

March 14, 1967

M. D. COOPER ETAL
CORRUGATED PANEL

3,308,596

Filed Nov. 4, 1963

3 Sheets-Sheet 1

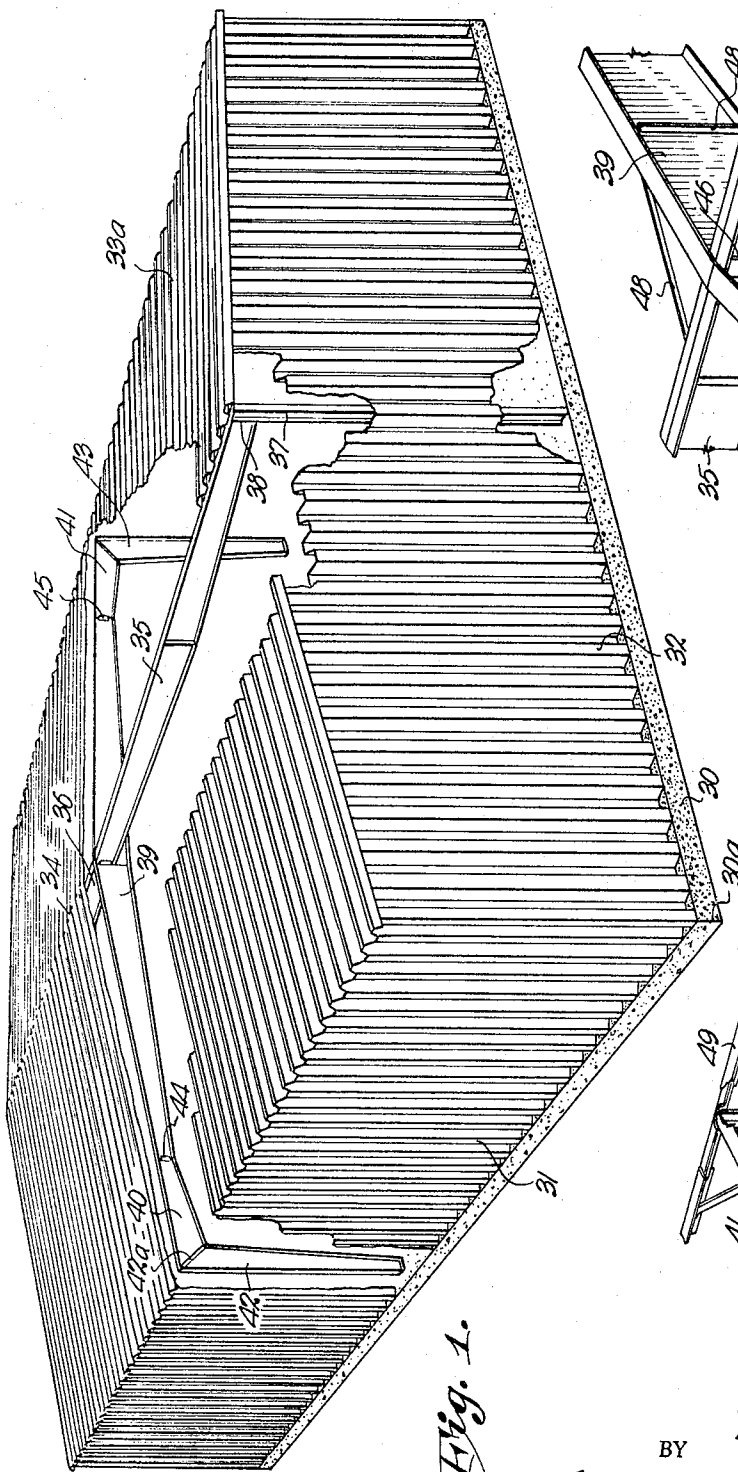


Fig. 1.

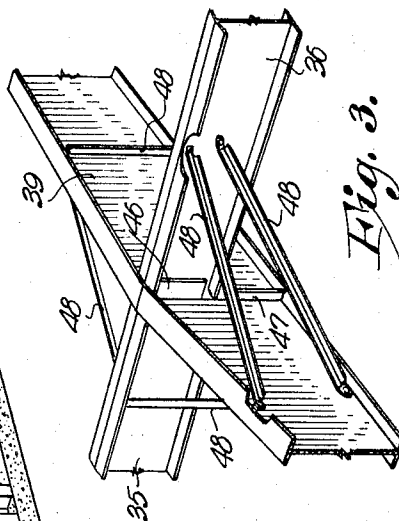


Fig. 3.

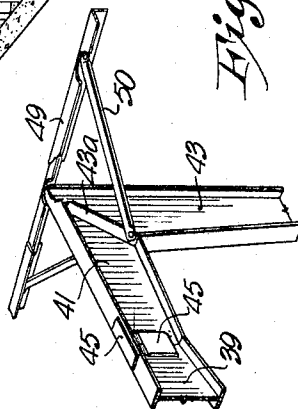


Fig. 2.

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3 Sheets-Sheet 2

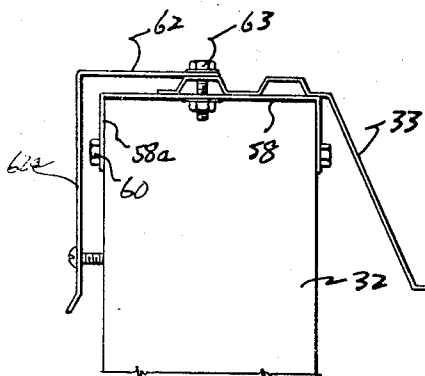
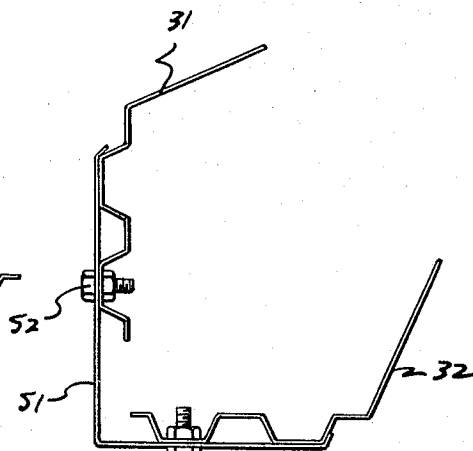


Fig. 5.



52 *Fig. 6.*

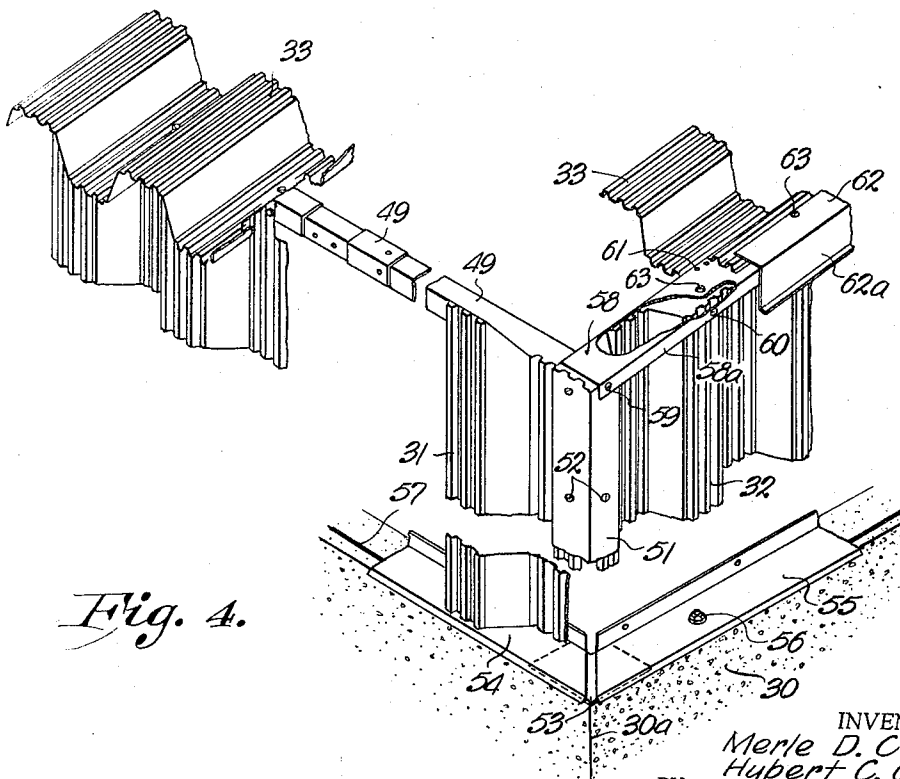


Fig. 4.

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3 Sheets-Sheet 3

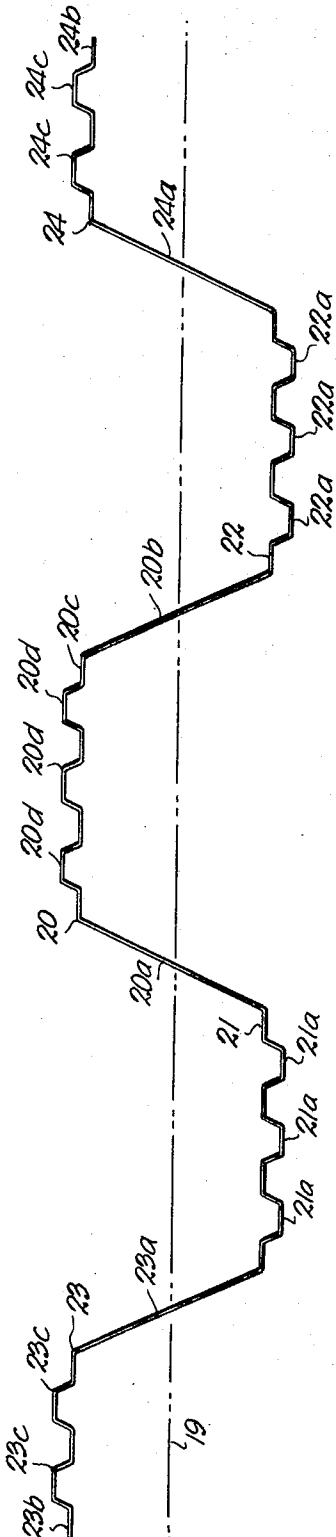


Fig. 7.

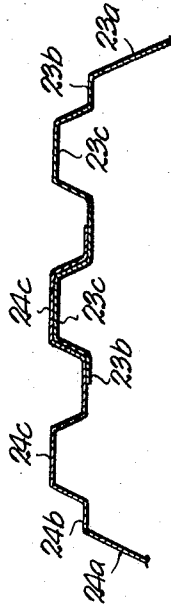


Fig. 8.

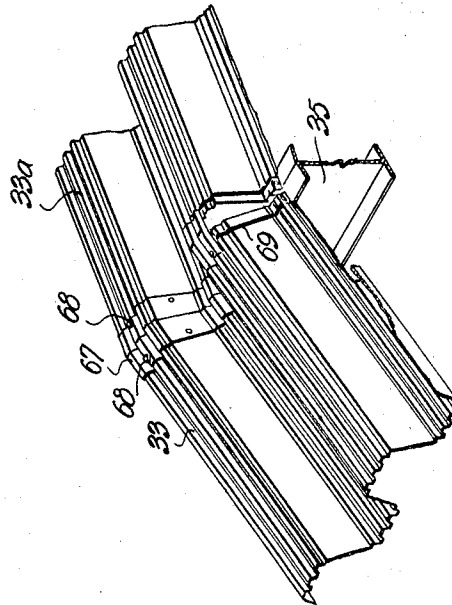


Fig. 9.

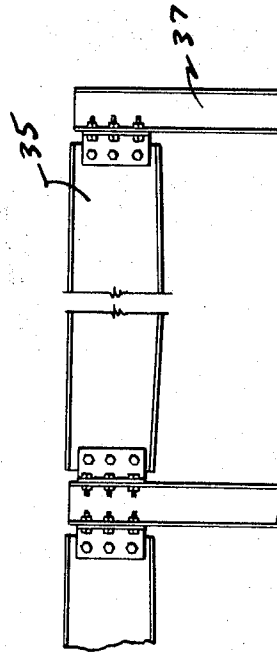


Fig. 10.

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3,308,596

CORRUGATED PANEL

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Filed Nov. 4, 1963, Ser. No. 321,216

2 Claims. (Cl. 52—630)

This invention relates to sheet metal walled and roofed buildings and refers more particularly to such buildings wherein the sheet metal walls and roofing are so configured and formed as to eliminate or reduce the need for conventional internal supports, such as frames, purlins and girts.

A number of prior art patents disclose complexity configured corrugated panels. The design patents to Haman et al. 164,990 and Haman et al. 165,978 show the use of minor corrugations in valleys between major corrugations. The design patent to Hield 178,605 shows the use of minor corrugations in a valley between major corrugations having cascades thereon. Beech 2,585 shows a corrugated metal panel with minor corrugations in the valleys between the major corrugations. Sagendorph 362,118 shows a corrugated metal panel having a single minor corrugation on the major corrugations. Sisson 1,800,363 shows (FIG. 11) minor breaks in the hills and valleys of a corrugated panel. Overholtz 2,073,706 shows minor corrugations in the valley between major corrugations having a minor corrugation thereon in a metal panel. Ashman, 2,417,899 shows a corrugated sheet having a minor corrugation in valleys between major corrugations, the major corrugations themselves having a minor corrugation thereon. These panel constructions, however, have not been used and are not usable (indeed, they were not designed for use) for or in frameless building constructions wherein the roof and wall panels are substantially self-supporting in mutual interconnection.

An object of the invention is to provide a low cost building construction and optimal roof and wall panel structure therefor.

Another object of the invention is to provide a low cost building construction usable for grain and for machinery storage.

Another object of the invention is to provide a low cost building construction employing wall and roof panels utilizing diaphragm action, the same enabling the substantial elimination of conventional wall and roof wind bracing.

Another object of the invention is to provide a novel low cost building construction and panel structure thereof wherein the interior of the building is substantially completely clean and uncluttered by the conventional frames, purlins, girts, sag rods or bracing.

Another object of the invention is to provide a low cost building construction wherein a tilt-up erection technique may be employed wherein end wall and side wall sheets may be subassembled into sections and such sections may be carried to the site by two men and tilted into place without the requirement of squaring or drifting of holes.

Another object of the invention is to provide a low cost building construction wherein, in the erection thereof, subassemblies may be made remote from the job so that crews may be kept busy in bad weather, erection techniques also being permissible which reduce on-the-job time sufficiently greatly so that structures can be erected in very bad weather.

Another object of the invention is to provide a low cost panel building construction wherein the panels and, therefore, the building are self-squaring.

Another object of the invention is to provide a low cost

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building construction which has maximum interchangeability of parts whereby to assure (1) easy erection, (2) easy stocking at dealer locations, (3) minimum shortages and shipping errors, (4) minimum inventory required of raw and finished goods, and (5) low cost due to making, handling and shipping large quantities of like pieces.

Another object of the invention is to provide a panel construction for low cost building constructions which panels will nest very well.

Another object of the invention is to provide a low cost building construction which provides a basic building block easily expanded into a multitude of different buildings.

Another object of the invention is to provide a building wall and roof panel construction utilizing both major and minor corrugations, the panel having a symmetrical pattern of corrugations and permitting panel edge lap in such fashion that the panel assembly corrugation pattern is symmetric.

Another object of the invention is to provide a panel construction having both major and minor corrugations wherein the panel is reversible.

Another object of the invention is to provide a universal panel construction wherein the panel may be lapped at the side major corrugation thereof or lapped in one-half width of the panel.

Another object of the invention is to provide a novel panel construction for metal wall and roof buildings, the panel having both major and minor corrugations, the minor corrugations positioned on the major corrugations, the panel also optionally fluted for control and removal of panel "oil canning." (The oil canning is fenced in by the minor corrugations, then limited areas are fluted.)

Another object of the invention is to provide a low cost building construction utilizing corrugated panels for the side walls and roof, the side wall panels, per se, acting as column structures and the roof panels, per se, acting as rafter structures with each entire panel area in each case being useful structurally.

Another object of the invention is to provide a low cost paneled building construction wherein, for all practical purposes, the paneled building walls are so strong by virtue of major and minor corrugations therein that they are self-supporting with frame members provided only for (1) something for the roof panels to tie to at the ridge and (2) a member steadying the frame member just mentioned by central right angle connection thereto.

Another object of the invention is to provide a panel design for a low cost building construction having the following features:

- (a) Panel must be symmetrical about the center line;
- (b) Flat width of panel must not exceed 48 inches;
- (c) Panel must have a coverage of some module of six inches, preferably 30 or 36 inches;
- (d) Panel should be designed so that a side lap splice will occur on any up corrugation or hill;
- (e) Panel must be of configuration that is adaptable to mass production fabricating methods;
- (fg) Panel should be stiff enough in all directions so that a "diaphragm" action may be obtained to eliminate the need for wind brace rods;
- (g) Preferably the design should be made using standard commercially available steel (yield point equal 33,000 p.s.i.).

Other and further objects of the invention will appear in the course of the following description thereof.

In the drawings, which form a part of the instant specification and are to be read in conjunction therewith, embodiments of the invention are shown and, in the various views, like numerals are indicated by like parts.

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FIG. 1 is a three-quarter perspective view from above of a building construction formed from and utilizing the uniquely corrugated wall and roof panel structures which incorporate the invention, the particular building shown utilizing a single rafter frame structural member running along the roof ridge with column members positioned at the ends thereof coupled with another single set of rafter and column members situated at right angles thereto.

FIG. 2 is a three-quarter perspective detail from above of the column and rafter juncture in the side wall members of FIG. 1.

FIG. 3 is a three-quarter perspective detail from above of the ridge juncture of the rafter structurals of FIG. 1.

FIG. 4 is a three-quarter perspective from above (with parts cut away for display therebelow) of the low side wall corner of the construction of FIG. 1.

FIG. 5 is a vertical section through the upper portion of the end wall of the structure seen in FIG. 4.

FIG. 6 is a horizontal section through the corner in the lower center of FIG. 4 below the eaves.

FIG. 7 is a transverse section through the inventive side wall and roof panel employed in the construction of FIG. 1.

FIG. 8 is a sectional detail of the side edge lap of two panels of the type shown in FIG. 7.

FIG. 9 is a three-quarter perspective detail from above showing the ridge closure of roof panels in the structure of FIG. 1.

FIG. 10 is a detail of the end wall column rafter connection of the building of FIG. 1.

Referring first to FIG. 7, therein is shown a corrugated panel of the type employed in the buildings described in this disclosure. The panel (viewed from the preferred inner side of application thereof) is an elongate rectangular corrugated sheet of metal having a central major corrugation therein generally designated 20 having side walls 20a and 20b and peak or top 20c. Side walls 20a and 20b are preferably straight and angled from the vertical (in the view) some 35° or 65° from the horizontal (in the view). Formed in preferably flat peak 20c are a plurality of (preferably three) minor corrugations 20d. The webs of the minor corrugations are preferably some 30° from the vertical or 60° from the horizontal (in the view). Flat panel portions 21 and 22 extend laterally on each side of major corrugation 20 and each has a plurality of, preferably three, minor corrugations 21a and 22a formed therein. The webs of corrugations 21a and 22a are preferably angled the same as those of corrugations 20d. Laterally of each panel portion 21 and 22 is formed a partial major corrugation generally designated 23 and 24, respectively, each having a single side wall 23a or 24a and preferably flat peak portions 23b or 24b. A pair of minor corrugations 23c and 24c are formed in each flat peak 23b and 24b. The size and configuration of minor corrugations 20d, 21a, 22a, 23c and 24c are all substantially identical. Thus, an edge engagement or connection may be made as in FIG. 8 wherein the end minor corrugation (23c and 24c for example) of each of two side edge partial corrugations of two panels configured as in FIG. 7 may be overlapped whereby to effect a juncture and make a continuous corrugated panel section. Alternatively, a greater overlay wherein the end partial corrugation overlaps part of a major corrugation of another panel may be made. It should be noted that the panel of FIG. 7, if inverted, would have two full major corrugations 21 and 22 with one full valley 20 and edge partial valleys 23 and 24. The panel is symmetrical around a mid line 19. The minor corrugations on the adjacent valleys and summits face or extend outwardly in opposed directions from said mid line 19 for greatest strength and rigidity.

An outline of the design parameters of a particular corrugated panel of the construction shown will now be given. The basic objective is to design a panel which will support a 20 p.s.f. live load plus its own dead load on the basis of a 20-foot simply supported beam. Further, the

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panel should meet all relevant specifications of the American Iron and Steel Institute (hereafter referred to as "AISI"). The panel must be able to be used as a column for load-bearing wall construction. It should have a maximum coverage in minimum weight.

The following limitations are effective or accepted:

(1) The panel must be symmetrical about the center line (reversible).

(2) The flat width of the panel must not exceed 48 inches.

(3) The panel must have a coverage of some module of 6 inches, preferably 30 or 36 inches.

(4) The panel should be designed so that a side lap splice will occur on an up corrugation or hill.

(5) The panel must be of a configuration that is adaptable to mass production fabricating methods.

(6) The panel should be stiff enough in all directions so that sufficient rigidity may be obtained to eliminate the need for wind brace rods.

(7) Preferably the design should be made using standard commercially available steel. (Yield point equals 33,000 p.s.i.)

With respect to (2), only one steel mill in the U.S. rolls a panel wider than 48 inches and thus wider requires payment of a premium. With respect to (3), first, the greatest panel width is desired and, second, in locating accessories (windows, doors and ventilators) such works out best. With respect to (4), it is desirable to hide fasteners from the inside and avoid their protrusion into the building used areas (especially sidewalls). Also regarding (4), such position aids in shedding water.

Procedure

A. The dead weight of the panel is estimated as 2 p.s.f.

B. The section modulus (SM) required is calculated. SM (required) $= 1.5 \times 22 \times 400 \div 20,000 = .660 \text{ in}^3$.

C. The maximum depth of panel per AISI Spec. 2.3.4. is established.

(1) Assume panel will be 24 gage.

(2) Depth $= 150 \times .0257 = 3.86$ inches. This is the depth between tangent points on the web.

D. The maximum flat width of flange that can be obtained before using some type of intermediate stiffener per AISI Spec. 2.3.1.1. is established.

(1) $b/t = 28.427$, $b = 28.427 \times .0257 = .732$ inch.

E. Using the dimensions established in C and D and referring to the limitations set forth in (2), an approximate panel cross section may be set forth.

(1) The depth shall be 4 inches between flanges.

(2) The major webs will be set at an angle of 65° with the horizontal.

(3) The panel coverage will be 30 inches.

(4) The repeating section will be 7½ inches wide.

(5) Inside radii on major webs will be .1875 inch.

(6) Three intermediate stiffeners will be used on the flanges in order that the side lap will come on a hill.

F. Calculations are now made to determine the depth of the intermediate stiffeners.

G. The final panel configuration can now be drawn.

(1) Dimensions of 7 minor flanges, 6 minor webs and 1 major web are in hand.

(2) Balancing the above dimensions against the 7½ inch repeating section and against the 48 inch flat material requirement, the panel configuration as shown in FIG. 7 results.

H. The section properties of the panel may now be calculated and a section modulus of 0.659 in.³ is found.

I. The weight of a 24 gage panel is calculated and found to be 1.50 pounds per square foot.

J. Rechecking the section modulus required based upon the new dead weight of the panel, the section modulus

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required is found to be 0.645 in.³, consequently all of the requirements have been fulfilled.

The building in FIG. 1 will now be described, FIGS. 2-6, inclusive showing details of the structure thereof (as well as FIG. 9). A concrete foundation 30, rectangular in form, preferably is supplied to support the building which broadly comprises and includes side walls generally designated 31 and 31a, end walls generally designated 32 and 32a and roof sections generally designated 33 and 33a. There are two side wall sections which oppose and run parallel to one another and two end wall sections of like orientation with respect to one another. Both the side wall and end wall sections are made up of a plurality of panels of the type shown in FIG. 7, engaged, one to the other, in the manner shown in FIG. 8. The upper ends of the end wall panels are cut so as to provide an upwardly tapering pair of wall sections, which latter meet at a ridge generally designated 34.

Underlying ridge 34 are a pair of ridge rafter members 35 and 36 connected at their outer ends to vertical column members 37 (one is not seen in the view) by a clip or pair of clips 38 in the manner seen in FIG. 10, right-hand portion of the view, and at their inner ends to the center portion of a transverse rafter member 39. The details of the rafter member connection at the center of the building are seen in FIG. 3. Rafter member 39 is connected at the outer ends thereof to outer rafter members 40 and 41. The latter comprise slightly upwardly and inwardly angled portions of integral column members 42 and 43. Any suitable clip connection as seen at 44 and 45 (FIG. 2) may be made between the column haunch sections 40 and 41 and the outer ends of transverse rafter member 39.

Looking at the central rafter connection of FIG. 3, rafter members 35 and 36, which are I-beams in transverse cross section (with the upper flange of each somewhat downwardly and outwardly tapered in each direction, as best seen in FIG. 9) are clipped by means of clips 46 (only one seen in the view) to central vertical stiffener 47 on each web face of transverse rafter member 39, itself an I-beam in transverse cross section. Clips 46 connect the web of rafter members 35 and 36 to stiffeners 47 on each side of the web of transverse rafter member 39. Sets of braces 48 interconnect the webs of members 35 and 36 with the web of member 39. These are bolted through the webs at the ends thereof. Column members 42 and 43 and haunch members 40 and 41 are I-beams in transverse cross section as are columns 37. At the juncture of the undersides of each of the two opposed roof sections 33 and 33a, with side walls 31 there are positioned eave angles 49 V-shaped in transverse section. Eave angles 49 have the vertex of the V thereof at the precise juncture of the rafter and side walls (inside) with the upper leg of the V in such position connected to the underside of the rafter by suitable holes formed therethrough and bolt means and the downwardly extending leg thereof connected to the panels of the side walls by bolt means passing through matching holes in the eave angles and upper side wall panels. The angles are spliced at lengths therealong as seen in the various views. In FIG. 2, it may be seen that eave angles 49 are connected to corner flange 43a (or 42a) of the transverse rafter member columns by flange braces 50.

The low side wall corner detail of the building of FIG. 1 shown in FIG. 4 will now be described. End wall 32 and side wall 31a join at a corner with a corner trim member 51 bolted by bolts 52 to the partial major corrugations on the side edges of the end panels of end wall 31 and side wall 32. Foundation 30 has corner 30a capped by corner cap member 53. The latter is overlaid by a pair of base angles 54 and 55 fastened to the foundation by bolts 56. The panels of the side and end walls overlie base angles 54 and 55 which are continuous along the foundation and sealed thereto by any suitable sealing compound, optimally as seen at 57. End wall upper cap

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58 overlies the upper end of corner trim 52, is fastened thereto as at 59 and also overlies the upper ends of the corrugated panels making up end wall 32 and is bolted thereto as at 60. The side edges of the end roof panels of roof section 33 are bolted to end wall panel cap 58 as seen at 63a and have a gable trim member 62 bolted to the top thereof also as at 63 with the outer downwardly depending flange 62a thereof overlying outer downwardly depending flange 58a of end wall panel cap 58. The major corrugations of the side walls are mitered upwardly as seen at 64 whereby to fit into and closely underlie the major corrugations of the roof sections and form a seal therewith.

Doors and windows may be formed in either the side of end wall sections of the building in conventional manner and such will not be described here. The ridge rafter panel sections 33 and 33a connection is seen in FIG. 9 wherein panel sections 33 and 33a abut or oppose adjacent their upper ends. The ends of sections 33 and 33a each overlie and rest on the tapered upper flanges of rafter members 35 and 36. Ridge closure member 67 fits over the said opposed section ends and is fastened thereto by bolts 68. A sealing compound seal may be employed as at 69. Ridge closure 67 is configured in the same manner as the panel ends which it overlies and is bolted to.

Typical panel dimensions will now be given, FIG. 7 being drawn in scale to same (save for thickness).

The panel width from the center of the left-most minor corrugation 23c to the right-most minor corrugation 24c is 30 inches. The width from the center of the left-most (or right-most) minor corrugation to the center of the center minor corrugation is 15 inches. The width of each valley (21 or 22) at the height thereof is 9.3125 inches and at the bottom is 5.6562 inches. The width of each minor corrugation at the top is 0.6250 inch and at the bottom 1.2382 inches. The height of the major corrugation and partial major corrugation from base to summit (excluding minors) is 4.000 inches plus or minus .062 inch. The height or depth of each minor corrugation is 0.4063 inch. The edge flange on each panel edge ranges in width from a minimum of 0.1875 inch to 0.4494 inch. Other than as mentioned above, all tolerances are plus or minus 0.031, noncumulative. Dimensions shown are based on 0.0291 material thickness.

From the foregoing it will be seen that this invention is one well adapted to attain all the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the structure.

It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

Having thus described our invention, we claim:

1. A corrugated panel having a single major corrugation centrally thereof,

elongate panel portions flanking said major corrugation and a pair of partial major corrugations flanking the latter,

a plurality of minor corrugations on the peaks of the major and partial major corrugations and a plurality of minor corrugations on the elongate panel portions between the major corrugations,

all of the corrugations, major and minor, running in the same direction on the panel,

the panel between those portions thereof with minor corrugation substantially straight,

there being an equal number of minor corrugations on

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the peak of the major corrugation and on the elongate panel portions flanking the latter, the minor corrugations positioned on the major and partial major corrugations extending, in transverse section, in the same direction, the minor corrugations in the said elongate panel portions extending in opposite directions to the latter, in transverse section, and the minor corrugation being evenly distributed on the peaks of the major and partial major corrugations and the elongate panel portions.

2. A corrugated panel wherein there are two major corrugations formed therein having three minor corrugations on each of the peaks thereof, one panel portion between said two major corrugations having three minor corrugations thereon and two side edge portions each adjoining one of said major corrugations and having each two minor corrugations thereon, all of the corrugations, major and minor, running the same direction on the panel,

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and the sets of minor corrugations adjacent one another extending, in transverse section, in opposite directions.

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