United States Patent

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[54] **HOLLOW STRUCTURE OF STACKED SHEETS**
2 Claims, 9 Drawing Figs.

[52] U.S. Cl. 161/113, 52/309, 52/615, 161/117, 161/123, 161/139
[51] Int. Cl. B32b 3/12, E04c 2/24
[50] Field of Search 161/68, 139, 113, 117, 123; 138/117, 155, 120; 52/615, 309, 415

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ABSTRACT: A hollow structure is formed of thin sheets of material such as, for example, paper, paperboard or Gypsum with preformed openings in the sheets. The sheets are stacked in a programmed sequence to define a cavity of a predetermined shape within the interior of the article. The exterior edges of the sheets are also programmed in sequence to define the desired exterior surface for the article such as, for example, a simulated brick wall surface. By appropriately programming the sheets with interiorly disposed portions, it is possible to form and shape internal elements within the hollow cavity. The method of forming the article includes the bonding of the sheets such as, for example, by flooding the hollow cavity with the bonding agent and permitting penetration of the bonding agent into the stacked sheets.

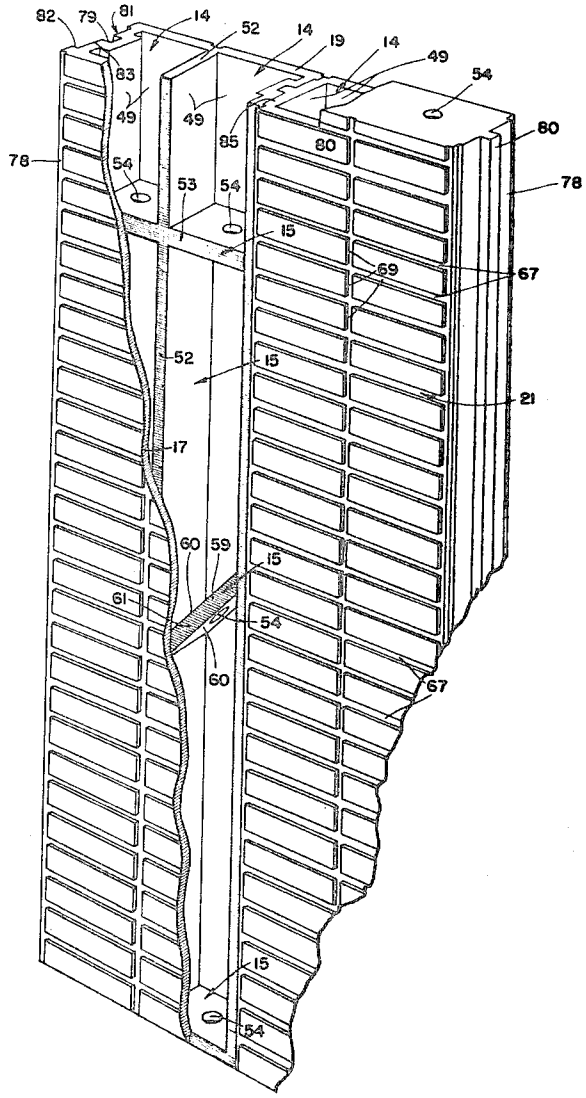


FIG. 1

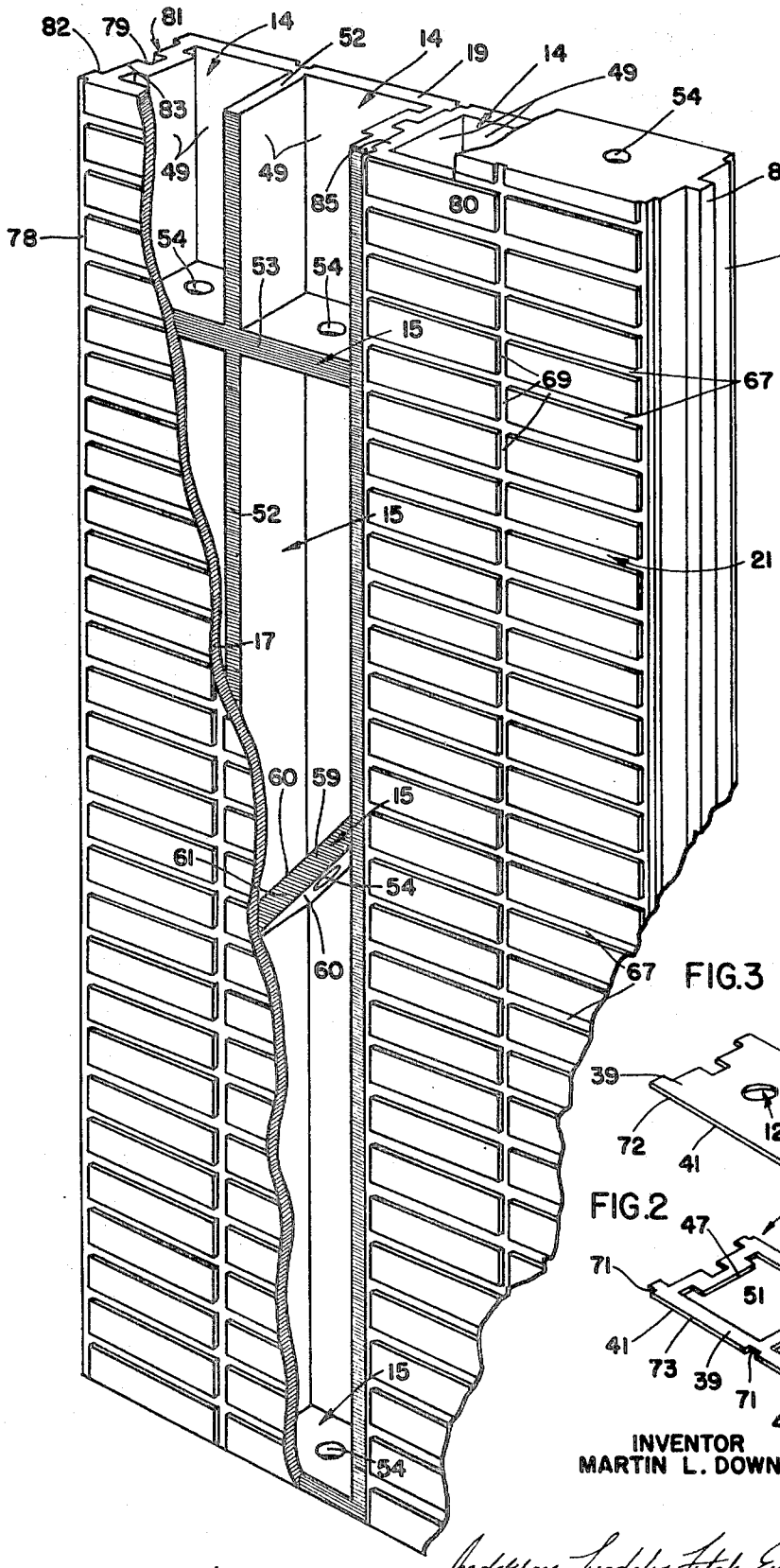


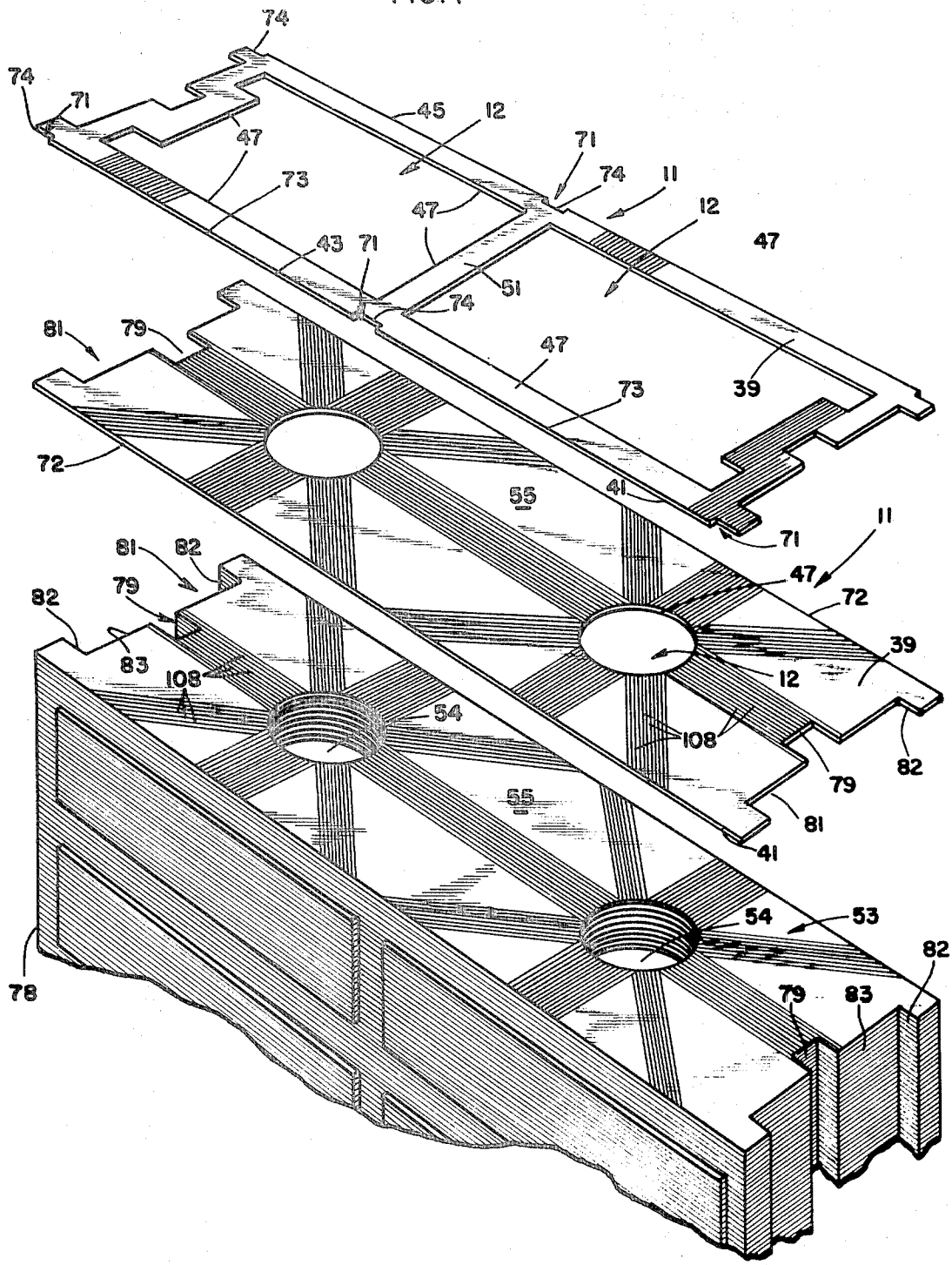
FIG. 3

FIG. 2

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FIG. 4



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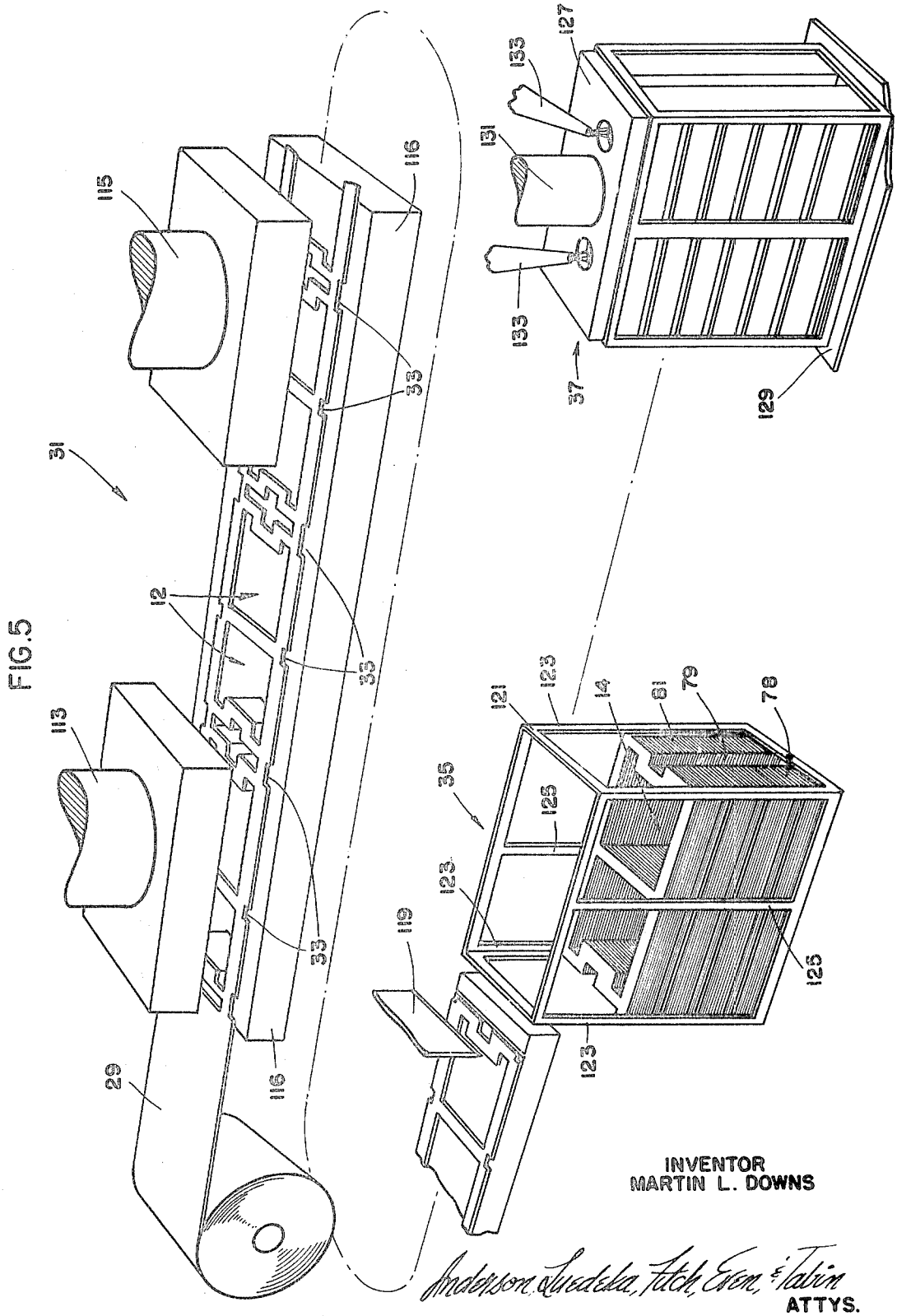


FIG. 5

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FIG.6

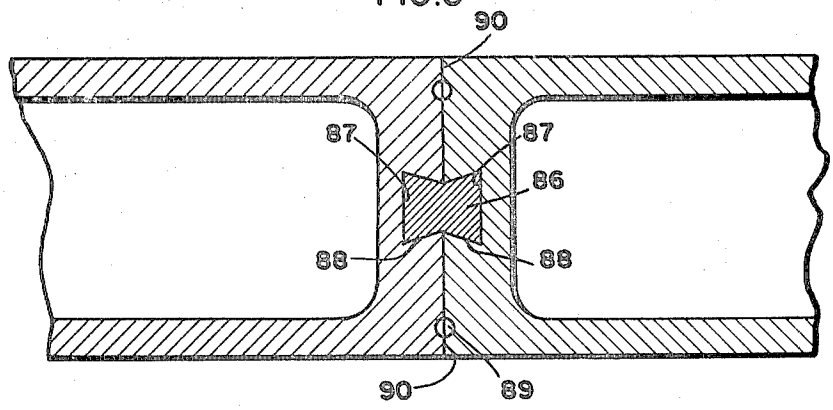


FIG.7

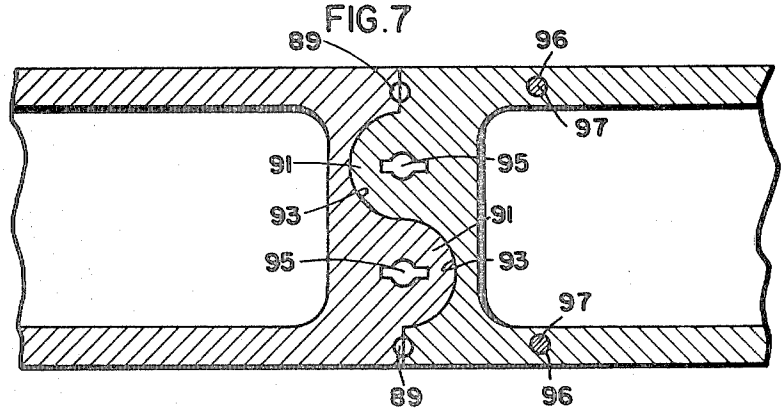


FIG.8

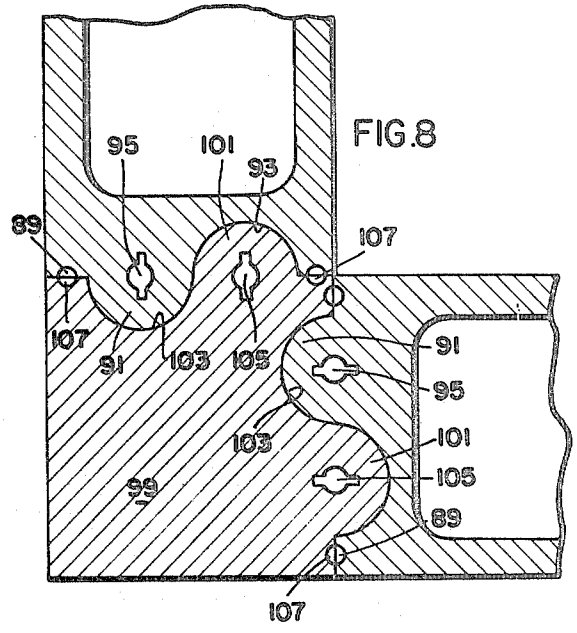
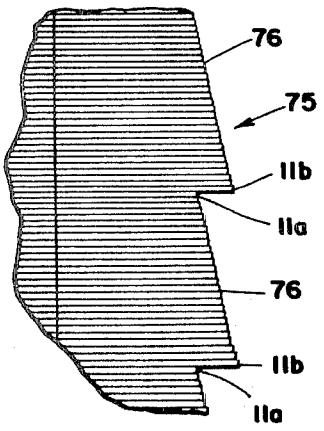


FIG.9



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HOLLOW STRUCTURE OF STACKED SHEETS

This invention relates to laminated hollow structures or articles suitable for various ends and uses and to methods of making the same.

Traditional methods of fabricating hollow structures such as, for example, platform skids, hollow core doors, aircraft foils, partitions or building walls, involve the making of many separate pieces such as facing walls, braces, headers, stops, spacers, studs, etc., each having different shapes and often made from different materials. These respective pieces must be collected at an assembly area, properly positioned relative to one another and then fastened together in a series of operations. For example, when fabricating an interior or exterior building wall, the various component pieces are collected at the assembly site, studs or framing members are fastened together and in place, stops, headers or the like are positioned and fastened in place, and then interior and facing walls are attached to the opposite sides of the framing to enclose the interiorly disposed members. The costs of collecting the component members and assembling thereof in this manner is overcome with the present invention.

A shortcoming of many hollow structures, particularly those having internal supporting members, is that the structures are made from a number of diverse materials each having a different rate of expansion or contraction. On the other hand, structures made from the same or similar materials, such as wood, often have the grains of the respective pieces misaligned. Such structures are subject to splitting, cracking, or separating from each other under temperature or moisture cycling due to the differential rates or directions of expansion or contraction.

With the present invention, many hollow structures made typically with wood, metal and plastic or combinations thereof, and, in the above-described manner, may be made from thin sheet materials of paper, paperboard, paper waste, gypsumboard or other mineral materials with laminar stacking and plying techniques which not only form the exterior of the structure but also form, at the same time, interior elements, such as stops, braces, studs or the like within the hollow interior of the structure. By suitably sequentially programming the outer facing edges of the sheets used to make the structure, its facing surfaces may be decoratively configured or textured, e.g., wall structures having brick, clapboard, or stone appearing surfaces. By additions of suitable bonding agents, fire proofing or other agents, the laminated paper or mineral sheet structure may be made with unexpected hardness, strength, rigidity, and unity desirable for outdoor use or in loading bearing situations.

Accordingly, a general object of the invention is to provide a new and improved structure and methods of making the same.

Other objects and advantages will become readily apparent from the following detailed description and the accompanying drawings in which:

FIG. 1 is a fragmentary, perspective view with a portion of a sidewall broken away to expose an interior of a hollow structure embodying the features of the invention;

FIG. 2 is a reduced-in-size perspective view of a sheet used in forming the structure of FIG. 1;

FIG. 3 is a reduced-in-size perspective view of another sheet used in forming the structure of FIG. 1;

FIG. 4 is an enlarged, exploded perspective view of several sheets used in forming the structure of FIG. 1;

FIG. 5 is a diagrammatic illustration of a manner of making the structure of FIG. 1;

FIG. 6 is a fragmentary, cross-sectional view of a manner of interlocking several wall structures made in accordance with another embodiment of the invention;

FIG. 7 is a fragmentary, cross-sectional view of another embodiment of the invention showing an interlocking pair of abutted wall structures;

FIG. 8 is a fragmentary, cross-sectional view of several wall members shown in FIG. 7 joined to a corner member; and

FIG. 9 is an enlarged, fragmentary view illustrating a manner of forming a clapboard surface for a wall structure.

As shown in the drawings for purposes of illustration, the invention is embodied in a hollow structure which is formed with a large number of thin, flat, laminated sheets 11 at least some of which have preformed openings 12 programmed in sequence (vertically in this instance) to form and shape internal hollows or cavities 14 and to form and shape internal elements 15 disposed in the interior of the structure between facing walls 17 and 19. By sequentially programming the widths, lengths and the shapes of the exterior edges of the sheets, the appearance of the structure is defined. For instance, a decorative surface 21 of simulated brick is provided for the illustrative wall structure. Thus, by suitably shaping the sheets and programming the stacking of the shaped sheets, it is possible to produce various hollow structures without, as in the prior art, machining cavities therein or without costly assembling of and fastening of many internal and external diverse elements.

As will be explained in greater detail hereinafter, hollow structures may be made primarily of relatively inexpensive materials such as paper, paperboard, paper waste, gypsumboard or the like which are made on mass scale basis with papermaking techniques, casting, molding or similar techniques. Papermaking or other continuous sheet forming machines offer the advantage of producing extremely long sheets for assembly into very long structures. For example, the illustrated wall structure may be as much as 50 feet in length and formed with literally hundreds of plies of thin, flat sheets of paper or paperboard stacked one upon the other to desired height, say 8 or 10 feet. It will be appreciated that the longitudinal dimension of the structure will usually be aligned with the machine direction of the sheets and that the grain or machine directional strengths, if any, will be aligned in this longitudinal direction. This is helpful in reducing splitting or cracking due to temperature or moisture cycling. By incorporating into the sheets or by selection of a suitable bonding agent such as, for example, sodium silicate, the assembled sheets may lose their individual characteristic softness of paper and be transformed into a hard, rigid, and strong structure capable of use as a building wall, either of a load or non-load bearing kind.

Before proceeding with a detailed description of the invention, the method of making the illustrated wall structure of FIG. 1 will be briefly described in connection with FIG. 5. A continuous web 29 of paperboard is fed forward, and, at a diecutting station 31, the preformed openings 12 are formed in the interior of the web and notches 33 are formed along the edges of the web. If desired, suitable control equipment at the diecutting station may render certain dies operative and other dies inoperative to provide a manner by which successive cuts may be changed in accordance with a desired sequence. At a severing station the web is severed transversely into sheets 11 of the desired length. The sheets 11 are stacked in a predetermined sequence, such as the sequence in which the sheets were formed, at an assembling station 35. After the sheets are registered and stacked the stack may be moved forwardly to a bonding station 37 at which a suitable bonding agent such as sodium silicate adhesive is added as by flooding the hollow cavity with the structure. The bonding agent is allowed to penetrate toward the outer edges of the sheets and along interfaces between the sheets and by capillary action into the fibers of the sheet. The penetration, i.e., depth, of the bonding may be limited by controlling various factors such as the viscosity of the bonding agent, the time allowed for penetration, and the amount of compressive forces being applied to the stacked sheets. After adhesive penetration has proceeded as far as desirable, the excess of the adhesive is removed, as by tipping the stack. The adhesive retained by and on the sheets is allowed to dry with the adhesive becoming hard and forming the rigid hollow structure.

Referring now in greater detail to the individual elements comprising the hollow structure, the preferred sheets 11 are relatively flat with spaced faces 39 and 41 which are substan-

tially parallel to one another and adapted to be abutted against faces of other adjacent sheets when forming the structure. The preferred sheets are thin in cross section or depth between the faces **39** and **41** as compared to the width or length dimensions of the sheets; and are typically ⅛-inch or less thick paperboard, paper, asbestos, gypsum or other mineral board or the like. The thickness of the sheet may be varied depending upon the process used to form the sheet, the composition of the sheet, and the ultimate properties desired for the finished structure. The width of the sheet, i.e., the distance between longitudinal edges **43** and **45** of the sheet, may be also varied considerably. It may be relatively narrow, such as only several inches for a door structure or in the range of 4 to 12 inches for a building wall or panel structure. The longitudinal length of the sheet may be, if desired, very long as this usually is in the machine direction for the paperboard. Hence, structures having lengths of 50 feet or more may be made. Thus, it will be seen that unlike many typical wall boards or other types of sheets, which are commonly limited to 4-feet by 8-feet sheets, because this is maximum width possible with machine on which they are formed, that structures of this invention may be made with heights and lengths considerably in excess of such dimensions.

Of particular importance in making inexpensive hollow structures is the ability to use relatively inexpensive materials such as a low-grade or scrap paper or paper formed such as on papermaking equipment utilizing low-grade furnishes. Blemishes, pinholes or the like in a given sheet of paper, which render the same waste for many uses, make relatively little difference in the quality of the final article or structure in this instance. It is to be understood that sheets **11** are not limited to any given material; but sheets of cellulosic materials and sheets made of inorganic materials such as asbestos, mica or the like are preferred because of low material and sheets formation costs. Also, continuous or large sheets may be handled and/or converted with conventional lines of equipment. Because the laminating techniques are used to make the ultimate structure, it is possible with the present invention to use asbestos or silicate fiberboard which would be too brittle and subject to cracking if attempted to be bent, scored or otherwise used in commercial building techniques.

Referring now in greater detail to the forming of the cavities **14** by the sequential programming of the performed openings **12** in the sheets **11**. In this instance, the preformed openings in each of the sheets **11** in the center section of the wall structure are formed with identically shaped openings **12** which have internal edges **47** arranged vertically relative to one another to define, collectively, vertical walls forming large rectangular cross-sectioned cavities or circular cavities, such as seen in FIG. **4**. More specifically, each of four planar vertical walls **49** defining a large hollow cavity is formed and shaped by the alignment in vertical planes of the edges **47** of many individual sheets shown in FIGS. **2**, **3** and **4**. Adjacent cavities are separated by narrow webs **51** in the sheets which are sequentially programmed to be vertically aligned and stacked to form vertically disposed cross walls **52** which are in the form of internal members which take the place of the conventional studs or cross frame members in conventional walls.

At various locations, the cavities **14** may be divided by a transverse wall such as a stop **53** into upper and lower portions and thereby prevent unrestricted air movement in the vertical direction throughout the height of the wall. If desired, each of the stops **53** may be provided with small vertically extending bores **54** of circular cross section to receive electrical conduits or to facilitate the fishing of electrical wires vertically through the interior of the wall. The stops **53** are formed by several of the abutted sheets having circular, performed openings within a central portion **55** of the sheets. As best seen in FIG. **4**, these central portions **55** are much wider than the webs **51** and are aligned in a vertical plane with the latter to constitute a part of the cross walls **52** as well as the header walls **53**. To obtain the necessary thickness, i.e., the vertical dimension, for the stop **53**, the desired number of sheets having central portions **55** are sequentially programmed and stacked. As the sheets having the central portions **55** are substantially solid relative to the sheets having the large rectangular openings, the former adds rigidity to the wall structure. Sheets similar to those used to make the stops **53** may be used to define a bottom wall for the structure and/or a top wall therefor with the illustrated bores **54** therein.

If desired, the sequential programming of several sheets having the proper openings **12** therein may provide internal, diagonally extending braces **59** like that illustrated in FIG. **1**. In this instance, the brace **59** is formed by providing the sheets comprising it with narrow webs **61** and having the edges **60** of the respective webs laterally displaced to each other. In this instance, each of the webs **60** has the same width and its edges **61** are offset laterally to define substantially parallel, opposite sides of the diagonal brace **59**.

In the illustrated wall structure, the exterior facing walls are formed with a simulated brick surface which is made by controlling the shape or width dimensions of the sheet and sequentially stacking the sheets having the various shaped outer edges to achieve the desired bricklike pattern. More specifically, the illustrated facing walls **17** and **19** are formed with a bricklike appearance having horizontal channels simulating horizontal mortar lines **67** and vertically disposed channels simulating vertically disposed mortar lines **69**. As can be best understood from FIGS. **2** and **4**, the sheets used to form the bricklike areas are formed with spaced notches **71** at the location of each vertical mortar line **69**, in this instance at both ends and at the center of the sheet. The marginal portions **73** of the sheets between the notches **71** will project from the plane of the mortar lines **69** to appear as the brick surfaces. The horizontal mortar lines **67** are formed by stacking the narrower width sheets (FIG. **4**) having straight, longitudinally extending edges **72** one upon another. The narrow-width sheets have a width equal to the distance between rear walls **74** of the respective notches **71** in the brick-forming sheets. Thus, a simulated brick surface is formed by stacking a series of wide sheets to provide the appearance of bricks spaced by horizontal mortar lines and stacking a series of narrow sheets providing the horizontal mortar lines between bricks. The painting of the mortar lines **67** and **69** with a grey or white color and the brick areas of a contrasting yellow or red color will enhance the appearance.

Many other simulated surfaces may be made by controlling the width of the sheet and sequentially programming the different widths of the sheets. For instance, a simulated clapboard surface **75** (FIG. **9**) may be obtained by forming a series of vertically inclined surfaces **76**. The sheets **11** illustrated in FIG. **9** have a progressively increasing width dimension from a minimum width for a sheet **11***a* to a maximum width for a sheet **11***b* which is stacked on a minimum width sheet **11***a*. The process is repeated to form a series of vertically tapered outer, clapboard appearing surfaces. A striated surface (not shown) for the walls may be formed by forming shallow recesses or grooves in edges of adjacent sheets which are all of substantially the same width.

To interlock several wall sections or structures together, the respective end walls **78** thereof may be formed with means including grooves, splines, or other configurations which would be difficult and costly to machine or cut at the ends of a conventional wall. For example, the end walls **78** may be made with centrally disposed, vertically extending grooves **79** (FIG. **4**) to receive narrow, vertically extending keylike projections **80** formed on other wall section or structure, as best seen in FIG. **1**. In the embodiment of the invention illustrated in FIGS. **1** and **4**, another wider channel **81** is defined by inner, longitudinally extending walls **82** which intersect a transverse wall **83** in which is formed the key-receiving groove **79**. A complementary shaped projection **85**, as best seen in FIG. **1**, is inserted into the wide groove **81** and abuts the respective groove defining walls **82** and **83**. In this manner, the wall sections are interlocked against sliding or shifting transversely to one another.

Another form of interlocking means used to join adjacent wall structures is shown in FIG. 6 with a vertical key 86 inserted into a pair of keyways 87 which are formed with reversely tapered sidewalls 88. The latter would be expensive and difficult to machine if formed in wood studs of conventional walls. Suitable semicylindrical, mastic slots 89 may be formed in the end walls of adjacent wall structures to receive a suitable sealing or mastic material at the vertically disposed joint. In this embodiment, end walls 90 of the structure are flat and abutted in a common plane.

Another form of interlocking means between wall structures, which would be difficult or expensive to machine in commercial wall structures, is illustrated in FIG. 7. More specifically, the end walls of the structures are formed with a sinusoidal shape including an arcuately cross section projection 91 and an arcuately shaped groove 93. The projections 91 and grooves 93 are complementary in size and the projection of one wall section fits into the groove of the other wall section. The interlocking projections on the respective wall sections prevent separation or sliding in a direction transverse to the plane of the facing walls. If desired, vertically disposed holes 95 may be formed at the ends of each of the wall sections to receive a rod, cable, strap or other member for registering of the sheets 11 during stacking and to facilitate the attachment of the wall structure to top or bottom plates. Also, mastic receiving slots 89 may be provided in the wall sections of FIG. 7.

The sheets 11 may be provided with other openings 96, as illustrated in FIG. 7, in the opposite sidewalls forming portions thereof. When forming the wall section, vertical rods 97 may be positioned and then each sheet 11 may be sequentially placed in position above the rods 97 and then lowered on the rods to abut the next lower sheet of the wall section. The rods 97 in the holes 96 register the sheets prior to bonding the sheets together and the rods 97 may be left in the wall section to facilitate carrying and handling the wall sections. Also, by having the ends of the rods project above and below the wall section, the rods may be fastened to top and bottom plates at the site location to lock the wall section in position.

Also, wall structures may be quickly and rigidly joined together or to a post 99, as best seen in FIG. 9, by use of interlocking means in the form of the sinusoidally shaped ends which are interfitted. More particularly, the post 99 is formed of plied sheets each having a pair of sinusoidally shaped sides in the form of projections 101 and grooves 103. The grooves 103 receive the end wall projections 91 and likewise the wall section grooves 93 receive the post projections 101 with the end walls of the respective sections tightly abutted against the post walls. The sheets forming the post 99 may also be provided with preformed openings which are aligned to form vertically disposed holes 105 which are adapted to receive rods, straps or other members used to secure the post in place. Also, the post may be provided with semicircular, mastic receiving grooves 107 for alignment with the similar grooves 89 in the wall structures. Thus, a convenient strong interlocking connection may be made with complex shapes which are too expensive or difficult to cut or machine in conventional walls.

Referring now in greater detail to the illustrated method of making the structures illustrated herein, the sheets 11 may be secured or bonded together in a number of ways, such as, for example, by applying adhesive to the upper and lower faces 39 and 41 of the sheets during stacking or by impregnating the sheets with a suitable adhesive which can be activated after the sheets are stacked. While these methods may provide a satisfactory product, improved results have been obtained by simultaneous bonding of the sheets by slushing or flooding the large rectangular, cross-sectioned cavities 14 with a liquid adhesive for a predetermined period of time while the sheets are held with a predetermined compression which limits the rate of penetration of the adhesive along the abutted faces 39 and 41 of the sheets. Also, the viscosity of the adhesive is controlled to limit penetration of the adhesive by capillary action through the body of the sheets. It is preferred that the adhesive penetration proceed substantially to the outer edges of the sheets so that the edges are also bonded together while they still remain relatively dry. After a predetermined period, the adhesive is allowed to drain from the cavities 14 and the retained adhesive is allowed to dry or cure. To assist the penetration of the bonding material between the stacked piles, the sheets 11 may be formed with superficial indentations or grooves 108, as best seen in FIG. 4, in one or both faces extending from a preformed opening 12 which will be filled with the bonding material. The grooves 108 serve as irrigation channels providing a more positive liquid flow along the faces of the sheets toward the edges thereof. The grooves 108 may be formed in the sheets at the time of manufacture or embossed therein by suitable embossing dies.

Sodium silicate adhesive has been used to bond paper based sheets into a strong, hard, rigid structure. A suitable sodium silicate adhesive is made by Philadelphia Quartz Company and sold as "N" grade. A suitable pigment may be also added to the adhesive so that the final coloring and finish is made simultaneously with the impregnation. In addition to the slushing technique, the exterior facing walls and the interior walls of the cavity may be brushed or spread with the bonding agent, particularly when containing a pigment. Various bonding agents other than sodium silicate may be used to bond the respective plies or sheets together, the particular selection of a known adhesive being a matter of the use of the structure, cost and other considerations.

Referring now to FIG. 4, a manner of making the wall structure will be now described in greater detail. A suitable furnish containing cellulosic fibers and inorganic filler, such as clay, and also including fire retardants and mold resisting material is formed into a continuous web of paperboard on a cylindrical papermaking machine (not shown). While areas of the screen of the cylinder of this kind of papermaking machine may be selectively covered with a resist to prevent paper formation at the area of the preformed openings 12, it is preferred that the web 29 be continuous and uninterrupted and that the openings 12 be formed at the diecutting station 31. In some instances, the web 29 may be fed directly from the papermaking machine, but usually the web will be wound in suitable supply rolls 111 which can be stored and transported to the location at which the structure will be built. In either event, web 29 is fed forwardly to the diecutting station 31 at which the web is die cut to form the preformed openings 12, notches 33 and end wall configurations. The diecutting apparatus may take many forms such as the vertically reciprocating rams 113 and 115 which carry suitable paper-cutting dies for cooperating with suitably shaped openings in a die block 116 disposed beneath the web. The material punched from the webs may be ejected down through the die block as the rams 113 and 115 return upwardly, all in a conventional manner. It is preferred that the diecutting apparatus have the capability of allowing a change in the size and shape of the preformed openings 12 and cut the edges of the web in the desired sequence to form the simulated brick wall surface. For instance, the diecutting machine may be controlled by a program tape on which are encoded the location of the dies to be rendered effective to make the desired cuts on the web. As an alternative, rotary cutting dies (not shown) may be used.

The web 29 may be cut into sheets at various locations either before or after diecutting the openings 12 and notches 33; and the web is illustrated as being severed into sheets by a reciprocating blade 119 after the openings have been formed. In the illustration of FIG. 5, the severing of the sheets forms the ends thereof with edges which will, when stacked and aligned, form the grooves 79 and 81 at the end of the wall section. Also, another diecutter (not shown) may be used to trim the edges of the web when forming the narrow-width sheet for the horizontal mortar lines. The length of the severed sheets will usually be quite greater than illustrated herein as one of the advantages in forming walls with the present invention is obtaining a long wall length. The sheets are illustrated as being short to facilitate illustration and description of the invention.

On the other hand, when forming other articles, the length to width ratio of the sheets may be less than that illustrated for the wall structure.

At the assembling station **35**, the sheets are registered and stacked by means such as a form **121** which has vertically disposed, registering bars **123** for abutting the ends of the respective sheets at each of the corners thereof. Centrally disposed, registering bars **125** are inserted into notches **71** at the center of the sheets and abut the edges **72** of the narrow-width sheets to assure that the rear walls of the centrally notch sheets and the narrow sheet edges are aligned in vertical planes for forming the vertical mortar lines. Alternatively, the form may include or consist only of the vertical rods **97**, such as illustrated in FIG. **7**, with each sheet **11** having holes **96** to receive the rods as the sheets are stacked sequentially on the rods **97**. In this instance, the sheets leaving the diecutting station are in the proper sequence for stacking and are thus sequentially programmed. On the other hand, the sheets need not be in the proper sequence for stacking as the sheets leave the cutting station as the proper sequencing and programming may be done at the assembly station by an operator having access to the various shapes needed.

In this preferred embodiment of the invention, the stacked sheets are placed in compression between an upper plate **127** and a lower plate **129** with a hydraulic ram **131** exerting a predetermined pressure on the sheets at the bonding station **37** at which the internal cavities **14** are also filled from dispensers **133** with the bonding agent, sodium silicate in this instance. The sodium silicate penetrates along the interface between a lower face **39** of one sheet and the upper face **41** of an adjacent sheet, and capillary action of the fibrous sheets draws the bonding agent into the sheet, per se, to wet the fibers thereof. When the bonding agent penetrates to the outer walls of the structure defined by the edges of the sheets, the remaining pool of bonding agent in the cavities is drained therefrom as by removing the bottom plate **129** or inverting the stack to allow the adhesive to flow from the top of the cavities. After this, the wall structure is sent forward to the drying or curing station at which the sodium silicate hardens and the sheets become rigid. It is preferred to hold the sheets in the form and under compression during the drying and curing of the adhesive to limit warpage. Any tendency of expansion of the cellulosic fibers during the cure results merely in densification of the sheets. If desired, suitable pigment may be added to the sodium silicate adhesive so that the finished coat is applied simultaneously with the bonding agent. After curing, the compression plates **127** and **129** may be unclamped and the structure is completed and ready for use.

As stated at the outset, various kinds of hollow articles or structures (these terms having been used interchangeably herein) such as, but not limited to walls, air foils, doors, etc., may be formed by bonding superimposed sheets of relatively thin material such as paper, paperboard, asbestos board or the like. By sequentially programming preformed openings in the sheets, the internal elements and hollow cavities may be formed without machining or the fastening of numerous parts. In a like manner, the edges of the individual sheets also may be sequentially programmed to form the outer facing walls with a desired shape and to form the end walls with suitable interlocking shapes. In some instances, such as when forming the dovetail keyway slots illustrated in FIG. **6**, the openings in the plies defining the sidewalls of the keyway slots are in one sense preformed openings **12** in that they define a hollow cavity and are in another sense part of the facing or end walls of the structure. Hence, the terms preformed openings and internal hollow cavities do not necessarily exclude a connection with the outer or surrounding walls.

While a preferred embodiment has been shown and described, it will be understood that there is no intent to limit the invention by such disclosure but, rather, it is intended to cover all modifications and alternate constructions falling within the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A low-cost, hollow structure having structural integrity and rigidity for supporting loads, comprising a plurality of sheets stacked in face-to-face relationship, said sheets being thin in that the sheets have a thickness substantially less than the width or length dimensions of said sheets, said sheets being formed of a fibrous material, at least some of said sheets having preformed openings with such sheets being stacked in a programmed sequence to define a cavity of predetermined shape within the interior of said structure, certain of said sheets having interiorly disposed portions abutted to form and shape an internal reinforcing element within said cavity, the exterior of said sheets defining an exterior surface for said structure, and means including a bonding agent for bonding said sheets together along the faces thereof to provide said hollow structure, said bonding agent impregnating said fibrous sheets and providing said fibrous sheets with a rigidity and hardness substantially greater than the rigidity and hardness of said fibrous sheets prior to the impregnation thereof, said internal element extending diagonally relative to vertical and horizontal directions with said cavity.

2. A hollow structure comprising substantially flat sheets stacked face-to-face, said sheets having a depth dimension substantially less than a width or length dimension, exterior edges of said sheets being assembled to define facing walls for said wall structure, at least some of said sheets having preformed openings, said preformed openings of adjacent sheets being programmed and assembled in sequence to define a predetermined contour for a cavity in said structure, said sheets being assembled to a height exceeding that of the width dimension of said sheets, and means bonding said sheets together to form said hollow structural wall, at least some of said sheets having grooves in the face of said sheet for conveying a liquid bonding agent outwardly from said preformed openings toward said facing walls for said wall structure.