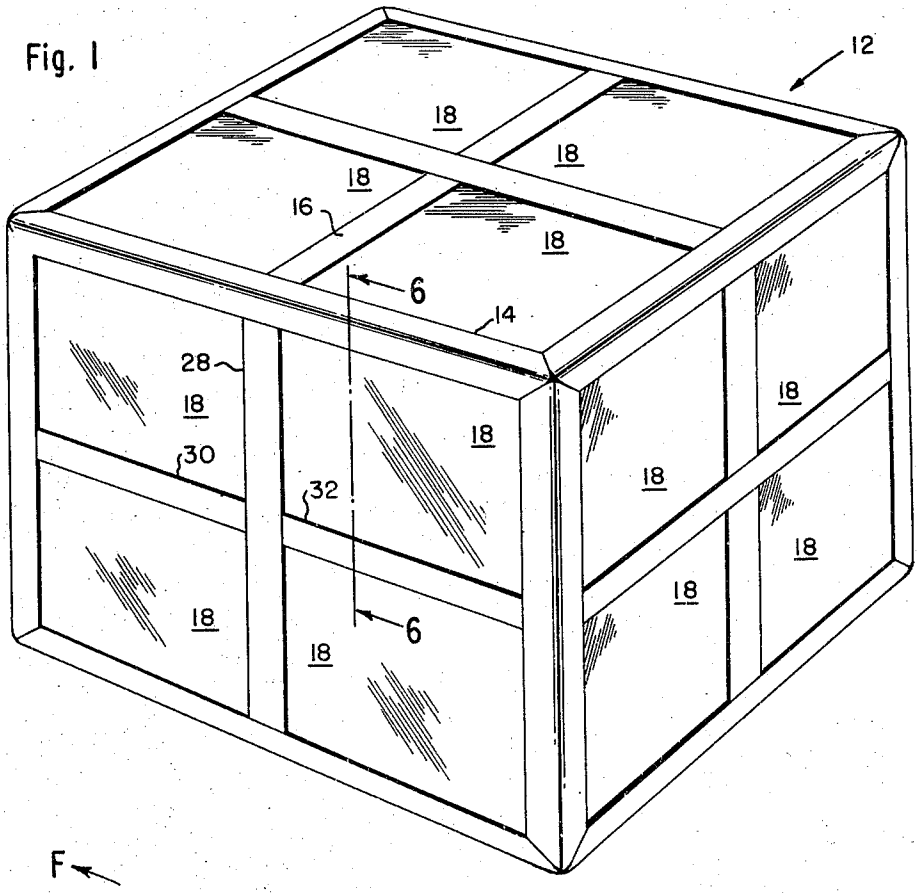
Sept. 6, 1960 J. S. HARDIGG 2,951,613

BONDED METAL PANELS AND ENCLOSURES

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Fig. 1



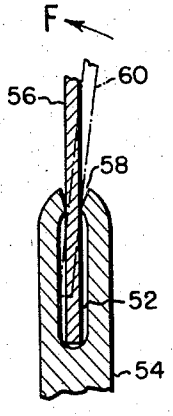


Fig. 3

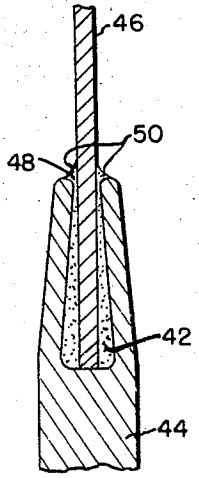


Fig. 2

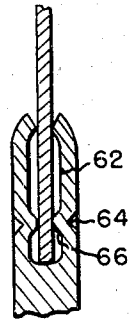


Fig. 4

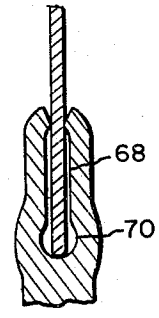


Fig. 5

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Fig. 6

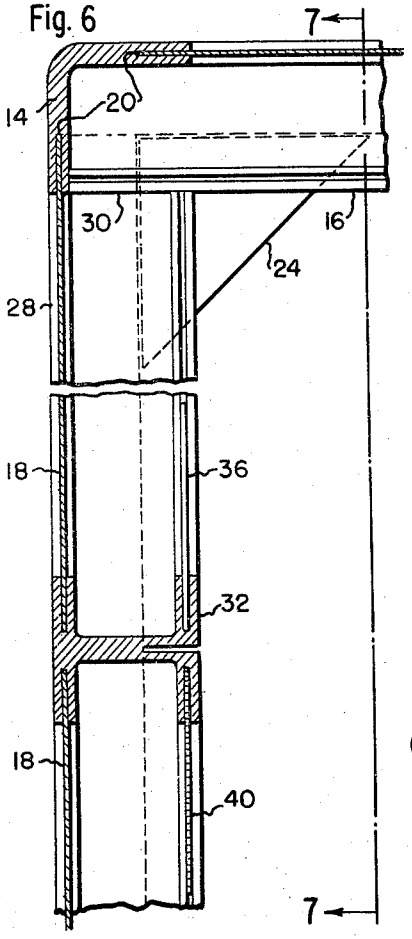
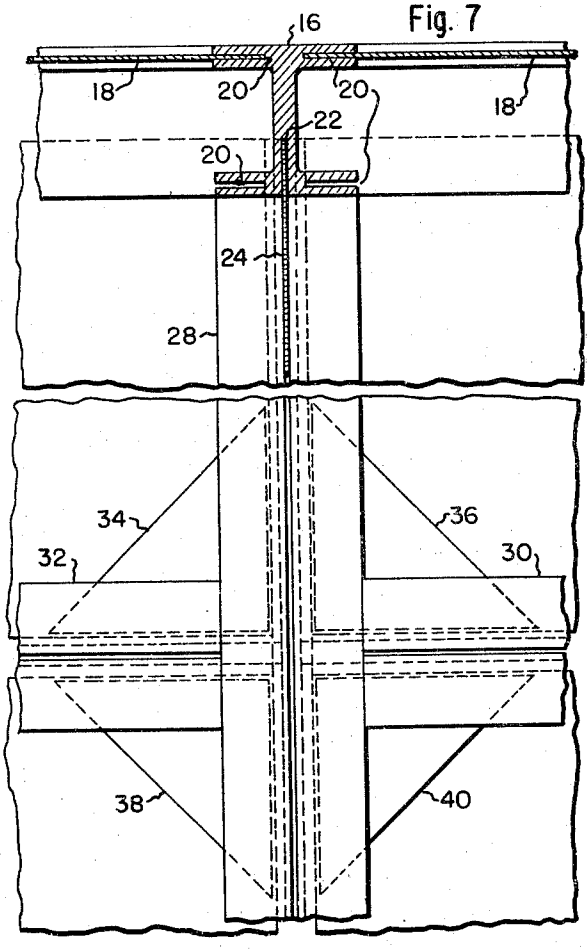


Fig. 7



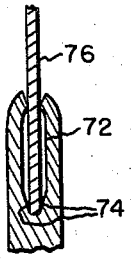


Fig. 8

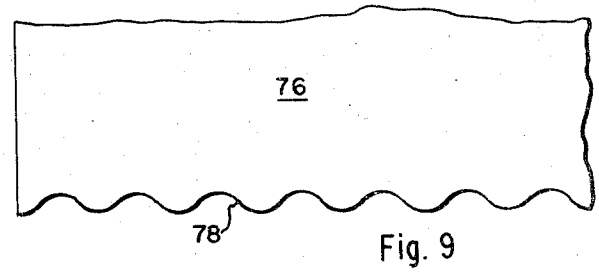
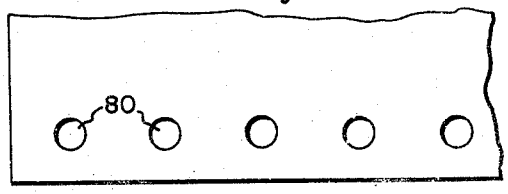


Fig. 9

Fig. 10



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BONDED METAL PANELS AND ENCLOSURES

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Filed July 23, 1957, Ser. No. 673,655

8 Claims. (Cl. 220—81)

The present invention relates generally to reinforced metal enclosures and panels, and more particularly to an improved reinforced construction formed of bonded structural members.

A principal object of this invention is to provide metal enclosures and panels which are easily assembled to form rigid structures capable of resisting racking forces, bending moments in various planes, and other destructive forces such as occur, for example, in shipment. Enclosures of this type are useful as storage and shipping crates, especially for delicate mechanical apparatus or materials sensitive to environmental conditions such as humidity, electrostatic fields, fungus and gaseous ingredients of the atmosphere.

The inherent properties of metal are well suited to the requirements of certain specialized types of storage and shipping crates and boxes. It is impervious to moisture and resistant to fungal growth. It will not warp under conditions of moisture, and in the case of certain metals such as aluminum, it is slow to oxidize and the oxide itself tends to form a protective layer to slow down further oxidation. Also, as compared with other materials, metal has great strength, and in the case of certain metals suitable for crating and boxing, such as aluminum, it is resilient and hence well adapted to absorb mechanical shocks.

Another object of this invention is to provide an enclosure having strength in the central region of each side panel as well as along the edges thereof.

A further object is to provide a form of assembly that does not require the usual bolts, screws, rivets, clamps, tabs, or other form of mechanical fastening means which latter are ordinarily adapted to cooperate with registered holes, slots, ribs or edges of the component members. By this means, it is desired to eliminate the problems of precision in manufacture that are attendant upon the necessity for accurate registration of the parts to permit the fastenings to be applied.

Still another object closely related to the foregoing is to provide a fully sealed enclosure having no holes or other openings to allow the penetration of moisture or other atmospheric ingredients.

With the foregoing and other objects in view, the features of the invention include the provision of reinforcing structural members having slots of an improved form and adapted to be assembled as a framework with the use of gussets received in the slots and bonded thereto.

Another feature is the provision of a reinforcing structural framework of the foregoing type having provision for assembly therewith of metal wall sheets similarly received in and bonded to the slots in the structural framework to complete the enclosure.

Other features of the invention relate to certain features and modes of construction and arrangements of the parts which will be more clearly understood with reference to the following description of a preferred embodiment and certain variants thereof as illustrated in the appended drawings, in which

Fig. 1 is an oblique view of a completed box according to the invention;

Fig. 2 is a fragmentary elevation in transverse section of a frame member and an associated gusset or wall sheet showing details of the preferred form of slot;

Figs. 3 to 5 are elevations similar to Fig. 2 showing alternative forms of slots;

Fig. 6 is an elevation in section taken on line 6—6 of Fig. 1 showing the interrelationships of frame members, gussets, and wall sheets;

Fig. 7 is an elevation at right angles to that of Fig. 6 and taken on line 7—7 thereof;

Fig. 8 is a view similar to Figs. 2 to 5 showing a third alternative form of slot;

Fig. 9 is a fragmentary side view of a gusset or wall sheet adapted for insertion in the slot of Fig. 8; and

Fig. 10 is a fragmentary side view of a sheet of alternative form for insertion in the slot of Fig. 8.

Referring to Fig. 1, there is illustrated an assembled enclosure **12** having visible frame members including edge members such as **14** and girth members such as **16**, assembled with a plurality of wall sheets **18**. The frame members and wall sheets are of metal, the sheets preferably being of relatively thin gauge sufficient to resist tearing upon accidental abrasion or denting. The frame members are preferably extruded with right-angle and I cross-sections and are of heavier gauge to impart the necessary strength to the enclosure against racking and twisting forces, as for example those which are imparted when the enclosure is suddenly turned over or dropped upon an edge while loaded with heavy contents. It will be observed that the enclosure is of neat appearance, having substantially smooth outer walls entirely of metal, with no openings for penetration of moisture or harmful atmospheric gases.

The construction of the enclosure **12** of Fig. 1 may be understood from an examination of Figs. 6 and 7. As stated above, the frame members are of two types, the edge members such as **14** having a right-angle section, and the girth members such as **16** being in the form of I-beams. The edge and girth members are preferably extruded in the shapes illustrated; or, if desired, the edge members may be formed from sheet stock, cut to size and bent to form angle members.

A number of edge slots **20**, hereinafter described in more complete detail, are formed throughout the length of each edge and girth member, there being two edge slots in each edge member and four in each girth member. In addition, each girth member has a slot **22** extending into the stem portion of the I-section at right angles to the slots **20**.

Associated with the slots **20** and **22** are sheet metal gussets of right triangular shape, these gussets providing the means for joining the girth members together. Thus, as viewed in Fig. 6, girth members **16** and **28** abut along a line **30** and are joined by a gusset **24** inserted in their respective slots **22**. The gusset is held in the slots by a suitable adhesive or bonding material of flowable form which fills the voids in the slot adjacent the sides of the gusset and sets or hardens to adhere firmly to the metal surfaces in contact therewith. For the adhesive use is preferably made of a conventional epoxy resin formulation, but it will be understood that any one of a variety of alternative formulations may be used. The depth of the slots is preferably sufficient to provide a bond of a strength equal to that of the gusset, and depends on the bonding strength of the adhesive.

The union of girth members at points other than the edges of the enclosure is also effected by gussets. Thus for example, as shown in Fig. 7 the girth member **28** is united with girth members **30** and **32** by four gussets **34**, **36**, **38** and **40**. These gussets are inserted and bonded

into the slots 20 of the respective girth members on the inside of the enclosure.

It will be recognized that a feature of the gusseted construction hereinabove described is that it provides a joint capable of transmitting bending moments in both the horizontal and vertical directions. The I cross-sections provide substantial strength against bending moments with a minimum weight of metal. Also, any forces tending to change the angle at which any two girth members are joined are resisted by the gussets and bonded joints.

It will also be understood that the initial step in assembly of the enclosure 12 consists in uniting the girth members as described above to form a framework. Once the girth members are joined, the wall sheets 18 may be inserted in the exposed outer edge slots 20, and bonded thereto as described above with reference to the framing gussets. To this end the sheets are first inserted in the slots 20 of the girth members, and then the edge members are fitted to the sheets by flexing the latter outwardly as required. A comparison of Figs. 6 and 7 will reveal that each girth member which overlies another at a corner, as for example the member 16, is cut off and relieved to fit closely with the edge member when assembly is completed.

A more detailed description of the technique of bonding the framing members to one another and to the sheets 18, in accordance with this invention, is as follows. Fig. 2 illustrates a preferred form of slot 42 in a typical frame member 44, joined with a typical gusset 46. The wall sheets 18 are preferably received in and bonded to slots of the same form as that illustrated, and in substantially the same manner. The slot 42 is preferably initially formed by extrusion with substantially parallel sides. Prior to assembly with the gusset, a predetermined quantity of bonding liquid per unit length of slot is distributed uniformly therein, this quantity being approximately equal to the void space per unit length that results after full insertion of the gusset. Then, the sides of the slot are compressed to the shape illustrated, thereby forming an opening 48 slightly wider than the gauge of the gusset.

When the gusset is inserted it presses into the adhesive, which flows upwardly along both sides of the sheet. If a small excess of adhesive has been provided, it oozes out at the top of the slot and forms fillets 50, as illustrated.

It will be appreciated that in assembly it is not always possible to keep the parts in perfect alignment as they are pressed together. Thus the gusset may enter the slot at a slight angle, entrapping the larger portion of the adhesive on one side. This tends to cause the adhesive to flow more rapidly along that side toward the opening 48. However, the restriction at the opening is sufficient to arrest the adhesive, which is ordinarily of viscous, glue-like consistency, thereby tending to accelerate the flow of adhesive up the other side. Thus the joint is firm due to the uniform distribution of adhesive on both sides of the gusset, and clean due to the restriction at the opening 48 of the slot which prevents excessive extrusion and loss of adhesive.

Fig. 3 illustrates and alternative form of slot 52 in a frame member 54, joined with a gusset 56. The slot 52 is substantially straight-sided except near its opening 58. It may be sawn or extruded as a straight-sided slot slightly wider than the thickness of the gusset, and its edges may then be pinched together to form the opening 58 approximately equal to the thickness of the gusset 56. If the slot is formed by extrusion it may have the narrow opening 58 imparted to it in that process. This opening provides a tight bond with negligible loss of the bonding liquid through extrusion from the opening of the slot in assembly.

Prior to insertion of the gusset 56 into the slot, a predetermined quantity of bonding liquid per unit length of the slot is distributed uniformly in the slot, this quantity being substantially equal to the void per unit length resulting after full insertion of the gusset. The mechanism by which a uniform distribution of liquid is insured may be understood by assuming that the gusset 56 is inserted at an angle to the slot 52 as illustrated by phantom lines 60. This tends to trap the greater part of the liquid on one side of the gusset, and as the gusset is forced toward the bottom of the slot the volume of void space on this side is reduced. Because the opening 58 fits the gusset and because of the viscosity of the liquid it cannot escape in any substantial quantity. The result is that the liquid tends initially to flow longitudinally of the slot and to be equally distributed therein while all entrapped air is allowed to escape around the ends of the gusset or through the opening 58. When the liquid completely fills the space available, further insertion of the gusset is prevented unless and until it has rotated in the direction of the arrow F, in which case the liquid is allowed to flow to the other side of the slot and to become equally distributed on both sides of the gusset. Thus insertion may be completed in this case only if the liquid is allowed to be evenly distributed, that is, only if the gusset is rotated in the slot as force is applied.

Fig. 4 illustrates another alternative form of slot 62 which is similar to the slot 52, except for the addition of indentations 64 at intervals along its length. These indentations provide inward projections 66 whereby rotation of the inserted gusset as described with reference to Fig. 3 is produced automatically by the force of insertion due to the tendency of the projections to centralize the inserted member and thereby to allow the liquid to flow equally to both sides of the gusset.

Fig. 5 shows another form slot 68 having an enlarged bottom portion 70 which facilitates equalizing flow of the liquid between the two sides of the gusset.

Fig. 8 illustrates still another alternative form of slot 72 which is similar to the slot 52 (Fig. 3) except that it is provided with tapered bottom wall portions 74. In this embodiment the tapered wall portions 74 tend to centralize an inserted gusset 76. The gusset is preferably provided with an uneven or wavy edge 78 as illustrated in Fig. 9, or holes 80 as illustrated in Fig. 10, to facilitate flow of the bonding liquid.

In the embodiments of Figs. 3 to 5 and 8 the opening of the slot is approximately equal to or slightly greater than the thickness of the gusset to be inserted, as in the embodiment of Fig. 2.

Panels and enclosures constructed according to the teachings of this invention are of superior strength and light weight and may be fabricated at minimum cost due to the efficient structural design and equalized distribution of applied forces and moments in various planes. The enclosure is neat in appearance and tight due to the improved slotted and bonded construction as hereinabove described.

Having thus described the invention, I claim:

1. An enclosure having a self-supporting framework including at least two generally rectangular girth assemblies composed of I-cross-section members having generally flat parallel portions, each of said members having a slot in an edge surface of one of the generally flat parallel portions thereof, said girth assemblies being perpendicular to one another and intersecting at their respective mid-points, respective slots being disposed in mutually perpendicular, substantially co-planar relationship, a number of gussets of substantially uniform thickness inserted in the slots of said members to join them in abutted relationship, a flowable bonding material substantially filling the void between each gusset and the walls of its associated slot, the opening of said slot not being appreciably wider than the thickness of said gusset, and each slot having a portion appreciably wider than its opening to facilitate the flow of said material to both sides of the gusset upon insertion thereof in the slot.

2. In a reinforced metal enclosure a sub-unit including an I-beam frame member comprising two pairs of substantially parallel, spaced flange portions disposed

at right angles to a common central portion, a slot disposed in the edge surface of each of said flange portions and being substantially parallel to said flange portion, at least one slot disposed in said central portion at right angles to the flange slots, a thin sheet member of substantially uniform thickness disposed in each of said slots, each of said slots having an opening slightly wider than the thickness of said sheet member to admit the latter, a body of flowable bonding material substantially filling the void between the sheet member and the walls of each slot, each of said slots having a portion appreciably wider than its opening to facilitate the flow of said material to both sides of the sheet upon insertion thereof in the slot.

3. In a reinforced metal enclosure a structural subunit including a pair of frame members having identical I-beam cross-sections, each of said frame members comprising two pairs of substantially parallel, spaced flange portions disposed at right angles to a common central portion, a slot disposed in the edge surface of each of said flange portions parallel to said flange portion, said frame members abutting each other at right angles to form pairs of corresponding flange slots, the slots of each of said pairs being disposed in mutually perpendicular, substantially co-planar relationship, a thin sheet member of substantially uniform thickness corresponding to each of said slot pairs, mutually perpendicular edges of each of said thin sheet members being disposed in the respective slots of its corresponding pair, each of said slots having an opening slightly wider than the thickness of said sheet member to admit the latter, a body of flowable bonding material substantially filling the void between the sheet member and the walls of each slot, each of said slots having a portion appreciably wider than its opening to facilitate the flow of said material to both sides of the sheet upon insertion thereof in the slot.

4. The structure of claim 3 wherein the sheet members disposed in the respective slots of each pair of spaced flange portions comprise a cover sheet and a triangular gusset sheet respectively.

5. In a reinforced metal enclosure a structural subunit including a pair of frame members having identical I-beam cross-sections, each of said frame members comprising two pairs of substantially parallel, spaced flange portions disposed at right angles to a common central portion, at least one slot disposed in the central portion of each of said frame members substantially perpendicular to said flanges, said frame members abutting each other at right angles to form pairs of corresponding central portion slots, the slots of each of said pairs being disposed in mutually perpendicular, substantially co-planar relationship, a thin sheet member of substantially uniform thickness corresponding to each of said slot pairs, mutually perpendicular edges of each of said thin sheet members being disposed in the respective slots of its corresponding pair, each of said slots having an opening slightly wider than the thickness of said sheet member to admit the latter, a body of flowable bonding material substantially filling the void between the sheet member and the walls of each slot, each of said slots having a portion appreciably wider than its opening to facilitate the flow of said material to both sides of the sheet upon insertion thereof in the slot.

6. In a reinforced metal enclosure a structural subunit including a frame member having an I-beam cross-section, said frame member comprising two pairs of substantially parallel, spaced flange portions disposed at right angles with respect to a central portion, a slot disposed in the edge surface of at least one of said flange portions, an edge member having an L-beam cross-section, said edge member comprising a pair of mutually perpendicular flange portions, a slot disposed in the edge surface of each of said last-recited flange portions, said edge member being positioned at right angles with respect to said frame member, one slot of said edge member being disposed in mutually perpendicular, substantially co-planar relationship with the slot of said frame member, a first thin sheet member of substantially uniform thickness having mutually perpendicular edges thereof disposed in said slots, each of said slots having an opening slightly wider than the thickness of said sheet member to admit the latter, a body of flowable bonding material substantially filling the void between the sheet member and the walls of each slot, each of said slots having a portion appreciably wider than its opening to facilitate the flow of said material to both sides of the sheet upon insertion thereof in the slot.

7. The structure of claim 6 and further comprising a second frame member substantially identical in construction to said first recited frame member, said second frame member being positioned at right angles to said first recited frame member and to said edge member so that a slot of said second frame member is disposed in mutually perpendicular, substantially co-planar relationship with the other slot of said edge member, a second thin sheet member of substantially uniform thickness having mutually perpendicular edges thereof disposed in said last-recited slots and bonded therein in identical manner to the bonding of said first sheet member.

8. The structure of claim 7 and further comprising a slot in the central portion of each of said frame members, said central portion slots being disposed in mutually perpendicular substantially co-planar relationship, each of said central portion slots being identical in construction to the flange slots of its frame member and being disposed at right angles thereto, a third thin sheet member of substantially uniform thickness having mutually perpendicular edges thereof disposed in said central portion slots and bonded therein in identical manner to the bonding of said first and second sheet members.

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