

March 3, 1942.

P. ZALKIND

2,274,765

LAMINATED SHEET

Filed May 14, 1935

3 Sheets-Sheet 1

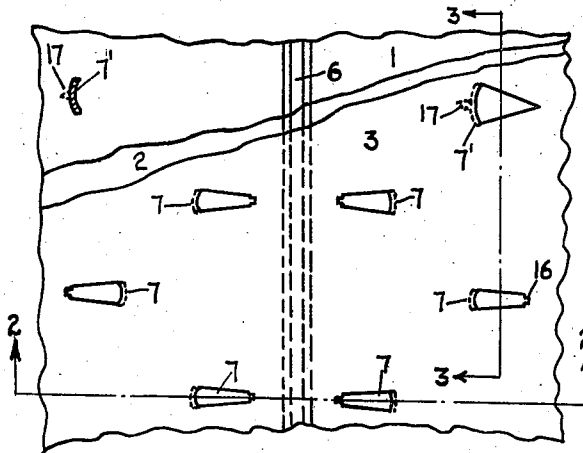


FIG. 1

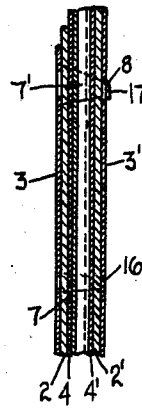


FIG. 3

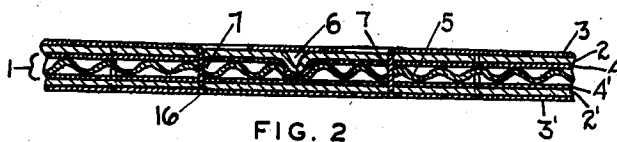


FIG. 2

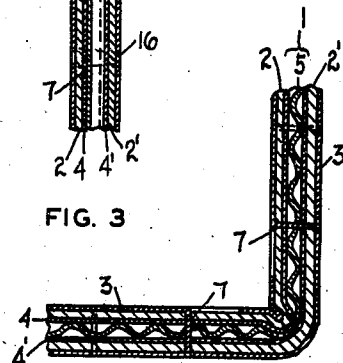


FIG. 4



FIG. 10

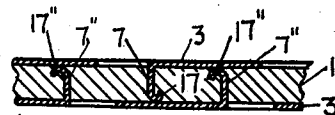


FIG. 5

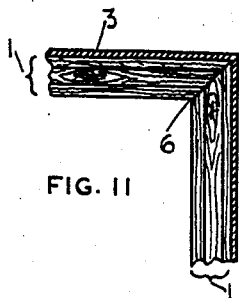


FIG. 11

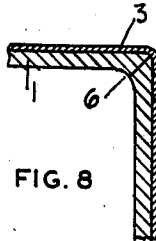


FIG. 8

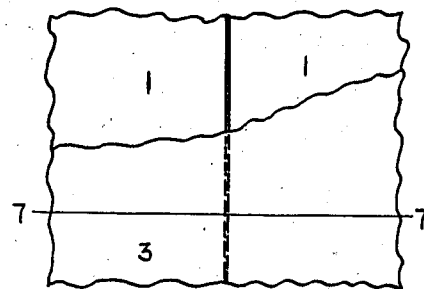


FIG. 6

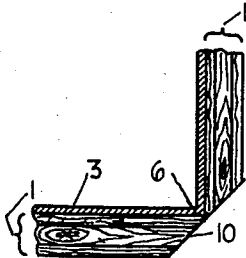


FIG. 12

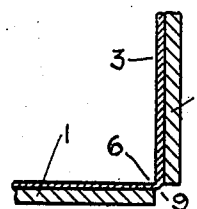


FIG. 9

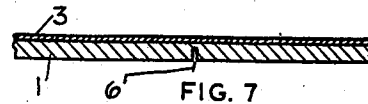


FIG. 7

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3 Sheets-Sheet 2

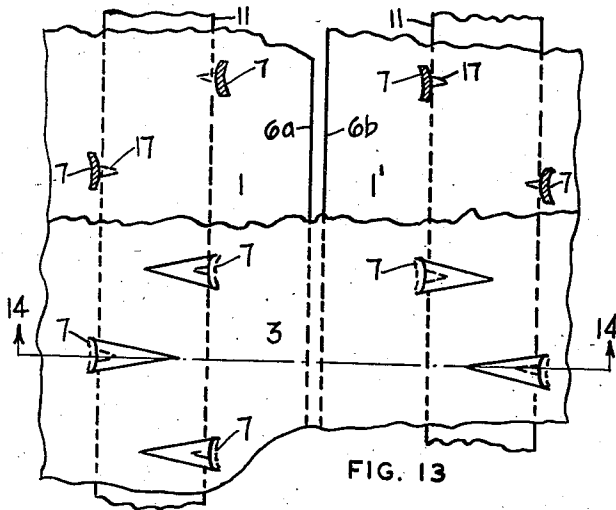


FIG. 13

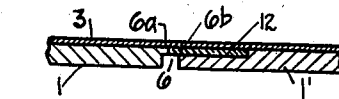


FIG. 16

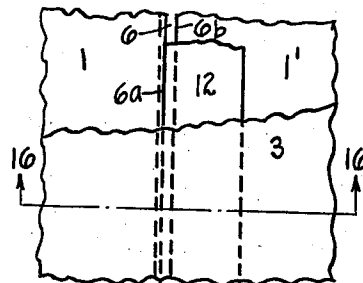


FIG. 17

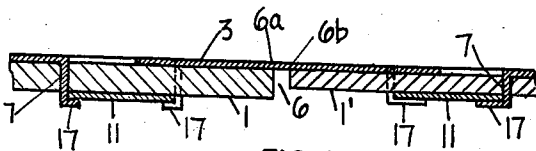


FIG. 14

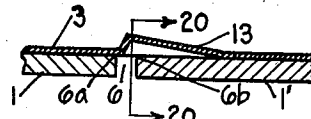


FIG. 18

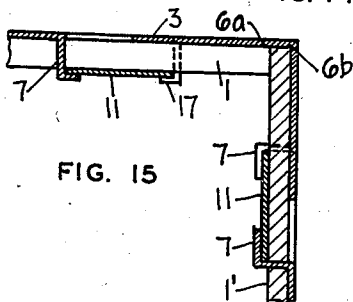


FIG. 15

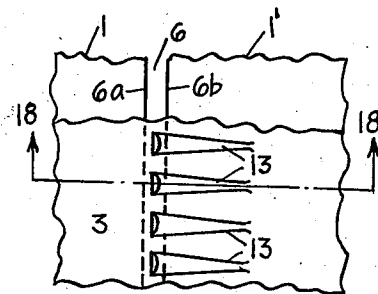


FIG. 19

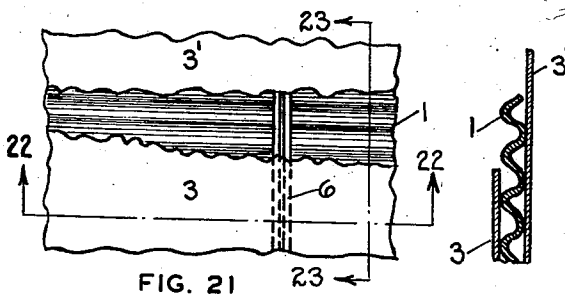


FIG. 21

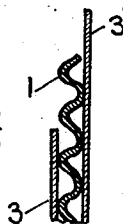


FIG. 23

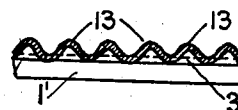


FIG. 20

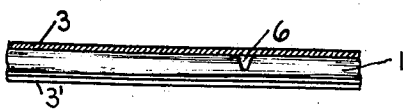


FIG. 22

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2,274,765

LAMINATED SHEET

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3 Sheets-Sheet 3

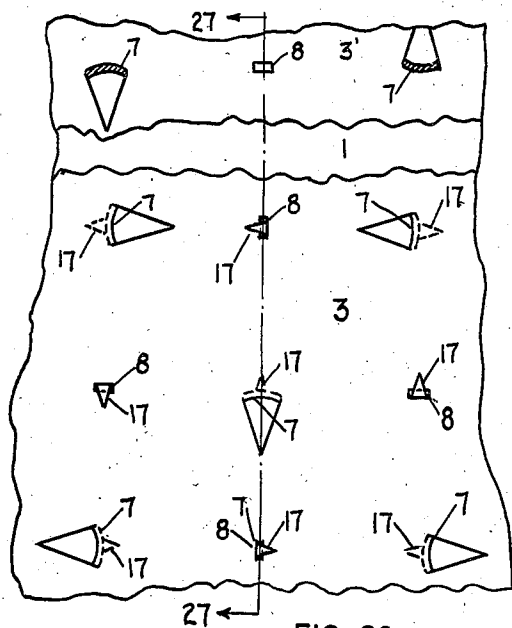


FIG. 26

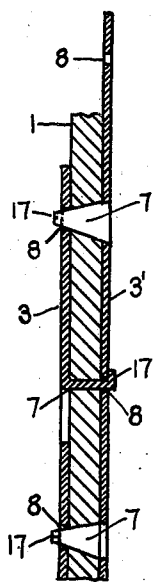


FIG. 27

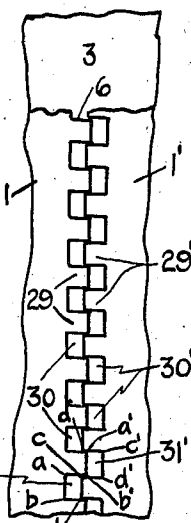


FIG. 33

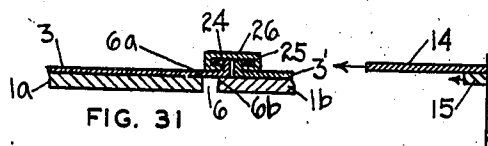


FIG. 31

FIG. 25

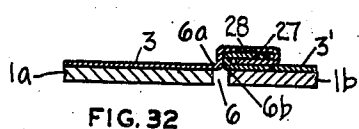


FIG. 32

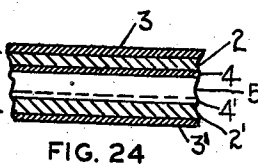


FIG. 24

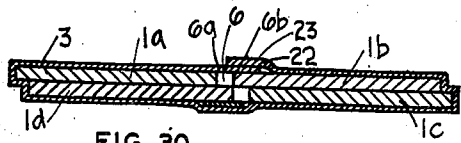


FIG. 30

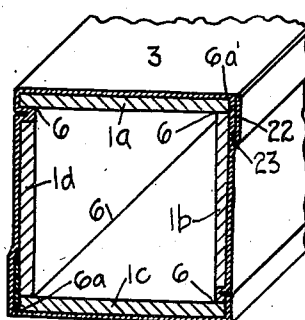


FIG. 29

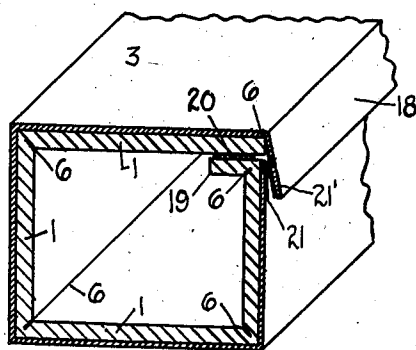


FIG. 28

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UNITED STATES PATENT OFFICE

2,274,765

LAMINATED SHEET

Philip Zalkind, New York, N. Y.

Application May 14, 1935, Serial No. 21,411

6 Claims. (Cl. 154-45.9)

My invention relates to a combination sheet of laminar construction having a fold line and comprising a lamina of metal and a non-metallic lamina, the fold line of the combination being produced by conditioning the non-metallic lamina.

I have discovered that scored fibrous sheet material may be combined in lamiform union with sheet metal such as steel or the like by suitable adhesive such as silicate of soda or various adhesive compositions such as are readily procurable on the market and that such a lamiform or sectional combining of sheet material with scored fiber sheet will permit bending of the combination along a predetermined line without any treatment of the metal for predetermining the bending line or lines, provided the fibrous material is of dominating rigidity in relation to the thickness and torsional resistance of the metal. The scoring of the sheet board material may be accomplished either before the union thereof with the metal or after union. In scoring after lamination of the board and metal, I have found that the metal remains unaffected.

I am aware that the combining of metal foil with paper materials is a common practice but I contemplate the use of metal of such gauge and strength, as distinguished from foil, that it adds definitely to the structural strength of the combined sheet. The metal I use has substantial body and could support itself in a horizontal position for a substantial length. It has considerable compressive and tensile strength and could not be manually torn apart. In itself, however, it buckles readily when subjected to compression. I have found that combining this metal with scored corrugated board or such other sheet material as herein referred to, produces an article of manufacture which can carry a substantial vertical compressive load, the metal supplying the strength and the board supplying the body.

I have found by numerous experiments that metal of the thickness of 30 gauge and heavier may be so combined and dominated as to predetermine bending lines when combined with other sheet material such as corrugated board, wall board, plywood, and the like without the requirement of providing a scoring or weakening in the metal to assist the predetermining of the bending lines in the metal.

In order to provide coordination of the juxtaposed edges and prevent excessive strains at the bending line where wood is used, I may space the wood sections from each other so that they are juxtaposed when the material is bent along

the scored line determined by the fibrous material.

I have found that this lamiform construction with relatively light metal will have the benefit of the bulk provided by the addition of fibrous material. Moreover, it will have the added rigidity attained from such combination and will not have the tinny sound or effect incident to the use of sheet metal alone even where the metal in itself is of sufficient thickness or bulk to provide the required strength.

It is obvious that this composition comprises a new article of manufacture adaptable for many uses in addition to specific illustrations thereof.

It is further my intention to provide in structures such as those herein described the quality of fire resistive protection. In combining, as above described, sheet metal and paper by means of silicate of soda, a very definite measure of fire protection is acquired by the structure, the silicate of soda itself lending fire resistive quality by its application to the paper material, and whereas ordinarily the application of silicate of soda on paper causes it to be brittle and to lose strength, its use in this manner does not weaken or lessen the effectiveness of the fibrous material in the structure for its intended use here.

In fact, I have discovered that I can impregnate corrugated board of low test or of non-test in a bath of fire resistive adhesive, as for instance, silicate of soda solution, and apply the corrugated board thus treated to a sheet of metal, such as steel, using the silicate of soda as a cementing material. The laminated sheet thus formed possesses considerable strength, and the corrugated board thus treated lends a greater strength to the combination than does untreated corrugated board of the same test. Similar results may be obtained in the same manner with various types of sheet material.

I may also make such a combination with an incombustible sheet material such as asbestos board, which in the forms ordinarily used commercially has insufficient strength by itself for any such constructions as are herein disclosed, but which by combination with the metal as herein disclosed, serves to give body and rigidity to metal and the thin metal in the combination serves to give the necessary strength for the structure.

Furthermore, the combination of fibrous material and metal may have interposed between them sheet material, such as asbestos paper to add to the fire resistive qualities of the container. Also I may treat both sides of the fibrous

material with metal, with the interposition of material such as asbestos paper either at the outer side or inner side or both the outer and inner sides.

My invention may be used for many purposes. It may be used for wall structures and by suitably providing fold lines at proper intervals may be bent around angles. It is thus readily adapted to be used in providing a metal faced, fire resistant sheathing on columns, or it may be used for flexible panels or partition screens. Also my invention is especially adapted for use in collapsible containers. It may be readily used to provide an inexpensive metal lined shipping container that may be collapsed till ready for use; or it may be used with metal faced furniture of various shapes and uses, such as filing containers and drawers, as well as other furniture, such as cabinets. In my copending application, Serial No. 739,962, filed August 15, 1934, I have disclosed the use of my lamiform combination sheet in connection with cabinets. The present application is a continuation in part of the above application, Serial No. 739,962. However, I do not limit the use of my lamiform sheet to use with cabinets; neither do I limit its use to the specific purposes recited in this paragraph, as its uses are many and various and the particular form is susceptible of considerable variation without departing from the scope and meaning of my invention.

Thus, depending upon the use to which my invention is to be adapted, I make use of various combinations of materials in layers, one of which is metallic and another of which is non-metallic and which by its condition determines the fold line on which the combination will bend.

In general for the non-metallic layer I can use either cellular material or solid material. The cellular material may be corrugated board, corrugated asbestos sheet, or the like; and where such corrugated material is used it may have a liner on both sides, or on only one side, or the metal may itself be the liner on each side.

Where solid material is used in the non-metallic layer, I can use either bending or folding material, such as fibre board and paper board; or non-bending or non-folding material, such as veneer, wood ply board, asbestos board, wall board, mineral composition board and chip board.

The metallic layer I prefer in general to be sheet metal of the order of 30 gauge thickness, but other thicknesses may be used depending upon the strength and thickness of the non-metallic layer in which the predetermined bending line is incorporated and the specific application or embodiment of the invention. Thus I have used steel over 26 gauge thickness and thinner than 38 gauge. Other metal than steel may be used; but I prefer the use of steel mainly because of its relatively low cost and high tensile strength. However, I am not limited to steel for the metallic element, as zinc, copper, tin, aluminum, brass, or other metals may be used.

I can use the laminated sheet in various combinations as to the position of the metallic member in the laminated structure. Thus I can use a single metallic layer in the combination, and such single metallic layer may be on one of the two surfaces of the sheet, or it may be used in combination with a plurality of non-metallic layers and may be covered on either or both sides by such a layer. Also, I can use a plurality of metallic layers in combination with a single non-

metallic layer or in combination with a plurality of non-metallic layers. Where two metallic layers are used, each layer may form one of the outside layers of the sheet, thus presenting an entirely metal-clad sheet.

The laminated sheet may be made fire-resistant, either by using a naturally fire resisting material, such as corrugated asbestos or other asbestos sheet as the non-metallic element; or by impregnating the non-metallic element to make it fire resistant. I have already explained how the use of silicate of soda as an adhesive material adds to the fire resistive quality of the non-metallic layer. Another means for providing fire resistive quality is to impregnate the non-metallic layer with a chemical which will evolve an inert gas when heated. This is particularly effective when the laminated sheet is metal clad entirely over both surfaces, as the impervious character of the metal covering will prevent either loss of chemical through volatilization or loss of gas when the chemical is decomposed by heat.

Various means may be used in joining the various layers of my laminar structure, and the means best suited will depend upon the specific application. Thus, I may use an adhesive material such as water glass, latex and casein, shellac, or other well-known binding agents for holding the various layers in position relative to each other. Another means of fastening which I have employed comprises punching prongs in the metallic layer, which prongs project into, and secure the non-metallic layer. This method is especially effective when a metallic layer is placed on either side of the non-metallic layer, the metal on one side having the punched prongs which extend through the non-metallic layer into corresponding piercings in the metallic layer on the other side. It is obvious that both the above methods of fastening may be combined in the same structure, or that riveting means may be used instead of prongs as a mechanical fastening means. Also where only one sheet of metal is used, I may use metallic washers or clips on the side away from the metal for backing the non-metallic element to receive and cooperate with the prongs, rivets or similar fastening means.

Where adhesive material is used to join the various layers, I may apply the adhesive material directly between the layers or may interpose a layer of paper between the layers to aid in binding the layers. Thus in joining a metallic layer to a non-metallic layer, a soft paper capable of readily retaining adhesive substance may be first applied to the metallic layer; and the metallic layer, with the paper backing, applied to the non-metallic layer through the medium of the adhered paper. In this manner it may be possible to obtain a more complete and uniform and a more secure joint between the metallic layer and the non-metallic layer than if the metallic layer were adhesively connected directly to the non-metallic lamination. In such a modification it becomes practical to use adhesive or plastic material of varying characteristics between the laminations.

The objects of my invention are to provide the advantages of a metal surface with the lightness, cheapness, bulk, body and rigidity of a non-metallic sheet; to eliminate the tinny sound of thin sheet metal structure by combining the sheet metal with a sound-deadening sheet; to add stability to a thin metal sheet by

securing it to a relatively thick backing or facing, or both; to provide a predetermined bend line in a sheet with a metal layer for manually bending the combined sheet on said bend line; to provide a laminated sheet, with a metallic and non-metallic layer, having greater structural strength than either the metallic or the non-metallic layer; to provide a novel sheet having fire resistive properties; to provide a substantially impervious sheet suitable for collapsible containers, cabinets, boxes, and the like.

It will be seen from these specifications that the above and other objects are accomplished by my invention.

My invention may be further explained in conjunction with the accompanying drawings which show a number of the various modifications by way of illustration but which are not intended to exhaust the various structural changes which may be made within the scope of my invention. In the drawings, which form a part of this specification:

Fig. 1 is a plan view, partly broken away, showing a sheet constructed according to my invention;

Fig. 2 is a cross-section along the line 2—2 of Fig. 1;

Fig. 3 is a longitudinal section through a prong on the line 3—3 of Fig. 1;

Fig. 4 is a cross-section similar to Fig. 2 showing the sheet bent at the score line;

Fig. 5 shows in cross-section an alternative form of securing the laminations;

Fig. 6 is a plan, partly broken away, of a modified sheet constructed according to my invention;

Fig. 7 is a cross-section along line 7—7 of Fig. 5;

Fig. 8 is a cross section similar to Fig. 6 showing the sheet bent at the score line;

Fig. 9 is similar to Fig. 8, with the sheet bent in the opposite direction;

Fig. 10 is a modified cross-section;

Fig. 11 is similar to Fig. 8, using the score of Fig. 10;

Fig. 12 is similar to Fig. 9, using the score of Fig. 10;

Fig. 13 is a plan view of a further modification;

Fig. 14 is a cross-section on line 14—14 of Fig. 13;

Fig. 15 is a cross-section similar to Fig. 14 with the sheet bent at the score line;

Fig. 16 is a cross-section of a further modification of my invention along line 16—16 of Fig. 17;

Fig. 17 is a plan view of Fig. 16;

Fig. 18 is a cross-section showing means of confining the bend line to a single one of two lines and is along line 18—18 of Fig. 19;

Fig. 19 is a plan view of Fig. 18;

Fig. 20 is a longitudinal section along line 20—20 of Fig. 18;

Fig. 21 is a plan view of a further modification;

Fig. 22 is a cross-section along line 22—22 of Fig. 21;

Fig. 23 is a longitudinal section along line 23—23 of Fig. 21;

Fig. 24 is an enlarged section;

Fig. 25 is a stress diagram showing the laminar sheet as a section of a beam;

Fig. 26 is a plan view showing a three ply laminated sheet with an alternative fastening means;

Fig. 27 is a cross-section along line 27—27 of Fig. 26;

Fig. 28 shows one application of my laminated structure;

Fig. 29 shows another application of my invention;

Fig. 30 is a view of Fig. 29 in the collapsed position;

Fig. 31 shows a modified form of the joint illustrated in Figs. 29 and 30;

Fig. 32 is a further modification of Fig. 31;

Fig. 33 is a plan view of a further modification similar to Fig. 13.

Referring to Figs. 1, 2, and 3, I have shown a multiple ply structure with the center lamination 1 of corrugated board. This corrugated board is shown as comprising the liners 4 and 4' and the corrugations 5. On either side of the corrugated board is shown a layer of insulating material 2 and 2' which may be asbestos paper or the like. The two outer metallic layers 3 and 3' are preferably of sheet steel of thickness of from 26 gauge to 38 gauge.

The dominating layer 1 of corrugated board is provided with a score line 6, which I have shown as a crease line. I have found that this score line will control the entire laminate structure, so that when the sheet is manually bent it will bend on this score line substantially as shown in Fig. 4. The score 6 is preferably formed in the non-metallic layer prior to its combination with the other layers as a unified structure; and with some of the material which I use in the non-metallic layer it is necessary that the fold line be incorporated with the sheet either prior to or during its assembly. However, when I use easily scorable material, such as corrugated board for the dominating lamination, the scoring may be done after the sheet is completely assembled, if I use suitable scoring means, and the score 6 provided in the lamination 1, through the laminae 2 and 3 without marring or otherwise affecting the metallic layer 3.

As shown in Figs. 1, 2 and 3, the several layers of the sheet are held in relation to each other by means of the prongs 7 punched out of the metallic sheet 3. In addition to these prongs which pass through the several layers of material, adhesive may be used to consolidate the layers and to prevent one layer from sliding on an adjacent layer. The prongs 7, preferably are of sufficient length that they coact with the small slots 8 punched in the metallic sheet 3'. These prongs 7 are shown as having been punched out with the tit 16. The distance from the start of the tit to the inner face of metallic layer 3 is substantially equal to the thickness of the non-metallic layers. Thus the tit enters the slot 8 in sheet 3' and the shoulder formed where the tit 16 joins the main prong 7 acts to keep the two metallic sheets in spaced relationship to each other a distance equal to the thickness of the non-metallic member. The ends 16 of the prongs 7, may be held within the slot 8 by any suitable means and thus securely bind the whole structure together. The shoulder on the prongs, which space the metallic members apart, are particularly desirable when the ends 16 are rolled or riveted into the slots 8.

In the upper portion of Figs. 1 and 3, I have shown an alternative form of prong 7'. As shown in Fig. 1, the prong is arc shaped in section. This adds materially to the strength of the prong; and if sheet 3 from which the prong 7' is formed is of heavier gauge than sheet 3', the prong may be made to pierce and penetrate sheet 3', thus forming the slot 8 with which the

prong cooperates. In the operation by which the prong is driven through the sheet 3', the end of the prong may be turned over as shown at 17 (Fig. 3), thus clinching the laminations securely together.

An alternative method of forming the prongs is shown in Fig. 5. In this figure prongs are formed from both the metallic layer 3 and the metallic layer 3', the prongs being formed alternately from the two sheets. The ends of the prongs 7 from the upper metallic sheet 3 pass through the non-metallic layer 1 and instead of passing through the metallic layer 3' are turned over and clinched into the non-metallic layer as at 17. The prongs 7' formed from the lower layer 3' also pass through the non-metallic layer and are clinched into it as at 17'. The clinching from both sides through one of the interior layers firmly unites all of the layers into an integrated structure.

It is of course understood that there may be used a greater or lesser number of layers than five as shown in Figs. 1 to 4. In Figs. 6 and 7, I have shown a two layer sheet in which the two layers are joined together by adhesive material alone. In these figures, 1 is the non-metallic layer and 3 is the metallic layer, and the score 6, in the non-metallic layer is shown as a cut score. This type of score is preferable when such material as veneer, wood ply board, asbestos board, wall board, mineral composition board, and similar material, which cannot be easily creased is used as the non-metallic layer, but a cut score may also be used with an easily creasable non-metallic layer such as paper board or corrugated board. When material such as chip board, paper board, or material of cellular structure is used as the non-metallic layer, the bending may be away from the metal as shown in Fig. 8 without exerting any considerable pressure. As a certain amount of crushing of the non-metallic layer takes place when the sheet is bent in this way, relatively dense and unyielding material, such as wood ply board would require considerable stress applied to make this form of bend, but it would bend on the predetermined score line.

In Fig. 9 I have shown the sheet material of Fig. 6 bent toward the metal layer. In this case there will be an unfilled corner 9, but little stress is required to make this bend even if the material of the non-metallic layer is quite dense and unyielding.

The necessity of high stress application during bending and the open corner may be obviated by slightly modifying the score line. Thus, as shown in Fig. 10, the score 6 is shown as a cut-out rectangular V notch in the non-metallic layer 1 of 3-ply wood adhesively attached to the metallic layer 3. When this structure is bent away from the metallic layer along the score line 6 as shown in Fig. 11, the sides of the V notch approach each other and form a miter joint when the sheet is bent to a right angle. When the sheet with this form of score line is bent toward the metallic layer, as shown in Fig. 12, the score 6 will open up and when the sheet has been bent to a right angle, the score line will be presented as a bevel edge 10. As is obvious, variations in the form of cut-out scores can be made to produce a great variety of corner shapes and angles.

A further modification of the cut score is shown in Figs. 13, 14 and 15. The same effect as by scoring a sheet of non-metallic material

is obtained when two separate pieces of material are laid edge to edge and combined with the metallic sheet, as shown in Fig. 13. Thus the non-metallic member is shown as the two separate sheets 1 and 1'. These sheets may be of different materials from each other, and they may (as shown) be of different thicknesses, sheet 1 being somewhat thicker than sheet 1', as clearly shown in Fig. 14. In laying up the structure, the edge of sheet 1 may be suitably spaced from the edge of 1'. Where solid material, such as ply wood, etc., is used, this distance should be slightly less than the thickness of the thinner of the two sheets; but where yieldable material like corrugated board provides one of the edges, spacing may be unnecessary. When the sheet is manually bent along the score line 6, the thicker of the two sheets will "ride" on the thinner sheet and form a tight fitting corner without strain or distortion of the non-metallic layer as clearly shown in Fig. 15.

Where the material of the non-metallic layer is easily yieldable, such as corrugated board, the sheets 1 and 1' may be of the same thickness as each other, but the same effect as that obtained from sheets of two thicknesses may be secured by slightly crushing one of the sheets adjacent to the score line and for a width equal to or slightly greater than the thickness of the uncrushed sheet. By this means, the crushed portion will act in the manner of the thinner of the two sheets shown in Fig. 14 and the thicker layer will ride on top of it in bending up an angle in the manner as shown in Fig. 15.

In the modification illustrated in Fig. 15, I have shown prongs punched out of the metallic layer functioning to unite the laminations. (These may be assisted by adhesive material between the layers.) These prongs 7 pass through the non-metallic layer and are clinched over the straps 11 made of metal or other suitable material. It will be noted that as shown in cross-section in the upper part of Fig. 13, the prongs are shaped to present a convex surface on the side adjacent to the strap 11. This shape has several particular advantages. First, the prong has greater strength than would a flat prong of the same thickness of metal, and it is therefore forced more easily through the non-metallic layer. Second, if the prong is pressed through the non-metallic layer against an unyielding backing, the arcuate shape will cause the end of the prong to bend toward the convex face when it strikes the unyielding surface, using the principle which I have disclosed in my copending application, Serial No. 693,841, filed October 16, 1933. The prong will thereby be bent so as to clinch over the backing strap 11.

When the two members 1 and 1' of the non-metallic element are spaced apart, there may be need for further means to precisely determine the bend line as to the particular edge of said space, otherwise the bend might come indiscriminately at the line 6a, or line 6b, or immediately. The difference in thickness of the material predetermines the bend line at the line 6b as shown in Figs. 13, 14, and 15. However, this same effect may be obtained in other means, using a non-metal layer of uniform thickness.

In Figs. 16 and 17 I have shown in cross-section a modification of a score line obtained by laying the non-metallic sheets 1 and 1' with their edges adjacent to each other but so spaced from each other as to provide a crease line of appreciable width. In this figure, sheet 1 and sheet 1'

are shown to be the same thickness, but though the score 6 is of appreciable width, the bend line is restricted to a line along 6a by the insertion of the strip 12 which provides a greater bend resistance to the combined sheet at the line along 6b than is presented by the sheet at the line along 6a. This definitely predetermines the bend to the line at 6a. Strip 12 may be of any suitable material providing bending strength exceeding the variations in strength of the metallic layer 3.

Where the score line is of such width as to provide more than one line on which the sheet could bend indiscriminately, the limitation of the bend line to a single predetermined line by providing differential strength of the several possible lines of bend may be accomplished in other ways than that shown in Figs. 16 and 17. A slight increase in the strength of the metallic sheet across one of the two possible bend lines will confine the bend to the other line. Such a modification is shown in Figs. 18, 19, and 20. Here the metallic sheet 3 is provided with corrugation or rib formations 13 extending over the edge 6b of non-metallic sheet 1'; but this corrugated or rib formation 13 does not extend over the edge 6a of non-metallic sheet 1. The strength of the laminated unit is thus greater at edge 6b than it is at edge 6a, thus a predetermined bend line occurs along the line at 6a.

I have found that where the non-metallic layer is wood ply board or similar material, an effective predetermination of the bend line may be secured using lock joint construction as shown in Fig. 33. In this figure, the metal lamination is shown at 3, and the bend line occurs along the space at 6 between the separate non-metallic sheets 1 and 1'. The non-metallic sheets 1 and 1' and the metallic sheet 3 are secured together by any suitable means, as for instance, by a proper adhesive substance.

The member 1 is provided with the line of projections 29 and the line of grooves 30. The member 1' is provided with the line of projections 29' and the line of grooves 30'. The projections 29 of sheet 1 fit into the grooves 30' of sheet 1'; and the projections 29' of sheet 1' fit into the grooves 30 of sheet 1. If the distance between the extreme ends of the projections 29 to the bottom of the grooves 30' and from the ends of the projections 29' to the bottom of the grooves 30 is substantially equal to the thickness of sheets 1 and 1', then the laminated sheet may be manually bent along the bend line 6 to form a perfect lock joint between the non-metallic members 1 and 1' to have a sharp linear bend in the metal.

It will be noted that if the sheets 1 and 1' are spaced either too close together or too far apart and if a thin metallic layer is used, then when the laminated sheet is bent in to right angular form to produce a lock joint in the non-metallic members, the outline of the teeth of the lock-joint may be perceptible in the metallic member 3. This can be entirely obviated by careful spacing of the sheets 1 and 1', which may be accomplished through the use of proper jigs, or by the means which I shall now describe.

It will be noted that a line of rectangular cut out spaces 31 is formed when the projections 29' are fitted into the grooves 30. Each of these spaces 31 is defined by the corners a, b, c, and d. Similarly, a line of rectangular cut out spaces 31' is formed by projections 29 and grooves 30'.

Each of these spaces 31' is defined by the corners a', b', c' and d'.

I find that, instead of using two separate pieces 1 and 1' with the teeth 29 and 29' respectively and the grooves 30 and 30' respectively, I may use a single sheet of non-metallic material with two adjacent lines of rectangular holes 31 and 31'. This single sheet, in which the portion of the left of the line of bending is joined to the portion to the right of the bend line by the jointures cb' and da', if attached to a metallic member, may have the portion to the left of the bend line precisely spaced for a perfect lock joint by properly proportioning the holes 31 and 31'. When the laminated sheet thus formed is bent along the bend line, the jointures cb' and da' will shear. The joint thus formed will be exactly the same as if the portion of non-metallic member left of the bend line had been a separate piece from the portion to the right of the bend line, and at the same time the two pieces had been perfectly spaced from each other.

A further modification of my invention is shown in Figs. 21, 22, and 23. In this modification the metallic layers 3 and 3' act as liners for the non-metallic corrugated layer 1. In this form the laminar sheet is quite stiff and must be shipped flat; but if the metallic member 3' is omitted and the sheet consists only of a single metal liner 3 with the corrugated non-metallic backing 1 secured thereto, then the sheet may be shipped in rolls.

It has heretofore been pointed out in this specification that the laminated sheet has considerably greater strength than has either the metallic layer or the non-metallic layer. In Fig. 24 there is shown an enlarged section of a laminated sheet consisting of the dominating non-metallic member 1 and the metallic covers 3 and 3'. The dominating non-metallic member is indicated as being a sheet of corrugated board with the liners 4 and 4' and the corrugated paper web 5.

If it is assumed that the metallic members are made up of sheet steel of #32 gauge (.01") thick, and that the corrugated board is 1/2" thick with 1/2" liners, then the total laminated sheet is approximately .127" thick. The safe bending moment of each of the steel sheets taken alone is represented by

$$M = 16000 \times \frac{1}{6} b d^2 = \frac{16000}{6} \times \frac{1}{100} \times \frac{1}{100} b = .267b \text{ in. lbs.}$$

so that the two sheets taken separately will have a combined safe bending moment of .533b inch pounds. The safe bending moment of the corrugated board alone is 1.5 inch pounds.

Now as a combined sheet, wherein the various laminae are properly secured to each other in such a manner that the adhesive strength is greater than the horizontal shearing forces that are developed by beam loading, the structure will withstand a much greater moment. This is represented diagrammatically in Fig. 25 wherein 14 and 14' represents the safe stress in the steel coverings and 15 and 15' represents the stress in the cardboard liners. Under these conditions the combined safe bending moment will be approximately 70b inch pounds, which is many times the bending strength of any of the separate laminations. In this respect, the structure resembles a slab of reinforced concrete, where the steel alone has substantially no bending strength, and the concrete alone has but little more; but when

the two are properly combined, there is produced a structure of great strength due to the proper spacing of the high strength material so as to develop a moment.

Likewise my metal clad structure is capable of acting as a vertical wall to support a vertical load in columnar relationship. As a vertical column, the metal as defined at No. 32 gauge would have a minimum radius of gyration of about .003", and with this radius could not support a vertical load as a column for a length greatly in excess of 1/2" in height. When properly combined with the corrugated paper so that the layers are secured to each other in a manner to develop web stresses, then the radius of gyration, for the same dimension sheet as was used above in figuring beam stresses, becomes about 1/8" and is therefore capable of supporting some load for a column height up to over a foot. By slightly increasing the thickness of the corrugated board the sheet may be designed to carry loads of greater height as desired, but the dimensions as given above are quite suitable for structures such as collapsible filing cases of the usual dimensions.

In Figs. 26 and 27, I have shown a laminated sheet formed from the metallic layers 3 and 3' and the non-metallic sheet 1. In this modification prongs 7 are formed in both of the metallic layers and cooperate with the slots 8 in the opposite metallic layer. The ends 18 of the prongs pass through the slots 8 and are clinched over at 17. When, as shown in Fig. 26, the prongs not only are formed in each sheet but also are alternately placed in each sheet so as to face in a different direction, a laminated sheet of great strength is thereby produced. The tapering portion of the prongs alternately coming from either metallic sheet and alternately facing in different directions on each sheet adds great stability to the entire structure and develops web stresses so that the sheet is quite strong either as a beam or a column as has just been explained.

In fact, I have found that where the prongs 7 wedge tightly into slots 8 before the ends 17 are turned over, the prongs alone will act to space the two metallic sheets, to fasten the two sheets to each other, and to act as the web members; and the structure will be very rigid even when the non-metallic member 1 is omitted.

Figures 28, 29, and 30 serve to illustrate several of the possible uses for my invention. In Fig. 28 there is shown a section of a collapsible tube adapted for use where a metallic surface, hermetically sealed container is required. In this figure the non-metallic layer is represented at 1 with the fold lines illustrated along the lines 6. It will be noted that, as shown, the metallic layer and the non-metallic layer are not coextensive in this illustration. The non-metallic layer is provided with the flap on tab 19 provided with the adhesive strip 20. When the laminated sheet is bent up as in Fig. 28, the adhesive strip 20 serves to unite the two ends of the non-metallic element. Also the metallic element is provided with the flap or tab 18. This tab may be tinned on the inner surface as at 21'. When this tab is turned down the inner tinned surface 21' coats with the outer tinned surface 21 on the angular tube. By properly applying heat along the outside of tab 18, a close juncture will be obtained by uniting the solder of the two abutting tinned surfaces, thus forming an impervious metallic layer entirely surrounding the non-metallic layer. The tube so formed will be collapsible until heads are applied

to the end of the tubes. These heads may be formed either from flaps provided on the main sheet or they may be separate sheets as shown in my copending application, Serial No. 693,841, filed October 16, 1933. In either case, abutting tinned seams similar to that provided on tab 18 may be provided on the joints of the head connection, whereby the box thus formed will be hermetically tight after all the joints are made up.

In Figs. 29 and 30, there are shown illustrations of the open spaced crease line as explained in Figs. 13 to 19 inclusive. In Fig. 30 is shown the tubular structure of Fig. 29 in collapsed condition. It will be noted that on the bottom of Fig. 30 is shown a joint of the same type as shown in Figs. 16 and 17 with the strip 12 provided to cause the bend to occur along the line 6a. No such strip 12 is shown at the joint shown on the upper part of Fig. 30, but the effect of such a strip is obtained by properly lapping the two ends of the metallic sheet when they are brought around to contact each other and to be united with each other by any suitable means, such as soldering. In this case, the portion 23 overlapping the portion 22 serves the same purpose as does the strip 12 acting with the sheet 3 on the joint on the lower portion. Thus the bend line will occur at 6a' rather than at 6b'.

Many variations of this means of conditioning the bend line may be used in my invention, and two such modifications are shown in Figs. 31 and 32. In these figures are shown means for joining the two edges of a single sheet to form a collapsible tube, such as is shown in Figs. 29 and 30, either Figure 31 or 32 showing a modification of the joint shown as the overlapping edges 22 and 23 in the upper portion of Fig. 30 and in the upper right hand corner of Fig. 29.

While I have shown the joined edges in Figs. 29 and 30 as being the two opposing edges of a single sheet, it is clearly indicated in Figs. 31 and 32 that the joined edges may be either the opposing edges of a single sheet formed into a tube, or they may be abutting edges of two separate sheets. Thus as in the case of a tubular structure such as shown in Fig. 29, each of the four sides may be covered with an integral metal sheet; or if desired, each of the sides may be an individual sheet of metal joined to the adjacent metal sheets by a joint such as shown in Figs. 31 and 32. In this way there will be formed an integrated built up sheet with the bend lines predetermined in the sheet in accordance with my invention.

Referring to Fig. 31, the dominating non-metallic material is shown at 1a and 1b and may be either a single sheet with a cut out score 6 or may be two separate sheets laid adjacent to each other to form the score 6. The metallic layer is shown as at 3 and 3' and may be either a single sheet forming opposed edges of a sheet bent to tubular form or may be two separate sheets, as has just been explained. The edge of sheet 3 is bent into a U at 24 and the edge of 3' is bent into a U at 25. These two U-shaped edge bends are united to each other by the strip 26, which fits over the outstand leg of each of the U-shaped edges, and is preferably pressed or rolled after being placed in such position. In this manner, the two sheets are firmly secured to each other. The bend line is conditioned in the laminated sheet thus formed at the score line 6. Moreover, the union of the metallic layer with the multiple ply of metal overlying the edge

6b, but not overlying the edge 6a, predetermines the line of bend exactly at 6a.

Fig. 32 is similar in every way to Fig. 31, except that another form of seam for joining the sheets 3 and 3' is shown. Thus instead of the metal strip 26 being used as a tie piece for joining 3 and 3', the sheets 3 and 3' are bent over and crimped on each other to form the joint. However, as in Fig. 31, the seam by lying over the edge 6b, predetermines the bend of the laminated sheet at 6a.

It will be understood that these examples are given merely to indicate in what manner my invention can be used, and that my invention is not at all limited to these specific examples, but instead has a broad general application for numerous purposes.

Many changes may be made in the details of my invention without departing from the scope thereof. Having described my invention in such a manner that it may be readily understood by one skilled in the art:

I claim:

1. As an article of manufacture for forming collapsible containers, a composite sheet of laminar material comprising a thickness of paper composition material of dominating rigidity securely joined to two layers of sheet metal of the order of 30 gauge, one on each side of said paper composition material, and a crease score line in said paper composition material formed without loss of paper from said paper composition material for determining a bending line in said article of manufacture.

2. As an article of manufacture for forming collapsible containers, a sheet of paper composition material; a sheet metal facing on each face of said material; and means for securely joining the several layers together, said joining means including prongs formed by punching out portions of one of said sheet metal facings, said paper composition material having a score line formed without loss of paper from said paper

composition material for determining the bend line of said article of manufacture.

3. As an article of manufacture, a sheet of laminar material comprising a thickness of non-metallic material securely joined to a layer of sheet metal, said non-metallic layer having a bend line formed by rectangular holes along which the laminated sheet may be manually bent, said rectangular holes being so positioned relative to each other that, upon bending said laminated sheet, a lock joint is formed in the non-metallic material.

4. As an article of manufacture, a sheet of laminar material comprising a thickness of non-metallic material securely joined to a layer of sheet metal, said sheet having a predetermined bend line, said bend line being determined by the said non-metallic material being discontinuous along said bend line and by a stiffening strip the edge of which is laid contiguous to said bend line, said strip being interposed between said metallic and non-metallic layers.

5. As an article of manufacture, a sheet of laminar material comprising a thickness of non-metallic material securely joined to a layer of sheet metal, said sheet having a predetermined bending line, said bend line being determined by the said non-metallic material being discontinuous along said bend line and by corrugations formed in said metallic layer transverse to said bend line and terminating at said bend line.

6. As an article of manufacture, a sheet of laminar material comprising a thickness of non-metallic material securely joined to a layer of sheet metal, said sheet having a predetermined bending line, said bend line being determined by the said non-metallic material being discontinuous along said bend line and by a multiple ply of metal formed from the metallic layer along said bend line, an edge of said multiple ply lying along said bend line.

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