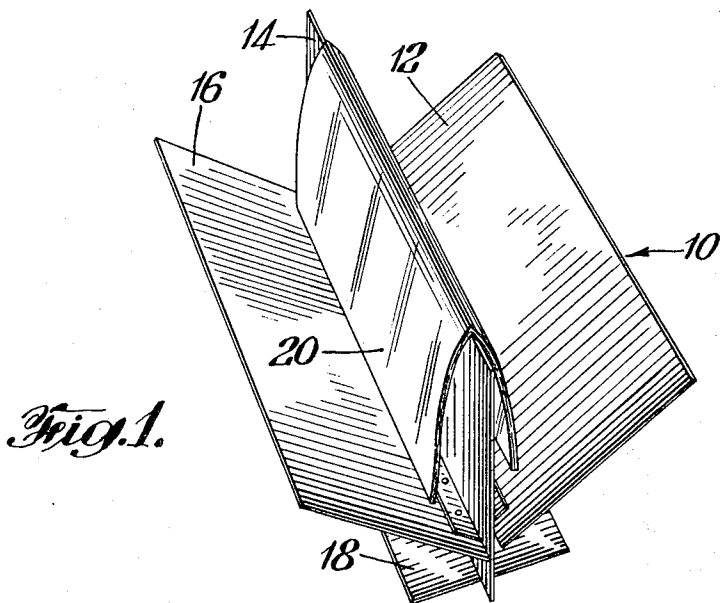
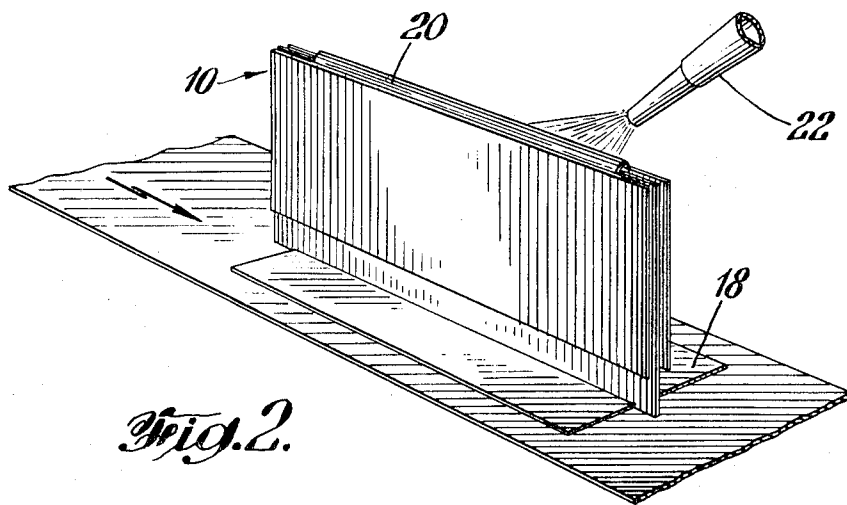


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BOUND PLASTIC BOOKS
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BOUND PLASTIC BOOKS

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1 Claim

ABSTRACT OF THE DISCLOSURE

Pages of heat-sealable material such as thermoplastic are superimposed to form a binding edge, the pages are then placed in a heat shield with only the binding edge exposed and radiant heat is applied to such binding edge to bind the pages together.

FIELD OF THE INVENTION

This invention relates to binding pages of heat sealable material into publication form particularly binding plastic pages by heat sealing.

THE PRIOR ART

With the introduction of the plastic publication such as plastic books there has been initiated a search for improved and simplified binding techniques over the conventional stitching and glueing methods associated with paper publications. The thermal properties inherent in thermoplastics have led to heat sealing techniques as a binding substitute. Thus, it has been proposed to place a stack of pages between the heating elements, in contact therewith and heat weld the pages together proximate the edges thereof. However, in addition to the pressure of contact on the pages from the elements there has been no shielding means to confine the heat to the immediate area designated for binding and the heat has spread to the adjacent page areas with consequent heat distortion problems. It has also been proposed to fuse plastic pages together by contacting the edges thereof with a hot plate extending over the whole binding. However, again is pressure disclosed in cooperation with the heating and moreover, it is difficult to confine the heat of binding the page edges and extensive portions of the pages suffer heat distortion. It has also been proposed to bind pages with a strip of heated extruded plastic applied to the edges of the pages. However, this process requires the additional steps of extrusion and positioning of the strip. Moreover, heat distortion of pages tends to occur as outlined above. See British patent application 647,803 to Schenfield, U.S. Pat. 2,232,640 to Schwartzman and U.S. Pat. 2,579,488 to Freeman for examples of the above binding methods.

The above methods all have in common the unchecked spread of heat to the pages beyond the binding area itself. Moreover, mechanical pressure is used in conjunction with the heat which tends to thin out the pages or otherwise distort them in the area of binding. Such thinned out areas tend to form weak seals and zones susceptible to tearing i.e. a tear once begun propagates itself along the thinned out strip of the binding. Hereofore the heating sealing method of binding plastic pages or other pages of heat-sealable material which effectively confined the heat employed to the binding area and avoided the use of mechanical pressure on the binding area has not been developed.

Accordingly, there has now been discovered a method for binding heat-sealable pages by heat sealing which is confined to the zone of the binding. Moreover, a strong binding seal is provided because the use of mechanical pressure is avoided thus eliminating the tendency of thinning at the cross-section and forming a "tear tape"

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contour. The method of the invention is particularly suitable for oriented plastic materials as well as non-oriented plastic materials for readily producing distortion-free bound books.

SUMMARY

Broadly the process of the present invention for binding pages of heat-sealable materials comprises superimposing pages of heat-sealable material so as to form a binding edge therefor, insulating said pages from heat except for the binding edge which is exposed and applying radiant heat to the binding edge to unite the pages in a binding.

By "radiant heat" is meant heat applied to material without mechanical contact by a solid heating element i.e. heat applied by radiation, conduction or convection or a combination thereof. Conduction includes heat conducted from hot gases such as by contacting the binding edge with a flame.

The invention will become more apparent from the following detailed specification and drawings in which:

FIG. 1 is an isometric view of a plurality of heat-sealable pages positioned in a support shield embodying the invention in an open position, and

FIG. 2 is an isometric view of the shield and pages of FIG. 1, the shield being closed.

DESCRIPTION

Referring now to the drawings, plurality of pages 20 are draped over the center plate 14 of support shield 10 as shown in FIG. 1. Shield 10 has, in addition to center plate 14, outside heat shield plates 12 and 16, the shield plates being hinged and all three plates coming together at base 18 as shown in FIG. 1. After the pages are draped over the center plate 14, the shield plates 12 and 16 are closed so that only the binding edge 20 of the pages is exposed, as shown in FIG. 2. With the pages being effectively insulated by shield plates 12 and 16, binding edge 20 is then exposed to radiant heat from heater 22 which unites the pages in a fused binding without mechanical pressure being applied as shown in FIG. 2. As indicated by the arrow in FIG. 2 the pages and support can be moved e.g. by conveyor belt past the heating source such as heater 22.

By the method of this invention the heat of binding is effectively confined to the binding area. Moreover, the heat is applied to the binding edge as radiant heat, e.g. heat provided by a spaced heating source or by contact with a flame, without the use of mechanical pressure which results in a binding that is not thinned in cross-section nor weakened in a tear-tape contour. Thus, by the method of the invention the sealable pages, particularly oriented plastic pages, can be readily bound to produce strong distortion-free seals at the spine of the book.

Illustrative of the thermoplastic resins which can be used in the present invention are the olefin polymers and the vinyl polymers. Included within the olefin polymers are both the olefin homopolymer resins and the olefin copolymer resins wherein a predominant amount of polymerized olefin monomer is present in the copolymer. The olefin monomers which are particularly useful in preparing such resins are the lower olefin monomers such as ethylene, propylene and butene. Olefin homopolymers include high and low density polyethylene, polypropylene and polybutylene, although high density polyethylene is preferred. Olefin copolymers include olefin monomers copolymerized with vinyl monomers. Of particular utility are the ethylene/vinyl copolymers.

Similarly the vinyl polymers included both the vinyl homopolymers and the vinyl copolymers wherein a predominant amount of polymerized vinyl monomer is present in the copolymer.

Illustrative of vinyl monomers containing the characteristic



group, and mixtures thereof which can be homopolymerized or copolymerized to form thermoplastic polymers and which can be utilized in accordance with the present invention are the following: vinyl aryls such as styrene, o-methoxystyrene, p-methoxystyrene, m-methoxystyrene, o-nitrostyrene, m-nitrostyrene, o-methylstyrene, p-methylstyrene, m-methylstyrene, p-phenylstyrene, o-phenylstyrene, m-phenylstyrene, vinyl naphthalene, and the like; vinyl and vinylidene halides such as vinyl chloride, vinylidene chloride, vinylidene bromide, and the like; vinyl esters such as vinyl acetate, vinyl propionate, vinyl butyrate, vinyl chloroacetate, vinyl chloropropionate, vinyl benzoate, vinyl chlorobenzoate, and the like; acrylic and alpha-alkyl acrylic acids, their alkyl esters, their amides and their nitriles such as acrylic acid, chloroacrylic acid, methacrylic acid, ethacrylic acid, methyl acrylate, ethyl acrylate, butyl acrylate, n-octyl acrylate, 2-ethylhexyl, n-decyl acrylate, methyl methacrylate, butyl methacrylate, methyl ethacrylate, ethyl ethacrylate, acrylamide, N-methyl acrylamide, N,N-di-methylacrylamide, acrylonitrile, chloroacrylonitrile, methacrylonitrile, ethacrylonitrile, and the like; alkyl esters of maleic and fumaric acid such as dimethyl maleate, diethyl maleate, and the like; vinyl alkyl esters and ketones such as vinyl methyl ether, vinyl ethyl ether, vinyl isobutyl ether, 2-chloroethyl vinyl ether, methyl vinyl ketone, ethyl vinyl ketone, isobutyl vinyl ketone, and the like; also vinyl pyridine, N-vinyl carbazole, N-vinyl pyrrolidine, ethyl methylene malonate and the like, and modified vinyl polymers such as polystyrene modified with rubber, polystyrene modified with hydrocarbon wax, and the like. Copolymers of the foregoing monomers are useful in this invention. Such copolymers include vinyl chloride/vinyl acetate copolymers; styrene/acrylonitrile; ethylene/vinyl acetate; ethylene/ethyl acrylate; ethylene/acrylic acid, ethylene methacrylic acid and their alkyl esters and the like; useful terpolymers are vinyl chloride/vinyl acetate/maleic anhydride, acrylonitrile/butadiene/styrene, and the like.

Also included among these thermoplastic copolymers are the "ionomers" which are the metal salts of ethylene/acrylic acid or ethylene/methacrylic acid copolymers in which the acrylic acid component is present in an amount up to about 40% by weight. The metals used in forming these salts may be sodium, potassium, iron, magnesium, calcium, copper, and the like.

Also included within this term are the blends of thermoplastic resins. Such resin blends can be tailored to provide desired characteristics. Preferred blends include polyethylene ethylene/vinyl acetate copolymer blends including those defined in copending patent application Ser. No. 581,436, filed Sept. 23, 1966 by Jack H. Gardner and ethylene/ethyl acrylate copolymer blends and may or may not also include pigments such as carbon black and titanium dioxide or colored pigments as well as inert fillers such as magnesium carbonate, clays, diatomaceous earth, magnesium oxide, and zinc oxide.

It should be noted that resin compositions formulated for the manufacture of book pages generally contain fillers and pigments to provide opaque, white or colored surfaces similar to paper. Other additives such as stabilizers, plasticizers, and antioxidants, anti-static agents, and the like are also usually present. Such additives can and usually are provided in the materials utilized in the present invention.

Other thermoplastic resins are also useful in this invention such as cellulose acetate, regenerated cellulose, polycarbonate, linear polyesters, polyhydroxyether, polysulfone, linear polyamides, rubber hydrochloride, poly(ethylene oxide), polytetrafluoroethylene, and similar thermoplastic resins which can be formed into films or sheets suitable for leaves in a book.

Books may be assembled by this invention wherein the successive leaves are not of the same material wherever the resins forming these leaves are mutually compatible in the melt with each other. Thus booklets with such bioriented polystyrene interior leaves may be bound together with covers made of thicker impact modified polyethylenes, pigmented and filled high density polyethylene thin sheets may be combined with medium density pigmented polyethylene sheet covers; or clear polypropylene film leaves may be intermixed with pigmented polyethylene leaves; polyhydroxyether films may be combined with polysulfone or polycarbonates, and so forth.

The method of binding of the present invention may be very effectively applied to sheets of filled or woven mats or "papers," made wholly or in part from the fibers made from thermoplastic resins. Such fibers are made from polyacrylonitrile, linear polyesters, linear polyamides, polypropylene, polyethylene and the like both oriented and unoriented. In addition sheets made from cellulose fibers which have been coated with thermoplastic resins such as polyethylene, in which the proportion of cellulose to polymer, may be as high as 80% to 20% respectively. Sheets of kraft paper up to .007" mil thick which are coated with films of polyethylene or polypropylene of thicknesses as thin as .0075" on both sides of the paper may be bound by the method of this invention.

The heat sealing characteristics of some of the above mentioned polymers are listed in Table I below.

TABLE I.—REPRESENTATIVE HEAT SEALING TEMPERATURE RANGES OF THERMOPLASTIC FILMS AND SHEETS

Material	Density of sp. gravity	Melting point, approx. ° F.	Heat sealing temp. range, ° F.
Low density polyethylene.....	0.92-0.92	225	230-400
Med. density polyethylene.....	0.93-0.94	235	240-400
High density polyethylene.....	0.94-0.96	260	260-425
Polypropylene.....	0.90	335	335-400
High density PE/EVA/filled.....	1.18	265	270-600
EVA copolymer, 18% VAc.....	.95	206	250-425
Ethylene/ethyl acrylate copolymer, 25% EA.....	.94	100	200-250
Ethylene/acrylic acid copolymer, 15% AA.....	.95	175	200-250
Ethylene/15% acrylic acid, 35% converted to Na salt.....	.96	180	300-350
Rigid polyvinyl chloride.....	1.30	180	200-360
Polyvinyl alcohol.....	1.21-1.31	220	320
Polyvinyl fluoride.....	1.38	280	350-400
Polyvinylidene chloride.....	1.68	200	280-300
Rubber hydrochloride.....	1.11	225	250-350
Plasticized PVC.....	1.20-1.45	180	325-360
Polycarbonate.....	1.20	320	420-450
Polyhydroxyether.....	1.23	220	350-400
Linear polyester (bioriented).....	1.15-1.39	490	490-500
Polystyrene (bioriented).....	1.05	225	250-325
Impact modified polystyrene.....	0.98-1.10	225	250-325
Cellulose acetate.....	1.25-1.35	340	340-450

The thermoplastic pages or leaves of the books of this invention can be finished by polishing, scuffing, embossing and by any of the techniques known to the art to impart a textured finish to the surface. The leaves can be in the form of film, sheet, foam films, fiber mats, and the like. Different types of sheets may be mixed together such as film for pages and sheets or foamed sheets for covers or inserts.

The support shield can take many forms provided it insulates the major portion of the pages from the heat that is being employed to bind the exposed portion of the pages. It can be two flat plates, for example, that are held together with the book pages inside and with the binding edge portion to be sealed extending a fraction of an inch outside. It can be, as a further example, a pair of shields and a center plate which is simply a frame to hold the pages or to drape the pages over prior to closing the shields over the pages. The shields and center member can have the same height in the closed position, but advantageously the center member is slightly shorter to reduce the exposed area of the binding edge portion to a minimum and to discourage formation of any binding bulge over the top surfaces of the shields. While the shields are preferably plates they can

also take other shapes and forms such as a pair of blocks which move together to hold the pages i.e. can take as many and varied forms as do bookends. Moreover, the shields need not be solid but can be apertured at a point removed from the source of heat that is serving to bind the book. Thus, a pair of shields can be solid in the upper portion and apertured in the lower portion remote from the heat sealing source. Although the heat shields are preferably connected and hinged as shown in FIGS. 1 and 2 these shields need not be connected as indicated above but merely pushed together and held in position during the heat sealing.

The support shields can be made of various heat resistant materials, conductive, such as metal, particularly aluminum and stainless steel or a non-conductive, for example, asbestos. If the support material is conductive, then the heat employed in sealing the book is readily conducted away; if the support shield is made of non-conductive material then the heat is prevented from reaching the book material significantly beyond the area of heat binding.

The heat source can be various provided the heating itself is applied to the portion of the pages to be sealed in a binding. Thus, the heating source can be an electric coil, a glass tube, a Micron wire heater and the like and it can even be an open flame. In a preferred embodiment the binding edge of the pages is brought in direct contact with a flame which flame gives intense heat and thus speeds up the sealing process.

Although the book material is desirably heated to a temperature at or a few degrees above the melting point of the particular material employed, as indicated in Table I, advantageously the material is heated well above the melting point short of the temperature that would degrade the plastic material, on brief contact or dwell time, e.g. less than 5 seconds, so that each book can be sealed rapidly at production line rates. However, it may be desirable to heat the book material, to be sealed, to a temperature within the heat sealing range indicated, for example, in Table I for a relatively long period of time, as by passing the pages in a support shield through a long furnace or other heated zone. However, the longer the time during which the seal is being heated the more effective must be the insulating shield; for example a water cooled shield may be necessary. Accordingly, it is preferable to use a relatively short heat binding cycle as by flame as described above or other sources such as a concentrated stream of heated gas including air or a high radiant heating source situated in close proximity with the binding edge portion of the pages.

The permissible heating time or dwell time of the binding edge of the pages being bound will be determined by the intensity of the heat being radiated to the binding edge portion and the thermostability characteristics of the book material. If the material is exposed to heat below the degradation temperature of the book material the maximum heating time is determined by the time required for heat to flow from the binding edge portion to the adjacent page portions in sufficient quantity to result in heat distortion, commonly more than 20 seconds. If the heat reaching the binding edge is above the degradation temperature of the book material then the maximum dwell time is usually measured in less than 20 seconds. On the other hand, the minimum dwell time can be measured in fractions of a second if the heat applied is within the heat sealing temperature range of the book material or higher.

As previously indicated the limits of the heating cycle are determined by either moving the book material through a heating zone or moving the heating source with respect to the book material. Preferably the support shield and enclosed pages with the exposed binding edge are moved, e.g. on a conveyor belt, past one or more heat sources, binding is accomplished and a book and shield are moved out of the heating zone.

The distance of the heat source to the binding edge portion is determined by the thermal characteristics of the book material, intensity of the heat source and the speed or rate at which the book material and the support shield move with relation to the heating source i.e. moves past the source. For example, in one group of trials it was found that a book consisting of three-folded predominantly polyethylene sheets draped over a center plate of the apparatus shown for example in FIGS. 1 and 2, were sealed to maximum seal strength in two passes at 18 feet per minute, with a one second delay between passes, through a flame about 1/4 inch thick and 3/4 inch long. The following table shows seal strength against a number of passes at 18 feet per minute.

TABLE II

Seal strength of 3 layer soft book vs. number of passes

Number of passes:	Seal strength, lbs./inch width
1	11.7
2	17.2
3	16.3
4	14.7
5	15.8
6	15.4

Although good seals could be produced using the shielding support under radiant and hot air heat, the most efficient heat transfer was experienced as indicated in the above table, using a forced natural gas-air flame. In another group of trials, book bindings 9 and 11 inches long, respectively, were sealed moving at a rate of 100 ft./min. through a horizontal gas-air flame which was about 8 inches long and about 1/4 inch thick. Much faster linear rates are anticipated with the use of many burners along the path of travel.

Draw-on covers can be attached by coating the back-bone i.e. the spine or binding edge of the book with a fusible hot melt adhesive whose melting point is lower than the heat distortion temperature of a cover material. The cover is brought in contact with the back-bone and is heated by a hot platen so as to fuse the hot-melt adhesive through the cover material and cause the cover to adhere to the back-bone. Especially effective for books made of polyethylene sheets is a hot melt consisting of low molecular weight ethylene/vinyl acetate copolymer and a tackifier such as rosin or a phenolic resin and a petroleum wax.

The following example is illustrative of the present invention and is not intended to limit the same. All parts in percentages are by weight unless otherwise specified.

EXAMPLE 1

A support shield was utilized to concentrate heat of binding only at the intended area of seal of several pages as described below. The support shield consisted of two pieces of two inch aluminum angle for a base and three plates. The center support plate was galvanized sheet metal .030 inch thick. The outer two shield plates were .063 inch thick aluminum mounted to the base by hinges. When the support shield was closed all three of the plates presented their top edges at the same level. With the support shield in the open position as indicated in FIG. 1, three folded layers of .005 inch predominantly polyethylene sheet were draped over the center plate. The two aluminum shield plates were swung upward enclosing and protecting all areas but the exposed spine or binding edge of the pages as shown in FIG. 2. A conveyor served to transport the support shield, enclosed about the pages, at constant speeds under the flame supplied by a Fisher natural gas-air multi-flame burner. Because only one burner was used the speed of the conveyor was set to 18 feet per minute, a speed that allowed the support shield to be placed and removed from the conveyor while in motion. Good seals were produced with two passes

at 18 feet per minute with one second delay between passes. Good seals were also produced with radiant heat and forced hot air. The fastest or most efficient heat transfer, allowing the book continuous movement, was experienced for a forced air-gas flame about ¼ inch thick, with the flame contacting the binding edge. It was clear that increased flame area would allow for increased conveyor rates. The book thus sealed exhibited superior seal of strength, no observable distortion to any of the pages nor thinning of the cross-sectional thickness of the sealed area, since no mechanical sealing pressure was used, providing a strong tear resistant seal.

What is claimed is:

1. A method for bookbinding a plurality of heat-sealable sheets of thermoplastic resin material which comprises;

- (a) folding said sheets on a suport shield,
- (b) cooperatively holding said folded sheets in place on said support shield by means of two outer heat shield plates, while allowing only the folded edge to be exposed, and
- (c) heating the exposed folded edge and all underlying folded edges of said plurality of folded sheets by means of radiant heat, and simultaneously fusing only

said folded edges together thereby uniting the sheets in a book form.

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