Jan. 31, 1961 E. J. DIDRICK 2,969,619

REINFORCED HOLLOW CONCRETE BUILDING PANEL

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Fig. 1.

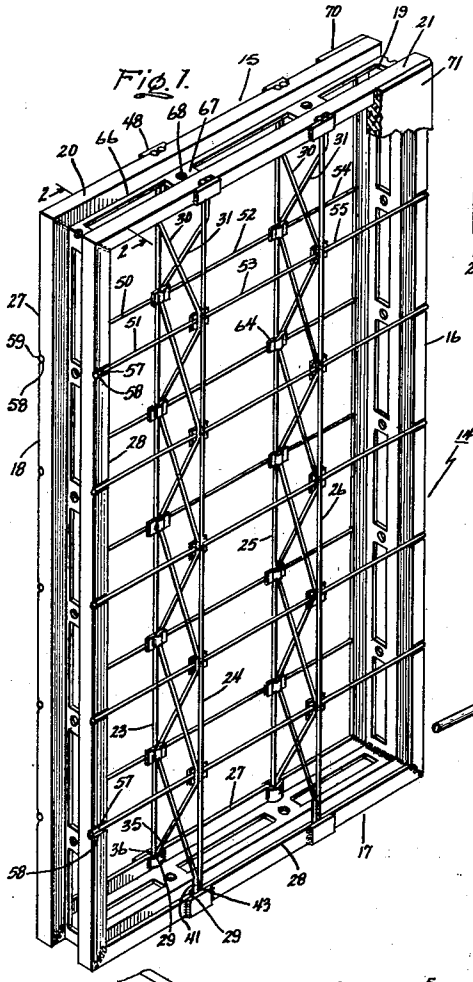


Fig. 2.

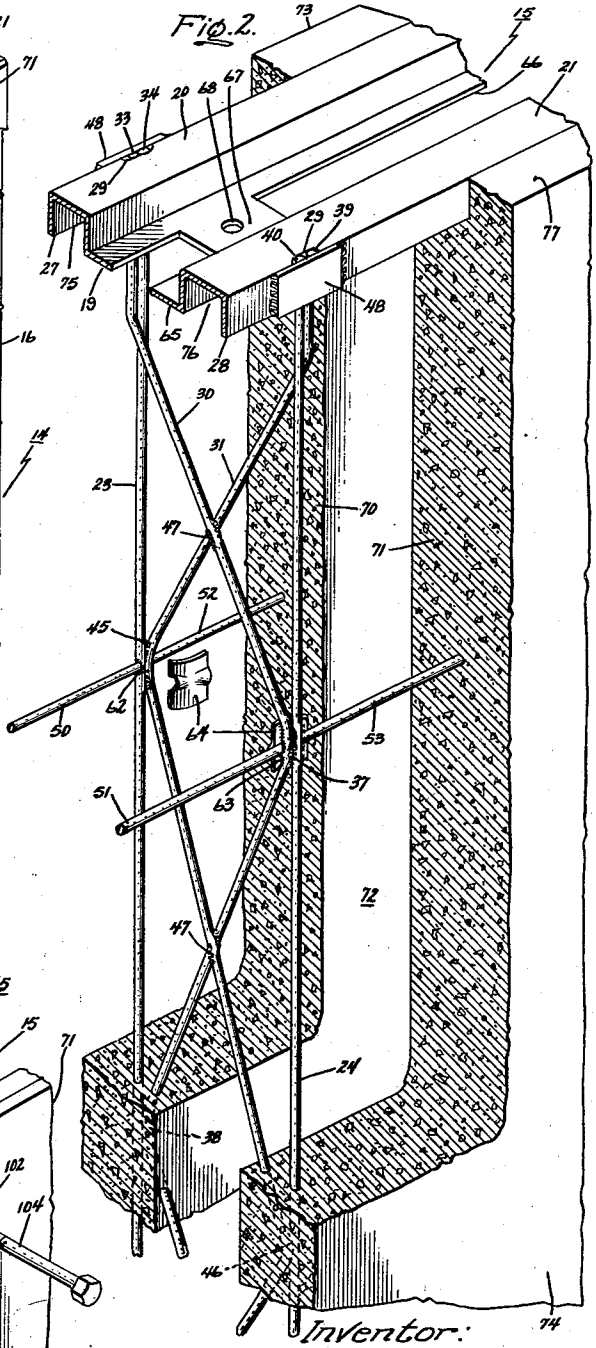
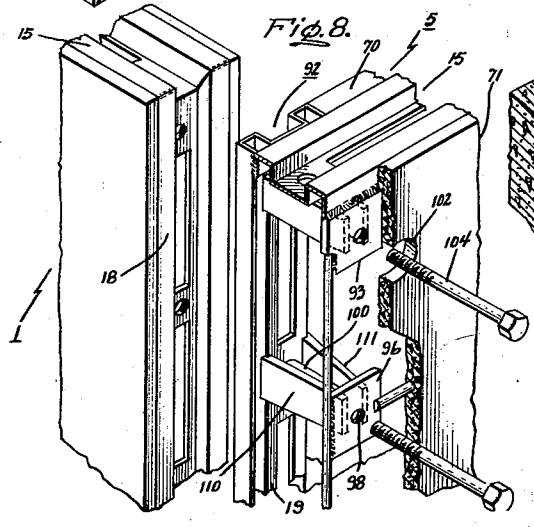


Fig. 8.



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REINFORCED HOLLOW CONCRETE BUILDING PANEL

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Fig. 15.

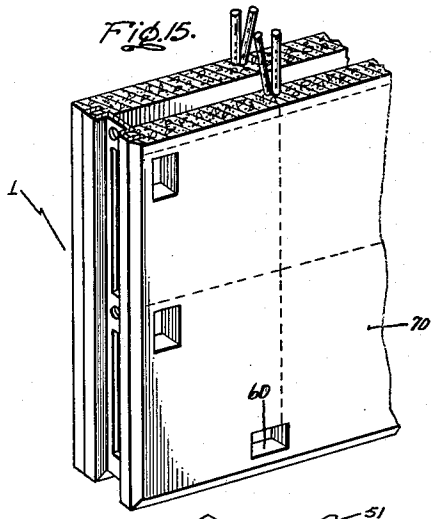


Fig. 14.

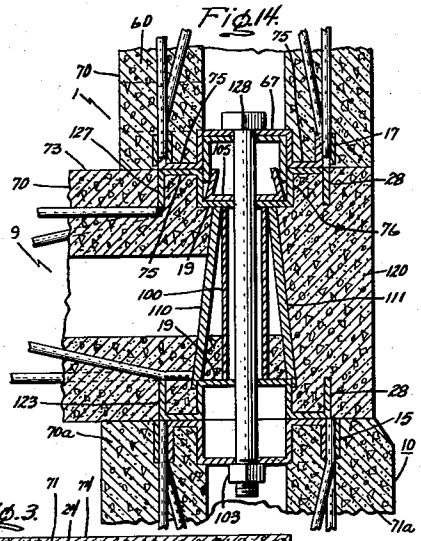


Fig. 9.

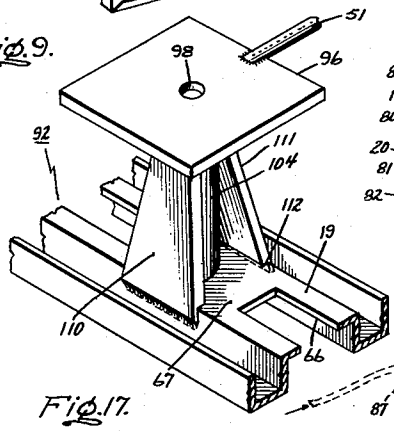


Fig. 3.

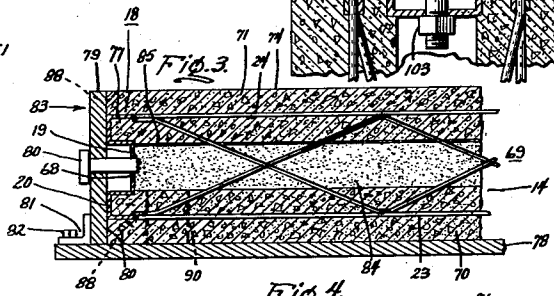


Fig. 4.

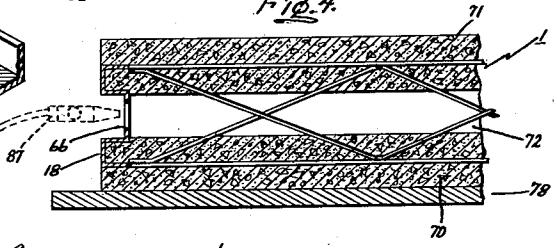
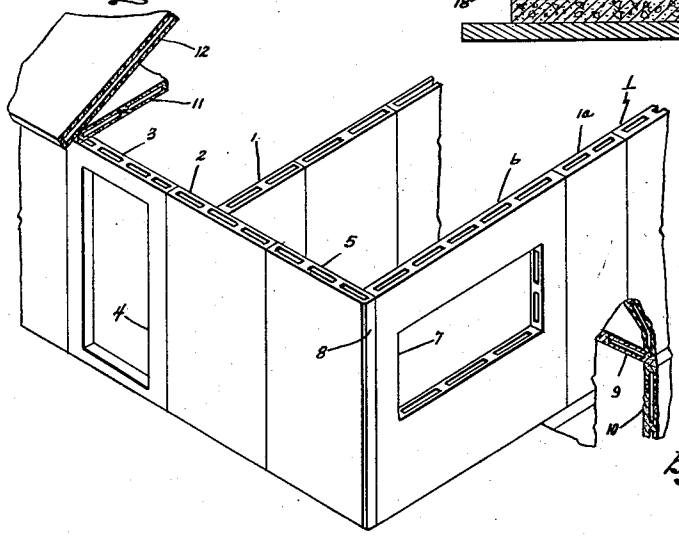


Fig. 17.



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REINFORCED HOLLOW CONCRETE BUILDING PANEL

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Fig. 5.

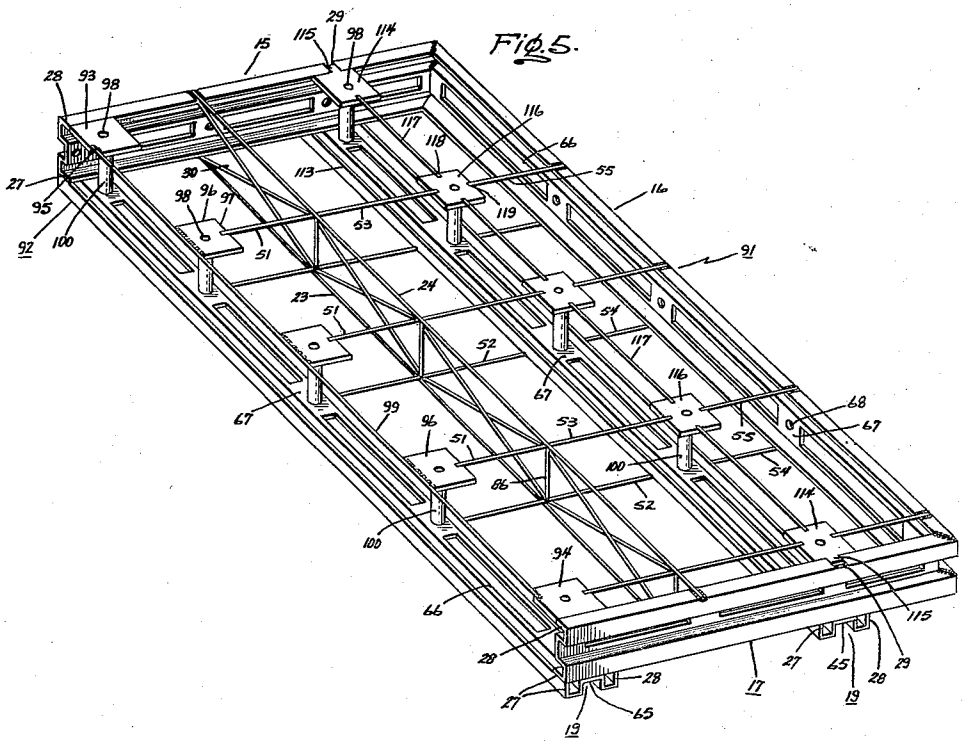
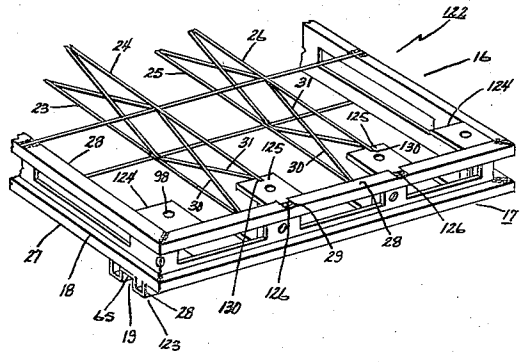


Fig. 11.



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REINFORCED HOLLOW CONCRETE BUILDING PANEL

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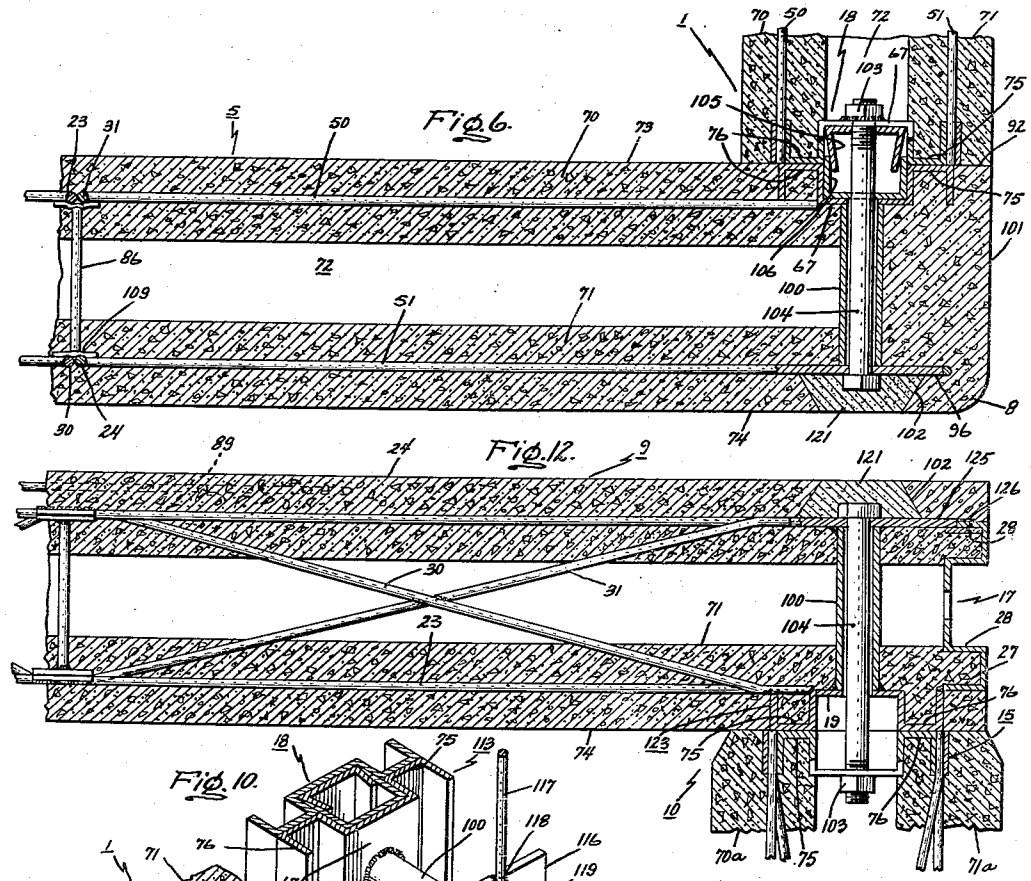


Fig. 6.

Fig. 12.

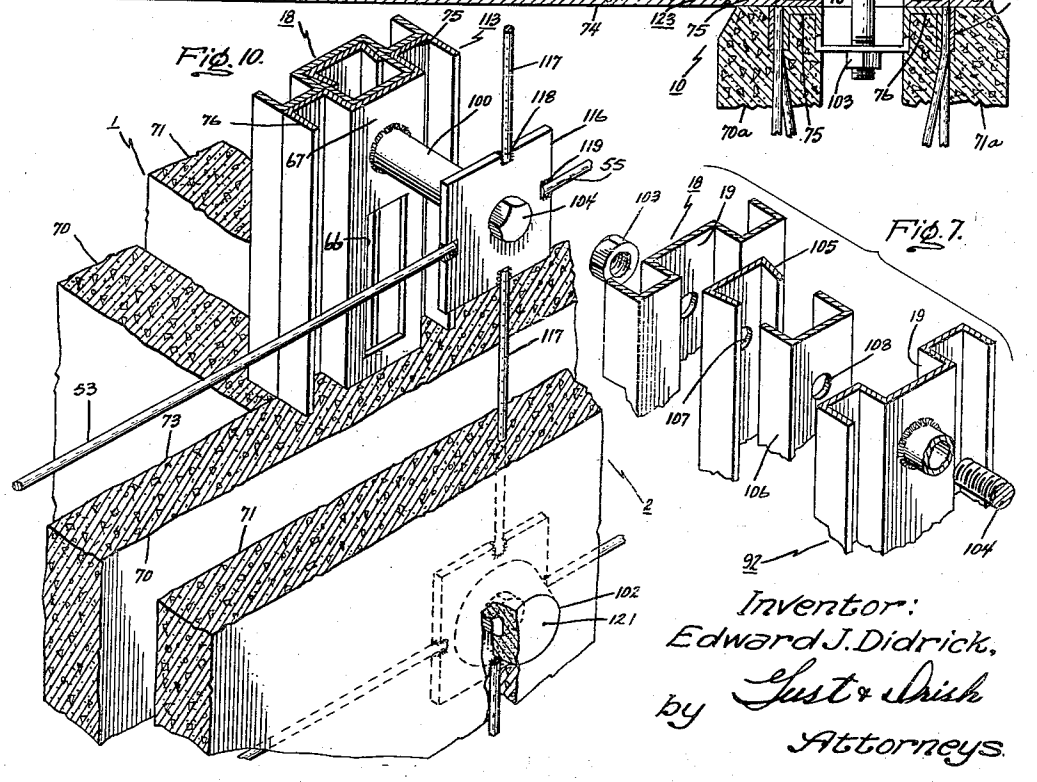


Fig. 10.

Fig. 7.

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REINFORCED HOLLOW CONCRETE BUILDING PANEL

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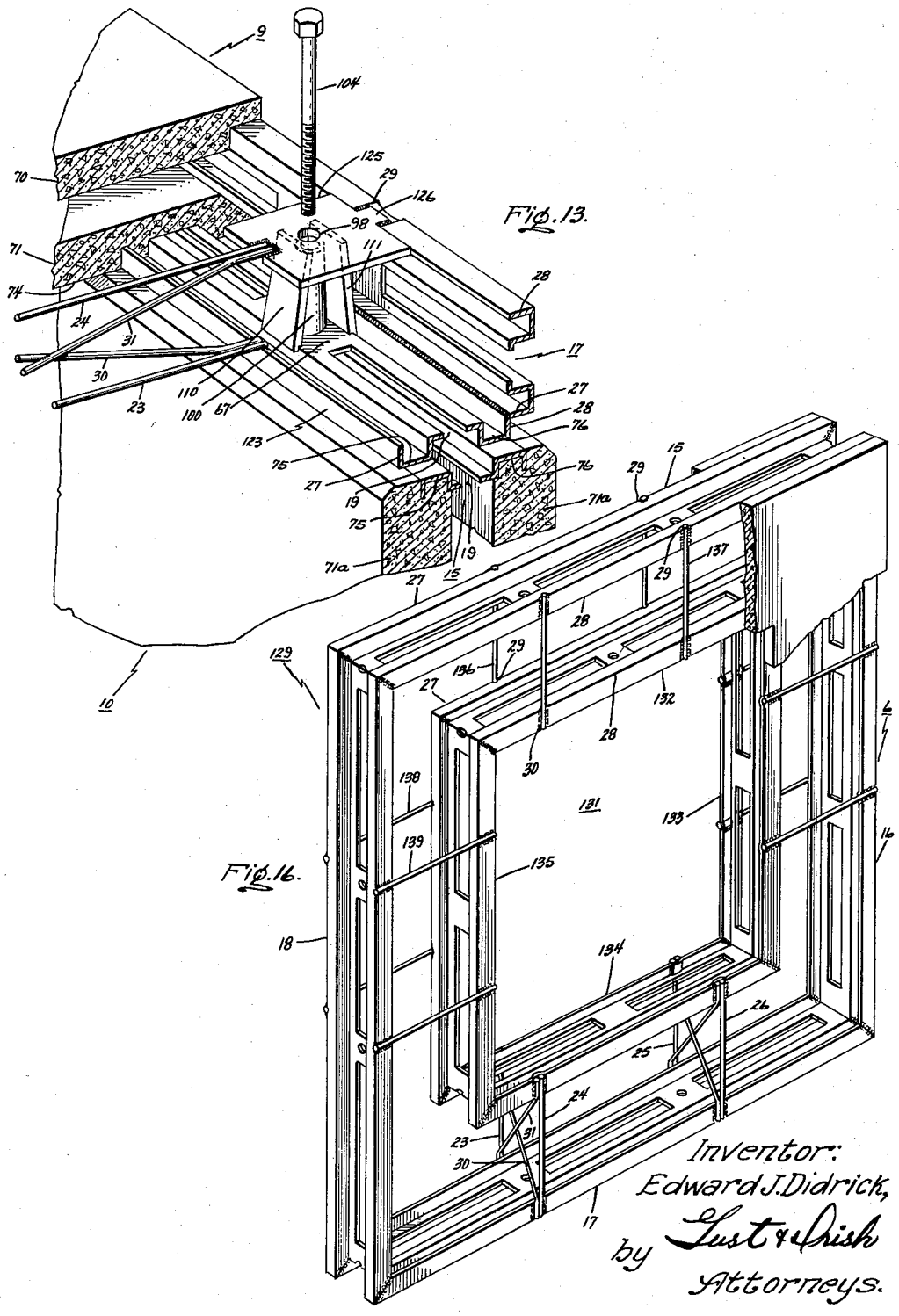


Fig. 13.

Fig. 16.

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REINFORCED HOLLOW CONCRETE BUILDING PANEL

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Fig. 19.

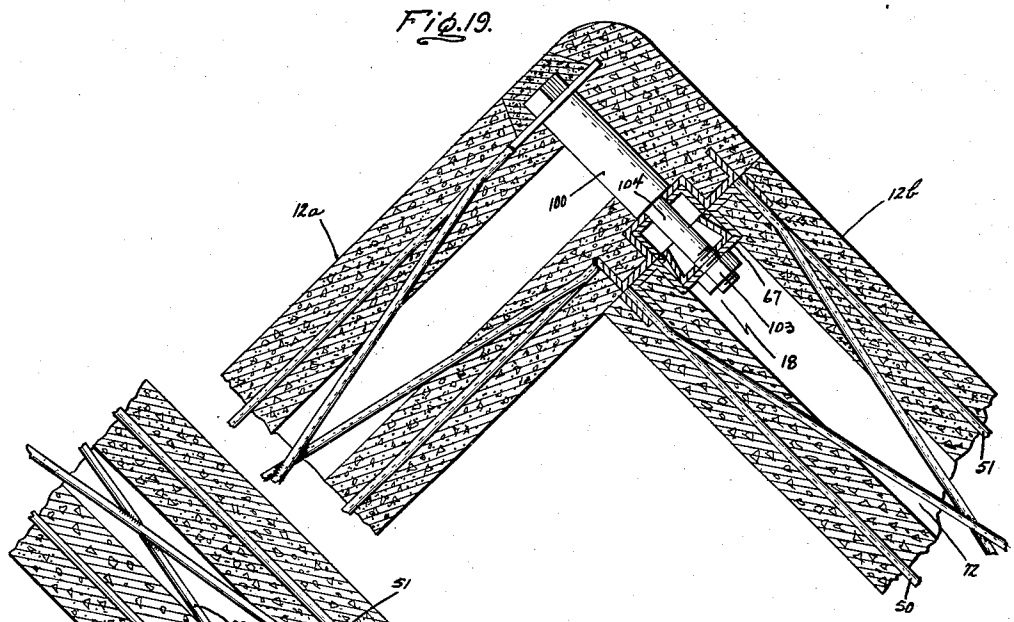
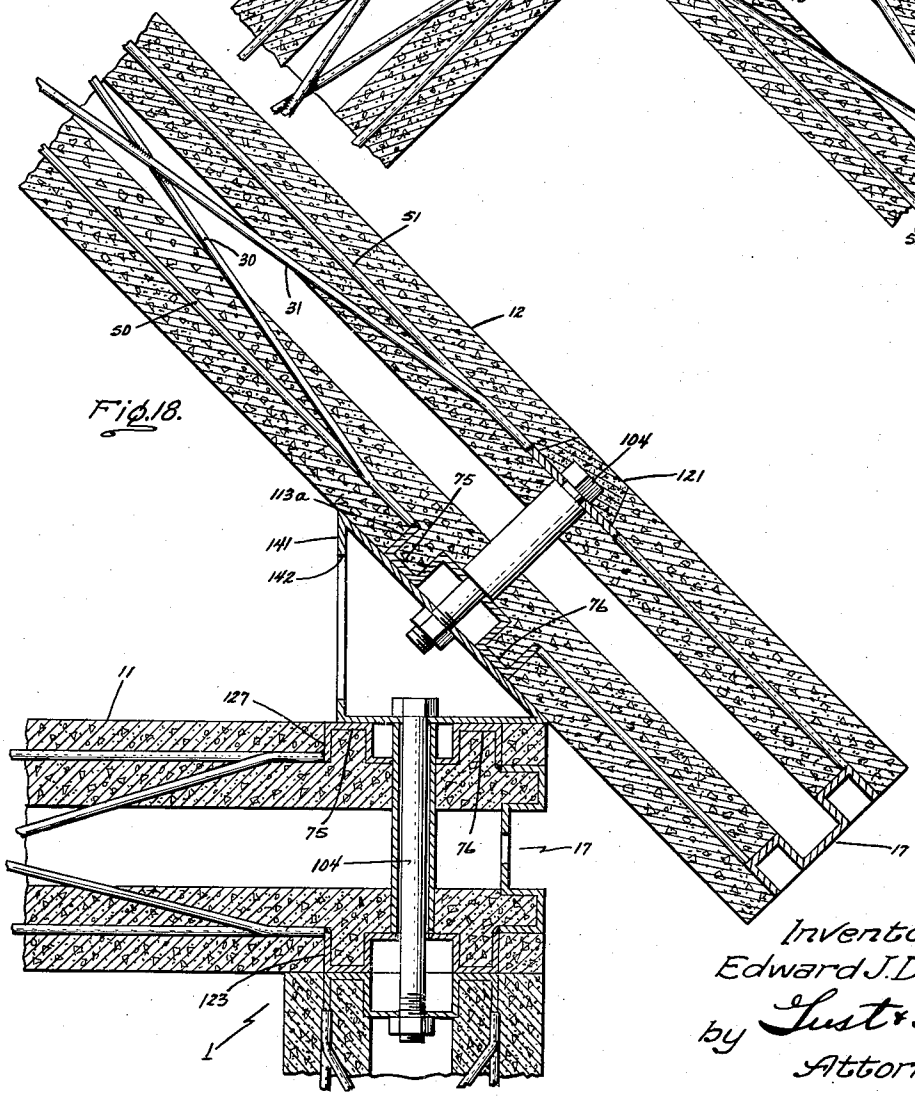


Fig. 18.



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2,969,619

REINFORCED HOLLOW CONCRETE BUILDING PANEL

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Filed Sept. 15, 1958, Ser. No. 761,209

11 Claims. (Cl. 50—437)

This invention relates generally to concrete panels employed in the construction of buildings and other structures, and more particularly to reinforced hollow concrete building panels which may be used for wall, floor, partition, foundation or roof elements and the like of buildings and to the interconnection of such panels to form a complete structure.

While reinforced hollow concrete building panels are well known in the art and to the present applicant, and while the use of such panels is potentially highly desirable in the construction of prefabricated buildings, both residential and commercial, prior panels known to the present applicant have been subject to numerous objections and so far as the present applicant is informed, no single panel construction has lent itself to utilization in all of the various types of panels necessary to assemble a complete building. For instance, while many hollow concrete building panels have been proposed, many such panels have not provided for intercommunication of the spaces between the slabs forming the walls of the panel, a highly desirable feature so far as heating, air conditioning, plumbing and wiring is concerned. Furthermore, the applicant is aware of no prior hollow concrete building panel construction providing simple means for rigidly interconnecting the panels at the installation site. Further, the reinforcing frame construction of many prior panels known to the present applicant has been exceedingly complex with a large number of different component parts being required to construct the different types of panels required for a complete building.

Therefore, it is desirable to provide a reinforced hollow concrete building panel construction in which panels of minimum weight and maximum strength are provided, the interslab spaces of each panel having maximum communication with the inter-slab spaces of adjacent panels. It is further desirable that such a panel construction provide for ready attachment at the installation site of one panel to another with the reinforcing frames of the panels requiring a minimum number of completely interchangeable components. It is of course highly desirable that such panels be readily constructed employing minimum material and labor and that they be readily transportable to the installation site, or in the alternative that they lend themselves to manufacture at the installation site.

It is accordingly an object of my invention to provide an improved reinforced hollow concrete building panel construction.

Another object of my invention is to provide an improved hollow concrete building panel construction in which maximum communication is provided between the inter-slab spaces of adjacent panels.

A further object of my invention is to provide an improved reinforced hollow concrete building panel construction in which the panels are readily interconnected.

A still further object of my invention is to provide an improved reinforced hollow concrete panel construction in which the reinforcing frame for each specific type of

panel required in a complete building is constructed of a minimum number of interchangeable components.

Further objects and advantages of my invention will become apparent by reference to the following description and the accompanying drawings, and the features of novelty which characterize this invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

My invention in its broader aspects provides a reinforced hollow concrete building panel having a rectangular metal reinforcing frame including elongated perimeter plate members respectively defining, i.e., bounding or outlining, at least three perimetral edges of the panel. First transversely spaced parallel elongated reinforcing means extend respectively between two opposite perimeter plate members and are secured respectively to opposite edges and elements are provided transversely interconnecting the first elongated means at spaced intervals. Second transversely spaced parallel elongated reinforcing means are provided extending at right angles to the first elongated means and respectively joining the same to frame means parallel with and spaced from the first reinforcing means and to opposite edges of the third perimeter plate member. The first and second elongated reinforcing means respectively lie in two transversely spaced parallel planes respectively substantially coextensive with the edges of the perimeter plate members and two transversely spaced planar slabs of concrete are provided having the first and second elongated means imbedded therein and respectively lying in planes generally coextensive with the planes of the elongated reinforcing means, the concrete slabs respectively terminating at the perimeter plate members. The perimeter plate members are preferably provided with spaced openings therein communicating with the space between the slabs and in the preferred embodiment of my invention, the perimeter plate members have a cross-sectional configuration formed by three interconnected channels with the middle channel facing outwardly and the outer two channels facing inwardly.

In the drawings:

Fig. 1 is a view in perspective showing the improved reinforcing frame construction for a basic wall panel in accordance with my invention;

Fig. 2 is a fragmentary view in perspective, partly broken away, further illustrating the basic wall panel construction of my invention;

Fig. 3 is a fragmentary side elevational view showing one step in the construction of reinforced hollow concrete building panels in accordance with my invention;

Fig. 4 is another fragmentary cross-sectional view showing another step in the construction of my improved panels;

Fig. 5 is a view in perspective showing the reinforcing frame construction in accordance with my invention for a composite panel including both corner and partition attaching arrangements;

Fig. 6 is a fragmentary cross-sectional view showing the attachment of two slabs in accordance with my invention to form an exterior corner;

Fig. 7 is a fragmentary view in perspective further illustrating the sealing arrangement employed in Fig. 6;

Fig. 8 is a fragmentary view in perspective illustrating a modified form of the construction of Fig. 6;

Fig. 9 is a fragmentary view in perspective further illustrating the construction of Fig. 8;

Fig. 10 is a fragmentary view in perspective illustrating the attachment of two panels in accordance with my invention to form a partition;

Fig. 11 is a fragmentary view in perspective of the reinforcing frame in accordance with my invention usable

in constructing a floor slab suitable for connection to a foundation slab;

Fig. 12 is a fragmentary cross-sectional view illustrating the assembly of a slab incorporating the frame construction of Fig. 11 with another slab in accordance with my invention;

Fig. 13 is a fragmentary view in perspective illustrating a modified form of the construction of Fig. 12;

Fig. 14 is a fragmentary cross-sectional view showing the connection of a floor slab with a lower foundation slab and an upper wall slab in accordance with my invention;

Fig. 15 is a fragmentary view in perspective further illustrating a method of attachment of certain slabs in accordance with my invention;

Fig. 16 is a fragmentary view in perspective illustrating the assembly of window or door casings as an integral element of the reinforcing frame in accordance with my invention;

Fig. 17 is a fragmentary view in perspective illustrating a portion of a building constructed with several types of slabs in accordance with my invention;

Fig. 18 is a fragmentary cross-sectional view illustrating the connection of a roof slab to the ceiling and wall slabs in accordance with my invention; and

Fig. 19 is a fragmentary cross-sectional view illustrating the connection of two roof slabs to form a roof peak in accordance with my invention.

Referring now momentarily to Fig. 17, a typical building constructed with my reinforced hollow concrete panels in accordance with my invention may, for example, comprise basic wall panels 1, panels 2 having basic wall panels 1 joined thereto so as to form a partition, panels 3 having a door opening 4 therein, panels 5 forming an exterior corner, panels 6 having a window opening 7 formed therein, the panel 6 being here shown as being joined to the panel 5 so as to form the exterior corner 8, floor panels 9 resting on foundation panels 10 and on which wall panels, such as a basic panel 1, in turn rest, ceiling panels 11 and roof panels 12. It will readily be seen that it is highly desirable that the hollow spaces in the interior of the various panels forming the building of Fig. 17 intercommunicate for heating, air conditioning, plumbing and wiring purposes, and it will readily be seen that it is necessary to provide means for readily interconnecting the several types of panels at the construction site.

Referring now to Figs. 1 and 2, there is shown a reinforcing frame construction 14 for a basic wall panel 1 as shown in Fig. 17. The reinforcing frame 14 is formed of four perimeter plate members 15, 16, 17 and 18 joined together at their corners, preferably by welding, to form a rectangle as shown. Each of the perimeter plate members 15 through 18 has its cross-section formed by three interconnected channels 19, 20 and 21, the middle channel 19 facing outwardly and the outer channels 20 and 21 facing inwardly, i.e., toward the interior of the frame 14.

In the illustrated reinforcing frame 14 of Figs. 1 and 2, two pairs of transversely spaced apart vertical elongated reinforcing rod elements 23 and 24, and 25 and 26 are provided extending between opposite perimeter plate members 15 and 17. The outer flanges 27 and 28 of the outer channels 20 and 21 forming perimeter plate members 15 and 17 are preferably provided with transversely aligned, longitudinally spaced apart recesses 29 with the ends of the elongated rod members 23 through 26, inclusive, being respectively seated therein and secured thereto in any suitable manner, as by welding.

The elongated vertical rod elements 23 and 24, 25 and 26, are maintained in their transversely spaced apart parallel relationship by criss-cross elongated rod elements 30 and 31. Considering first the elongated rod element 30, it will be seen that its one end 33 is seated in recess 29 in flange 27 of the perimeter plate member 15 beside end 34 of vertical rod element 23 and that its other end 35 is seated in a corresponding recess 29 in flange 27 of perimeter plate member 17 beside the other end of vertical rod element 23. The portion of rod element 30 intermediate of its two ends 33 and 35 is carried back and forth between vertical rod elements 24 and 23 as shown, so that a first part 37 of rod element 30 at a point spaced from end 33 thereof abuts a side of vertical rod element 24, a next part 38 evenly spaced from part 37 abuts a side of vertical rod 23 and so on. Likewise, rod 31 has its one end 39 seated in recess 29 in flange 28 of perimeter plate member 15 beside end 40 of vertical rod element 24 with its other end 41 being seated in corresponding recess 29 in flange 28 of perimeter plate member 17 beside end 43 of vertical rod member 24. Intermediate portions of elongated rod 31 are likewise carried back and forth between elongated vertical rods 23 and 24 so that part 45 of rod 31 in transverse alignment with part 37 of rod 30 abuts a side of vertical rod 23, part 46 in transverse alignment with part 38 of rod 30 abuts a side of vertical rod 24 and so on. Thus, it will be seen that rods 30 and 31 cross, as at points 47 intermediate their parts 45 and 46, etc., and 37 and 38, etc., which abut the elongated vertical rods 23 and 24 at equally spaced intervals. The ends of the vertical elongated rods 23 and 24 and the criss-cross rods 30 and 31 may be retained in the recesses 29 in flanges 27 and 28, respectively of perimeter plate members 15 and 17 by gusset plates 48 secured to outer flanges 27 and 28 in any suitable manner, as by welding, as shown.

A plurality of pairs of horizontal transversely spaced apart parallel elongated rod elements are provided, each such pair comprising rod elements 50 and 51, 52 and 53 and 54 and 55. Considering first rod elements 50 and 51, it will be seen that end 57 of rod element 51 is seated in recess 58 in flange 28 of perimeter plate member 18 with end 59 of horizontal rod 50 likewise being seated in recess 58 in flange 27 of perimeter plate member 18, the ends 57 and 59 of rods 50 and 51 being respectively secured within the recesses 58 in a suitable manner, as by welding. It will readily be seen that the recesses 58 in common with rods 50 and 51 are in transverse alignment. The other end 62 of rod 50 is arranged abutting the side of vertical rod 23 adjacent its junction with part 45 of rod 31 while the other end 63 of rod 51 abuts part 37 of rod 30, ends 62 and 63 of rods 50 and 51 being respectively secured to vertical rod 23 and part 37 of rod 30 in any suitable manner, as by welding. It will likewise be seen that horizontal rod elements 52 and 53 extend respectively between vertical rod elements 23, 24 on the one hand and 25, 26 on the other hand in the same manner, being respectively secured thereto and likewise, that horizontal rod elements 54 and 55 extend between vertical rod elements 25 and 26 and flanges 27 and 28 of perimeter plate member 14, as shown. The vertical, horizontal and criss-cross rod elements may be more firmly secured together at their respective junctions by gusset members 64 welded thereto as shown; gusset members 48 and 64 may not be required in many constructions.

The web portions 65 of the middle channels 19 of the perimeter plate members 15 through 18 are respectively provided with a plurality of elongated openings 66 formed therethrough, as shown, the openings 66 being spaced apart by web sections 67 in transverse alignment respectively with vertical rod elements 23, 24 and 25 and 26 in the case of plate members 15 and 17, and horizontal rod elements 50 through 55 in the case of plate members 16 and 18. Each of the web sections 67 of plate members 15 through 18 in turn has a central opening 68 formed therein for a purpose to be hereinafter described.

It will now be seen that the vertical rod elements 24 and 26, the horizontal rod elements 51, 53 and 55, and the flanges 28 of the perimeter plate members 15 through 18 lie generally in one plane whereas the other vertical rod elements 23 and 25 and horizontal rod elements 50, 52 and 54 together with the flanges 27 of perimeter plate members 15 through 18 lie in another plane transversely spaced from the first plane.

A pair of transversely spaced apart planar concrete slabs **70** and **71** are provided respectively lying in the same planes as vertical rod elements **23** and **25** and horizontal rod elements **50**, **52** and **54** on the one hand, and vertical rod elements **24** and **26** and horizontal rod elements **51**, **53** and **55** on the other hand. It will be seen that the vertical rod elements **23**, **25** and the horizontal rod elements **50**, **52** and **54** are imbedded in the slab **70** while the vertical rod elements **24** and **26** and the horizontal rod elements **51**, **53** and **55** are imbedded in the other slab **71**. It will further be seen that the width of the web portion **65** of the middle channel **19** of the perimeter plate members **15** through **18** is substantially the same as the space **72** between the two slabs **70** and **71** and that the outer faces **73** and **74** of the slabs **70** and **71** respectively extend outwardly from the planes of the flanges **27** and **28** of the perimeter plate members **15** through **18**. It will lastly be observed that the concrete slabs **70** and **71** have their edges terminating at and defined by the web portions **75** and **76** of the outer channels **20** and **21** of perimeter plate members **15** through **18** and that the outer flanges **27** and **28** thereof are respectively imbedded in the edges of slabs **70** and **71**.

It will now be seen that the elongated openings **66** in the web portions **65** of the perimeter plate members **15** through **18** communicate with the space **72** between the slabs **70** and **71** so that when two basic wall panels **1** are arranged in edge-to-edge relationship, as shown in Fig. 17, their respective inter-slab spaces **72** between their respective concrete slabs **70**, **71** are in communication for air conditioning, heating, plumbing and electrical wiring purposes. It will be seen that the edges of the slabs **70** and **71** adjacent web portions **75** and **76** of the channels **20** and **21** may be bevelled if desired, as at **77**. The central openings **68** in the web sections **67** intermediate the elongated web openings **66** are employed for securing adjacent panels together as will be hereafter more fully described.

A typical basic interior wall panel in accordance with my invention has an outside dimension four feet by eight feet and a thickness of six inches, each slab **70** being two inches thick and the intermediate space being two inches wide. The perimeter plate members **15** through **18** in such a typical wall panel are preferably formed of one-eighth (⅛) inch cold rolled steel four and one-eighth (4⅛) inches wide and one (1) inch high and the various rod elements may be formed of conventional one-half (½) inch reinforcing steel rod. In such a typical interior wall panel, the vertical rod elements **23** and **24** and **25** and **26** are each spaced from the outer surfaces of channels **20** and **21** of perimeter plate members **16** and **18** by sixteen (16) inches and from each other by sixteen (16) inches, i.e., a total of forty-eight (48) inches while each pair of horizontal rod elements comprising rod elements **50** through **55** are spaced from channels **20** and **21** of perimeter plate members **15** and **17** and from each other by sixteen (16) inches, a total of ninety-six (96) inches, or eight (8) feet.

Turning now to Figs. 3 and 4, in fabricating my improved reinforced hollow concrete building panel, the reinforcing frame **14** is first assembled and welded together in the form shown in Fig. 1, it being observed that the only stock required is the triple-channel steel from which the perimeter plates **15** through **18** are formed, conventional steel reinforcing rods, and small metal plates for the gussets **48** and **64**, if necessary. The frame assembly **14** is then placed in a jig **69** having a smooth bottom plate **78** formed of suitable material, such as steel, plates **79** cooperating with the perimeter plate members **16** and **18** (only one being shown) and corresponding plates cooperating with the perimeter plate members **15** and **17** (not shown). The frame **14** is retained within the jig by means of suitable pins **80** extending through the openings in the plates **79** of the jig (and also in the other plates of the jig), the pins **80** projecting into the openings **68** in the web sections **67** of the plate members **15**, **16**, **17** and **18** of the frame **14**, and thus retaining frame **14** in the position shown in Fig. 3, suitably spaced from the bottom plate **78**.

The plate **79** abutting and supporting perimeter plate member **18** and its counterpart (not shown) abutting and supporting the opposite perimeter plate member **16** are preferably adjustably mounted on the bottom plate **78** in any suitable manner, as by brackets **81** and bolts **82**. With frame **14** in position as shown in Fig. 3, plate **79** may be moved inwardly in the direction shown by the arrow **83** with the bolts **82** then being secured in order to prestress the elements comprising the frame **14**. It will be readily understood that compensating outward movement of the plates abutting and supporting the perimeter plate members **15** and **17** may be necessary. It will be observed that compressing the vertical perimeter plates **16** and **18** results in placing the horizontal rod elements **52** and **55** in compression and the vertical rod elements **23** through **26** in tension. Securing the plate **79** of the jig and its opposite counterpart in the position to compress frame **14** by means of bolts **82** retains the frame **14** in its prestressed condition while the cement forming the slab **71** is poured and allowed to set.

Plumbing, heating and electrical components as required by the building plan may now be installed in the frame **14**. The layer of cement forming slab **70** is then poured into the jig to the level shown, i.e., to the inner flange of channel **20**, i.e., the lower flange of the middle channel **19**. This cement is allowed to set and a layer **84** of foundry sand is then poured on top of the slab **70** to the level of the upper flange of the middle channel **19**, as shown, the layer **84** being tamped until it is solid. A sheet **85** of thin transparent plastic is then laid down over the layer of sand **84**, the sheet **85** being severed or slit to accommodate the criss-cross reinforcing members **30** and **31**; this plastic sheet **85** in the resultant structure forms a vapor barrier. Finally, the concrete forming slab **71** is poured to the desired level as defined by the height of the plate **79** and its counterparts.

It will now be readily seen that after my improved panel has been removed from the jig in which it was formed, the prestressed tension applied to the vertical elongated rod elements **23** through **26** results in the slabs **70** and **71** being placed in compression. It will be observed in instances when my panel **1** is vertically arranged, any tendency for the slabs **70** and **71** to bulge outwardly under their own weight is resisted by the criss-cross reinforcing rods **30** and **31**. In other instances, such as in the lower walls of two story constructions or floor panels, it may be found desirable to add transverse spacing elements between vertical rod elements **23** and **24**, and **25** and **26**, such spacers **86** disposed at the junctions of rod elements **23** and **24**, **25** and **26** with the horizontal rod elements **50** through **55** and the criss-cross rod elements **30** and **31** being shown for example in Fig. 5; where spacer bars **86** are used, gussets **64** will be retained with a small recess **109** therein for seating bars **86**.

It will now be seen that the smooth bottom plate **78** forms an extremely smooth outer face on the slab **70** and that the outer face **74** of the slab **71**, being exposed, can have exterior design troweled therein before the concrete has set or brick or stone veneer can also be applied to the outer face of the lower slab **71** before setting; if no decorative finish is desired, outer face **74** may be troweled smooth with conventional techniques.

After the concrete forming the slab **71** has set, the pins **80** are removed, the plates **79** are removed, and with the panel **1** still resting on the bottom plate **78** of the jig, the sand layer **78** is exhausted from between the concrete slabs **70** and **71** through the openings **66** in the perimeter defining plate members **15** through **18**, as by means of an air hose, shown in dashed lines at **87**. The concrete slabs **70** and **71** may then be steam cured, if desired,

through the openings 66 in the plate members 15 through 18. The bottom plate 78 of the jig is then raised from its horizontal position shown to a vertical position, and the finished panel 1 is removed from the bottom plate 78 and carried in vertically suspended fashion by means of suitable hooks engaging the openings 66 and/or 68 in the perimeter plate member 15 of frame 14. It will be understood that granular insulating material may be employed in lieu of sand, such material being left between slabs 70 and 71. The term "hollow" as herein employed thus contemplates presence of insulating material in space 72 between slabs 70 and 71.

It will be readily understood that the beveled edge 77 on the slab 71 may be troweled in after the concrete has been poured, as shown in dashed lines in Fig. 3, and that the corresponding beveled edge around the perimeter of the slab 70 may be formed by placing suitable triangular members around the bottom plate 78 of the jig in abutment with the plates 79, as shown by the dashed lines at 88. In instances where my improved panel construction, of the type shown in Figs. 1 through 4, is employed as a foundation wall, or for any other reason additional strength is needed, it is merely necessary to increase the thickness of the slabs 70 and 71, the intermediate space 20 remaining the same but the extent to which the outer faces of the slabs are spaced from the planes of the flanges 27 and 28 of the perimeter plate members 15 through 17 being suitably increased. It may also be desirable in instances where the panel 1 is employed as a floor slab to lay down reinforcing steel mesh after the slab 71 has been partially poured, as suggested in dashed lines at 89 in Fig. 12.

Referring briefly to Fig. 15, it may also be desirable to cast suitable openings 60 in one of the slabs, such as slab 70, the openings 60 providing interior access to openings 68 in middle channel 19 of the perimeter plate members 15 through 18 so that two adjacent slabs 1 may be bolted together in edge-to-edge abutting relationship (as shown in Fig. 17) by means of suitable bolts passed through the respective mating openings 68 in each slab. Openings 60 may conveniently be formed by merely placing suitable cores on the bottom plate 78 of the jig, as shown in dashed lines at 90 in Fig. 3. Openings 60 not only serve to provide access for bolting adjacent panels together, but further serve to accommodate electrical outlets, plumbing, or heating and air conditioning outlets, etc. Following installation, unused openings 70 may be grouted-in. In the alternative, the connecting bolts may be manipulated through the openings 66 in the top plate member 15 by use of a suitable elongated wrench member.

Referring now briefly again to Fig. 17, it will be observed that the simple basic wall panel 1 hereinbefore described is not completely suitable for forming an exterior corner, shown as being formed by the panels 5 and 6 in Fig. 17, since here, it is not desirable to have an exposed perimeter plate member with its openings 66 communicating with the space intermediate the concrete slabs 70 and 71; it is necessary in this case that a solid concrete end or corner 8 be provided as shown. In order to provide such an exterior corner, reference will now be had to Figs. 5, 6, 7, 8 and 9 in which like elements are indicated by like reference numerals. Fig. 5 shows a reinforcing frame 91 for a panel in accordance with my invention for forming both an exterior corner and an interior partition. Frame 91 here comprises perimeter plate members 15, 16 and 17 identical in form to those employed in the panel 1 hereinabove described. The fourth perimeter plate member 18 has, however, been eliminated and a corner plate member 92 provided having the same cross-sectional configuration as the perimeter plate members 15, 16 and 17, plate member 92 extending between perimeter plate members 15 and 17 adjacent their ends remote from perimeter plate member 16 and abutting one respective side edge of each. More particularly, the plate member 92 has the web portion 65 of its middle channel 19 disposed in abutting relationship with the outer flanges 27 of perimeter plate members 15 and 17, i.e., with the middle channel 19 facing outwardly, the edges of flanges 27 and 28 of plate member 92 likewise abutting flanges 27 of perimeter plate members 15 and 17, as shown.

A pair of plate elements 93 and 94 are provided respectively abutting the edges of flanges 28 of perimeter plate members 15 and 17, the plate elements 93 and 94 thus being transversely spaced from and parallel with the plate member 92. An elongated rod element 99 extends between plate elements 93 and 94, being seated in recesses 95 formed in the edges thereof and secured thereto, as by welding. Elongated rod element 99 is thus transversely spaced from and parallel with the corner plate member 92. A plurality of other plate elements 96 are provided at evenly spaced intervals, plate elements 96 having their edges secured to the side of elongated rod element 99, as by welding, as shown. Horizonal rod elements 51 respectively join plate elements 96, being seated in recesses 97 in the edges thereof opposite from elongated rod 99, being secured thereto, as by welding. Horizontal rod elements 50 are respectively secured to the edge of flange 28 of plate member 94 and to the corner of its middle channel 19, as by welding, as best seen in Fig. 6.

Each of the plate elements 93 and 94 and 96 has a central opening 98 formed therein respectively in alignment with openings 68 in web sections 67 of corner plate member 92. A plurality of tubes 100 respectively connect the web sections 67 of plate member 92 and the plate elements 93, 94 and 96, tubes 100 having their central openings in alignment with the openings 98 in the plate elements 93, 94 and 96 and openings 68 in web sections 67 of plate member 92.

Referring now particularly to Fig. 6, when the frame 91 arranged for forming an exterior corner is cast, interior plate members are provided on the jig 69 (not shown) in order to form an integral section 101 of concrete joining slabs 70 and 71 and forming the fourth perimetral edge of a panel, corner 8 being suitably formed as desired. In addition, suitable openings 102 are provided in the exterior face 74 of slab 71 communicating with openings 98 in the plate elements 93, 94 and 96. It will be seen that as cast, the corner plate member 92 has the web portions 75 and 76 of its channels 20 and 21 respectively flush with the outer surface 73 of slab 70.

In order to join a basic panel 1 to my exterior-corner forming panel 5 thus far described, a plurality of suitable nuts 103 were provided abutting the inner surface of web sections 67 of perimeter plate member 18 of panel 1 respectively in alignment with the openings 68 therein and secured thereto, in any suitable manner, as by welding as shown; nuts 103 must obviously be secured to the web sections 67 prior to pouring of the concrete slabs 70 and 71 of panel 1. Panel 1 is then arranged with its vertical perimeter plate member 18 (or 16, as the case may be) parallel with and abutting corner plate member 92 of corner panel 5, i.e., with its web portions 75 and 76 of its channels 20 and 21 respectively abutting the corresponding web portions 75 and 76 of corner plate member 92 of corner panel 5. Suitable bolts 104 are then respectively passed through openings 98 in plate elements 93, 94 and 96 and the respective tubes 100 and openings 68 in web sections 67 of plate member 92, being still further passed through the respective openings 68 in the web sections 67 of perimeter plate member 18 of panel 1 and threaded into nuts 103 thereby to secure panel 1 and corner panel 91 in tight engagement, as shown.

It may be desirable to provide sealing means at the junction of panel 1 and corner panel 5 (or for that matter at the junctions of two basic panels 1) and for this purpose, as additionally seen in Fig. 7, a pair of elongated interlocking channel elements 105 and 106 are provided

disposed within the middle channels 19 of the cooperating plate members 92 and 18, as shown. It will be observed that the interlocking channel members 105 and 106 are provided with aligned openings 107 and 108 to accommodate the bolts 104. It will further be seen that the flanges of channel 105 are bent inwardly so as to fit within the flanges of the channel 106 and thus, as the bolts 104 are tightened within the nuts 103, a wedging action takes place to provide a tight seal.

Referring now particularly to Figs. 8 and 9 in which like elements are still indicated by like reference numerals, in addition to the tubes 100 respectively interconnecting plate elements 93, 94 and 96 and plate member 92 of Figs. 5 and 6, it may be desirable to provide a pair of strut members 110 and 111 respectively joining each of the plate elements 93, 94 and 96 to the corners of the middle channel 19 of the plate member 92, on either side of the tube 100, as shown. Strut members 110 and 111 respectively have one end secured to the respective plate element 93, 94 and 96 on either side of the tube 100, as by welding, with their other ends being grooved, as shown at 112 so as to in effect "sit" on the corners of middle channel 19, being welded thereto, as shown. I prefer the use of struts 110 and 111, particularly on exterior corners, in order to prevent collapse of channel 19, due to excessive tightening of bolts 104.

Referring now again to Fig. 5 in conjunction with Fig. 10, it will be seen that the arrangement in accordance with my invention for joining a panel 1 to a panel 2 so as to form a partition (as shown in Fig. 17), is very similar to that described above for providing an exterior corner. Referring now specifically to Fig. 5, it will be seen that the reinforcing frame 91 is provided with another plate member 113 extending between the perimeter plate members 15 and 16 intermediate their ends and parallel with perimeter plate member 16, plate member 113 abutting and being secured to the respective edges of the plate member 16. More specifically, in common with plate member 92, plate member 113 has the same triple channel cross-sectional configuration as the other plate members previously described, and has the web portion 65 of its middle channel 19 arranged abutting flanges 27 of perimeter plate members 15 and 16, the edges of outer flanges 27 and 28 of plate member 113 likewise abutting flanges 27 of perimeter plate members 15 and 17.

Here, plate elements 114 are disposed with edges respectively abutting flanges 28 of perimeter plate members 15 and 17 in transverse parallel alignment with the plate member 113. Plate elements 114 may be provided with projections 115 seated in and respectively welded to depressions 29 in flanges 28. Other plate elements 116 are again provided in equally spaced apart relationship, being transversely spaced and parallel with the plate member 113. Here, plate elements 114 and 116 are vertically interconnected by vertical elongated rod elements 117 extending in transversely spaced parallel relationship with plate member 113 and being respectively seated in corresponding notches 118 in the plate elements 114 and 116 and being secured thereto by welding. Likewise, horizontal rod elements 53 and 55 are joined to plate elements 116, being seated in notches 119 and secured thereto by welding. The corresponding horizontal rod elements 52 and 54 are secured to the edges of flanges 27 and 28 and to middle channel 19 of plate member 113, in the manner shown for instance in Fig. 6. The plate elements 114 and 116 again have central openings 98 formed therein and again, tubes 100 respectively interconnect plate elements 114 and 116 with web sections 67 of plate member 113 being respectively in alignment with the openings 98 in the plate elements 114 and 116 and the openings 68 in the web sections 67. It will, of course, be readily appreciated that the strut members 110 and 111 and the construction shown in Figs. 8 and 9 may be employed in addition to the tubes 100 extending between plate member 113 and plate elements 114 and 116.

Reference to Fig. 10 will now readily reveal that in common with the corner panel construction, the web portions 75 and 76 of channels 20 and 21 respectively of plate member 113 are flush with the surface 73 of slab 70. A basic panel 1 is thus attached to the panel 2 to form a partition in identically the same manner as the attachment of the corner panel 5 thereto. Wall panel 1 is thus arranged with its perimeter plate member 18 (or 16, as the case may be) in abutment with the plate member 113 of the partition panel 2, web portions 75 and 76 of plate member 18 again respectively abutting plate portions 75 and 76 of the plate member 113 with bolts 104 securing panels 1 and 2 together. It will be observed that in both the corner and partition panel joining arrangements, the openings 102 in face 74 of concrete slab 71 may, if desired, be grouted in after assembly, as at 121.

Referring now to Figs. 11, 12 and 13, in which like elements are still indicated by like reference numerals, the construction of a floor slab 9 for attachment to a foundation slab 10 (Fig. 17) will be described, the mechanical arrangement for effecting this attachment being very similar to that described above in connection with the formation of exterior corners and partitions. Here, with particular reference to Fig. 11, the reinforced frame assembly 122 has a plate member 123 extending between the vertical perimeter plate members 18 and 16 adjacent their junctions with the horizontal perimeter plate member 17, plate member 123 being secured to the respective edges of perimeter plate members 18 and 16. More specifically, plate member 123, which takes the same triple channel form as the other plate members, has its web portion 65 of its middle channel 19 abutting flanges 27 of the vertical plate members 18 and 16, the edges of the flanges 27 and 28 of channel 123 likewise abutting flanges 27 of plate members 18 and 16. As will be most clearly seen by reference to Figs. 12 and 13, the edge of flange 28 of plate member 123 abuts flange 27 of perimeter plate member 17 with a right angle relationship, being preferably secured thereto as by welding, as shown.

Here, a pair of plate elements 124 are provided respectively arranged in the corners defined by and abutting flanges 28 of perimeter plate members 17 and 18 on the one hand and 17 and 16 on the other hand, and other plate elements 125 are provided having projections 126 seated in and secured to recesses 29 in flange 28 of perimeter plate member 17. It is thus seen that the plate elements 124 and 125 are transversely spaced from and parallel with the plate member 123. Plate elements 124 and 125 respectively have central openings 98 formed therein in alignment with openings 68 in web sections 67 of plate member 123 and, in common with the exterior corner and partition panel constructions, plate elements 124 and 125 are respectively connected to web sections 67 of plate member 123 by tubes 100 respectively in alignment with the openings 98 and 68. The vertical rod elements 24 and 26, and criss-cross rod elements 31 have their ends respectively seated in notches 130 in plate elements 125, being secured thereto, and the other vertical rod elements 23 and 25 and criss-cross rod elements 30 have their ends respectively secured to flange 27 of plate member 123, as best seen in Fig. 13. Reference to Fig. 13 will further reveal that the strut members 110 and 111 of Figs. 8 and 9 may be used along with the tubes 100 in the panel 9 of Figs. 11, 12 and 13.

As best seen in Figs. 12 and 13, after the panel 9 has been cast as previously described, it will be observed that again the web portions 75 and 76 of the channels 20 and 21 of the plate member 123 are flush with the face 74 of concrete slab 71. Floor panel 9 may then be joined to a foundation panel 10 (identical with the basic wall slab 1, however, having thicker concrete slabs 70*a* and 71*a*) in the same manner as the junction of wall panel 1 and exterior corner panel 5 or wall panel 1 and partition panel 2. More specifically, web portions

75 and 76 of plate member 123 of floor panel 9 are arranged abutting the corresponding web portions 75 and 76 of horizontal perimeter strap member 15 of foundation panel 10, the two panels 9 and 10 being secured together again by means of bolts 104 extending through openings 98 in plate elements 124 and 125, through tubes 100, openings 68 in web section 67 of plate member 123, and openings 68 in section 67 of perimeter plate member 15 threadingly to engage nuts 103 secured thereto prior to casting of panel 10. If desired, the sealing arrangement of Fig. 7 may be included in the spaces defined by the middle channel 19 of plate member 123 of panel 9 and perimeter plate member 15 of panel 10.

Referring now briefly to Fig. 14 in which like elements are again indicated by like reference numerals, a construction is shown in which a floor panel 9 may be secured to a foundation panel 10 and in turn have a wall panel 1 secured to the upper face 73 of its slab 70. Here, the plate elements 124 and 125 of Figs. 11, 12 and 13 are eliminated and replaced by another plate member 127 arranged identically to the plate member 123 but extending between flanges 28 of plate members 18 and 16. Plate member 17 of Figs. 11, 12 and 13 is also eliminated. Wall panel 1 is then arranged with its perimeter plate member 17 (or 15, as the case may be) in abutment with the plate member 127 of floor panel 9, i.e., with its web portions 75 and 76 respectively abutting web portions 75 and 76 of plate member 127. Here, tubes 100 alone, or with strut members 110 and 111 interconnect middle channels 19 of plate members 127 and 123. In order to secure all three panels 1, 9 and 10 together, elongated bolt members 128 are provided extending through openings 68 in web sections 67 of perimeter plate member 17 of panel 1, corresponding openings 68 in web sections 67 of plate member 127 of panel 9, tube 100, openings 68 in web sections 67 of plate member 123 of panel 9, and finally through openings 68 in web sections 67 of plate member 15 of the foundation panel 10 into threading engagement with nut 103, as in the case of the previous figures. Here, access opening 60 in slab 70 of panel 1 are employed for manipulating the bolts 128; it will be readily understood that bolts 128 may be dropped downwardly through an opening 66 in the top perimeter plate member 15 of panel 1 and manipulated through openings 60. In the case of a floor panel exposed to the exterior, I prefer to eliminate plate member 17 and to substitute a concrete section 120, in the manner of section 101 of the corner panels of Figs. 5, 6, 8 and 9.

Referring now to Fig. 16, there is shown a reinforcing frame 129 for a window panel 6. Referring briefly to Fig. 17, it will immediately be understood that the width of my panel is not necessarily limited to four feet, and that panels of any reasonable length can be constructed in accordance with my invention. Thus, I contemplate that the jig assembly 69 for casting my improved reinforced hollow concrete building panels may be eight (8) feet wide by forty-four (44) feet long. Likewise, it will be understood that panels shorter than four (4) feet may be constructed, for example the panel 1*a* of Fig. 17. Thus, window panel 6 in accordance with my invention may be constructed in any width up to forty-four (44) feet to accommodate a window of any desired width.

Returning now to Fig. 16, reinforcing frame 129 again is provided with perimeter plate members 15, 16, 17 and 18 having the same cross-sectional configuration as the plate members of the previous figures. Here, the window casing 131 is formed by four (4) perimeter plate members 132, 133, 134 and 135 again having the same cross-sectional configuration as the other plate members. The window casing 131 is supported within the outer perimeter plate members 15 through 18 by means of vertical elongated rod elements 136 and 137 respectively having their ends seated in recesses 29 in flanges 27 and 28 of perimeter plate members 15 and 132. Likewise, horizontal elongated rod elements 138 and 139 respectively extend between perimeter plate members 18 and 135 on the one hand and 16 and 133 on the other hand, being respectively seated in corresponding recesses 29 in flanges 27 and 28. The bottom perimeter plate member 134 of window frame 131 is secured to the bottom perimeter plate member 117 by means of the same criss-cross vertically extending rod arrangement of the previous figures, i.e., vertically extending elongated rod elements 23 and 24, and 25 and 26 and criss-cross rod elements 30 and 31 respectively secured to flanges 27 and 28 of perimeter plate members 17 and 134 in the same manner as the attachment to the comparable flange members of perimeter plate members 15 and 17 of Fig. 1.

It will be readily comprehended that a door panel 3 (Fig. 17) is constructed in the same manner as the window panel 6 of Fig. 16, with, however, the bottom perimeter plate member 134 of the door opening 131 directly abutting the bottom perimeter plate member 17 of the outer frame.

Referring now to Figs. 18 and 19, it will be seen that my improved reinforced hollow concrete building panel construction lends itself readily to use as roof panels as well as for wall and floor panels. Referring first specifically to Fig. 18, the ceiling panel 11 (Fig. 17) is constructed identically to the floor panel 9 of Fig. 14, i.e., with transversely spaced parallel plate members 123 and 127 on either side thereof abutting flanges 27 and 28 of perimeter plate member 17. Roof panel 12 has its frame constructed in a manner very similar to that shown in Fig. 5, with however having its plate member 113*a* extending horizontally rather than vertically, i.e., parallel to the rod members 50 through 55 rather than parallel with the rod members 23 through 26. An elongated member 141 having a triangular cross-section is positioned abutting web portions 75 and 76 of plate member 127 of ceiling panel 11, being secured thereto by means of the bolts 104. Plate member 113*a* of roof panel 12 is likewise arranged with its web portions 75 and 76 abutting member 141 and is secured thereto by its bolt 104. It will be seen that suitable spaced openings 142 provided in the elongated member 141 permit manipulation of the bolts 104 which respectively secure member 141 to the ceiling panel 11 and the ceiling panel 11 to the wall panel 1 on the one hand, and the roof panel 12 to the member 141 on the other hand. It will be observed that the perimeter plate member 17 of the roof panel 12, by virtue of its openings 68 in its middle channel 19, is readily suitable for the attachment of a gutter.

Referring now to Fig. 19, it will be seen that the peak of the roof is formed by utilizing roofing panels 12*a* and 12*b* having the exterior corner arrangement of Fig. 6, preferably including the sealing arrangement shown particularly in Fig. 7.

It will now be seen that I have provided an extremely flexible reinforced hollow concrete building panel construction in which all of the various types of panels required to form a complete building structure are readily assembled, utilizing the same elemental component parts and the same method of assembly. As previously indicated, the hollow spaces 72 between the concrete slabs 70 and 71 of my various types of panels are all interconnected by virtue of the elongated openings 66 in their perimeter plate members 15 through 18 and thus heating, plumbing, air conditioning, and electrical wiring is readily installed; it will be readily seen that it may be desirable to incorporate certain plumbing, heating or air conditioning elements within the individual panels in accordance with the respective heating, air conditioning or plumbing layout for the building being constructed at the time the respective panels are originally cast, with the necessary interconnections being

made at the time of installation of the panels. It will further be seen that I have provided extremely simple means for interconnecting the various panels to form a complete building structure, no prior reinforced hollow concrete panel construction known to the present applicant possessing such ready interconnectability.

The improved reinforced hollow concrete building panels in accordance with my invention are unusually light in weight and exceedingly strong, are readily transportable, and readily assembled, either at a remote manufacturing site or at the actual building site.

While I have illustrated and described various embodiments and features of my invention, further modifications and improvements will occur to those skilled in the art, and I desire therefore that it be understood that my invention is not limited to the specific embodiments and features shown, and I intend in the appended claims, to cover all modifications which do not depart from the spirit and scope of this invention.

What is claimed is:

1. A reinforced hollow concrete building panel comprising: a rectangular metal reinforcing frame including elongated plate members defining at least three perimetral edges of said panel, said plate members respectively having a cross-section formed by three interconnected channels with the middle channel facing outwardly and the outer two channels respectively facing inwardly, at least one pair of first transversely spaced apart elongated rod elements extending between two opposite plate members with their ends secured respectively to the outer flanges of the outer channels thereof, at least one pair of second transversely spaced apart elongated rod elements extending at right angles to said first rod elements respectively joining the same to frame means parallel with and spaced from said first rod elements and to the outer flanges of the outer channels of the third of said plate members, at least one pair of third elongated rod elements, each of said third rod elements having at least one of its ends secured to an outer flange of the outer channel of one of said two opposite plate members adjacent an end of one of said first rod elements, each of said third rod elements having a portion spaced from said one end thereof secured to the other of said first rod elements adjacent a respective second rod element whereby said third rod elements cross intermediate their respective one end and spaced portions, said third rod elements being secured together at their crossing points, respective first and second rod elements of said pairs lying in two transversely spaced parallel planes respectively substantially coextensive with the opposite edges of said plate members; and two transversely spaced planar slabs of concrete having respective first and second rod elements imbedded therein and respectively lying in planes generally coextensive with said two planes, said slabs respectively terminating at said plate members.

2. The combination of claim 1 in which the outer flanges of said outer channels having transversely aligned depressions formed therein, the said ends of at least said first and third rod elements being respectively seated in said depressions, members respectively spanning said depressions and secured to said outer flanges for retaining said rod element ends therein, and other members respectively reinforcing the junctions of said first, second and third rod elements.

3. A reinforced hollow concrete building panel comprising: a rectangular metal reinforcing frame including four elongated plate members respectively defining the four perimetral edges of said panel, said plate members respectively having a cross-section formed by three interconnected channels with the middle channel facing outwardly and the outer two channels respectively facing inwardly, at least one pair of first transversely spaced parallel elongated rod elements extending between a first two opposite plate members with their ends respectively secured to the outer flanges of the outer channels thereof, at least one pair of second transversely spaced elongated rod elements extending between the other two opposite plate members with their ends respectively secured to the outer flanges of the outer channels thereof, said second rod elements being respectively secured to said first rod elements at their crossing points, at least one pair of third elongated rod elements extending between said first two opposite plate members with their ends respectively secured to the outer flanges of the outer channels thereof adjacent ends of said first rod elements, said third rod elements crossing each other intermediate said first two plate members and said second rod elements and being respectively secured to said first rod elements adjacent said second rod elements, said first and second rod elements respectively lying in two transversely spaced parallel planes respectively substantially coextensive with said opposite edges of said plate members, and two transversely spaced planar slabs of concrete having said first and second rod elements imbedded therein and respectively lying in planes generally coextensive with said two planes, said concrete slabs respectively terminating at said plate members.

4. The combination of claim 3 in which said second rod elements respectively comprise segments having one end abutting said first rod elements and the other end secured to outer flanges of the outer channels of said other two plate members.

5. The combination of claim 3 in which said first and second rod elements are respectively secured to the outer flanges of said outer channels, the width of the web portions of said middle channels being substantially the same as the transverse width of the space between said slabs, said slabs respectively having their outer faces disposed in planes spaced outwardly from the respective planes of said outer flanges of said outer channels with said outer flanges being respectively imbedded in the edges of said slabs, the web portions of said middle channels having a plurality of elongated openings formed therein communicating with the space between said slabs, the web sections intermediate said openings being respectively in transverse alignment with said first and second elongated elements, each of said web sections having an opening formed therein for securing said panel to another building member.

6. A reinforced hollow concrete building panel comprising: a rectangular metal reinforcing frame including at least three elongated plate members defining respective perimetral edges of said panel, another elongated plate member extending between two opposite plate members of said three plate members, said plate members respectively having a cross-section formed of three interconnecting channels with the middle channel facing outwardly and the outer channels facing inwardly, said other plate member having the web portion of its middle channel respectively abutting the outer flange of one outer channel of said opposite plate members, first elongated reinforcing means including an elongated rod element transversely spaced from and parallel with said other plate member with its ends respectively secured to the other outer flanges of the other outer channel of said two opposite plate members, said elongated means including at least one plate element abutting and secured to said rod element intermediate its ends, at least one pair of second elongated reinforcing means extending at right angles respectively to said other plate member and said first elongated means and respectively joining said other plate member and said plate element to the respective opposite edges of the third of said plate members, reinforcing means transversely interconnecting said other plate member and said plate element, said other plate member and said plate element having aligned openings formed therein; and a pair of transversely spaced planar concrete slabs, one of said slabs imbedding one of said second reinforcing means and the other of said slabs

imbedding said first reinforcing means and the other of said second reinforcing means, the outer face of said one slab being flush with the web portion of the outer channels of said other plate member, said slabs terminating respectively at said three plate members, said slabs having their edges respectively embedded in the outer flanges of the other channels of said three plate members, said other slab having an opening formed therein in alignment with said aligned openings in said other plate member and said plate element whereby said panel may be secured to an edge of another panel.

7. The combination of claim 6 in which said reinforcing interconnecting means is a tube in alignment with said aligned openings in said other plate member and said plate element.

8. The combination of claim 6 in which said other plate member is adjacent the ends of said opposite plate members remote from the third of said plate members and said slabs are integrally joined by and terminated on one side in a section of concrete adjacent said other plate member.

9. The combination of claim 6 in which said reinforcing interconnecting means comprises a pair of plates respectively having one end abutting said plate element on either side of the opening therein and their other ends abutting the web portion of the middle channel of said other plate member adjacent its corners and on opposite sides of the opening therein.

10. A reinforced hollow concrete building panel comprising: a rectangular metal reinforcing frame including elongated plate members respectively defining at least three perimetral edges of said panel, said plate members respectively having a cross-section formed by three interconnected channels with the middle channel facing outwardly and the outer two channels respectively facing inwardly, means including first transversely spaced parallel elongated rod elements extending respectively between two opposite plate members and secured respectively to the outer flanges of the outer channels thereof, rod elements joined to and transversely interconnecting said first elongated elements at spaced intervals, and means including second transversely spaced parallel elongated rod elements extending at right angles to said first elongated elements and respectively joining the same to frame means parallel with and spaced from said first elements and to the outer flanges of the outer channel of the third of said plate members, said first and second elongated elements respectively lying in two transversely spaced parallel planes respectively substantially coextensive with the outer flanges of the outer channels of said plate members; and two transversely spaced planar slabs of concrete having said first and second elongated elements embedded therein and respectively lying in planes generally coextensive with said two planes, said concrete slabs respectively terminating at said plate members; said plate members having elongated openings formed in the web portion of the middle channel and communicating with the space between said concrete slab.

11. The combination of claim 10 in which the width of the web portion of said middle channels of said plate members is substantially the same as the transverse width of the space defined between said concrete slabs with said slabs respectively having their outer faces disposed in planes spaced outwardly from the respective planes of said outer flanges of said outer channels and with said outer flanges being respectively embedded in said slabs, and in which said elongated openings in said middle channel web portions are longitudinally spaced apart with the web sections intermediate said elongated openings being respectively in transverse alignment with said elongated rod elements and having an opening formed therein for securing said panel to another building member.

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