erection process. As a result while the total amount of pouring is drastically reduced (as compared to conventional building techniques) the frequency of such pourings is not — two separate concrete pourings are required for the erection of each story — whereby substantial delays are still encountered. Moreover, the plumbing and wiring which typically extends through the vertical support walls must traverse twice the number of joints encountered in conventional structures, whereby the time, labor and material required to complete the plumbing and electrical system of the building is substantially doubled.

Finally, while the split level alternate corridor arrangement per se enhances interior design flexibility (i.e., duplex apartments with double exposure) the U-shaped structural member has certain inherent design limitations in connection with such an arrangement which may be overcome only by major variations in that member.

Disclosed herein is a structural system of the type described which provides all of the aforementioned advantages over conventional structures yet substantially avoids these drawbacks.

The system herein described is based upon a precast structural load bearing member in the form of an "H," including a horizontal cross member formed integral with and extending between two vertical side flanges each one story in height. In the preferred embodiment herein specifically disclosed, the cross member is disposed half way between the top and bottom of the flanges and defines the horizontal floor and ceiling supports of a building section. Alternate building sections are formed by stacking "H" members directly atop one another, a building unit (defined herein as a space enclosed between two horizontal supports and two vertical supports) of one story in height being defined between successive cross members. Standard precast planks are supported at each end atop the H flanges and extend between alternate "H" building sections thereby to define additional building sections (hereinafter called "P" sections) between each "H" section, the units in the "P" sections being offset vertically from the units of the "H" sections by one half story.

The "H" members are preferably prefabricated of reinforced concrete in standard widths, the width (parallel to the "H" flanges) of each "H" unit being equal to one or more of such standard widths depending upon the number of "H" members positioned contiguously end to end. For a typical multi-story building designed in accordance with the preferred embodiment herein disclosed, two such series of alternate "H" and "P" building sections are provided in parallel spaced relationships, the spaced "H" sections of each series preferably being aligned. The horizontal planks defining alternate P sections extend completely across the space between the two series of building sections, thereby to define continuous horizontal supports defining continuous floors and ceilings for aligned P sections. The continuous floors and ceilings of consecutive P sections are connected by narrow horizontal supports, spaced at either side from the aligned "H" sections of the two series to define stairwells.

In the embodiment here described these narrow horizontal supports together with the continuous floors they connect are adapted to define public corridors on selected levels, the remaining levels having continuous floors being utilized substantially fully for occupancy units. Prefabricated stairway units are provided within the stairwells and provide independent access from the corridors to all levels of the building.

The basic pattern may be repeated to form a variety of external building configurations. An elevator shaft and public stairway is preferably formed in a location replacing a "P" section of the building.

The system disclosed herein provides numerous major advantages both of a structural and design nature. In terms of basic structure, the "H" member provides a significantly improved load bearing capacity as a result of the lateral supports every one half story (approximately 4-½ feet) and, indeed, that load bearing capacity is even further enhanced by the fact that alternate half story levels are formed with precast completely integral joints between horizontal and vertical supports. Moreover, this is accomplished without increasing the number of poured joints through which the plumbing and wiring must run thereby substantially reducing the time and labor involved in on-site construction work. In addition the "H" member structural arrangement facilitates the provision for the pouring of a substantially completely reinforced monolithic joint of a type which is difficult to attain with the "U" member system. Finally, the planks utilized with the present system are of a type readily commercially available. As a

result, a given facility designed for producing "H" members as herein disclosed can supply these members for substantially twice the number of structures as would be the case for the "U" system. Stated in other terms, the "H" system requires only half the number of specially designed elements for a given structure. Moreover, it will be apparent that the "H" elements can be arranged for shipment and storage in substantially the same space (as a like number of "U" elements) so that effective storage and shipping capacity is substantially doubled thereby to insure a smooth flow of materials.

From a design standpoint, the system here disclosed provides maximum flexibility in the exterior shape and size of the building as well as the interior design of occupancy units, all of which is provided using the same basic structural components and techniques with little variation. For example, as a result of the split level, alternate corridor arrangement, numerous occupancy units may be provided with double exposure at opposite sides of the building and those units may extend to two or more levels.

Moreover, unlike the "U" system, the "H" system provides further flexibility in the size, shape and staggered arrangement of the building units. For example, the size of the "P" sections may be easily varied simply by using standard planks of varying size thereby to provide a size variation in one building section independently of others without the need for specially designed structural members. Indeed, it is even possible to vary the staggered relationship of adjacent building units by using "H" elements having the cross member offset from the center of the vertical flanges. In addition, the height of an occupancy unit may be varied merely by the omission of a plank, preferably at the uppermost "P" units.

Perhaps most importantly, the "H" system is extremely well suited for construction of buildings directly on uneven terrain, without any significant additional expense.

Finally, the roof and facade of a building constructed in accordance with the system herein disclosed may take a variety of forms and shapes.

To the accomplishment of the above and to such other objects as may hereinafter appear, the present invention relates to a system for the construction of multi-story buildings as defined in the appended claims and as described herein with reference to the accompanying drawings, in which:

FIG. 1 is a simplified fragmentary cross sectional view of a multi-story structure showing the basic construction system of the present invention;

FIG. 1A is a fragmentary exploded view in perspective of one of the structural poured joints of the system of FIG. 1;

FIG. 2 is a cut away exploded perspective view of a segment of the structural framework of a typical multi-story high rise structure constructed in accordance with the present invention and showing all structural elements forming the foundation and a typical story of said building;

FIG. 3 is a perspective illustration of the seven basic structural elements utilized in the structure shown in FIG. 2;

FIG. 4 is an exploded perspective view, partly cut away, of a building provided from the structural framework of FIG. 2 showing an exemplary layout of occupancy units, public corridors and public vertical access means;

FIGS. 5A, 5B and 5C are fragmentary perspective views of three alternate roof configurations in accordance with the construction system of the present invention;

FIG. 6 is a perspective view, partly cut away, of a completed building constructed in accordance with the system of the present invention showing an exemplary facade;

FIG. 7 is a perspective view, partly cut away, of the structural framework of a typical low-rise multi-story structure constructed in accordance with the system of the present invention;

FIG. 8 is an illustration of the basic structural elements utilized in the construction of the building of FIG. 7;

FIG. 9 is a front elevational view of a low-rise structure constructed in accordance with the system of FIG. 7 and showing an exemplary facade;

FIG. 10 is a front elevational view of a low-rise building constructed in accordance with the system of FIG. 7 directly on uneven terrain and showing still another exemplary facade; and

FIG. 11 is a front elevational view of the structural framework of a building similar to that of FIG. 10 with the facade cut away.

Referring now to the drawings and in particular to FIG. 1, there is illustrated the basic structural system utilized in accordance with the present invention to provide the structural framework of a multi-story building. As there shown, that basic structural framework is defined by two basic structural elements here designated H and P, both of which are illustrated in perspective in FIG. 3. The H element comprises a horizontal planar cross member 10, the ends of which are integrally connected to two identical vertical flange members 12 along the center lines thereof. The P element comprises a simple horizontal plank 14 having oppositely extending projections 16 at each corner thereof to define a recess 18, the purpose of which will be hereinafter apparent.

As best shown in FIG. 1, the basic structure is formed by spanning the vertical flanges 12 of consecutive spaced H elements in one tier with planks P. Thereafter another tier of H elements are placed atop the H elements of the first tier, the edges of the planks P being sandwiched between the aligned vertically stacked flanges 12 of consecutive stacked H elements. The two flanges 12 and plank P sandwiched therebetween are then permanently joined after which the process is repeated to form another story of the building.

The cross members 10 of the vertically stacked H elements define the floors and ceilings of a plurality of vertically aligned building units (hereinafter termed H building units), those units defining one building section such as sections 20, 22 and 24 (hereinafter termed H sections). Similarly, the vertically aligned planks P form the floors and ceilings of a plurality of P building units defining a P section of the building such as 21 and 23.

As illustrated in the preferred embodiment of FIG. 1, the planks P are vertically offset from the cross members 10 of the H elements in adjacent building sections by one half of one story. Accordingly, the resulting structural pattern comprises alternate H and P building

sections having H and P building units staggered in split level arrangement.

Elements H and planks P are preferably formed of precast reinforced concrete. The planks P are presently commercially available in a variety of sizes. The elements H may be specially cast in a facility designed for that purpose. The structure illustrated in FIG. 1 requires only one poured concrete joint per building section for each story of the building.

One such joint is illustrated by the enlarged exploded perspective of FIG. 1A. As there shown, reinforcing elements **26** extend through and outwardly of the edges **12***a* of flanges **12** and the recessed edge **18** of plank P. Those reinforcing members are overlapped and intertwined in the recessed area defined between projections **16** to provide continuous reinforcement throughout the joint. At the same time, the necessary electrical wiring and plumbing is operatively connected after which the joint is poured in conventional manner. It will be apparent that as so constructed the basic structural framework comprises an essentially monolithic network of flanges **12,** planks P and cross members **10** having continuous reinforcement throughout. As a result a very high degree of structural integrity and load bearing capacity is attained. Indeed, the vertical support members defined by flanges **12** are laterally braced at alternate sides every one half of one story through a monolithic joint to provide a load bearing capacity heretofore unattainable with conventional construction techniques.

Using the basic structural framework and technique just described, a variety of structures having exceptionally flexible and versatility of design may be constructed. One such structure exemplary of the major advantages of this structural system is illustrated in FIG. **2.** That structure and many variations thereof may be rapidly and economically erected using the seven structural elements shown in FIG. **3.** Those elements include the basic H element prefabricated in two additional widths here designed H′ and H″, a modified H element made in two widths H_1 and H_1', the basic plank P made in one additional width P′, a modified plank P_1, a connecting element B and two stairway elements S and S_1.

Elements H_1 and H_1', comprise a cross member **30** integrally connected at either end to a pair of parallel flanges **32.** The primary difference between the elements H and H_1 is that in the H_1 element the flanges **12***a* on one side of the cross member **30** are considerably shortened. This may be conveniently accomplished by blocking off the H element mold in a suitable manner. The modified plank P_1 comprises a horizontal planar support **34** having lateral projections **36** extending in opposite directions from the corners at one end of the support **34** and a pair of projections **38** extending from opposite sides of the support **34** at locations adjacent to but spaced from the corners of the other end of the support.

The connecting element B comprises a pair of spaced beams **40** preferably of square cross section spanned by a narrow planar connecting member **42,** the beams **40** extending substantially laterally beyond the edges **42***a* of the member **40** at **41.** The opposite edges **42***b* of member **42** extend longitudinally approximately only to the center line of the beams **40** thereby defining an L-shaped ledge **44.**

Stairway element S comprises two flights of stairs **46** and **48** separated by an intermediated landing L_1 and having a bottom landing L_2. Stairway element S_1 comprises a single flight of stairs **50** between a bottom landing L_3 and a top landing L_4. Bottom landings L_2 (of element S) and L_3 and top landing L_4 are provided with notches N_2, N_3 and N_4, respectively, on their undersides. In addition, a notch N_1 is provided at the underside of the top step of flight **46** on stairway element S. The purpose of these notches become apparent hereinafter.

All elements are preferably prefabricated of fully reinforced concrete and may be cast on a mass production scale and shipped to the construction site when needed. In a typical structure, such as that illustrated in FIG. **2,** all elements have a length L of approximately 21 feet. Typical widths W for these elements would be as follows:

ELEMENT	WIDTH
H	9′
H′	8′
H″	10′
H_1	8′
H_1'	10′
P	12′
P′	7′9″
P_1	11′
B	12′

Moreover, the width of the stairway elements S should be approximately equal to the length of the extensions **41** of the beam **40.** For example, if connecting section **42** is 6 feet wide then the extended portions of beam **40** (having a total length of 12 feet) and the width of stairway element S are each 3 feet.

Selected H elements may be varied simply by blocking out part of the standard mold during the casting process. For example, elements H, H′, and H″ may be formed with a pair of notches N_6 at aligned corners, those notches being adapted to receive the ends of beams **40** of element B as will hereinafter be described. In addition, elements H_1 and H_1', are utilized as vertical end walls and may be selectively provided with openings D and W to form doors and windows, respectively, in those walls.

Turning now to FIG. **2,** there is illustrated in exploded perspective an exemplary structure constructed in accordance with the present invention. That structure comprises two groups or series of building sections designated X and Y, each series having a plurality of alternate H and P building sections built up in the manner previously described with respect to FIG. **1.** Series X and Y are spaced from each other along their entire lengths to provide a longitudinally extending central passage **50** adapted to receive stairways and public corridors in a manner hereinafter described.

As shown in the lower segment of FIG. **2,** construction is begun by mounting contiguous pairs of H elements on conventional foundation elements F. While as here specifically illustrated, each series X and Y is two elements wide, it will be apparent that any desired number of H elements may be disposed contiguously to form H building sections of any desired width. It will also be appreciated that the widths of parallel series X and Y need not be equal. As here specifically shown one story of series X and Y each comprise two such pairs of H elements defining two spaced H building sections designated 52_x and 54_x in series X are defined by elements H_1', one such element **62** being spaced at one

end from H building section 52_x and another such element **64** being spaced from H building section 54_x. Similarly, one end of series Y is defined by H_1**1**, element **66** spaced from H building section 52_y. However, in the specific building design here illustrated the Y series is extended (downwardly to the right as viewed in FIG. 1), the remaining building sections in that series running parallel to and being aligned with a third series of building sections designated Z, and spaced from series Y by a second central passage **58.** For example, as shown in the lower right hand corner of FIG. **2,** the third H section 56_y of series Y is aligned with and spaced from the first H section 56_z (upwardly to the left as viewed in FIG. **2**) and defines one end wall of series Z. The H1′ elements **62, 54, 66** and **68** are all firmly mounted in conventional corner foundation members F1.

Disposed adjacent H section **54***y* in the space between that section and the next H section **56***y* is a public vertical access means **70** defined by an H1′ element and an H″ element with their flanges **12** and **32,** respectively disposed contiguously to form vertical walls **71** and **73.** That vertical access **70** disposed between walls **71** and **73** comprises an elevator shaft **72** defined between the cross members **10** and **30** of these elements and a public stairway **74** defined between the cross member **10** of the H″ element and the flanges **12** of the H elements formed in H section **54***y*. The element H1′ defining elevator shaft **72** is provided with openings D forming doors to provide access to the elevator at the ground floor (or basement).

THe flanges **12** of each of the H elements directly adjacent passage **50** is provided with a notch N_6 facing that passage. Those notches provide a mounting ledge for the beams **40** of elements B. As best illustrated in the upper portion of FIG. **2,** an element B is adapted to straddle passage **50** between each pair of aligned H sections in series X and Y. For example, in the typical story illustrated at the top of FIG. **2** a B element **80** straddles the H elements of H sections **52***x* and **52***y* and B element **82** straddles the H elements of H sections **54***x* and **54***y*. The ends of beams **40** are dimensioned to fit snugly into notches N_6 of aligned H flanges **12,** those beams having a height and thickness such that they form with the top edges **12***a* of flanges **12** a continuous edge extending completely across the width of the structure. The connecting supports **42** of the B elements are disposed atop those beams and have a reduced width sufficient to define stairwells **84** at either side thereof. A plurality of planks P are laid edge to edge spanning the continuous parallel edges defined by flanges **12** and beams **40** of consecutive H building sections thereby to form a continuous P building section therebetween. For example, referring to the typical story of the building shown in FIG. **2,** it will be seen that a P building section **53** comprises four planks P forming a continuous horizontal support spanning H section **52** (comprising sections **52***x* and **52***y* and B element **80** therebetween) and H section **54** (comprising sections **54***x* and **54***y* and B element **82** therebetween). Similarly, the terminal H sections of the building are operatively connected to the end elements H1′ by four P planks across the entire width of the building thereby to form a terminal P section of the building. Thus P section **51** is formed on each story by four P planks extending between H section **52** (i.e., H sections **52***x* and **52***y* and B element **80**) and the end H_1 elements vertically aligned above H_1′ elements **62** and **66.**

P section **55** in the specific embodiment of FIG. **2** is constructed in a somewhat different manner and comprises two slightly offset sections **55***x* and **55***z* on opposite sides of vertical access means **70.** Thus two planks P and P′ and a slightly modified plank P are disposed contiguously to bridge the end wall of series X formed by H_1 sections vertically stacked above H_1′ element **64** and H section **54***x*, the modified plank P extending over the top edge of vertical flanges **12** and **32** defining wall **71** of the story below. The projection **16′** at one corner of that modified plank P is extended toward the opposite corner sufficiently so as to operatively engage the flange **32** of the H_1 element on which it rests. A P_1 element is adapted to bridge the space between H section **56***y* and elevator shaft **74,** that element having its opposing projections **36** and **38** supported on the flanges **12** of the H elements of H section **56***y* and the cross member **30** defining the elevator shaft in the story below.

Similarly at the other side of vertical access means **70** section **55***z* is defined by two P′ elements and a modified plank P (identical to the modified plank P on the other side of vertical access means **70**) bridging H section **55***z* and the H_1 element (not shown) stacked vertically above H1′ element **68.**

It will be apparent from the foregoing that the planks P and P′ and horizontal connecting support elements B on a single level together define a continuous horizontal supporting surface as illustrated in FIG. **2** constituting a main level of the building. One such main level is provided for each story of the building, each main level being broken up by H sections at either side of connecting element B vertically disposed above and below the main floor by one half of one story.

It will be appreciated that the connecting elements B are aligned and together with the coterminous planks P afford a continuous horizontal support through the center of the structure on which a public corridor may be provided. However, by providing for stairwells **84** flanking elements B at either side, the need for public corridors on every main floor of the building may be eliminated.

Thus in the specific embodiment here illustrated, within the stairwells **84** defined at either side of elements B in each P section of the building a plurality of stairway elements S are mounted. As noted hereinbefore, those elements are each one full story in height and are provided with a bottom landing L_2 and notches N_1 and N_2 at the top and bottom respectively adapted to fit on beam **40***s* of elements B. Accordingly, those elements are supported between the beam **40** at one end of one element B and the beam **40** at the other end of the next consecutive vertically aligned element B in the next higher story. The bottom landing L_2 of the element S is thus joined in coplanar relationship with one main level of the building while the top step provides access to the next higher main floor of the building. Moreover, the intermediate landing L_1 is exactly one half of one story above the lower landing L_2 and thus is coplanar with the cross members of the intermediate H elements and provides access to that H unit.

The stairway elements S at either side of elements B are preferably disposed in reverse direction so as to provide reverse structural trussing. Thus as illustrated in FIG. **2,** the stairway elements adjacent H section **52***x*

extends upwardly to the right and bridge a floor of P section **51** with the next higher floor in P section **53,** while the elements S adjacent H section **52***y* extend upwardly to the left, bridging a floor of P section **53** with the next higher floor of P section **51.**

The construction of the lower right hand extension of the building (as viewed in FIG. **2**) comprising parallel series Y and Z is identical to that already described and shown for the parallel X and Y series and it will be appreciated that this pattern may be continued for as long as desired, with or without additional vertical public access means **70.**

It will be appreciated that the structure may be constructed quite efficiently at an extremely rapid pace heretofore unattainable. This is because less structural elements per/unit are required than heretofore and only a single continuous joint connecting each consecutive building section is required for the completion of each story. Thus, for example, a moderate size building of the type illustrated in FIG. **2** could be constructed at a pace of one story a day, weather permitting (a typical crane can handle approximately 30 structural elements per day).

The pleasing and aesthetic appearance and increased versatility of interior design of the present structural system is illustrated in FIG. **4** which is a partially cut away view of a completed building formed on the structural framework of FIG. **2** showing only those interior walls defining separate occupancy units. The building has been divided into seven differently designed occupancy units generally designated **1–7** which are repeated throughout the structure with varying frequencies. Units not in the same vertical line which are repeated bear an additional letter designation. For example, units **5***a* and **5***b* represent two vertical lines of identical occupancy units. Since the repetition frequency of units is every other story as will hereinafter appear, only two consecutive stories 400 and 500 of the structure are here illustrated in full.

Referring specifically now to story 400 it will be seen that continuous P section **51** is divided by means of an interior wall **410** into a substantially rectangular occupancy unit **1** and the substantially square upper level of a split-level occupancy unit **2***a*. A corridor C is defined by internal walls **411** along the entire length of the XY parallel series of building sections and extends a few feet into P section **51** to the internal wall **412** thereby to define entrances E**1** and E**2***a* to occupancy units **1** and **2***a* respectively. Unit **2***a* includes a lower level defined by H section **52***y* and connected to the upper level thereof by stairway SW_2a. The corresponding section **52***x* at the other side of corridor C defines the upper level of a second duplex apartment **4.** Access to occupancy unit **4** is had through entrance E**4** in the corridor wall which connects the upper landing of a stairway SW_4 with the corridor C. The intermediate landing of stairway S_4 is coplanar with the upper level of occupancy unit **4** and the lower landing thereof provides access to the lower level of split-level occupancy unit **4.**

A generally square occupancy unit **3** is provided adjacent the entrance to unit **4** in P section **53** of the building, access to that unit from corridor C being provided by entrance E_3. Opposite unit **3** in building section **53** at the other side of corridor C is the upper level of occupancy unit **2***b* which is level with corridor C and connected thereto through entrance E_2b. The lower level of unit **2***b* is defined by building section **54***y* and is connected to the upper level thereof by stairway SW_2b. Across the corridor from the lower level of unit **2***b* in section **54***x* is the lower level of another duplex occupancy unit **2***c*. The upper level of that unit is defined in building section **55***c* connected to the lower level by stairway SW_2c, the entrance to that unit being provided at the upper level by entrance E_2c. (It will be apparent that the lower half of the stairways providing access to occupancy units **2** are merely blocked off — only the upper half connecting the upper and lower levels of these units is utilized).

Directly aligned with entrance E_2c across the corridor C is an entrance E**8** to the public stairway defined by S_1 elements in the manner illustrated in FIG. **2.** The elevator shaft **72** is divided by internal wall **414** into two elevator cabins **72***a* and **72***b*, entrances E**9** and E**10** being provided on corridor floors to the elevators. A widened corridor area CA is provided in front of elevator shaft **72,** that corridor area being defined by plank P_1 as shown in FIG. **2** and being effective to connect the corridor C with a corridor C′ defined between parallel extending series of building sections Y and Z forming the next extension of the building. The pattern of occupancy units starting with building sections **56** may follow that established along corridor C or may vary in any desired way.

Referring now to the next higher story of the building **500,** it will be seen that continuous P section **51** is divided by internal wall **510** into the lower level of an occupancy unit **4′**, access to which is provided by an entrance on the next higher corridor leading to stairway SW_4', and the upper level of an occupancy unit **5***a* access to which is provided through stairway SW_5a, the lower landing of which is level with corridor C at entrance E_5a. Internal walls **512** and **514** separate unit **5***a* from the upper level of an enlarged occupancy unit **6***a*, that upper level extending completely across the continuous P section **53** and being separated from an identical occupancy unit **6***b* disposed in reverse orientation by internal wall **516.** Access is provided to the lower and upper levels of occupancy unit **6***a* via stairway SW_6a leading to the depressed entrance E_6a at corridor C. Accordingly, it will be seen that occupancy units **6***a* and **6***b* are relatively large luxury split-level apartments, the upper level of which is provided with exposure at either side of the building. Occupancy unit **6***b* in building sections **53** and **54***y* and occupancy unit **5***b* in building sections **54***x* and **55** are identical to units **6***a* and **5***a*, respectively, and are disposed as mirror images thereof on either side of wall **516.**

Since level **500** does not include a public corridor, no elevator doors or stairway entrances to vertical public access means **70** are provided on this floor. Adjacent elevator shafts **72,** directly above widened corridor area CA and duplex occupancy unit **2***d* in level 400, is a luxury split-level occupancy unit **7,** the upper level of which is formed on P section **55** and the lower level of which is defined by H section **56***z*. A stairway SW_7 extends from the upper level of unit **7** to the corridor C on level **400,** the lower landing thereof being flush with the corridor C at entrance E**7** and the intermediate landing thereof being flush with the lower level of unit **7.** It will be apparent that the pattern of occupancy units on level **500** just described may be repeated in the Y-Z series of building sections beginning with unit **6***c*.

It will be appreciated from the foregoing that by appropriate positioning of entrances and internal walls, a virtually limitless variety of occupancy units may be designed having a variety of shapes and sizes. The preferred embodiment here shown is only illustrative of the versatility of my structural system and should not be construed to limit the possible internal design of the structure. For example, while the embodiment of FIG. 4 includes public corridors on alternate levels of the building, it will be apparent that with appropriate design changes corridors may be provided only on every third level or may be vertically spaced at even greater intervals. Moreover, while only single level and two level units are shown, the system is equally conducive to occupancy units having three or more levels. In addition, it will be appreciated that by providing H sections having cross members **10** which are offset vertically from the center line of their flanges **12**, the levels of adjacent building sections may be offset by more or less than one half story. (For example, if H elements having cross members disposed one-third of one story from the top edge of their flanges are utilized, then the H sections of the building will be disposed one-third of one story below and two-thirds of one story above the adjacent P sections thereof.) Finally, the width of the P sections of the building may be varied simply by using planks P of different dimensions without the need for any other structural changes.

Various roof designs are possible for structures of the type here described, three such roof designs being illustrated in FIGS. **5A**, **5B** and **5C**. FIG. **5A** shows a stepped roof, each building section comprising one step vertically spaced from the preceding step by one-half of one story. This stepped configuration is achieved by the use of a modified H element here designated H_2 having the upper half of one flange **12** removed, the lower half of that flange forming the vertical step **90** in alternate building sections. The remaining vertical steps **92** are defined by the top half of the other flange **12** of elements H_2. Element H_2 may be formed merely by blocking off the appropriate section of the H mold during casting. The roof may be stepped down at either side, may be continuously stepped in one direction or in the case of buildings having substantial length may be stepped up and down several times to provide an undulating appearance. In any case, the stepped roof configuration provides the possibility of double and in some cases triple exposure for all occupancy units at the top level of their respective building sections (vertical steps **90** and **92** may have appropriate window openings therein). Indeed, if desired, appropriate door openings may be formed in steps **90** and **92** whereby the stepped roof sections may define terraces with appropriate railings. If this is done, the basic unmodified H section may be used, the upper half of one flange **12** defining a terrace railing.

FIG. **5B** illustrates the natural roof structure which results from the structural pattern of FIG. **2**, the connecting element B merely being replaced by a plank P. If desired, the H roof sections may be used as enclosed terraces, a natural stairway access being provided from the uppermost adjacent P unit (see FIG. **2**).

The conventional flat roof illustrated in FIG. **5C** is achieved by utilizing a pair of oppositely facing H_1 elements to span consecutive H elements. Thus as shown in FIG. **5C**, a first H_1 element is disposed with its flanges **32** extending upwardly, its cross member **30** spanning two consecutive H elements (in place of a plank P). A second H_1 element is disposed atop the first H_1 element with its flanges extending downwardly, a building unit of substantially one full story being defined between the cross members **30** of the opposing H_1 elements. Planks P are used to span the flanges **32** of consecutive H_1 elements thereby to complete the substantially flat roof. A particular advantage of this roof structure resides in the provision of alternate units at the top of each H section of one and one half stories in height, thereby to provide an occupancy unit or portion thereof with a high ceiling, something which is virtually unattainable with conventional building systems. It will be appreciated that various other roof designs, including combinations of those here illustrated are possible.

Similarly, the structural system here described provides great flexibility of facade design. One such design is partially illustrated in FIG. **6** and comprises a series of facade panels **86** of up to four stories in height disposed centrally at the end of each building section, appropriate horizontal panels **88** defining window openings provided at each side thereof and at the corner **94**.

My new structural system has thus far been described in connection with the construction of high rise structures, typically used for luxury apartments or offices. The same basic structural framework however may be conveniently adapted for the construction of low cost low rise structures of the townhouse or garden apartment variety. One such structural framework is illustrated in exploded perspective in FIG. **7**. The structure there specifically illustrated comprises three parallel series of alternate H and P sections here designated **100, 102** and **104** constructed in accordance with the basic system shown in FIG. **1**. Series **100** utilizes the basic H elements and planks P previously described and illustrated in FIG. **3**. The remaining series **102** and **104**, however, utilize modified H elements here designated H_3 and modified planks here designated P_2. As best illustrated in FIG. **8**, elements H_3 comprise the basic element H having one flange **12** and the cross member **10** relieved at one corner to provide a large notch N_7. Similarly, the modified plank P_2 is provided with a large notch N_8 at one corner, the projection **16''** at that corner being moved to one side of the notch N_8.

Referring again to FIG. **7** it will be seen that the notches N_7 on a pair of contiguous H_3 elements are paired in opposing relationship and are in opposing relationship to the notches N_8 on the modified planks P_2 in the next adjacent P section of the building. As a result, those four opposed notches define a vertical opening in the structure thereby to provide stairwells at alternate joints between H and P sections of the building. For example, in FIG. **7** four building sections **105, 106, 107** and **108** are illustrated. A first stairwell **110** is defined by the notches N_7 and N_8 in the elements P_2 and H_3 of P section **105** and H section **106**, respectively. Likewise a second stairwell **112** is defined by the notches N_7 and N_8 in the elements P_2 and H_3 of P section **107** and H section **108** respectively. Precast stairway elements S (such as the one shown in broken lines in FIG. **7**) may be mounted within stairwells **110** connecting the cross members **10** of the H_3 elements with the next higher and lower levels formed by planks P_2. The stairway elements are preferably of a width equal

to the width of notches N_7 and N_8 whereby two vertical lines of stairway elements S_2 are provided in series **102** and **104** respectively. These lines of stairway elements are preferably disposed in opposing orientation as best illustrated in FIG. **7.**

It will be apparent that the structural framework of FIG. 7 lends itself well to a variety of convenient internal apartment configurations. For example, one or more of the stairwells may be utilized to provide for duplex or even triplex apartments, the remaining stairwells providing public access. Indeed, a stairwell may be used to provide public access to the bottom levels, the top two or more levels being utilized for a single apartment. Moreover, various roof designs such as those already described are feasible.

Similarly the facade may be designed in a variety of ways to provide a unique and pleasing appearance. Two of the many possibilities are illustrated in FIGS. **9** and **10** for three and four story structures, respectively of the town house type. The appearance of buildings utilizing the present system is enhanced not only by the split level design including the undulating or stepped roof which tends to radically break up the monotony of box-like structures but also by the possibility of a split level stilted type foundation such as that embodied in the building of FIG. **9.** Not only does this design add to the uniqueness of appearance but also the spaces underlying the alternate P sections may be utilized for example as a car port. Various other design possibilities will be apparent.

A significant advantage of the structural system here disclosed both with respect to high rise and low rise structures is its unique adaptability to variations in terrain which in many cases obviates the expensive process of altering a hilly site prior to building. This is exemplified by the low rise building illustrated in FIGS. **10** and **11.** As there shown the structure may be stepped up or down by one full story (i.e., 9 feet) for every two building sections (i.e., 40 feet) thereby to closely approximate uneven terrain such as the terraced terrain **120** of FIG. **10** or the straight inclined terrain **122** of FIG. **11.** In any case, the flanges **12** of the lower H elements serve as natural stilts one-half story in height.

It will be appreciated from all of the foregoing that the structural system herein disclosed provides a major improvement over prior structural systems and techniques for the construction of multi-story buildings. My new structural system provides for enhanced structural integrity, increased speed of construction and internal and external design flexibility heretofore unattainable.

The use of the precast reinforced structural elements disclosed herein is adapted to provide a substantially monolithic network of horizontal and vertical supports arranged to provide offset levels in adjacent building sections. As a result of the fewer number of structural elements required and the provision for only one series of poured joints per building story, the possible speed of erection of a building in accordance with the present system is considerably enhanced. Moreover, the provision for internal stairway elements connecting at least three levels of three consecutive building sections together with the elimination of the need for corridors on every main level of the building provides for maximum utilization of floor space and for an internal design flexibility of almost limitless scope.

Finally, the use of an H building element as the primary structural element substantially increases the versatility of external design of the building including the possibility of stepped or undulating roofs or foundations which provide not only a unique appearance and a variety of penthouse design possibilities, but also may be used to conform the building to an even terrain.

While only a limited number of embodiments of the present invention have been herein specifically described, it will be apparent that many variations may be made therein, all within the scope of the invention, as defined in the following claims.

I claim:

1. A multi-story building structure comprising at least first and second series of contiguous building sections, said building sections separated by vertical support walls extending in a first direction, each building section comprising a plurality of vertically aligned building units separated by spaced horizontal support members defining the floors and ceilings of said units, the horizontal support members in adjacent units being vertically staggered, said first and second series of building sections being spaced from one another in said first direction and having their building sections in alignment, means connecting the horizontal support members on the same level in selected building sections of said first and second series, respectively, to define continuous floors and ceilings in said selected building sections of said first and second series, respectively, spanning means within said space defined between said first and second series of building sections extending in a second direction substantially transverse to said first direction and operatively connecting the continuous floors and ceilings of said selected building sections on the same level thereby to define the main levels of said building, and vertical access means at each side of said last mentioned connecting means within said space operatively connecting the continuous floors and ceilings of said selected building sections on consecutive main levels of said building with the horizontal support members of the nonselected building sections therebetween at levels intermediate said main levels, whereby public corridors extending in said second direction may be formed on selected main levels of said building, said corridors extending between said vertical access means, said vertical access means being adapted to provide access from said corridors to all remaining levels of the building, the floor space of the remaining levels of said building being substantially fully utilized as occupancy space.

2. The structure of claim **1,** wherein said vertical support walls separating consecutive building sections each comprise a plurality of vertical support members each one building story in height vertically stacked in end to end relationship, the horizontal planar support members in the non-selected building sections comprising cross members prefabricated integrally with the vertical support members between which they extend, and said vertical access means extending parallel to said horizontal support means.

3. The structure of claim **2,** wherein said spanning means comprises a pair of spaced parallel beams operatively connected at either end to said vertical support members defining aligned non-selected building sections in said first and second series respectively, and a planar connecting member operatively connected at either end to said beams and spanning same, said con-

necting member being substantially smaller in width than the distance between said first and second series of building sections, said continuous floors in said selected building sections being defined by one or more planks operatively connected to and extending between the spaced vertical support members and beams of consecutive non-selected building sections.

4. The structure of claim **3,** wherein said spanning means is prefabricated with said connecting member formed integral with said beams.

5. The structure of claim **3,** wherein said vertical access means comprises stairway elements operatively disposed within said non-selected building sections in the space between said two series at opposite sides of said connecting member, said stairway elements operatively connecting the continuous floors of consecutive selected building sections on consecutive main levels with the cross members defining intermediate levels in the non-selected building sections therebetween.

6. In combination, a structural framework for a multi-story building using precast structural H elements, each of said H elements comprising a planar cross member adapted to form the horizontal supports of a building section and having two parallel flanges at either end thereof extending substantially perpendicular to said cross member by a distance of substantially one building story and adapted to form the vertical structural supports of said building, said H element being integrally cast, and means extending throughout said cross member and said flanges providing continuous reinforcement of said H element, said framework comprising a series of spaced H building sections each comprising a plurality of said H elements disposed in vertically stacked relationship with their flanges in vertical alignment, consecutive H building sections being spaced from one another in a direction perpendicular to said vertical flanges, and horizontal support means extending across the space between consecutive H building sections and operatively connecting said spaced H building sections at the joints between the flanges of consecutive vertically stacked H elements thereof.

7. The structural framework of claim **6,** wherein said horizontal support means comprises planks and wherein opposite ends of said planks are vertically supported atop the flanges of horizontally aligned H elements in consecutive H building sections, the next higher H elements of said building sections having their flanges vertically supported on the ends of said planks, whereby opposite ends of said planks are sandwiched between the flanges of consecutive vertically stacked H elements in consecutive horizontally spaced H building sections.

8. The structural framework of claim **7,** wherein said planks are formed of precast reinforced concrete.

9. The structural framework of claim **8,** wherein the reinforcing means within said planks extend outwardly thereof at opposite ends thereof.

10. The structural framework of claim **9,** wherein each opposite end of said plank defines a recess intermediate the sides thereof, and further comprising means defining a monolithic joint between the flanges of consecutive vertically stacked H elements and the recessed end of one of said planks sandwiched therebetween.

11. The structural framework of claim **10,** wherein said recess of said plank end in said monolithic joint contains concrete and operably connected portions of said reinforcing means of said plank and said flanges.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,805,461 Dated April 23, 1974

Inventor(s) Ajzyk Jagoda

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

Inventor: Ajzyk Jagoda, 285 Aycrigg Ave.,
Passaic,,N. J. 07055

Signed and sealed this 12th day of November 1974.

(SEAL)
Attest:

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Attesting Officer

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