July 2, 1957 R. MILLER 2,797,446

BUILDING CONSTRUCTION

Filed June 19, 1952 6 Sheets-Sheet 1

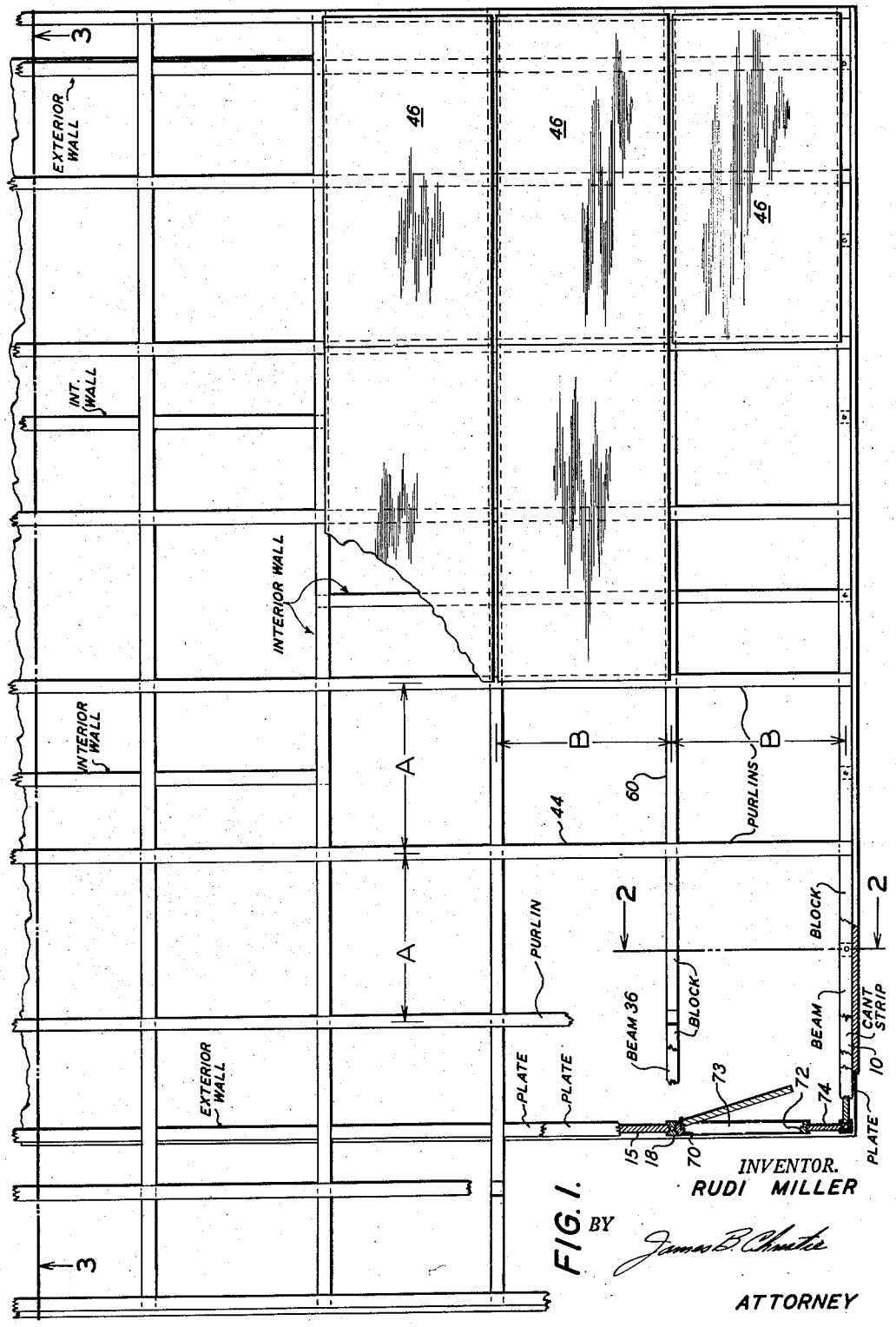


FIG. 1.

INVENTOR.
RUDI MILLER

BY James B. Christie

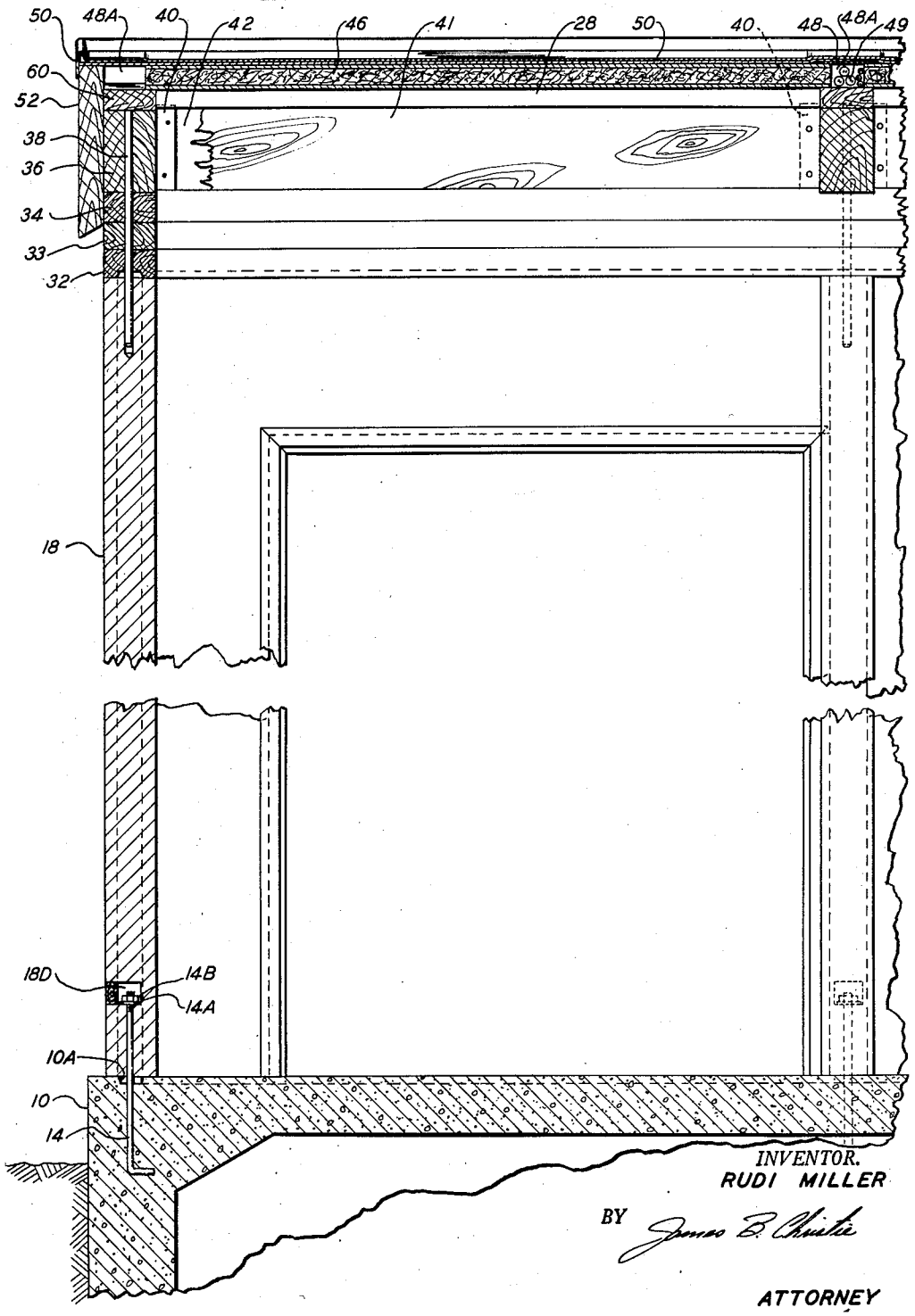
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BUILDING CONSTRUCTION

Filed June 19, 1952 6 Sheets-Sheet 2

FIG. 2.



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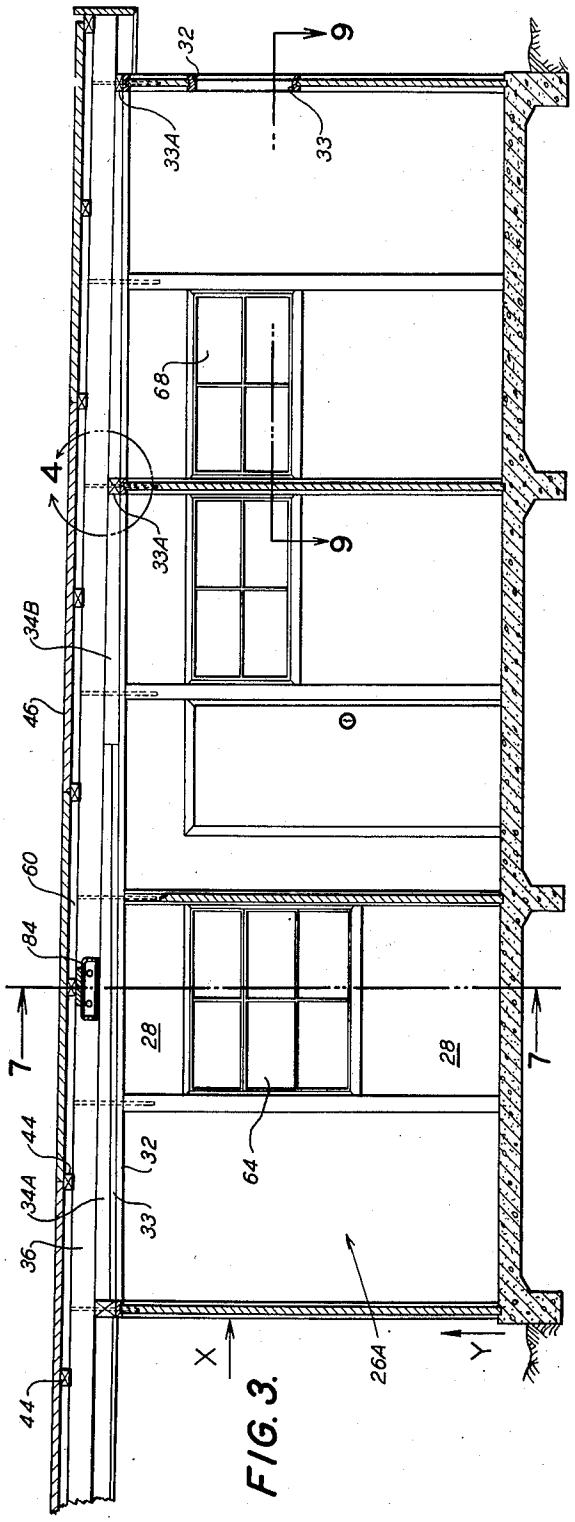


FIG. 3.

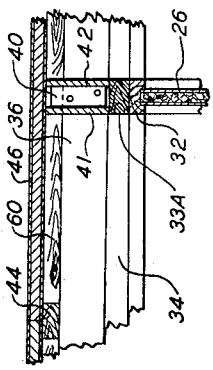


FIG. 4.

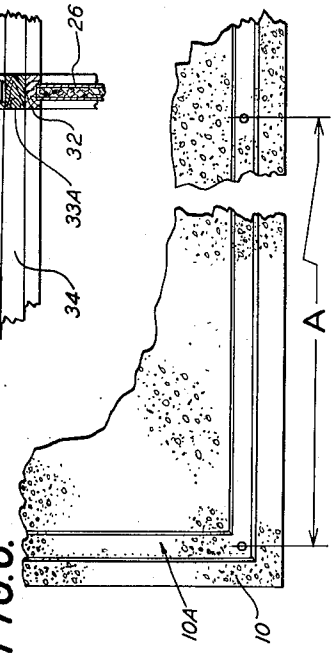


FIG. 6.

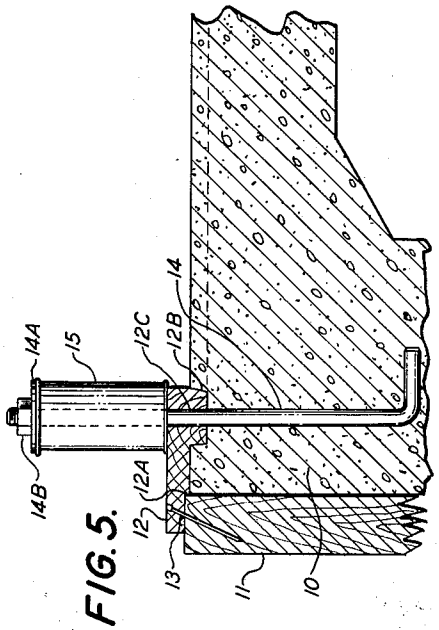


FIG. 5.

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BUILDING CONSTRUCTION

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FIG. 7.

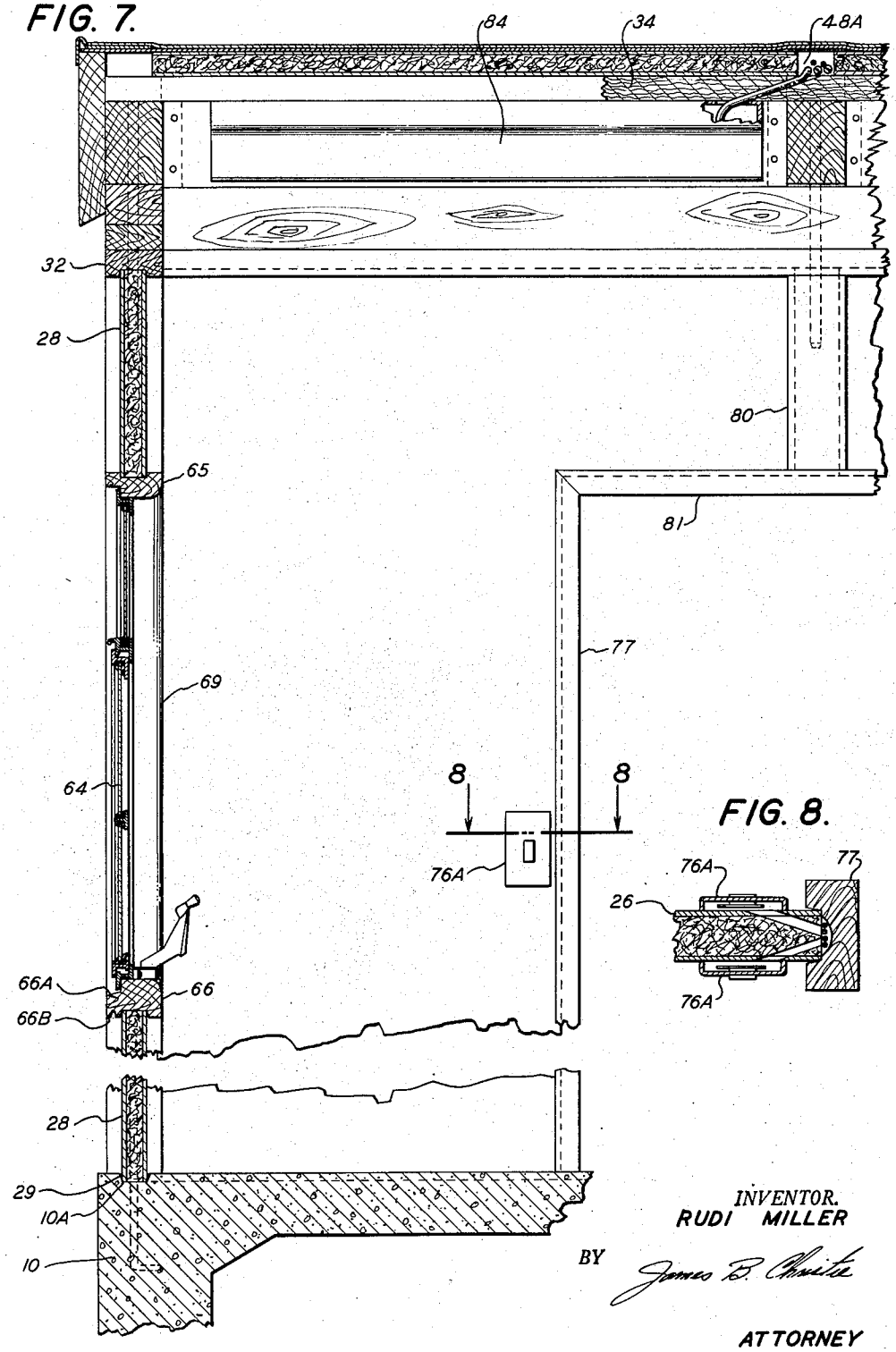


FIG. 8.

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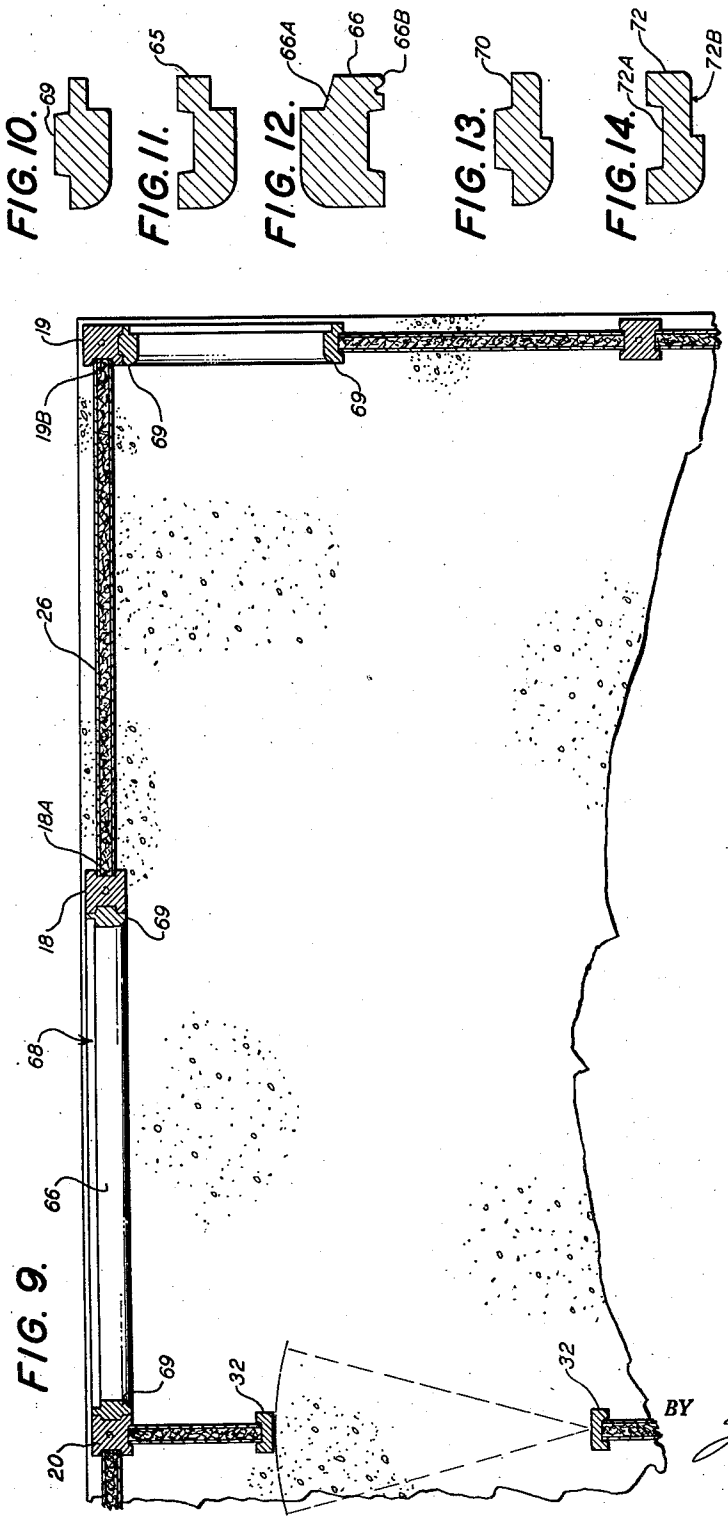
BY James B. Christie

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July 2, 1957 R. MILLER 2,797,446

BUILDING CONSTRUCTION

Filed June 19, 1952 6 Sheets-Sheet 5



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BUILDING CONSTRUCTION

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FIG. 20.

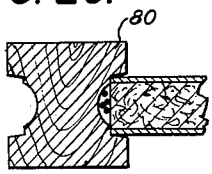


FIG. 21.

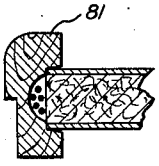


FIG. 22.

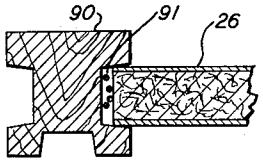


FIG. 23.

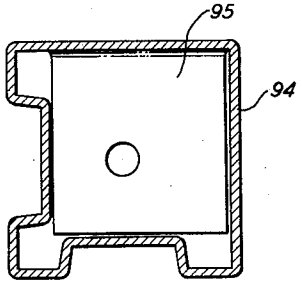


FIG. 24.

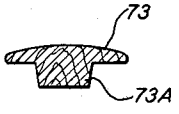


FIG. 25.

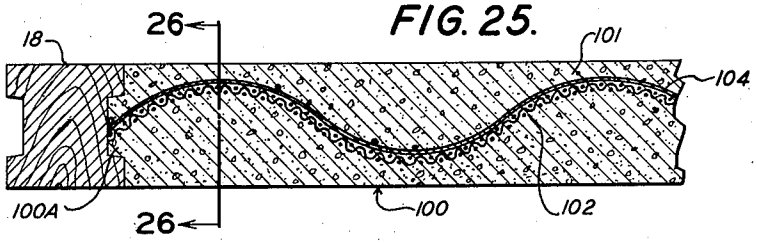


FIG. 26.

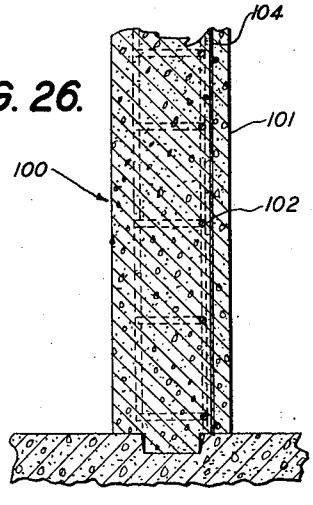
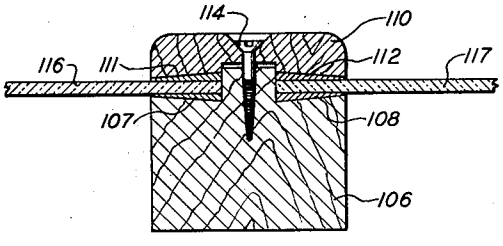


FIG. 27.



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Patented July 2, 1957

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BUILDING CONSTRUCTION

Rudi Miller, Huntington Beach, Calif.

Application June 19, 1952, Serial No. 294,351

6 Claims. (Cl. 20—2)

This invention relates to a new type of building structure and new methods of construction both particularly designed for prejoinered structures of modular coordination. The term "prejoinered" is intended to signify preforming of all or most of the structure parts so that construction thereof is merely a matter of assembly. A prejoinered house within the scope of this definition differs from a so-called prefabricated house in that there are no such assemblies fabricated prior to actual erection. The structure herein defined is, by reason of the techniques employed in its construction, characterized by low cost, ease of assembly, and greater strength than conventional buildings.

The conventional dwelling is essentially custom made in that the various parts thereof are formed and shaped at the building site to fit the particular requirements of the custom designed building. As defined above, a prejoinered house differs from the conventional structure in that all of the components are pre-cut, shaped, etc. and are laid down at construction site in condition for final assembly. To best accomplish prejoinering of all the elements of a structure, it is desirable to hold to a minimum the number of basic separate components and to standardize such components wherever possible.

I have now developed an entirely new approach to the method of construction, i. e. the method of joining the various parts of a building by a rational approach to its fastenings, which enables a reduction of the total number of separate elements required and at the same time results in a building which is stronger, lighter and more fireproof than a conventionally constructed unit of comparative size.

In this regard the invention contemplates the method of constructing a building which comprises anchoring wall studs directly to a wall-receiving base which may be concrete, wooden slab or the like, mounting stressed rigid wall panels between the studs and engaging the base whereby the studs are maintained parallel to each other and perpendicular to the footing at any shear loading less than that required to buckle the panels. The upper ends of the studs are interconnected with a top plate which is also engaged by the wall panels, and roof rafters are supported in vertical alignment with the studs so that the module of the rafters is the same as that of the studs. The rafters are fastened to the studs by means of a fastener inserted vertically through the rafter top plate and into the stud. This fastener is preferably a bolt and may also be simply a metal or wood pin structurally cemented in place. This vertical fastener and rigid stressed wall panels serve to convert any shear loading, frequently referred to as "wind loading" or "racking load," to a vertical component applied against the fastening means holding the studs to the base, such means being hereinafter described.

The invention contemplates as a basic embodiment a modular coordinated structure comprising wall panels of a single module, wall studs vertically extending from a wall-receiving base, and a top plate extending between adjoining studs, the respective edges of the wall panels being sealed to the engaged surfaces of the base, studs and top plate, whereby each panel is inflexibly associated as a unit with the associated studs, base portion and cap plate.

The wall-receiving base member, studs, and top plate are preferably grooved or channeled to receive the edges of an associated panel, the module of the panel and stud spacing being such as to permit such edge engagement. In this preferred construction the panel edges are sealed in the receiving grooves with a conventional structural adhesive. In this fashion the panels are stressed and the only way that the structural framework can deform under a racking or compressive load is by deformation of the stressed panel.

The base member is conveniently a concrete footing or slab provided with a panel-receiving groove when it is poured. The structure of the invention is hereafter described in detail in conjunction with such a concrete slab, but as the description proceeds it will be apparent that the structure does not have such base means as a limiting feature.

A cap plate is laid over the studs and is preferably also grooved to receive the wall panels. Roof rafters are supported above the studs and in vertical alignment therewith, it being the practice when a planar roof is contemplated to insert a cant strip between the plate and the rafters to provide the desired pitch to the roof beams or rafters. A separate pin or bolt is passed through each rafter into each of the underlying studs, thereby holding the rafter top plate and cant strip (if employed) in the desired vertical alignment with the studs.

This method of tying the superstructure to the bearing walls is believed to be unique and is possessed of many advantages over conventional fastening techniques. One such advantage is simplicity. Since each of the several structural elements involved is pre-drilled to receive the tie pin or bolt, it need only be driven into place as the assembly advances to the proper stage. Moreover, the single fastening means serves to tie together several of the basic structural elements of the structure, thereby avoiding the multiplicity of fastening means conventionally employed to accomplish the same purpose. Another important aspect of this means of tying the structure together is the consequent facility of disassembly and without injury to the structural components. Although this feature may not be of much consequence with respect to residential dwellings, it is of major importance when the structure finds use as army barracks and in other temporary installations.

Purlins are transversely arranged on the rafters; roof sheathing in the nature of panels, which may be identical to the wall panels, is supported on the purlins and is covered by suitable waterproof roofing membrane. A facia board extending around the periphery of the structure and enclosing the end and side faces of the rafters is a desirable but not a necessary element of the structure.

One unique feature of the structure of the invention is that of modular coordination in which a single module is used throughout whereby identical panels may be employed for both wall and roof surfaces. Moreover, and as a consequence of such modular coordination, wall sections are interchangeable, and door and window units may be interchangeably located at will. All of the supporting studs are standardized, separate and standard sections being employed to frame windows and doors, as hereinafter described.

The structure of the invention, as generally described above, exhibits many unique and highly desirable features. The data herein set forth with respect to conventional structural forms for comparative purposes is taken from Strength of Houses, Building Materials and Structures Report 109, U. S. Department of Commerce, 1949. The average weight of frame houses per face area is reported as 6.04 lbs./ft.,^{2} whereas the average for masonry houses is 70.4 lbs./ft.^{2}. In contrast the structure of the invention weighs less than five pounds per square foot of face area. Moreover, and because of the fastening techniques employed, the present structure is con-

siderably stronger than conventional construction for reasons which will become apparent.

The invention will be more clearly understood by reference to the following detailed description of a typical structure constructed in accordance with the invention, such description being taken together with the accompanying drawings in which:

Fig. 1 is a plan view of a partially completed structure with only a part of the roof sheathing in place;

Fig. 2 is a sectional elevation taken on the line **2—2** of Fig. 1 showing in detail the manner of anchoring studs to the footing and the top plate, cant strip, rafter and roofing assembly;

Fig. 3 is a section taken on the line **3—3** of Fig. 1 showing a side sectional view of the superstructure shown in transverse section in Fig. 2;

Fig. 4 is an enlarged sectional detail taken on the line **4—4** of Fig. 3;

Fig. 5 is a partial sectional elevation through the footing showing the pouring forms and method of supporting stud anchoring bolts;

Fig. 6 is a partial plan view of a slab as poured in the form shown in Fig. 5;

Fig. 7 is a sectional elevation taken on the line **7—7** of Fig. 3 showing window construction detail;

Fig. 8 is a horizontal section taken on the line **8—8** of Fig. 7 showing wiring detail;

Fig. 9 is a horizontal section taken on the line **9—9** of Fig. 3 showing detail of the vertical framing of doors and windows;

Figs. 10 through 19 are enlarged transverse sections through various framing members of the structure;

Fig. 20 is a transverse section through a modified stud;

Fig. 21 is a transverse section through a similarly modified door framing member;

Fig. 22 is a transverse section through another modified form of stud;

Fig. 23 is a transverse section through a sheet metal stud;

Fig. 24 is a vertical section through a door sill member;

Fig. 25 is a horizontal section through a portion of an alternative form of panel;

Fig. 26 is a vertical section taken on the line **26—26** of Fig. 25; and

Fig. 27 is a transverse section through a structural member adapted to support glass panels.

The structure illustrated in the drawings is best described by reference to a step by step assembly thereof.

Referring first to Figs. 5 and 6, concrete footing **10** is poured in a form comprising an exterior form wall **11** having a cap **12** extending inwardly from its upper edge and circumscribing the entire form. The cap member **12** is longitudinally grooved at its outer lower edge **12A** to insure that the cap will be properly indexed to the form wall when fastened thereto by toenails **13**. The cap **12** includes a longitudinally extending, downwardly projecting shoulder **12B** with tapered side edges, the shoulder effecting a tapered groove **10A** (see Fig. 6) in and circumscribing the footing. The cap **12** is bored at appropriate linearly spaced intervals on the longitudinal center line of the shoulder, bore **12C** appearing in Fig. 5. A J bolt **14** is supported through the bore **12C**, its vertical position being fixed by a sleeve **15** engaging between the cap member and a washer **14A** held on the upper end of the bolt by nut **14B**. Each of the several other J bolts are similarly supported from the cap **12** while the footing is being poured to insure that they each project uniformly above the form.

A concrete footing as illustrated is not a limiting feature of the invention. A conventional wood sub-flooring may furnish the wall supporting base means above referred to. In any case it is preferred that the support means be grooved or channeled to receive the wall panels. Such channeling may be effectuated in many different ways. By way of example, a channeled wood member can be fastened to a concrete footing as a sill. A wood member, such as the herein described cap plate (see Fig. 15), is satisfactory for this purpose.

In the particular embodiment illustrated a slab floor is provided which is conveniently poured integrally with the footing. The slab is grooved as is the footing to receive interior walls by means of a suitable form member (not shown) similar to the cap member impressed in the wet slab.

To remove the cap **12** from the footing after the concrete is set, nut **14C**, sleeve **15** and the washers **14A**, **14B** are removed from the bolt, and the cap is lifted from the top of the bolt after withdrawing the toenail **13**. The end result is a footing with a continuous circumferential groove in its upper face as above mentioned and with J bolts rigidly anchored therein and projecting upwardly therefrom on the center line of the groove. In this particular instance a module of 50½ inches has been selected for the entire building and the J bolts are accordingly on 50½ inch centers.

The next stage of construction involves anchoring studs to the several J bolts. The several forms of studs are shown in transverse section in Figs. 16, 17, 18 and 19 and differ only with respect to whether they are to find use in linear wall sections, interior or exterior corners, wall joints or wall intersections. Stud **18** shown in Fig. 18 is substantially square in transverse section with symmetrical grooves **18A** and **18B** formed in opposite sides and extending from top to bottom of the stud. All studs of this particular type are hereinafter identified by the reference character **18**. Stud **19** shown in Fig. 19 differs from the stud **18** only in that grooves **19A**, **19B** are formed at adjacent faces thereof, it being obvious that this stud finds use at an outside corner. Stud **20** shown in Fig. 17 has grooves **20A**, **20B** and **20C** in three of its side faces and finds use at a wall junction. Stud **21** shown in Fig. 16 has grooves in each of its side faces for receiving intersecting walls.

A stud **18** is shown in Fig. 2 fastened to the footing **10** by J bolt **14**. The stud is drilled through its bottom end to receive the J bolt and is rabbeted at **18D** to receive nut **14B** and washer **14A**. In this fashion the stud **18** is firmly anchored to the footing without an intervening mud sill. In this manner the stud is firmly anchored to the footing, the force required to remove it therefrom being measured by the shear modulus of a cylindrical section of the stud itself as defined between the washer **14A** and the footing. It is important in the described structure that the studs be anchored thus firmly since wind loading and racking load are translated by the rest of the structure into vertical force components on the studs. This fact alone differentiates the present structural concepts from the now conventional methods.

As each stud is placed in the proper and predetermined location, a wall panel is inserted in the receiving groove of the stud by sliding the panels into position sideways. The adjoining stud is then mounted to confine the opposite edge of the panel.

Referring to Fig. 9 a wall panel **26** is inserted to engage in the groove **18A** of stud **18** and thereafter stud **19** is positioned as shown and anchored to the footing. Panel **26** is actually wider than the outside dimensions of the adjacent studs and as a consequence extends into the receiving grooves and as a consequence is locked between the studs. Along its bottom edge the panel resides in the groove **10A** of the footing which is conveniently filled with a mastic prior to insertion of a panel to form a stressed liquid and air seal. The manner in which a panel rests in the footing groove is shown in Fig. 7 wherein a partial panel **28** extends from the footing to a window hereinafter described. In Fig. 7 a small layer of mastic **29** is shown surrounding the lower edge of the panel **28** in the footing groove **10A**. In a similar fashion the vertical edges of the panels are sealed in the retaining stud grooves with a suitable structural adhesive.

Passing for the moment over the provision for doors and windows, the structure is next ready for assembly of the superstructure. The superstructure is best illustrated in Figs. 1, 2 and 3. A top plate **32** shown in transverse section in Fig. 15 is laid across the top of all of the studs. The top plate is grooved at **32A** to fit over the upper edge of the wall panel **26** which, by design, extends above the upper edge of the stud **18** (see Fig. 7). This feature serves not only as an anchor for the plate **32** but completely seals the peripheral edges of the wall panel in aligned grooves formed in all of the circumscribing supporting structure. In the section view of Fig. 2 a second top plate **33** is superimposed on the top plate **32**, the second top plate constituting a conventional two by four and being required at this point in the structure to attain the necessary roof pitch as explained in greater detail with relation to Fig. 3.

A cant strip **34** is laid on top of the second top plate **33** as shown in Fig. 3 and is in some portions of the structure laid directly on the first top plate. Referring for the moment to Fig. 3, the cant strip **34** is shown in two sections **34A**, **34B**, both of which are identical with the second top plate **33** underlying the section **34A** of the cant strip so as to provide continuous pitch from right to left of the structure as illustrated in Fig. 3. Although the structure is illustrated in considerable detail as having a planar roof requiring the particular arrangement of cant strips, etc. as described, it will accommodate other roof shapes, as for example a hip roof, with equal facility.

Roof rafters **36** are laid on top of the cant strip and as is conventional lie parallel to each other at spaced intervals. The module of the rafters in this instance matches that of the studs, such relationship being essential to carry out the invention as hereinafter made apparent. Each of the rafters, cant strips, top plates and the upper portion of the stud **18** are drilled to receive a pin **38**. Preferably the pin **38** is slightly larger than the receiving holes drilled in the several elements mentioned so that it must be forced downwardly from the rafter through the cant strip, top plates and into the stud **18**. It is also desirable to seal the pin in position with structural adhesive forced into the pin-receiving holes together with the pin. This pin **38**, and its counterpart connecting the several rafters to each of the respective aligned studs is the only means required for joining all of these elements to the studs. As an alternative to the pin **38**, driven into position as described, a so-called "secret bolt" type connection may be used in which a conventional bolt is inserted in the manner of the pin **38** and anchored in a nut buried in the lower end of the pin-receiving hole in the stud.

Each of the rafters has in vertical alignment with any interior or exterior wall section a protruding flange **40** extending on the center line of the wall section so that dust plates **41**, **42** may be attached between adjacent rafters to the corresponding flanges **40** to form a continuous wall surface.

Referring to Fig. 3, which is a view transversely of the view of Fig. 2, purlins **44** are placed at spaced intervals across the rafters transversely thereof and panels **46** conveniently identical to the wall panels are laid on top of the purlins. As shown in Figs. 1, 2 and 3 the end edges of the roof panels **46** abut on the center line of a purlin **44**, the side edges being spaced from each other along an underlying rafter **36**. The reason for this spacing will be apparent if it will be remembered that the module of the rafters is 50½ inches corresponding to that of the studs with the wall roof panels being identical and of somewhat narrower module. There will be the same side spacing between the roof panels as between the wall panels. Such side spacing is desirable, forming by means of a cover strip **48** (Fig. 2), an enclosed channel or raceway **48A** in which electrical leads **49** may be carried to any part of the structure.

In Fig. 2 the roof pitch is perpendicular to the plane of the paper and succeeding layers of roofing paper **50** are observed overlying the roof paneling **46**. A conventional metal gravel stop **50** is fastened around the periphery of the roof and a facia or barge board **52** is mounted to the exposed edges of the rafters. The facia board is preferably mounted by means of "secret" bolts as above described.

Blocking **60** (Fig. 2) is provided along the top of the rafter between the purlins **44** for supporting the roof sheathing **46**. Fig. 4 is an enlarged section taken on the line 4—4 of Fig. 3 showing this construction in detail. This particular section is of an interior wall at the point of approach to an exterior wall showing a wall panel **26**, top plate **32** and second top plate **33A** running between adjacent cant strips **34**, the rafter **36**, purlin **44**, rafter cleat **40** and the dust blocks **41** and **42**.

The second top plate **33** shown in transverse section in Fig. 2 and in elevation in Fig. 3 underlies the cant strip **34** and is parallel thereto. The second top plate **33A** shown in section in Figs. 3 and 4 extends between purlins and transversely thereto.

Window and door construction is best seen in Figs. 7 and 9, the former being a vertical section taken on the line 7—7 of Fig. 3 and the latter being a horizontal section taken on the line 9—9 of Fig. 3. Referring to these drawings the window **64** in Fig. 7 is a conventional steel sash casement window which forms no part of the present invention as such. The window is framed by horizontal members **65**, **66** shown in enlarged section in Figs. 11 and 12 respectively. Each of these pieces is shaped to present a faced inner surface, a longitudinal groove for mounting on the wall sections **28** which are identical except for size with the complete wall panels **26**. The member **66** has a tapered outer lip **66A** as a conventional sill drain and a drip sill **66B**. Corresponding vertical framing members of any window are shown in Fig. 9 which shows the window **68** of Fig. 3. Each of the windows **64**, **68** extend between adjacent studs, and identical vertical framing members **69**, shaped to engage in the stud groove, provide an interior facing and an exterior milled peripheral groove aligned with and identical to the horizontal framing members. The vertical window framing members **69** are shown in enlarged section in Fig. 10.

Smaller windows are made by cutting a section of appropriate size out of a wall panel, framing the top and sides of such an opening with framing members **65** (Fig. 11) and the bottom of such opening with framing member **66** (Fig. 12) as in window **64** shown in Fig. 7. The framing members are affixed to the associated wall panel with structural adhesive applied in the panel-receiving grooves before mounting.

Door framing is shown in horizontal section in Fig. 1 and in elevation in Fig. 2 and includes a framing member **70** engaging with the stud **18**, the member **70** being shown in enlarged transverse section in Fig. 13 and a framing member **72** grooved at **72A** to engage a wall panel **74** and milled at **72B** to provide a door stop. The member **72** is shown in enlarged transverse section in Fig. 14. The member **72** is also used as a door header for both internal and external doors, the groove **72A** providing means for affixing the framing members along the side and upper edges of the door opening. A door does not require association with a stud. An opening may be cut in either an interior or exterior wall panel and framed on two sides by structural members **72** and on the third by structural members **32** to which the door is hinged. The member **32** is also the top plate as previously described retaining the same reference numeral because of such identity.

As shown in Figs. 1 and 2 a door sill **73** is mounted in the groove **10A** in each exterior door. The sill **73** is shown in sectional elevation in Fig. 24 and includes a protruding flange **73A** by means of which the sill is cemented in groove **10A**.

Fig. 8 is a horizontal section taken on the line 8—8 of Fig. 7 and shows the manner of carrying low voltage electrical wiring to light switches **76**, **76A** mounted on opposite sides of an interior wall panel **26**. In this instance a framing member **77** runs along the side of the interior wall panel as to define a doorway not detailed. The member **77** has the conventional wall panel-receiving groove, and, in addition, the groove is provided with a concave bottom surface so as to provide a crescent shape passageway between the inner end face of the wall panel **26** and the grooved bottom, this passageway serving to carry suitable low voltage wiring from the exteriorly mounted low voltage relay (not shown) through the raceway **48A**.

Referring now to Figs. 20 and 21, there is shown respectively in transverse section a stud **80** and a header **81** similar respectively to the stud **18** and the header **72** but modified to include a convex bottom groove for carrying wiring similar to that of the member **77** shown in Fig. 8. By using elements thus modified the wiring in the vertical framing member **77** (Figs. 7 and 8) may be carried through the header **81**, modified stud member **80** and from thence through the cap plate, etc. to the wiring raceway **48A** between the roof sheathing. In Fig. 7 an overhead light fixture **84** is shown in side elevation, the same fixture being shown in transverse section in Fig. 3 with electrical wiring carried from the raceway **48A** through the purlin **34** into the fixture.

Fig. 22 shows a stud **90** similar to the stud **20** of Fig. 17 and illustrating another manner of accomplishing wiring space in the stud itself. In the stud **90** the wall panel-receiving grooves are deeper than in the stud **20**, are tapered so as to limit the insertion of the wall panel **26** providing a passageway for wires **91** and increased mastic gripping surface, the wires in any instance being embedded in the mastic with which the grooves are filled.

Fig. 23 shows in transverse section a stud **94** similar in configuration and function to the stud **19** in Fig. 19. The stud **94**, however, is constructed of sheet metal to show the facility of such construction and is provided with bottom and top plates **95** (the bottom plate being visible in the drawing) by means of which the metal stud is fastened to the footing and to the superstructure respectively.

One of the features of the invention is the effect of the manner of tying the studs to the footing and the superstructure to the studs. Referring to Fig. 3, assume a wind loading of x at the point X represented by the arrow on the side of the house lying perpendicular to the plane of the paper. This wind loading of course sets up a shear of racking force on the transverse side, the effects of which may be considered with reference to the wall section **26A**. It is to be remembered that this wall section projects at each of its edges into receiving grooves in the respective studs, cap plate and footing, and that the superstructure is tied to the studs by pins projecting through the rafters, etc. into the studs and shown in the drawing in dotted lines. Any force exerted at X would have the tendency to lift the lower left-hand corner of the panel **26A** as shown in the drawing. However, since this is obviously impossible, without shearing the material of the stud beneath the washer **14A** (Fig. 5), the effective component of the force X is a vertical force Y indicated by an arrow adjacent the footing. This vertical force is therefore absorbed by the J bolt holding the panel supporting stud against the footing and is merely a tensile force and not a shear force. As a consequence the racking strength of the building, this being its permissible wind loading factor, is extremely high and may be from two to four times as high as that of conventionally constructed buildings of similar shape and size.

The wall and roofing panels may be any rigid or semi-rigid prefabricated sheathing. One excellent material, and that illustrated as the panel **26**, is a commercially available product comprising asbestos cement sheets exteriorly laminated to a central insulating core.

Another highly satisfactory type of panel is shown in horizontal and vertical section respectively in Figs. 25 and 26. Panel **100** shown in the figure comprises lightweight concrete **101** formed on a reinforcing core **102** consisting of four inch mesh 18 gauge steel net preferably vertically corrugated as shown, or otherwise configured so that the major portion of the reinforcing is laterally of the neutral axis. This panel differs from the above described panel **26** in its substantially homogeneous construction and also in that it is dimensioned to a thickness corresponding with that of the stud. A typical lightweight concrete used for this purpose is derived from a slurry proportioned as follows: One sack of lightweight aggregate (24 lbs.), one sack of cement (92 lbs.) and sixteen gallons of water. Such a panel includes the reinforcing core which weighs from 3 to 3½ lbs. per sq. ft. The panel **100** is molded with a peripheral rib **100A** engageable in the grooves of the circumscribing structural members, stud **18**, etc. As protection against radiation, a lead sheet **104** may be embedded in the panel together with the core. The same type of lead sheet here shown may be incorporated in any of the other illustrated panels for the same purpose.

A structure in accordance with the invention embodying panels of either of the types described above has a higher racking strength and at the same time only about one-half the U factor of even an insulated conventional structure. The U factor is a measure of the heat transconductance of a wall in terms of B. t. u.'s per square foot of wall area per hour per degree Fahrenheit temperature differential with a 15 mile per hour wind.

Obviously other forms of paneling may be employed providing they are such as to result in acceptable strength and insulating characteristics. Different forms of paneling may be used in the same structure if desired providing they conform to a given module. Such combination may be appropriate for decorative purposes, it being observed that the panel **26**, for example, will result in wall surface broken by the vertical lines of projecting studs, whereas the panel **100** will exhibit a flush wall surface.

With an understanding of the nature of the described structure, the ease of assembly can be appreciated. One or two men are entirely capable of assembling a moderately sized dwelling in less than 80 man hours of work. Significantly, disassembly of the structure is equally as simple and may be accomplished without destroying any of the principal components which may therefore be reused to reassemble the structure at a later time.

In disassembly, the superstructure is first removed in the reverse order in which it is assembled, and as previously described, the only material destroyed in this procedure being the waterproof membrane covering the roof sheathing at the junctions of the roof panels. The principal portions of the superstructure are disassembled by the simple expedient of removing the tie pins or tie bolts which tie the rafters and top plate to the stud. If such disassembly is contemplated, the use of tie bolts for this purpose is preferred as being easier to remove than a driven pin. If the individual wall panels have been sealed in their respective receiving grooves by structural adhesive, as is preferred practice, this adhesive may be conveniently dissolved by injection under pressure of a suitable solvent. This may be accomplished in a number of ways and by apparatus forming no part of the present invention. The seal is destroyed in a matter of minutes by such a solvent and the stud supporting J bolts may be removed, whereby the walls and framework of the structure may be taken down piece by piece in rapid sequence. These pieces may, of course, be stored and reused without supplement to rebuild the same structure or even a somewhat modified structure, the latter accomplished by interchanging wall sections, doors and windows, in the manner above described.

The invention is particularly adapted to greenhouse construction, the realizable racking strength and ease of assembly and disassembly of a structure in accordance

with the invention being particularly advantageous in such application. To build a greenhouse the concrete or laminated panel members embodied in the above described structure are replaced by glass panels, for which purpose the structural members such as studs, rafters (referred to as roof "bars" as appearing in greenhouses) and the like are modified to receive a glass panel.

A stud **106** is shown in transverse section in Fig. 27, the stud being adapted to receive top and bottom fastenings as above described. The stud **106** is notched at opposite corners of one side, the notches having bottom surfaces **107**, **108** beveled at an angle of approximately 5° from a transverse plane. A channeled cap **110** is mounted on the notched side of the stud with the lips **111**, **112** of the channel beveled oppositely of the surfaces **107**, **108**. The cap is affixed to the stud by screws, preferably countersunk as screw **114** in the figure. Glass panels **116**, **117** are held between the corresponding longitudinal edges of the stud and cap, and the longitudinal cavity of wedge-shaped cross section formed by the beveled mating surfaces of the notched stud and channeled cap are filled with structural adhesive. The glass panel is held in this fashion between mating longitudinal knife edges under a compressive force only, there being no shear developed in the illustrated gripping means. The glass panels are stressed, and since glass is capable of taking an appreciable racking load an extremely strong structure results. This in turn prevents the vibrations and racking which ordinarily account for high glass mortality in greenhouses. In effect, the glass employed in the present structure is stressed to increase the structural rigidity to a point to avoid or minimize damage of the glass itself.

Roof rafter or tie bars are similarly constructed so that glass panels may be mounted in the roof. Apart from the modification of the panel-receiving structural elements in the illustrated manner, a greenhouse is constructed in the same manner described in detail above.

Many modifications will be apparent from the foregoing description with respect to materials, designs and the like. Two types of wall panels have been described in detail. Innumerable others will occur to those familiar with this art. The structure particularly illustrated herein is provided with a sloping planar roof. Flat roofs, hipped roofs, peak roofs, or the like, are equally feasible and do not require alteration in the basic structural techniques employed. A hip roof, for example, may be assembled by incorporation of a beveled strip intermediate the rafters and top plate. Furthermore, and as mentioned above, a concrete-supporting surface is not essential, although presently preferred. The studs and wall panels may be anchored and sealed respectively in any type of supporting surface, as for example grooved wood or metal sills which in turn may be anchored to a wood sub-floor or a concrete footing.

No attention has been given herein to finishing techniques, i. e. painting, papering, plastering or the like, but any of these may be employed in any desired combination to achieve the aesthetic results sought. The invention is in no way concerned with such practices. Similarly, there is no discussion of heating and plumbing which may be carried out to suit the requirements of each situation and which are unrelated to the structural techniques herein presented.

I claim:

1. A structure comprising a concrete footing having vertically projecting bolts secured in the footing at spaced intervals, studs secured each by a single one of the bolts at spaced intervals directly to and projecting vertically from the footing, a top plate connecting the tops of all of the studs, spaced parallel rafters supported on said top plate on the module of the studs, fastening means extending through the rafters, top plate and into the associated underlying stud, and rigid panels mounted between adjacent studs to form walls.

2. A structure according to claim 1 wherein adjacent studs are grooved from top to bottom of their adjoining faces, and the rigid panels are wider than the space between adjoining studs so as to extend into said grooves.

3. Apparatus according to claim 1 wherein said rigid panels are larger than said studs and the concrete footing and top plate are respectively grooved with the end edges of the panels extending below and above the studs into the grooved footing and top plate respectively.

4. A structure according to claim 1 wherein said rigid panels are larger than the area enclosed by adjoining studs, footing and top plate and each of the studs, footing and top plate are grooved to receive the side and end projecting edges of the panels.

5. A structure comprising a concrete footing, studs bolted at spaced intervals directly to and projecting vertically from the footing, first rigid panel members extending between adjacent studs, a top plate spaced from the footing a distance less than the height of first rigid panel members and connecting the tops of all of the studs, parallel arranged spaced cant strips extending from one side of the structure to the opposite side and supported by the studs and top plates, spaced parallel rafters supported on said cant strips, fastening means extending through the rafters, cant strip, plates and into the underlying studs, purlins transversely arranged on the rafters, second rigid panel members disposed as roof sheathing on the purlins, and roofing material disposed on the sheathing.

6. A structure according to claim 5 wherein the first and second rigid panels are narrower than the module of the studs and rafters, and the first rigid panels are disposed between adjacent studs and the second rigid panels are supported on said purlins with the side edges thereof extending parallel with the rafters so that an elongated channel is formed by the spaced apart side edges of the panels, means covering the channel whereby a raceway is formed for carrying electrical wire.

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