Jan. 13, 1970 T. HALLIS, JR 3,489,067
METHOD FOR IMPROVING THE BENDING QUALITY OF WATER RESISTANT CORRUGATED PAPERBOARD
Filed March 9, 1966 2 Sheets-Sheet 1

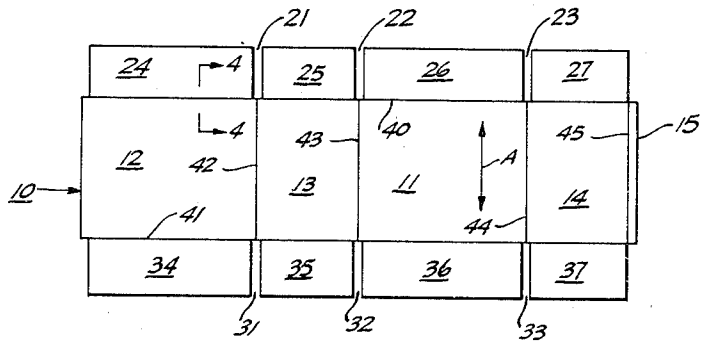


FIG. 3

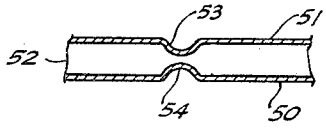


FIG. 4

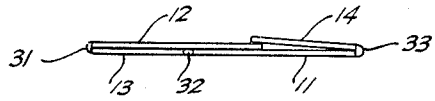


FIG. 5

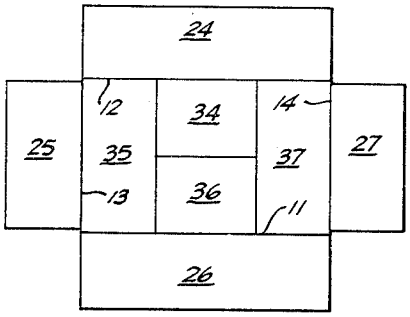


FIG. 6

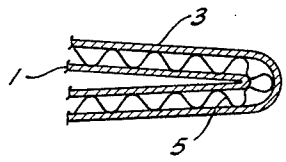


FIG. 1

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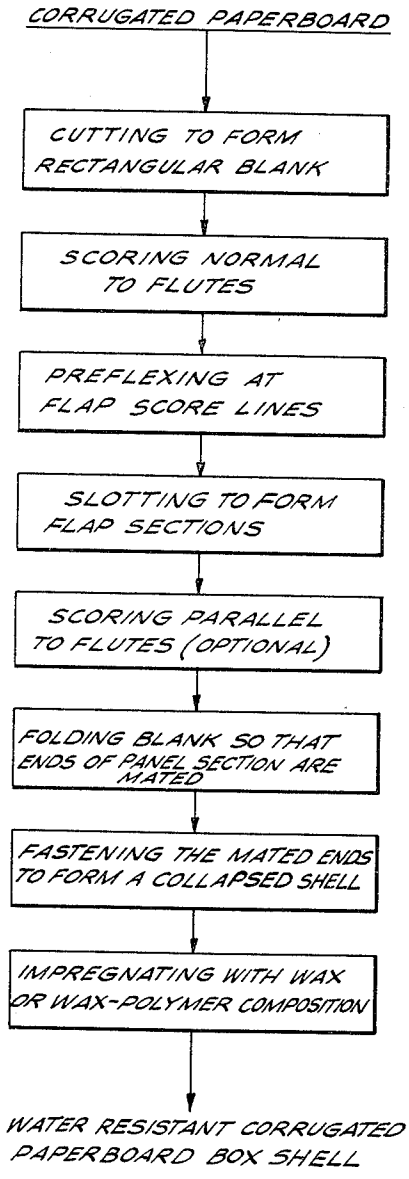


FIG. 2

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3,489,067

METHOD FOR IMPROVING THE BENDING QUALITY OF WATER RESISTANT CORRUGATED PAPERBOARD

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U.S. Cl. 93—58 7 Claims

ABSTRACT OF THE DISCLOSURE

A method for providing flexible folds in a corrugated paperboard rendered water resistant by impregnation with solidifiable wax and wax polymer compositions that impart increased rigidity to the paperboard, the treated paperboard being rendered flexible at the folds by preflexing the paper board along the desired fold lines prior to impregnation with the solidifiable waterproofing agent. The paperboard is conveniently preflexed by bending, and can also be scored along the fold lines prior to preflexing.

This invention relates to a method for improving the bending quality of a corrugated paperboard impregnated with a solidifiable material which imparts rigidity to the paperboard; and more particularly, to a method of forming a flexible fold in an impregnated water resistant corrugated paperboard. The invention has particular application in the manufacture of water resistant corrugated fiberboard boxes.

Corrugated paperboard has found wide use in a variety of applications where a relatively inexpensive, intermediate strength structural material is required, the manufacture of inexpensive storage and shipping containers constituting one of the primary high volume uses of this material. However, a principal deficiency of conventional corrugated paperboard is its poor durability and strength when wet, which limits the type of goods suitable for handling in these containers and necessitates special precautions to prevent exposure of the container to moisture during storage and shipment. To overcome this problem, a corrugated paperboard product which exhibits superior strength on exposure to moisture has been developed. Moisture resistance is achieved by impregnating corrugated paperboard with a waterproofing agent, such as wax or wax-polymer compositions. The impregnated product retains substantial wet strength, even when contacted with liquid water, thus permitting shipment of wet goods and eliminating the necessary of protecting the carton from external water.

Water resistant fiberboard boxes are conventionally pregnated corrugated paperboard, sometimes called wet pack boxes, have been found particularly useful in the storage and shipment of certain produce and other perishable goods as the commodity can be iced without damage to the boxes. In one application, water resistant boxes containing the perishable goods are loaded into refrigerated railroad cars or trucks and the entire cargo packed in ice. In another application, crushed ice is placed directly into the boxes, either before or after packing the perishable commodity. In either case, boxes manufactured from this impregnated corrugated paperboard are substantially unaffected by water from the melting ice, thereby maintaining their body and shape during transit and affording convenient means of handling the perishable goods at the destination.

Water resistant fiberboard boxes are conventionally mass produced from flat paperboard roll stock by one or more automatic or semi-automatic machines performing a series of sequential steps which corrugates the raw

paperboard and transforms it into finished boxes ready for assembly. Water resistant boxes, like most fiberboard boxes, are usually produced and distributed collapsed into flat shells ready for final assembly at the poin of use.

Both water resistant and ordinary corrugated fiberboard boxes are conventionally manufactured by substantially similar methods. However, in an additional step, the water resistant boxes are impregnated with waterproofing agent, usually by dipping the collapsed shell into a bath of molten waterproofing agent and allowing excess material to drain therefrom. The waterproofing agent solidifies on cooling to form a water resistant solid. The saturation technique of waterproofing is superior to other techniques wherein only a coating of water resistant material is deposited on the surface of the paperboard. With the saturation application, the waterproofing agent penetrats into the paperboard in considerable quantity to from a cohesive structure of paperboard and solidified waterproofing agent. The waterproofing agent, particularly in the case of wax-polymer compositions, imparts increased strength and rigidity to the paperboard in addition to rendering it water resistant. The degree of saturation of the paperboard with the waterproofing agent depends on the absorptivity of the paperboard, the soaking and draining times, the properties of the waterproofing agent, and the dip and drain temperatures. These variables are normally controlled so that the paperboard is partially saturated with waterproofing agent, the degree of saturation depending on an economic balance between the improvement desired and the cost of the waterproofing agent.

As in the case of conventional boxes, the collapsed water resistant fiberboard shells are prepared for use by opening the collapsed shell into a rectangular box shape, and closing and sealing the bottom flaps. The box is then filled and subsequently closed by folding and sealing the top flaps. The assembly, filling and closing steps are frequently performed by machine operation, although these operations can also be accomplished wholly or in part by hand.

While conventional boxes in most cases have been satisfactorily assembled, filled and closed in the aforedescribed manner, a serious problem has resulted in the assembly and closure of water resistant fiberboard boxes. It has been found that the impregnated corrugated fiberboard used in the manufacture of water resistant boxes often will not withstand the bending necessary to assemble, fill and close the box without rupture or tearing of the paperboard. While some failure of the panel and bottom flap folds has been experienced, the most acute problem is failure of the top flap folds since, in most cases, these flaps suffer more severe flexing. In a typical operation the top flaps are folded outward either 90 degrees or 180 degrees to afford easier access into the top of the box during the filling operation, and then are closed by a reverse fold of either 180 degrees or 270 degrees, depending on the magnitude of the initial fold. The bottom flap and panel folds are normally flexed to a lesser degree, although even so, bottom flap and panel score cracking is not uncommon.

In practice, the impregnated paperboard facings have been found to rupture and tear along the fold lines during the assembly and filling operation to the extent that the box must be discarded, often requiring the additional costly step of manually transferring the goods to a new container. It is not unsual that a flap will be completely torn from the box on bending. More seriously, a fold will be sufficiently weakened that the box will structurally fail during transit, causing loss or damage to the contained goods. Thus, not only does fold failure cause poor appearance, but these failures also have increased

the cost of using water resistant fiberboard boxes and curtailed a wider acceptance of these containers. The foregoing problem is not limited to a single box manufacturer, but has been more or less universally encountered by all manufacturers of water resistant corrugated fiberboard boxes, despite the fact that a variety of corrugated fiberboards and waterproofing materials have been employed.

Accordingly, it is an object of the present invention to provide a method of improving the bending quality of an impregnated corrugated paperboard. Another object is to provide a method of forming a flexible fold in a corrugated paperboard impregnated with a solidifiable waterproofing agent which imparts increased rigidity to the corrugated structure, and especially where the fold is transverse to the flutes of the corrugated paperboard. A still further object is to provide an improved method of manufacturing water resistant corrugated fiberboard boxes. An even further object is to provide a method of manufacturing impregnated corrugated fiberboard boxes having flexible flap and panel folds. These and other objects will be apparent to one skilled in the art from the following description of this invention.

The invention is illustrated by the drawings in which the same numerals refer to corresponding parts, and in which:

FIGURE 1 is a schematic illustration of the structural deformation caused by bending a corrugated paperboard;

FIGURE 2 is a schematic diagram illustrating the steps of manufacturing water resistant corrugated paperboard boxes in accordance with the method of this invention;

FIGURE 3 is a plan view of box blank;

FIGURE 4 is a cross-sectional view of a score line taken along the line 4—4 of FIGURE 3;

FIGURE 5 is a side elevation view showing the edge of the collapsed box shell obtained by folding the box blank; and

FIGURE 6 is a top view of an assembled water resistant corrugated box.

Briefly, the bending quality of a corrugated paperboard impregnated with a solidifiable material which imparts rigidity to the paperboard can be improved by preflexing the paperboard along the fold line after corrugation but prior to impregnation with the waterproofing agent. In a preferred embodiment of the invention, the corrugated paperboard is first scored along the joint, and then preflexed. Preflexing can be accomplished by bending the paperboard sufficiently to cause extension of the fibers immediately adjacent the fold. A fold formed in this manner can withstand many flexures at the fold line without tearing of the paperboard or rupture of the waterproofing agent. This technique is particularly suited to the manufacture of water resistant corrugated fiberboard boxes as both the top and bottom flap folds and the panel folds are amenable to preflexing prior to impregnation of the corrugated paperboard with waterproofing agent.

A substantially rigid corrugated paperboard structure can be folded along crease or score lines either parallel with or transverse to the flutes of the corrugating medium. The line along which the fold is made is a substantially straight line extending completely across the material being folded. The term "bending quality" as used herein is intended to mean the ability of a substantially rigid corrugated paperboard to bend or fold along these lines so that adjacent sections of a unitary piece of corrugated paperboard situated on opposite sides of a fold line are movable with respect to each other. A corrugated paperboard having good bending quality is capable of being repeatedly flexed or folded without tearing or damage of the structure to the point that the paperboard is seriously weakened.

The method of this invention is generally useful in forming flexible folds in any corrugated paperboard subsequently impregnated with a material which renders the paperboard more rigid and brittle than the untreated board. Corrugated paperboards susceptible to impregnation generally include those having one or more layers of corrugating medium adherently attached to flat facings. Commercial corrugated fiberboard structures suitable for impregnation include single face construction wherein a single corrugating medium is adherently attached to a single flat facing, single wall (double faced) construction wherein a single medium is interposed between two exterior facings, double wall construction formed by three flat facings having a medium disposed between each of the facings, and triple wall construction formed by four flat facings and three intermediate corrugating mediums alternately disposed therebetween. The adherent layers are usually glued together with water soluble starch, although a modified starch is preferred in the case of corrugated fiberboard produced for water resistant box construction.

A corrugated paperboard useful in the manufacture of water resistant boxes comprises a light weight corrugated paper adherently interposed between two relatively light weight flat sheets of paperboard. It is to be understood that the thickness of the various individual members can be selected to impart the necessary strength to the corrugated paperboard products, the term "relatively light weight" being employed to indicate that the thickness or gage of the component materials is relatively small as compared to the thickness of the ultimate structure. The faces of a single wall (double faced) corrugated paperboard are often of different weights, with the heavier material usually being placed on the interior of the box. In general, the minimum paper weight employed in corrugated paperboard for water resistant box construction is 26 pounds per thousand square feet. The combined weight of facings usually ranges between 52 and 264 pounds per thousand square feet of corrugated paperboard, and between 52 and 180 pounds per thousand feet for single wall (double faced) paperboard.

The thickness of a corrugated paperboard is dependent upon the thickness of the facings and the flute construction. Flutes have been commercially standardized by prescribing the flute height and the number of flutes per foot. Type A-flutes are $\frac{3}{16}$ inch in height with approximately 36 flutes per lineal foot, type B-flutes are $\frac{3}{32}$ inch in height with approximately 51 flutes per lineal foot, and type C-flutes are $\frac{9}{64}$ inch in height with approximately 42 flutes per lineal foot. Other types of flute construction are also employed in special application. The total thickness of the corrugated structure can vary from approximately $\frac{3}{32}$ inch to about $\frac{9}{16}$ inch for heavy triple wall construction.

When a corrugated paperboard is folded, the inside face (relative to the fold) is sharply flexed on a radius of the magnitude of the thickness of the face material. Although there is a sharp bend or flexure of the face material, the fibers of the paper are not greatly stretched. The corrugating medium is subjected to a very complicated series of distortions, depending in part on whether the fold is parallel or transverse to the direction of the flutes. The outer face of the corrugated paperboard (again relative to the fold) is flexed over a larger radius than the inside face, the radius of flexure being up to 30 times the thickness of the face material depending upon the construction of the particular fiberboard. However, although the bending radius is less severe, the outside face must stretch a substantial distance. The length of the semicircle over which the outside face must stretch for a 180 degree bend is indicated as follows for various thicknesses of corrugated paperboard:

Thickness, inches	Length of semicircle, inches
$\frac{3}{32}$	0.29
$\frac{1}{8}$	0.39
$\frac{5}{32}$	0.49
$\frac{3}{16}$	0.59

It is apparent that the stretch required increases markedly with the thickness of the paperboard.

The structural effects encountered when corrugated paperboard is folded parallel to the direction of the flutes is illustrated in FIGURE 1, wherein there is shown a typical single wall corrugated comprised of interior facing **1**, exterior facing **3** and corrugated member **5** folded through an angle of approximately 180 degrees. Interior facing **1** is flexed sharply at the fold, outer facing **3** is flexed over a much larger arc and corrugated member **5** is at least partially collapsed. Similar structural effects are encountered when the corrugate is folded normal to the direction of the flutes.

In a desirable product the paper in the outside face and the absorbed waterproofing material, either within the paper or on its exterior surface, must stretch without tearing. The exact amount of paper which participates in this stretching is not known, but observations suggest that only fibers quite close to a line directly opposed to the inside bend line participate in the stretching phenomena. When a very hard and brittle board is folded, there is very little stretch before rupture. A relatively sharp and straight break is created extending the full width of the piece subject to bending. In commercially desirable water resistant corrugated paperboards, stretching occurs for the full width of the piece with no tearing of the paper or rupture of the waterproofing material. In intermediate cases, small tears of various lengths appear in the section subjected to stretching. It is apparent that when a corrugated paperboard is subjected to reverse bending, the opposite result is effected with the unstretched face formerly on the inner side of the fold then subjected to stretching.

The bending quality of a corrugated paperboard subsequently impregnated with a solidifiable waterproofing agent can be improved at a fold line by first flexing the structure at the fold line prior to impregnation. Although the exact theory of the mechanism by which increased flexibility is imparted to an otherwise substantially rigid structure is not completely understood, it has nevertheless been demonstrated that prefixing of the material at the fold line prior to impregnation establishes a flexible fold which exhibits a substantially good bending quality, even after impregnation. It is believed that at least two different effects cooperate to produce this increased flexibility. First, as described above, the fibers in the paper, and particularly those in the face material are stretched in the area adjacent the fold line. The structure, by virtue of this stretching, loses rigidity. This rigidity is not completely restored by impregnation as the waterproofing agent exhibits at least a small amount of elasticity. Secondly, the thickness of the corrugated paperboard is reduced at the fold line by the preflexing, thereby affording less mass of paper at this critical area to absorb waterproofing agent. The reduced quantity of waterproofing agent absorbed at the fold line further reduces the rigidity imparted to the structure by the waterproofing agent.

Preflexing of the corrugated paperboard can be simply effected by bending or folding the material along a line desired to have increased flexibility imparted to it. In the simplest embodiment of this invention, one section of a corrugated sheet is bent through an angle of up to 180 degrees prior to impregnation of the corrugated with waterproofing material. In another embodiment the corrugated paperboard is bent through an angle of up to 180 degrees, and then straightened or restored to its original configuration prior to impregnation. The amount of preflexing required to impart a desired amount of flexibility to a fold, as indicated by the angle through which the material must be bent, is dependent upon the thickness and strength of the paperboard as well as the strength and saturation of the waterproofing agent. Therefore, the amount of preflexing required is determined by the bending necessary with any particular corrugated paperboard to impart a desired degree of flexibility to a fold when the paperboard is finally impregnated with waterproofing agent.

Increased flexibility can be imparted to a fold by first bending the material through an angle of up to 180 degrees in one direction, and then reverse bending the material through an angle of up to 180 degrees in the opposite direction from its original position. The material can then be straightened to its original position prior to impregnation with waterproofing material. In the application of this embodiment of the invention, it is apparent that the fold can be flexed through a combined angle of up to 720 degrees, i.e., 180 degrees in a first direction, 360 degrees in a reverse direction (180 degrees to restore the paperboard to its original configuration plus 180 degrees to completely fold the paperboard in the opposite direction), and finally 180 degrees to return to the original configuration.

It is further within the scope of the present invention to repeat any of the foregoing bending operations so that the material is flexed through a total angle exceeding the maximum angle obtainable by a single bending operation. Total flexure angles exceeding 720 degrees can accordingly be obtained where required.

In a further preferred mode of practicing the method of this invention, the material is scored along the desired fold line to facilitate bending of the paperboard. Scoring is accomplished by compressing the corrugated paperboard along a desired fold line sufficiently to stress the material at the fold beyond its yield point so that permanent deformation occurs which weakens the structure sufficiently to facilitate folding of the material along the desired line without unnecessary loss of strength. The scoring operation should not be sufficiently extreme as to produce a cut or tear in the facing material, yet must be sufficient to cause the necessary deformation of the paperboard. Scoring can be accomplished by any one of a number of commercially practiced methods whereby the paperboard is deformed in various configurations, the depth and width of the score line being controlled to produce desired results. A score line regarded as commercially satisfactory to impart increased flexibility to a corrugated paperboard used for conventional box construction, can usually be combined with reflexing to impart flexibility to impregnated corrugated paperboard.

The method of this invention is useful in improving the bending quality of a corrugated paperboard impregnated with any solidifiable material which imparts increased rigidity to the corrugate structure. Solidifiable materials found useful in increasing the water resistance of corrugated paperboard include various waxes, such as paraffin waxes derived from petroleum, and mixtures of these waxes with minor proportions of a polymer capable of improving various properties of the wax. Preferred compositions found useful in impregnating corrugated paperboard to improve its water resistance generally include a major proportion of a refined paraffin wax; a minor proportion of a polymer such as polyethylene, or the like; and a small amount of various additives imparting improved properties to the solidified composition. The polymer content of the mixture is typically between about 2 and about 20 weight percent, and the additive content less than 1 weight percent.

As previously disclosed, the method of this invention has particular application in the manufacture of water resistant corrugated fiberboard boxes. Corrugated fiberboard boxes are conventionally manufactured on a commercial scale by an integral process in which flat paperboard roll stock is corrugated and formed into box shells. Although a wide variety of corrugated paperboards and box designs can be employed in the construction of commercial water resistant corrugated fiberboard boxes, the bulk of these boxes are of the self-enclosing RSC (regular slotted container) design constructed from a single

piece of single wall (double faced) corrugated consisting of two outer facings and an intermediate fluted member. Three paperboard roll stocks are formed into an integral structure by a continuous corrugating machine which forms the corrugating medium into a series of arched trusses and attaches the flat paperboard facings to the medium with adhesive applied the tips of the flutes. Conventional corrugators used to manufacture corrugated fiberboard for box construction are frequently equipped to score the material in a direction normal to the flutes of the medium and to cut the fiberboard into blanks of appropriate size, thus performing the first steps of the actual box-making operation. The transverse score lines produced on the corrugator extend the length of the blank and defines two spaced flap sections on either side of an intermediate panel section.

The scored box blank is subsequently passed to machines which slot the blank normal to the flap score with slots extending from the outer edge of the blank to the score line so as to subdivide each flap section into four flaps. The slots in each of these flap sections are situated opposed to a corresponding slot in the other flap section. The slotted blank is scored parallel with the flutes to form score lines extending across the panel section between opposed slots. If desired, breathing vents, drain holes, hand grips, and the like can be cut into the blank. Also various advertising or identification can be printed onto the blank, the printing being oriented so that it will be properly displayed on assembly of the box.

At this stage of manufacture, the box comprises a flat sheet of paperboard having four opposed flaps on either side of an intermediate panel section subdivided by parallel score lines into side and end panel sections. The flaps are defined by the slots and transverse score lines extending the length of the panel section. The score lines facilitate bending of the paperboard on assembly of the box.

The box shells are formed by folding the blank along the panel score line situated at approximately its midpoint so that the blank is essentially folded double. The overlapping mating ends of the panel section, having a lip cut for this purpose, are joined by gluing, stapling, or the like, to form the manufacturer's joint which is located adjacent the corner of the box diagonally opposite the initial fold. At this point the shell is conventionally dipped into a liquid reservoir of the molten waterproofing agent for a controlled length of time, and then removed therefrom and allowed to drain for a specified period at a controlled temperature.

The foregoing method of manufacturing water resistant corrugated paperboard boxes is more fully illustrated in FIGURE 2 where therein is shown a sequence of steps including (1) cutting a corrugated paperboard to obtain a substantially rectangular box blank; (2) scoring at the flap folds normal to the direction of the flutes; (3) preflexing the corrugated paperboard at the flap score lines by bending the paperboard along the score line; (4) slotting the blank to form the flaps; (5) optionally scoring at the corner folds parallel to the flutes; (6) folding the blank at a corner fold so that the ends of the panel section are mated; (7) fastening the mating ends of the panel sections to form a collapsed box shell; and (8) impregnating the shell with molten wax or wax-polymer composition. Where printing is desired, it is preferably performed simultaneously with the slotted step.

One embodiment of the box blank formed in accordance with the method of this invention is illustrated in FIGURE 3 wherein there is shown a generally rectangular blank **10** of corrugated paperboard from which a folding box or carton is assembled. The blank is usually cut so that the flutes in the panel sections are in a vertical direction when the box is assembled, which direction is indicated in FIGURE 3 by arrow A. The blank includes an integral front panel **11**, back panel **12**, right hand (relative to the front of the box) end panel **13**, and left hand end panel **14**. Lip **15** is adjacent to and integral with end panel **14**. Slots **21**, **22** and **23** are provided to define top flaps **24**, **25**, **26** and **27**. Opposed slots **31**, **32** and **33** define bottom flaps **34**, **35**, **36** and **37**. The blank is scored at **40** and **41**, normal to the direction of the flutes to facilitate folding of the flaps. Also, the blank can be optionally scored along the lines **42**, **43**, **44** and **45** in a direction parallel to the flutes to facilitate folding at the corners. A suitable score is illustrated in FIGURE 4 wherein there is shown a section of single wall corrugated comprised of interior face **50**, exterior face **51**, and corrugated number **52** deformed at **53** and **54** to facilitate folding. As illustrated in FIGURE 5, the blank is formed into a collapsed box shell by folding along the score lines, such as **42** and **44**, and fastening the mating ends at lip **15**. FIGURE 6 illustrates one mode of assembling the impregnated collapsed shell into a water resistant box, shown her with the top flaps opened.

The corrugated paperboard can be preflexed by the aforementioned bending along score lines at any stage of the box manufacture prior to the impregnation step. Either selected folds can be treated by preflexing, or all the folds can be so treated. As a practical matter, it is often convenient in many operations to preflex the flap folds immediately upon scoring, and to subsequently preflex the panel folds in a separate operation prior to folding the blank to form the shell. The particular choice of sequence largely depends upon the equipment available and the preference of the operator.

While the resulting product of the foregoing process is a self-enclosing water resistant corrugated box, it is apparent that by only slight manipulation of the process techniques within the skill of the art, various water resistant corrugated fiberboard containers and products can be produced.

In another aspect, this invention pertains to water resistant corrugated fiberboard boxes impregnated with solidifiable waterproofing materials, which boxes have folds rendered flexible by preflexing according to the method of this invention prior to impregnation.

It is well known that the bending quality or stretch of a paper is a function of the moisture content of the paper, the paper becoming more brittle and rigid at low moisture contents. The moisture content of the paper seeks equilibrium with the atmosphere to which it is exposed, moisture contents of from about 0 to 30 weight percent resulting from varying the relative humidity over a range of from 0 to 100 percent. Accordingly, preflexing of the corrugated paperboard is desirably performed under conditions wherein the unimpregnated paperboard has sufficient moisture content to stretch through the necessary bending angle without tearing of the paper. Thus, it is within the scope of this invention to control the moisture content of the paperboard during the preflexing step at a sufficiently high value that the flexed paperboard will bend without tearing. In many applications, sufficient flexibility can be attained at moisture contents above about 2 weight percent water. However, it is preferred that the moisture content be controlled above about 4 percent, and more preferably within a range of between about 6 and about 15 weight percent. These moisture contents can usually be obtained by controlling the relative humidity of the atmosphere to which the paperboard is exposed between about 30 and about 80 percent, and most desirably between about 40 and about 60 percent.

The invention is further described by the following examples which are illustrative of various embodiments thereof, but are not intended as limiting the scope of the invention.

EXAMPLE 1

A flat piece of commerical single wall corrugated fiberboard 19½ inches by 18 inches in size having 42 pound and 69 pound faces and a 33 pound medium corrugated in a type B-flute is scored normal to the flutes and tested for flexibility. The flexibility test consists of