May 29, 1973 W. H. ABILDGAARD ET AL 3,736,200

MEIHOD FOR VACUUM MOLDING BOOK BINDINGS

Original Filed June 16, 1969 8 Sheets-Sheet 1

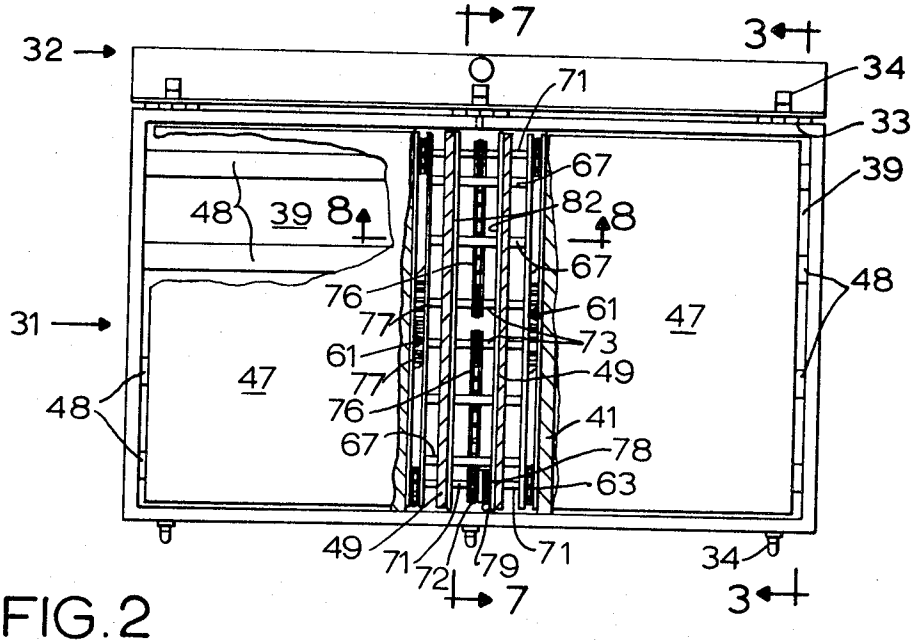


FIG. 2

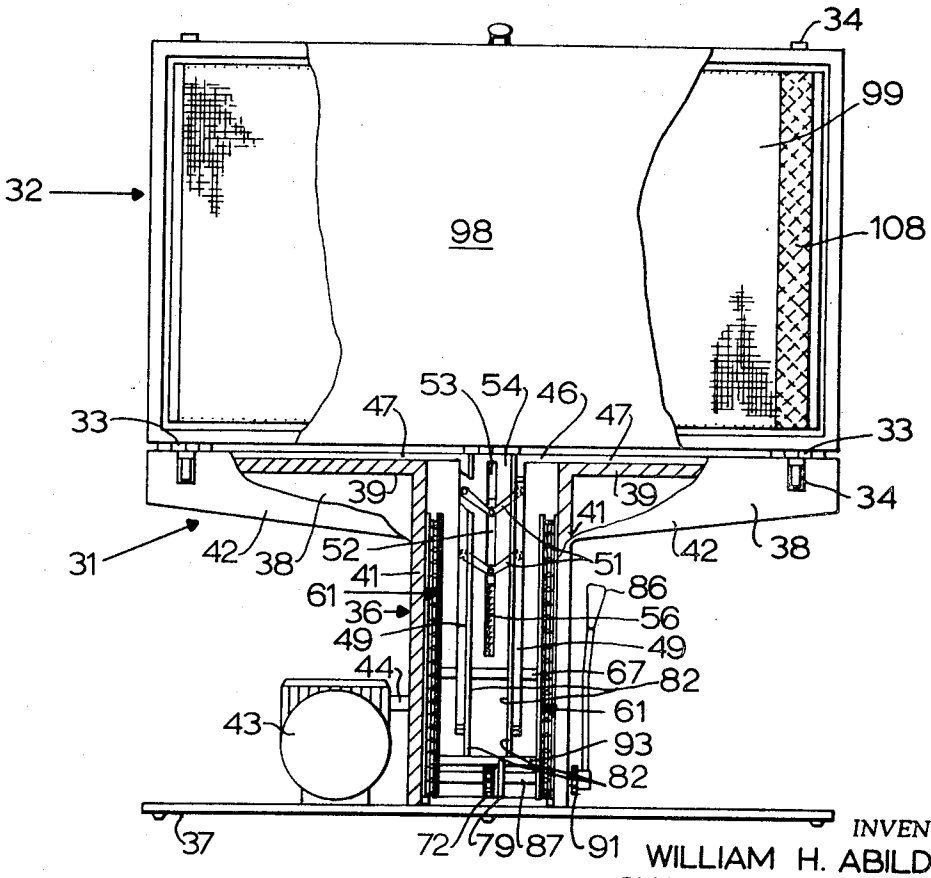


FIG. 1

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METHOD FOR VACUUM MOLDING BOOK BINDINGS

Original Filed June 16, 1969 8 Sheets-Sheet 2

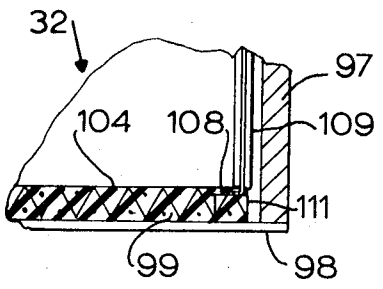


FIG. 4A

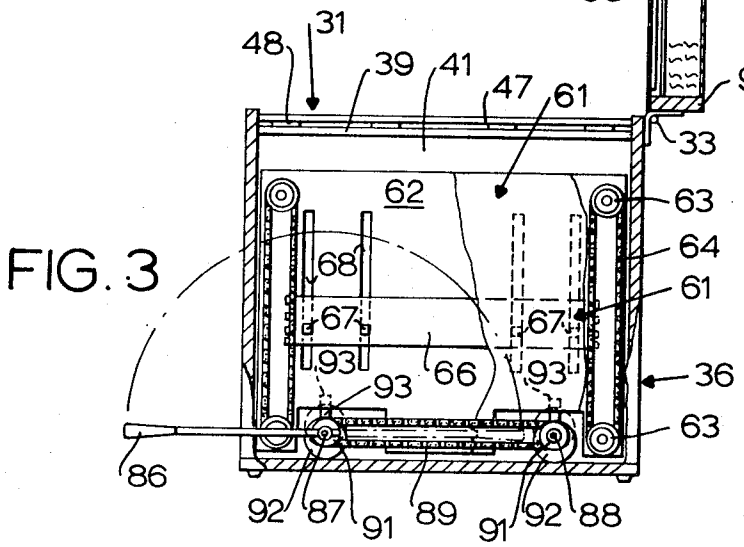
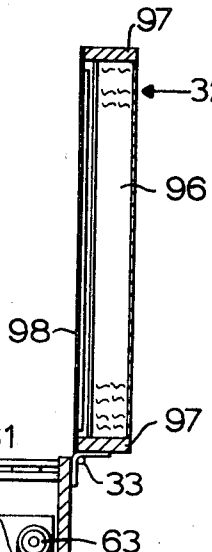


FIG. 3



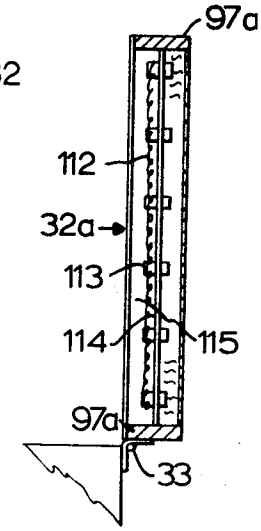


FIG. 3A

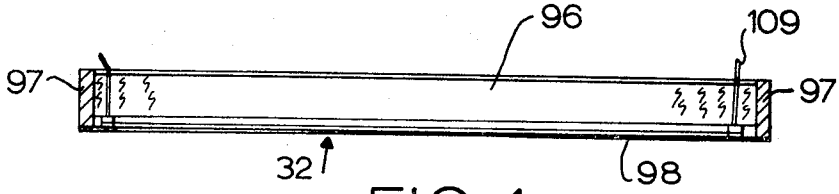


FIG. 4

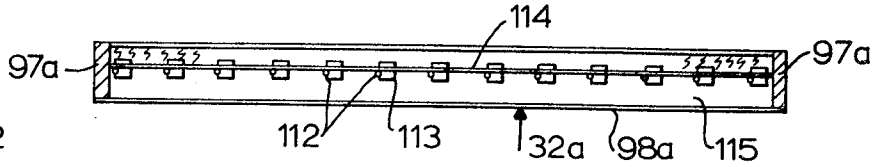


FIG. 6

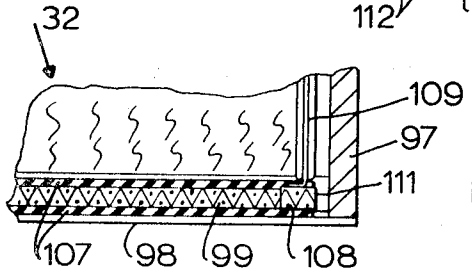


FIG. 5

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METHOD FOR VACUUM MOLDING BOOK BINDINGS

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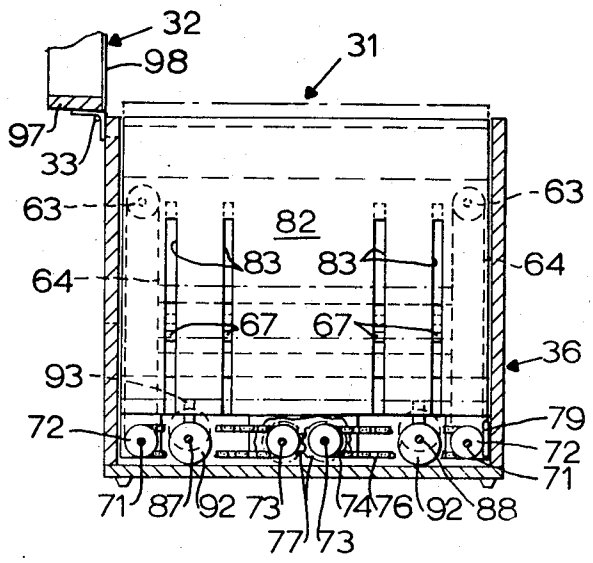


FIG. 7

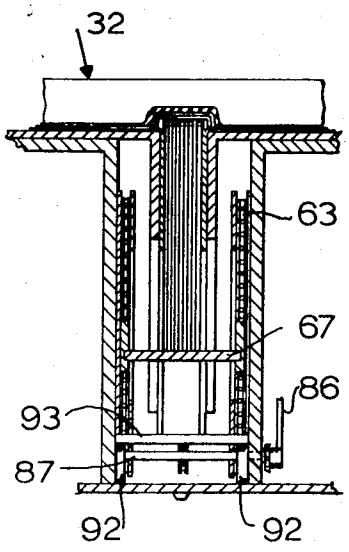


FIG. 8A

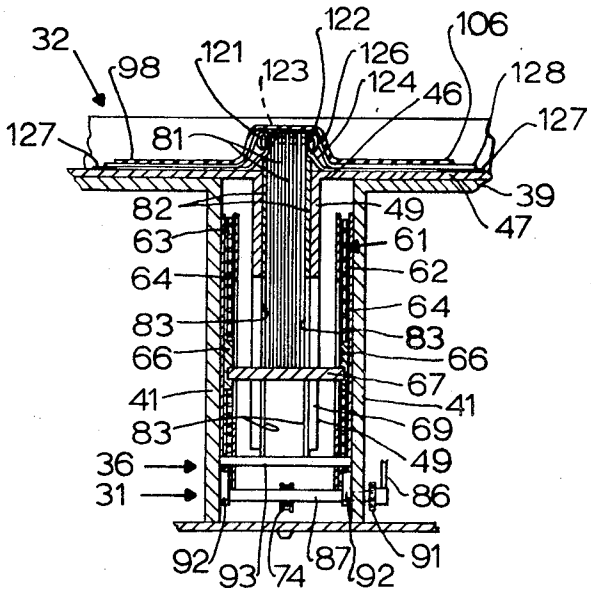


FIG. 8

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METHOD FOR VACUUM MOLDING BOOK BINDINGS

Original Filed June 16, 1969 8 Sheets-Sheet 4

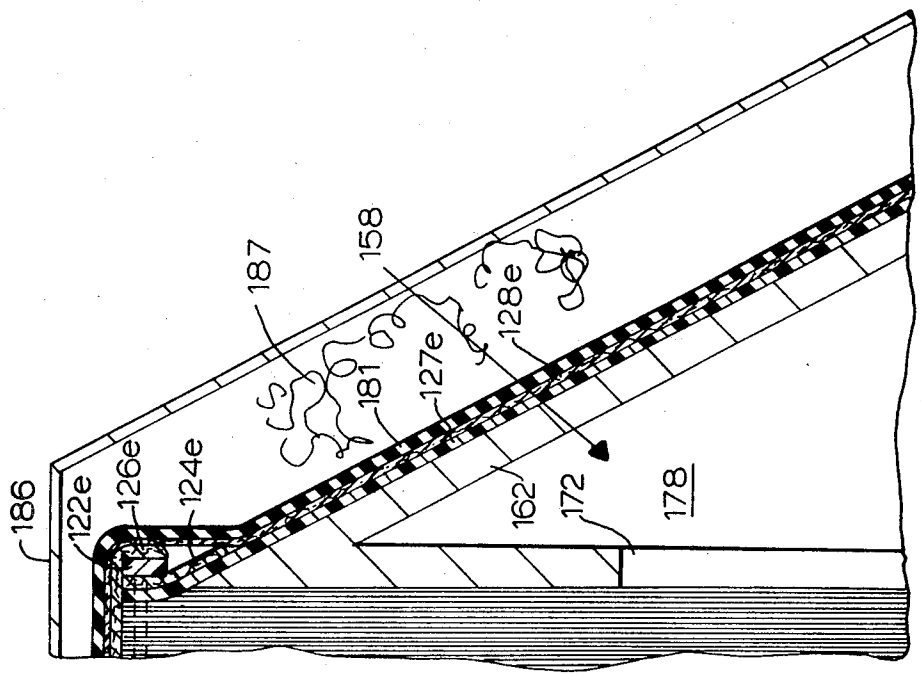


FIG. 22

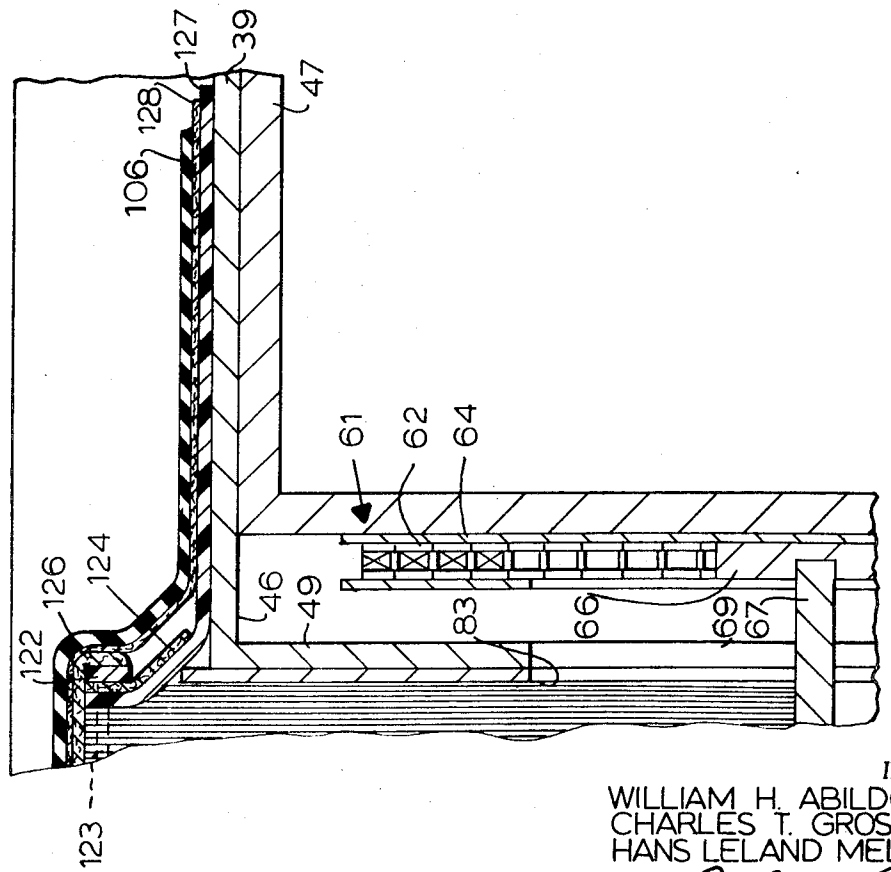


FIG. 8-B

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MEIHOD FOR VACUUM MOLDING BOOK BINDINGS

Original Filed June 16, 1969 8 Sheets-Sheet 5

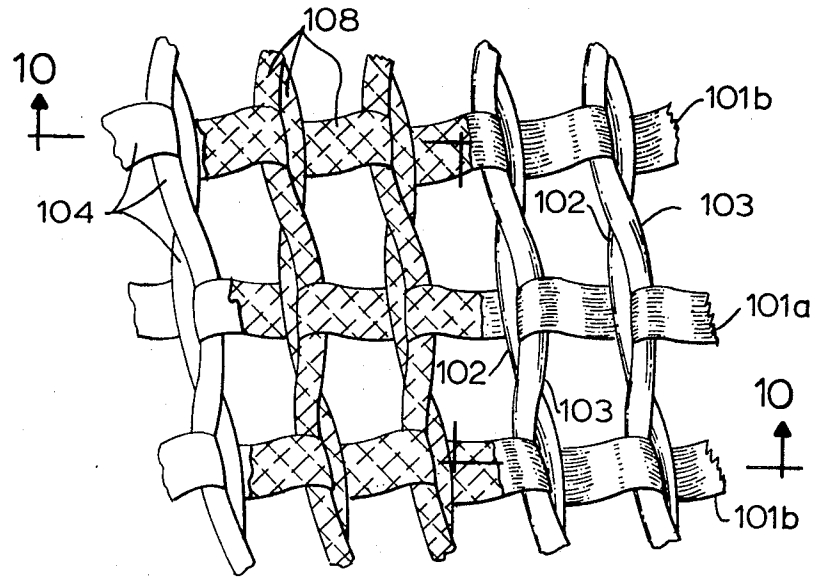


FIG. 9

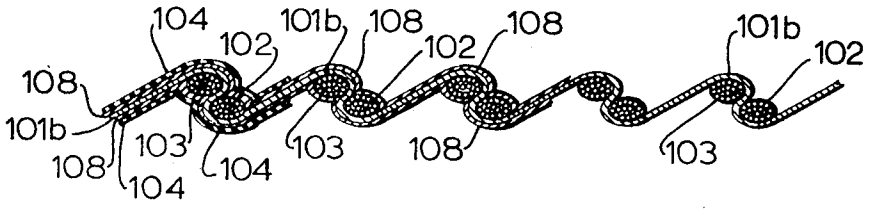


FIG. 10

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MEIHOD FOR VACUUM MOLDING BOOK BINDINGS

Original Filed June 16, 1969 8 Sheets-Sheet 6

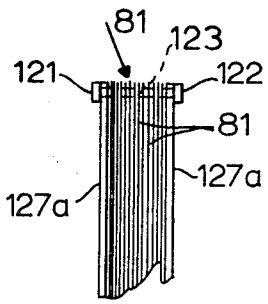


FIG.11

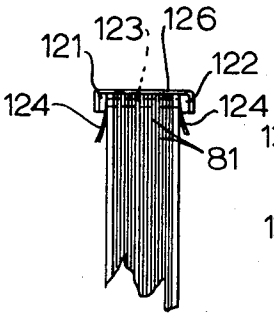


FIG.11A

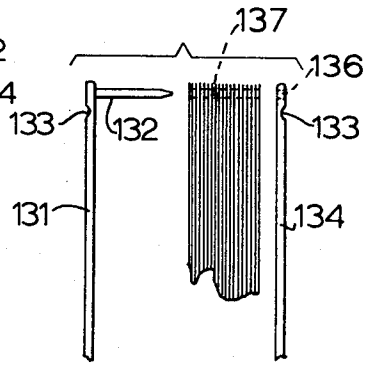


FIG.12

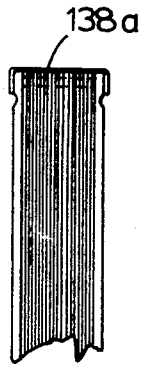


FIG.12A

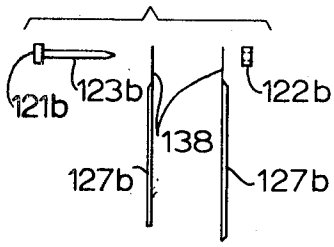


FIG.13

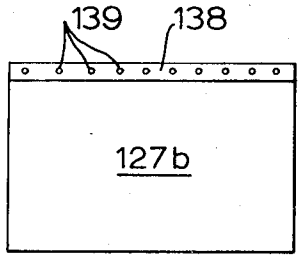


FIG.13A

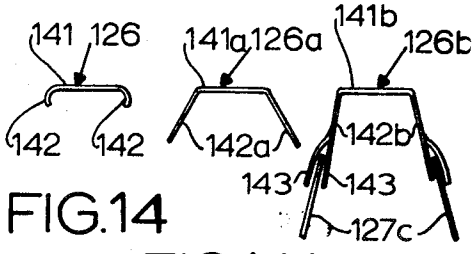


FIG.14

FIG.14A

FIG.14B

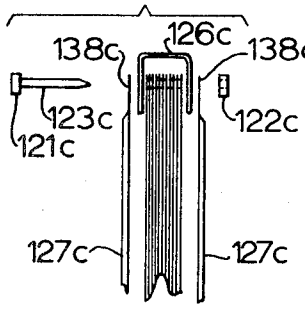


FIG.15

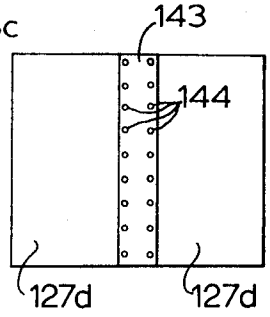


FIG. 16

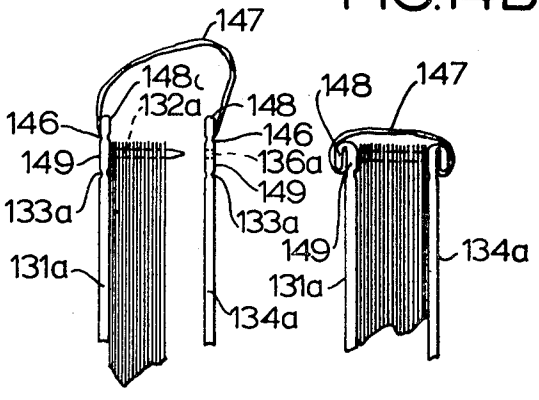


FIG. 17

FIG. 17A

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METHOD FOR VACUUM MOLDING BOOK BINDINGS

Original Filed June 16, 1969 8 Sheets-Sheet 7

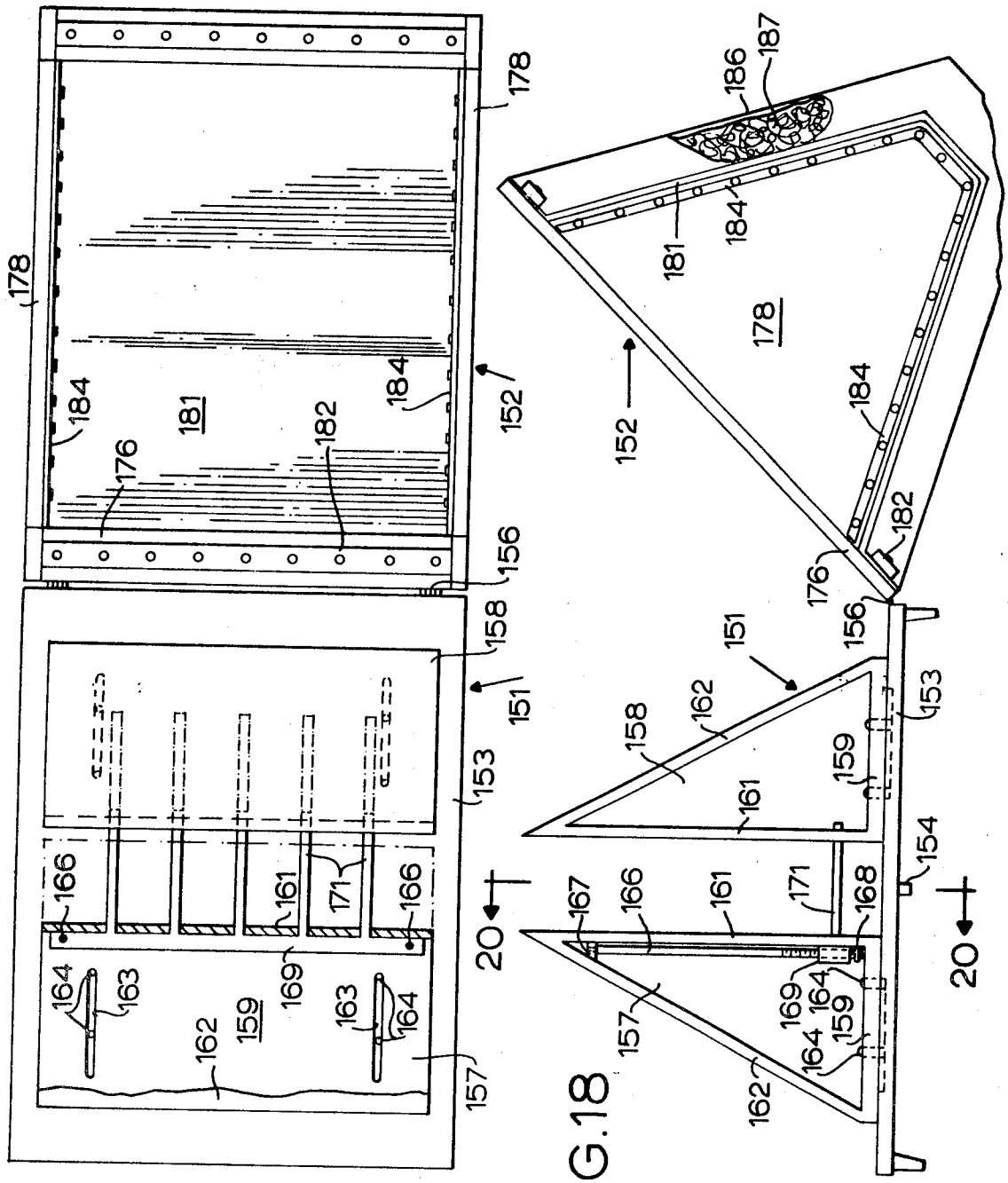


FIG. 19

FIG. 18

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METHOD FOR VACUUM MOLDING BOOK BINDINGS

Original Filed June 16, 1969 8 Sheets-Sheet 8

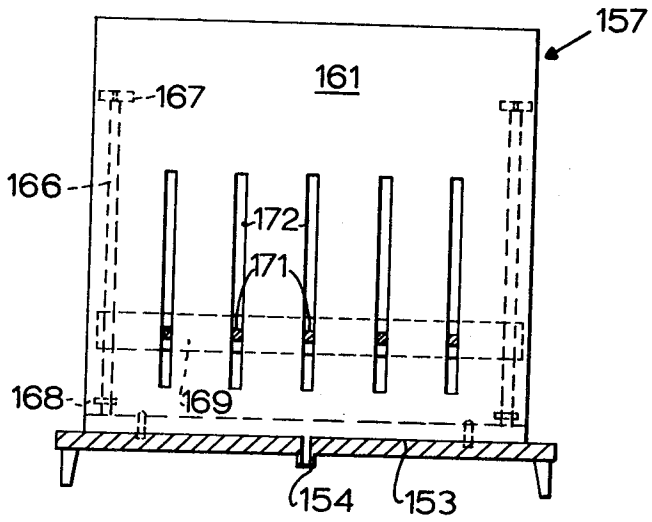


FIG. 20

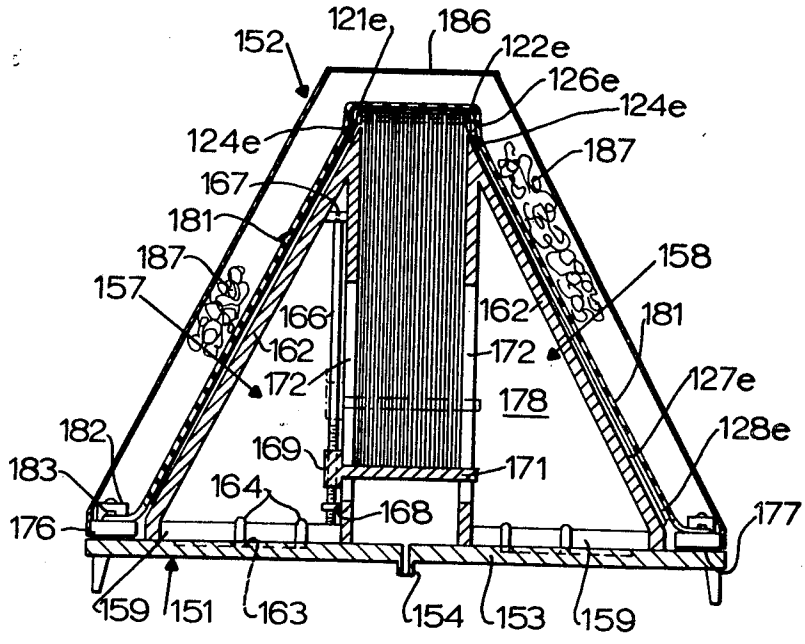


FIG. 21

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United States Patent Office 3,736,200 Patented May 29, 1973

3,736,200

METHOD FOR VACUUM MOLDING BOOK BINDINGS

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Original application June 16, 1969, Ser. No. 833,382, now Patent No. 3,608,116, dated Sept. 28, 1971. Divided and this application Mar. 10, 1971, Ser. No. 122,949
Int. Cl. B29c *17/04, 27/00;* B42c *19/00;* B32d *31/00*
U.S. Cl. 156—85 11 Claims

ABSTRACT OF THE DISCLOSURE

The method involves softening thermoplastic book covers and spine caps by application of heat and simultaneously applying a vacuum on the inside of a flexible membrane so that atmospheric pressure forces the membrane against the covers and spine, molding the same together and joining the spine to the edges of the pages. By use of a prepared casting release paper, simulated grain may be embossed in the covers and various legends and ornamentation applied. The molding of the cover may laminate various layers of plastic of different thicknesses, colors, etc. The edges of the covers are rounded during molding. Panels or imbedded inserts may be formed in the covers or spine.

This application is a division of Ser. No. 833,382, now Pat. No. 3,608,116.

This invention relates to a new and improved method for vacuum molding book bindings.

A principal feature of the present invention is the fact that an apparatus and method are provided which simultaneously perform a plurality of different steps in the vacuum molding of a book. Although one or more of the steps may be omitted, a principal feature of the invention is the fact that the book produced in accordance with the present invention incorporates a variety of different features all performed in a single machine.

A principal feature of the invention is the provision of a binding for the book. Such binding joins the cover of the book and the pages. As hereinafter explained, characteristics of the binding are subject to considerable variation, depending upon the final appearance desired. An essential feature of the present invention, however, is the fact that the front and back covers are vacuum molded and are simultaneously caused to adhere to the book pages.

A second feature of the invention, which is optional depending upon characteristics of the cover desired, is the embossing of the cover sheets with a pattern, such as a simulated leather grain. Thus during the vacuum molding of the cover, casting release paper may be used which is finished with a textured surface and such surface is transferred to the cover. A variety of different textures may be selected by the user. In addition, the release paper may be finished with a scuff coating which is transferred to the cover at the time that the release paper is stripped from the cover after completion of fabrication. Such scuff coating, as well understood in this art, forms a barrier which inhibits bleeding of the plastic ingredients of the cover.

Still another optional feature of the present invention is the printing on the cover of legends and ornamentation of various types. Such legends and ornamentations may be initially applied to the release paper and are transferred to the cover or spine of the book during the vacuum molding operation and prior to the stripping of the release paper from the completed book. Alternately, the covers may be printed or silk screened prior to insertion in the machine and the release paper used only for texturing and scuff coating.

A principal feature of the invention is the fact that the cover is vacuum molded. The result of vacuum molding is the rounding of the edges and back of the cover because of the application of pressure to the soft cover during the vacuum molding step. Optionally, the cover may be formed with ornamentation. A characteristic ornamentation is the formation of a panel on the cover or spine into which a label may be applied by glue or other means. Optionally, an insert may be imbedded into the cover or spine during the molding process. Such an insert may be an envelope into which a label may be slipped. Such label may, for example, carry the title of the book and other information. Optionally, a title panel or label may be heat-sealed to the cover or spine during the molding process if panel or label and cover are of compatible, heat sealable thermoplastics.

Another feature of the invention, which is also optional, is the fact that one or both of the covers may be laminated during the molding process. Thus the outer sheet of the cover may be apertured or pierced to reveal an underlying sheet which may be of a different color or texture, thereby ornamenting the cover or applying legends thereto. Furthermore, by selecting layers to be laminated together of various thicknesses or rigidity, the thickness or rigidity of the cover may likewise be varied. Furthermore, if the layers are non-continuous the cover may be made thicker or more rigid in certain areas than in others.

In essence, the apparatus hereinafter described secures in position the pages of the book, the covers and, optionally, the spine binding. Certain of these elements are thermoplastic and the apparatus softens the plastic by application of heat, and simutlaneously molds the elements together by drawing a vacuum within a flexible vacuum molding membrane.

Another feature of the invention is the provision of means for forming the covers and spine hinged together along lines spaced forwardly of the back edge of the book and fabricating the cover in such manner that there is an absence of fillets between the covers and spine. As hereinafter described in detail, in one form of the invention, the position of book pages relative to the covers is altered after the vacuum has been applied, thereby eliminating the fillet which would otherwise be created.

Another principal feature of the invention is the provision of a membrane or blanket which constitutes a barrier between the atmosphere and the vacuum area to which the pages, spine and covers of the book are exposed. Atmospheric pressure acting upon the exterior surface of the membrane causes the same to flex and conform to the shape of the book to be formed. Thus the blanket is preferably of a material which flexes readily and within reasonable limits conforms to the shape of the book to be manufactured.

Another important feature of the invention is the fact that the blanket may be formed with a heating element such as carbon cloth embedded therein and suitable electrical terminals applied to the carbon cloth so that it functions as a resistance heating element. Thus the blanket

not only serves as a barrier between the atmosphere and the vacuum existing within the machine, but also serves as a heating element to soften the plastic.

One important advantage of the invention is that the entire book is molded in a vacuum. Thus all the elements of the book are molded under uniform conditions. If only the cover and spine cap were thus molded, a variable vacuum seal might result. The apparatus and method eliminated air pockets and form the most compact book possible. If the adhesives and other substances used have objectionable odors or other irritating characteristics when at normal or elevated temperatures, forming the entire book in a vacuum enables fumes to be drawn out and discharge to atmosphere; optionally this method allows these fumes to be filtered prior to discharge to the atmosphere.

Other objects of the present invention will become apparent upon reading the following specification and referring to the accompanying drawings in which similar characters of reference represent corresponding parts in each of the several views.

In the drawings:

FIG. 1 is a front elevational view of one form of the invention partially broken away in section to reveal interior construction;

FIG. 2 is a top plan similarly broken away;

FIG. 3 is a sectional view substantially along the line 3—3 of FIG. 2;

FIG. 3A is a fragmentary view similar to FIG. 3 of a modification;

FIG. 4 is a sectional view through the cover;

FIG. 4A is a fragmentary enlarged view of a modification;

FIG. 5 is a view similar to FIG. 4A of still another modification;

FIG. 6 is a view similar to FIG. 4 of a further modification;

FIG. 7 is a sectional view taken substantially along the line 7—7 of FIG. 2;

FIG. 8 is a fragmentary sectional view taken substantially along the line 8—8 of FIG. 2 showing the parts in one position of the cycle of operation;

FIG. 8A is a view similar to FIG. 8 showing the parts in another position;

FIG. 9 is an enlarged plan view of a heating element for the device;

FIG. 10 is a fragmentary sectional view taken substantially along the line 10—10 of FIG. 9;

FIGS. 11–17A are schematic views showing various modified book binding elements;

FIG. 18 is a side elevational view of modified apparatus;

FIG. 19 is a top plan thereof partially broken away to reveal internal construction;

FIG. 20 is a sectional view taken substantially along the line 20—20 of FIG. 18; and

FIG. 21 is a sectional view through the apparatus of FIGS. 18–20 with the cover closed.

In the form of the invention shown in FIGS. 1–8, inclusive, there is provided a base 31 and a cover 32 hinged together along one horizontal edge by means of hinge 33. When the cover is closed and latches 34 engaged, an airtight seal is provided.

Base 31 has a pedestal 36 which rests upon a bottom platform 37. On either side of the top of the pedestal is a horizontal ledge portion 38. Thus, in each ledge portion 38 there is a horizontal flat table 39 extending from the side edges inwardly to pedestal 36 and then having sides 41 extending downwardly on the outside of the pedestal to the bottom platform 37. The bottom of ledge 38 is reinforced by gussets 42. A vacuum is drawn by means of pump 43 having conduit 44 through one of sides 41 communicating with the interior of the base 31.

The machine is adjustable for different book thicknesses. The spacing between sides 41 limits the thickness of the completed book. Within such maximum limit, the book thickness is controlled by L-shape plates 46. Top flange 47 of each plate 46 is supported by ledge 38. To facilitate sliding movement of flange 47 relative to ledge 38, strips 48 of fibre glass reinforced "Teflon" tape or the like may be laid transversely on the top of ledgge 38. Such tape 48 facilitates sliding and also provides a slight gap between flange 47 and plate 39 through which air may circulate during the application of vacuum to the machine.

The vertical flanges 49 of each L-shape plate 46 extend down between the side plates 41. To insure that the plates 47 are centered relative to the center of the machine, levers 51 are hinged to each vertical flange 49 and also to bar 52 which slides in a vertical slot 53 in back 54 of pedestal 36. A spring 56 is fixed to back 54 and to bar 52 and thus insures that the two vertical flanges 49 are spaced equally from the center of pedestal 36.

Immediately inside the vertical sides 41 of the pedestal on either side of the machine are sub-frames 61, each consisting of two vertical plates 62 spaced a short distance apart. In the space between plates 62 are top and bottom sprockets 63 at the front and back of the machine. Vertical front and back continuous chains 64 travel around sprockets 63. Fixed to each chain 64 so as to travel therewith in an end of a horizontal bar 66. Transverse horizontal page-support bars 67 interconnect bars 66 at intervals and to permit bars 67 to reciprocate vertically relative to sub-frame 61, the plates 62 forming the same are formed with vertical slots 68. The vertical flanges 49 of L-shape plates 46 are formed with vertical slots 69 corresponding in position to the page-support bars 67 so that said bars 67 may reciprocate vertically relative to plates 46. The height of bars 66 relative to sub-frames 61 is adjustable. Thus shaft 71 for each lower sprocket 63 carries sprocket 72. Adjacent the center of the machine are two horizontal transverse shafts 73 carrying sprockets 74. Chains 76 interconnect sprockets 72 and 74. Shafts 73 also carry mating gears 77. Front shaft 71 carries a worm gear 78 which meshes with worm 79. By turning worm 79, bars 67 may be raised and lowered to accommodate different page widths.

As hereinafter explained, at the commencement of fabrication of the book, the spine edges 81 of the book pages are located above the level of the horizontal flanges 47 of the L-shape plates 46. Particularly where the book being made is thin, there is a possibility that the edges 81 may be bent over during application of vacuum. To eliminate such possibility, a pair of page-support plates 82 is located with one immediately within each vertical flange 49. Plates 82 are vertically slidable relative to plates 46 and vertical slots 83 corresponding to the position of bars 67 are formed in page-support plates 82 to permit adjustment of the position of bars 67.

At the commencement of the fabrication operation, the page-support bars 67 and the page-support plates 82 are in raised position (FIG. 8). After the vacuum has been applied and the blanket 98 (hereinafter described) stretched into the fillet to the fullest possible extent, the page-support bars and page-support plates are lowered. The vertical movement is controlled by a handle 86 on transverse horizontal shaft 87 which is connected to a similar shaft 88 at the rear of the machine by chain 89 traveling around sprockets 91 on shafts 87 and 88. Shafts 87 and 88 interiorly of pedestal 36 carry cams 92. Transverse horizontal bars 93 rest upon cams 92 and the bottom edges of page-support plates 82 and sub-frame 61 rest upon said bars 93. Thus when handle 86 is pulled forwardly through 180°, both the page-support bars 67 and the page-support plates 82 are lowered an amount equal to the difference between the high dwell and low dwell of cams 92.

The cover 32 is of a hollow sheet-metal construction filled principally with glass-wool insulation 96. Cover 32 comprises a frame 97 for a vacuum molding membrane or blanket 98 and also contains the heating element which softens the plastic. In the preferred form of cover shown

in FIG. 5, the heating blanket is of novel construction. The heating element **99** comprises carbon cloth of a type presently commercially available. One such carbon cloth is manufactured by Hitco Materials Division of Gardena, Calif. The material is comprised of a fibrous amorphous carbon material. The filament diameters are about .003 inch. Preferably the fabric is woven in a square weave so that the cloth flexes in a horizontal direction as viewed in FIG. 1. A similar carbon cloth is manufactured by the Carbon Products Division of Union Carbide Corporation and is described in Technical Information Bulletin No. 113B.

A preferred square woven carbon cloth is shown in detail in FIGS. 9 and 10. The threads **101***a* and **101***b* of the warp and the threads **102, 103** of the woof each consist of a plurality of carbon filaments, the filaments of threads **102, 103** being twisted and those of thread **101** being substantially flat and only slightly twisted. Warp thread **101***a* passes under each first woof thread **102** and over each second woof thread **103**. Next adjacent woof thread **101***b* passes over thread **103** and under thread **102**, it being observed that threads **102, 103** cross over each other between one warp thread **101** and the next, but threads **102, 103** are never twisted relative to each other. Thus the cloth stretches along the warp threads the threads **102, 103** separating from each other under such stress.

To prevent shorting of the carbon cloth when it is folded, the threads **101, 102, 103** are preferably sprayed with or dipcoated in silicone rubber coating **104**, such as COHRlastic silicone rubber manufactured by the Connecticut Hard Rubber Company, New Haven, Conn., No. 9255, as described in Technical Bulletin CHR. Dow-Corning No. 3145 adhesive-sealant is similarly effective for this purpose, as described in Bulletin 08–3263 of March 1968 of the Electronic Products Division of Dow-Corning Corporation, Midland, Mich. It will be understood that other silicone rubber and other insulating materials may be employed. The thickness of coating **104** may be sufficiently great so that the material is sealed by a layer **106** and a vacuum molding blanket is formed thereby (FIG. 9). On the other hand, the blanket may be formed by laminating the coated or uncoated carbon material to top and bottom layers **107** of silicone rubber sheeting (FIG. 5). The silicone rubber stretches even more readily than the carbon material and thus conforms to the shape of the object being molded when vacuum is applied.

A novel terminal for the carbon material is one aspect of the present invention. Heretofore, carbon materials have been connected to a source of current by relatively crude clamping methods. In accordance with our invention, before the silicone rubber **104** is applied to the carbon material, the carbon cloth **99** is preferably electroplated at either end. Thus in one method of forming the terminals, the ends of the element from which the blanket is to be formed are immersed in copper sulphate solution and copper **108** is electroplated onto the carbon material by conventional electro-plating techniques. The terminals of the electric wires **109** are then attached to the copper plated ends **108** by solder **111**, thereby effecting an electrical connection which is extremely efficient and effective. Preferably the blanket is sprayed with silicone rubber **104** after the terminals have been completed.

An alternate form of heating element is shown in FIGS. 3A and 6. Coils **112** of electrical wire of the type used as heating elements of toasters and heaters are supported at intervals by S-shaped clips **113** which project from perforated plate **114** at intervals along the length of the cover **32***a*, said plate being received in the ends of **97***a* of cover **32***a*. When electric current is applied to the heating elements, the coils glow and the air space **115** and the rubber vacuum blanket **98***a* are heated by a combination of radiant and convection heating. The hot vacuum blanket **98***a* in time softens the plastic material beneath it.

At the commencement of the operation, the spine edges **81** of the pages of the book are fastened. A preferred means for fastening the edges is shown in Abildgaard and Groswith patent application, Ser. No. 799,045, filed Feb. 13, 1969 now Pat. No. 3,596,929, entitled "Apparatus for Binding Sheets and Products." Briefly, narrow plastic strips **121, 122** extend along the length of the left and right adjacent edges **81**, respectively. The strips are interconnected by studs **123** at spaced intervals which project through spaced holes in the pages adjacent edges **81**. The projecting ends of studs **123** are cut off flush with the outside of strip **122** and are also secured to strip **122** by deformation of the cut ends in various ways as described in said application. In accordance with one modification of the present invention, before strips **121, 122** are applied to the edges **81**, plastic wings **124** may be installed on top of the outer pages and under strips **121, 122** (see FIGS. 8 and 11A). The wings **124** may be separate elements or integral with the covers.

To cover over the spine of the book, an extruded thermoplastic channel-shaped cap **126** may be used. One such cap **126** is shown in FIGS. 11A and 14. The base of the channel fits over the edges **81** of the pages and the sides of the channel fit over the outside of strips **121, 122**. Since cap **126** is thermoplastic, when heat and pressure are applied, as hereinafter explained, cap **126** is secured to strips **121, 122** and securely molds the same together and to the cap. Adhesive inside cap **126** causes the cap to adhere to spine edges **81** of the pages. At the same time, the cover sheets **127** which are similarly thermoplastic, are molded to wings **124**, thereby forming a completed book. The means and method whereby said operation is performed is hereinafter described.

It is preferable that covers **127** be connected to the book along hinge lines and that the hinge lines be spaced slightly inward of the spine edges of the pages, as ordinary book covers are hinged to the spine binding. The wings **124** may provide the desired hinges. The mechanism for location of the hinges is hereinafter described.

At the commencement of operation, cover **32** is opened and handle **86** controlling cams **92** is retracted so that the bars **93** are raised, thereby raising bars **67** and plates **82**. The elevation of bars **67** is adjusted by turning worm **79** depending upon the width of the pages. Accordingly, at the commencement of operation as shown in FIG. 8, the strips **121, 122** rest upon the upper edges of page-support plates **82** and the bottom edges of the pages rest upon page-support bars **67**. The L-shape plates **46** are moved inwardly so that the vertical flanges **49** press the page-support plates **82** firmly against the book pages. Plates **82** prevent the pages from bending over. Appropriately sized thermoplastic cover sheets **127** are then placed resting upon the horizontal flanges **47** of L-shape plates **46** and their inner edges rest upon wings **124** so that the wings will be molded together with the covers. If wings **124** are an integrally molded part of covers **127**, said covers and wings are assembled next to the first and last pages of the book when strips **121** and **122** are secured together. A casting release paper **128** is then laid over each cover **127** and preferably also over cap **126** on the spine. Such paper **128** has the characteristics that plastic materials molded thereupon will part from the paper after molding and cooling. Such papers are commercially produced by the S. D. Warren Division of Scott Paper Company, and others, and are readily commercially available. Various textures may be embossed in the paper during manufacture, such as various leather-grain simulations and such simulations are in turn imparted to the outside of covers **127** during the manufacturing process. For ornametal purposes, decorative borders, names and other legends may be silk-screened or otherwise applied onto the casting release paper **128** in reverse printing and such

material is absorbed into the thermoplastic covers and cap during molding. By techniques well known in the transfer art, legends may be typed onto a transparent plastic material and affixed to the casting release paper, the transparent plastic and art thereon becoming molded into the finished product surface. Scuff coating to prevent bleeding of plastic ingredients may also be applied.

The cover **32** is then closed and latches **34** engaged, forming an airtight seal between membrane **98** and base **31**. Electric current is then applied to the heating element **99**. Pump **43** is started creating a vacuum within base **31** and under membrane **98**. When this has occurred, handle **86** is brought forward, turning cams **92** and causing plates **82** and bars **67** to be lowered about one-half inch from the position of FIG. 8 to the position of FIG. 8A. Continued application of vacuum causes membrane **98** to conform to the shape of the spine and covers, thereby eliminating the fillets which would otherwise occur where the spine and covers join. Continued heating softens the plastic material of **127**, cap **126** and wings **124**.

First elevating the spine edges as in FIG. 8, and then lowering same to the position of FIG. 8A, is a preferred method of fabrication. The length of wing **124** between strip **121** (or **122**) and the inner edge of cover sheet **127** in the condition of FIG. 8 is a curved line approximating the hypotenuse of a right triangle, the short side of which is the amount of projection of plate **82** above flange **47**. Before plate **82** is retracted, the square of the length of the short side added to the square of the long side of the triangle equals approximately the square of the curved hypotenuse. When plate **82** is retracted, the sum of the shortened length of the short side plus the length of the long side of the triangle now equals approximately the length of that portion of the membrane previously called the hypotenuse, thus eliminating the fillet caused by the membrane **98** over the right angle formed by the page support plate **82** and the horizontal flange **47** of plate **46**. This unique and novel fillet removal technique serves to tuck membrane **98** into the right-angle area, insuring adequate pressure and heat in the vital hinge area.

The covers, strips and page edges are thus bonded together. The (optional) texture of the casting release paper **128** is transmitted to the softened spine cap **126** and covers **127**, and any printed or ornamental material on the casting release paper is transferred onto the book covers. Application of the vacuum under membrane **98** rounds the edges in covers **127**. Furthermore, if any panels or other inserts are attached to the casting release paper **128**, or laid upon the covers or spine, they are imbedded to the cover or spine. Instead of a single cover thickness, various laminae may be used to vary the cover thickness and rigidity and also to ornament the same, all as hereinbefore explained.

After the molding process is conducted for a sufficient length of time, the heating and vacuum are discontinued. The cover is opened and the casting release paper stripped from the completed product.

The completed book, in a preferred form of the invention, has a spine which comprises cap **126** which adheres to the spine edges **81** of the pages of the book and to strips **121**, **122** between which studs **123** extend through holes in the pages. The wings **124** are fixed to strips **121**, **122** and the edges of covers **127**. Wings **124** are flexible and facilitate hinging of the covers relative to the spine.

A modified construction is shown in FIG. 11. The covers **127*a*** are installed under the strips **121**, **122**. Optionally, a spine cap (not shown) is installed over the strips **121**, **122** and is bonded to the back edges of the pages as well as to the strips. A thin layer of heat-activated or pressure-sensitive adhesive previously applied to the inside of the spine cap **126** will assist in adhesion to the edges of the pages.

FIGS. 12 and 12A show a further modification. In this form of the invention top cover **131** is formed with integral studs **132** similar to studs **123**. A reduced thickness portion **133** is formed inward of the spine edge of cover **131** to function as a hinge. The back cover **134** is formed with holes **136** to receive studs **132** in a manner similar to strip **122**. Cover **134** also has reduced thickness hinge portion **133**. After the covers **131**, **134** are assembled with studs **132** projecting through holes **136** and holes **137** adjacent the spine edges of the pages, the excess length of the studs are trimmed off and the ends are distorted to permanently bond the studs to cover **134**. Thereupon a spine cap **138*a*** is installed with its base engaging the spine edges of the pages and flanges thereof engaging the edges of the covers **131**, **134** rearwardly of the reduced thickness portions **133**. Upon molding, as hereinbefore described, the pages, spine cap and covers are secured together.

FIGS. 13–13A is a further modification. In this form each cover **127*b*** is formed with a reduced thickness area **138*a*** along its spine edge. The studs **123*b*** pass through holes **139** in the reduced thickness portions **138**, as well as the holes in the second strip **122*b***.

Alternate spine caps are shown in FIGS. 14, 14A and 14B. The form **126** shown in FIG. 14 is similar to that used in FIG. 11 or 11A as well as cap **138*a*** shown in FIG. 12A. In FIG. 14, the base **141** or web of the channel is rigid and extending along either edge thereof is flange **142**. In FIG. 14A, flange **142*a*** is thinner and wider. The flanges **142*a*** are preferably placed on the inside of covers **127**, although they may be placed on the outside prior to heat and pressure being applied during vacuum molding. In FIG. 14B, the flanges **142*b*** of the channel cap **126*b*** are formed with double wings **143** outward of the spine. The spine edges of covers **127*c*** are inserted between the double wings **143** and are vacuum molded thereto.

In FIG. 15, the spine cap **126*c*** is formed of a material which shrinks upon application of heat. The covers **127*c*** have apertured reduced thickness portions **138*c*** at the spine edges which form the hinges. The strips **121*c***, **122*c*** are installed and upon application of heat the spine portions **126*c*** shrink to the proper dimension, depending on the thickness of the particular number of pages which comprise the book. The covers **127*c*** are bonded to the cap **126*c*** and the strips **121*c***, **122*c***.

In FIG. 16, as a preliminary step, a shrinkable center strip **143** is provided to which on either side is bonded a cover **127*d***. The shrink portion **143** is formed with a double row of holes **144** so that when strips (not shown but similar to **121**, **122**) are installed the studs project through holes **144** as well as the holes in the pages therebetween. Upon application of heat the center portion **143** shrinks to the proper width depending upon the thickness of the pages in the book.

FIGS. 17 and 17A are still a further modification. In this form of the invention each cover **131*a***, **134*a*** is formed with two reduced thickness portions **133*a***, **146**. Between the two portions **133*a***, **146** on the front cover **131*a*** are studs **132*a*** and on the back cover **134*a*** are holes **136*a***. A heat shrink web **147** connects the outer portions of each cover, the inner edges of the web preferably extending inward to portion **146**. When the book is assembled and the excess stud material removed, the outer areas **148** beyond areas **146** are folded outwardly and back to overlap the intermediate portions **149** (between areas **133*a*** and **146**). Upon application of heat and pressure in the vacuum molding process, the heat shrinkable center web **147** shrinks so that it is tight. The various layers of the covers and spine are bonded together in permanent fashion.

A modified apparatus is illustrated in FIGS. 18–21. This apparatus consists of a base **151** and cover **152**. Base **151** has a bottom plate **153** provided with nipple **154** for connection to a vacuum pump. Plate **153** is provided with hinges **156** along one side edge. One side edge of cover **152** is likewise connected to hinge **156**.

Mounted on plate **153** are left and a right support members **157, 158**, respectively. Viewed in front elevation, each support is a right triangle consisting of base **159**, vertical side **161** at the inside end of base **159** and a slanted side **162**, the latter making an angle of about 60° with base **159**. Bases **159** are formed with transverse slots **163** receiving pins **164** secured to bottom plate **153**. Hence supports **157, 158** may be moved inwardly and outwardly to adjust for different book thicknesses. Mounted in left-hand support **157** at front and back are vertical threaded rods **166**. The top of each rod **166** is supported by brackets **167** and the bottom is received in a hole in bottom plate **153**. Knobs **168** may be used to turn rods **166**. Extending from front to back within left-hand support **157** is horizontal bar **169** formed with threaded holes which receive rods **166**. Hence by turning knobs **168**, bar **169** may be raised and lowered. Extending from bar **169** and extending into right-hand support **158** are a plurality of transverse, horizontal page support pins **171**. The vertical sides **161** of both left-hand and right-hand supports are formed with vertical slots **172** to permit pins **171** to raise and lower. By adjusting the height of bar **169** and thus by adjusting the height of pins **171**, support for books of different page widths is provided.

Cover **152** consists of a rectangular narrow base **176** provided on its under surface with a gasket **177** which seals against bottom plate **153** when the cover is closed. Cover **152** has trapezoidal front and back ends **178**, their bases being equal to the width of bottom plate **153** and the height being sufficient to clear the tops of supports **157, 158**. The angle of the sides of the cover is about equal to the angle of sides of support **157**. Extending between the front and back end is a flexible and stretchable membrane **181**. The bottom edges of the membrane are attached to base **176** by means of clamps **182**, clamps **182** having a sealing gasket **183** which seals to membrane **181**. The front and back edges of membrane **181** are sealed to the front and rear ends **178** by means of clamps **184**. Cover **152** is provided with an outside casing **186** which encloses heat insulation material **187**.

Membrane **181** may be similar to membrane **98** in the preceding modification. Thus membrane **181** may contain a carbon cloth heating element, either laminated between silicone rubber sheets or coated with silicone rubber of sufficient thickness so that the membrane is airtight. Such membrane functions both as a heating element and as a vacuum blanket. Alternatively, the membrane may be a vacuum blanket but contain no heating elements. One external form of heating element may be the provision of heating coils (not shown) within cover **152** similar to the coils **112** illustrated in FIG. 3A. It will occur to those skilled in the art that various means for heating the cover may be employed, such as hot air blowers and the like.

In use of the modification, FIGS. 18–22, the book pages are first assembled as in the preceding modification, as by use of strips **121***c*, **122***c*. The position of bar **169** is first adjusted by turning knobs **168** so that pins **171** support the edges of the pages at such elevation that strips **121***c*, **122***c* rest upon the top edges of supports **157, 158**. Supports **157, 158** are moved inwardly so that they engage the outer pages of the book. Ordinarily, it is not necessary to clamp supports **157, 158** tightly in place because atmospheric pressure against the supports will ordinarily force the same inwardly when the interior of the apparatus is subjected to vacuum with sufficient force to securely clamp the pages.

Thermoplastic cover sheets **127***e* are laid along the slanted sides **162** of the supports in proximity to wings **124***e* which are under strips **121***e*, **122***e*. A plastic cap **126***e* is installed over the spine with the sides thereof extending down over the outside of strips **121***e*, **122***e*. A layer of casting release paper **128***e* is then laid over covers **127***e* and spine cap **126***e*, said release paper being similar to that of the preceding modification. Cover **152** is then placed

over base **151** and clamped thereto by means of clamps (not shown). Heat is applied to the cover either by energization of the carbon cloth in membrane **181**, or by other means. At the same time, a vacuum is drawn in the interior of the apparatus by means of a pump (not shown). Atmospheric pressure forces membrane **181** tightly against the materials resting on supports **157,158** and a vacuum molded book is produced. Various modifications of the book structure have hereinbefore been described. When the book has been formed, cover **152** is removed and the release paper **128***e* stripped from the book covers.

What is claimed is:

1. The method of molding a book comprising supporting in the approximate position of final assembly the pages, fastening means for said pages which hold said pages together in book form, thermoplastic book covers, and a thermoplastic spine cap lying in contact with the spine edges of said pages and overlapping the spine edges of said book covers, totally enclosing said pages, book covers and spine cap in an airtight membrane, drawing a vacuum within said membrane and thereby subjecting the pages, book covers and spine cap to vacuum heating said cap and covers to soften same and conforming and bonding said book covers to said spine cap and said spine cap to the spine edges of said papers, whereby said cap, covers and pages are molded into an integral book.

2. The method of claim **1** in which said membrane molds said covers to form rounded edges on said covers.

3. The method of claim **1** which further comprises applying casting release paper over said covers and immediately under said membrane before heating said cap and covers and stripping said paper from said covers after the book is molded.

4. The method of claim **3** in which said paper is embossed and the embossing on said paper is molded into said covers.

5. The method of claim **3** in which said paper is printed and the printing on said paper is transferred to at least one of said covers.

6. The method of claim **1** in which several layers of thermoplastic covers are superimposed, whereby upon molding of said book said layers are laminated together.

7. The method of claim **6** in which at least one said layer is discontinuous relative to another layer whereby upon lamination the properties of said cover are different in one area than in another area.

8. The method of claim **1** in which the fastening means for said pages and said covers are integral.

9. A method of molding a book comprising: fastening the spine edges of the pages of the book, supporting the pages in a holder with the spine edges of the pages exposed, applying flexible members extending outward from adjacent the spine edges of said pages, applying a thermoplastic cap over the spine edges of the pages and over portions of said flexible members, applying thermoplastic covers on said holder disposed at angles to said pages and in contact with portions of said flexible members, applying a molding blanket over said cap and covers and sealing same to said holder, heating said cap and covers to soften same, drawing a vacuum within said blanket so that atmospheric pressure forces said blanket against said cap and covers to conform and bond said cap to said pages and said flexible members and said covers to said flexible members.

10. The method of claim **9** in which said cap is of a heat-shrinkable material, initially of a width greater than the thickness of said pages, whereby upon heating said cap, said cap shrinks to a width conforming to the thickness of said book.

11. The method of claim **10** in which said cap is initially attached to the edges of said covers.

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