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J. B. FELTON, JR., ET AL

3,322,318

CELLULOSE FIBER CANS

Filed Nov. 12, 1963

FIG. 1

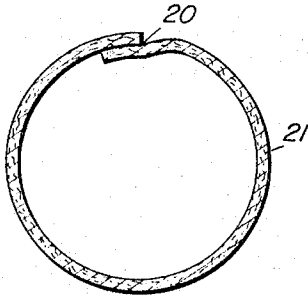


FIG. 2

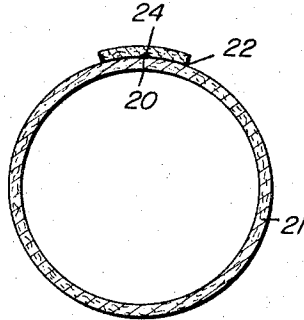


FIG. 3

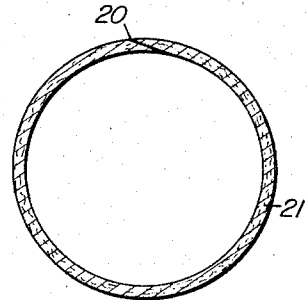


FIG. 4

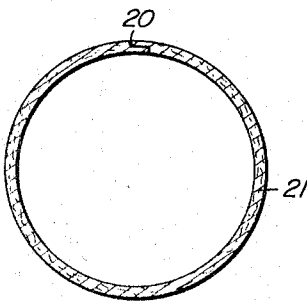


FIG. 5

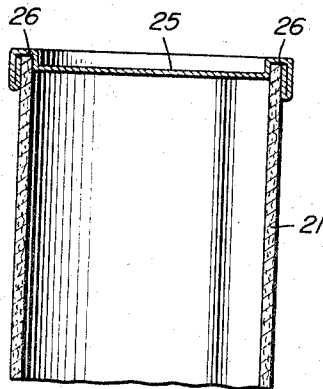


FIG. 6

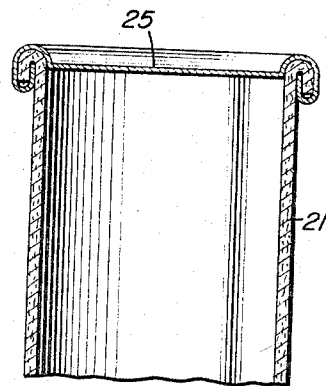


FIG. 7

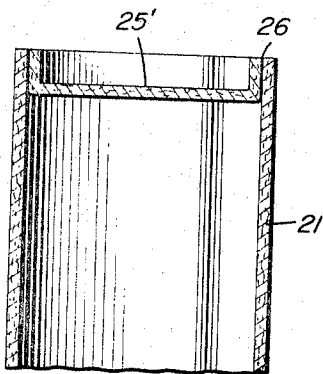
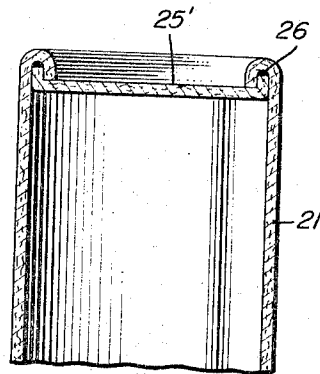


FIG. 8



3,322,318

CELLULOSE FIBER CANS

Joseph B. Felton, Jr., Mount Pleasant, John F. Turner, North Charleston, and Archie D. Duncan, Jr., and William J. Funderburk, Charleston, S.C., and Roger Bart, Weston, Conn., assignors to West Virginia Pulp and Paper Company, New York, N.Y., a corporation of Delaware

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This invention relates to containers which can be employed in the packaging of thermally processed foods and more particularly relates to such containers constructed of thermosetting resin-impregnated non-woven cellulose fiber webs and to methods of preparing these containers.

The familiar tin can has proved to be a very effectual and economical package for a great variety of products. In recent years, however, other less costly containers have been developed which have replaced the tin can for the packaging of certain of these products. These newly developed containers have been constructed primarily of paper or paperboard in combination with metal foil or thermoplastic resin coatings, and are now being employed widely for packaging such diversified products as motor oil, frozen fruit juices, and refrigerated bakery goods. While the tin can has lost some markets to fiber cans, the tin can remains essentially unchallenged in its use for packaging thermally processed foods. The less expensive fiber cans have hitherto been incapable of withstanding the rigorous conditions involved in thermal processing and the only competition at all with the tin can in this area of use has been from the more expensive glass containers and aluminum cans.

Thermal processing of foods involves cooking of the food product after it has been sealed in the can or container, so as to destroy all organisms that might cause spoilage. The exact conditions employed in thermal processing vary considerably depending primarily upon the particular type of food product being canned. However, regardless of the type of food being canned, thermal processing involves the use of relatively high temperatures in the presence of water or steam, resulting in internal and external pressures being alternately applied to the can. The temperatures and related conditions employed in thermal processing require the use of cans constructed from materials having much better physical characteristics than are provided by present fiber based cans.

A fairly typical example of conditions encountered in thermal processing is in the canning of peas. The first step is to blanch the peas at a temperature of about 160° F. Peas at this temperature are then packed into the can with hot water. While still open, the cans are "exhausted" usually by heating in a steam chamber or by passage of a steam jet over the open end to remove any air. The cans are next sealed and processed in a steam autoclave at 240° F. for varying lengths of time, depending on can size, to destroy any injurious organisms. At the temperature employed in this last step a gage pressure of about 8 p.s.i.g. is developed in the autoclave. As the liquid in the can is heated, an almost equal pressure is built up within the can. The net result is that very little pressure differential exists while the can remains in the autoclave. When the sealed can is removed from the autoclave, however, the pressure on the outside of the can is rapidly decreased to atmospheric while the contents of the can, still being at about 240° F. maintain the internal pressure of about 8 p.s.i.g. As the can cools the internal pressure in the can decreases, finally becoming zero, and passes to a negative interior gage pressure, or vacuum, due to the cooling of the contents to a temperature below that at which the cans were sealed.

The can structure must consequently be able to withstand the effects of high temperature, high humidity and moisture, pressure and vacuum. The characteristics of paper, paperboard, and similar non-woven cellulose fiber webs are such that both high temperature and humidity or water have a significantly detrimental effect on the strength properties resulting in severe loss of ability to withstand the pressure and vacuum. To our knowledge, no presently available fiber can construction is consistently capable of performing satisfactorily under the conditions of thermal processing. While it is conceivable that, by greatly increasing the quantities of materials employed in the available fiber cans and by encapsulating the cellulose web so as to eliminate all contact of steam or water with the web, a can could be made which would provide satisfactory service, such cans would be wholly impractical due to their great bulk or high cost.

The primary object of the present invention is to provide a can constructed of non-woven cellulose fiber web material which can practically be employed for packaging of thermal processed foods and which can compete with the common tin can.

Other objects will become apparent from the following disclosure.

We have found that a can capable of being employed in the packaging of thermal processed foods and in substantial all other packaging uses in which the tin can is currently employed can be constructed from pressure cured thermosetting resin-impregnated non-woven cellulose fiber webs.

In the practice of this invention, non-woven cellulose webs, such as paper and paperboard, are impregnated with a thermosetting resin and the resin cured under pressure in the web structure. The resultant thin sheets of cured resin-impregnated web can thereafter be cut to size, and formed into the desired shape to make the body wall of a can. The finished can is ultimately produced by the attachment of the required end or ends which may be made of the same resin-impregnated web material as that employed in the can body, tinplate, aluminum, or any other suitable materials such as high temperature-resistant molded plastics. While, in general, the basic steps employed in converting the thin sheets of resin-impregnated web into a can body are similar to those employed in making cans from tinplate, the great differences in the properties of the impregnated webs used in this invention compared to those of tinplate require that significantly different methods be employed in conducting these basic steps, as will be evident from the disclosure hereinbelow.

The non-woven cellulose fiber webs employed in this invention possess certain characteristics which would apparently make them totally unsatisfactory for use under the conditions involved in thermal process packaging. Cellulose fibers derived from any source, whether they are the naturally occurring pure fiber of cotton or the pulp obtained by stringent chemical treatment of wood, are seriously effected by both heat and moisture; the two conditions which are characteristic of thermal processing. Non-woven cellulose fiber webs which are produced by the felting of a large number of substantially individual cellulose fibers derive their strength from the mechanical entanglement of the fibers with one another and from physio-chemical bonding of the fibers to one another at their points of contact. Both of these fiber-to-fiber bonding mechanisms are seriously affected by moisture and/or heat. For example, paper can lose up to 90% of its strength by soaking it in water and may lose about 30% of its strength by subjecting it to an environment at 220° F. In addition, the detrimental effects of both moisture and temperature are greatly increased when they occur in conjunction with one another as is encountered during thermal processing.

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In spite of these inherent disadvantages in the characteristics of non-woven cellulose webs, these webs when combined with thermosetting resins in accordance with the principles of this invention can satisfactorily be utilized in making cans for thermal process packaging.

A wide variety of thermosetting resins may be employed in the practice of this invention. Satisfactory resins include the allyl resins which are based upon such diallyl prepolymers as diallyl phthalate or diallyl isophthalate and which are cured to the thermoset state with peroxide catalysts, the amino resins (excluding urea-aldehyde resins which lack the required resistance to moisture) which are based upon the reaction of a polyamine such as melamine and an aldehyde such as formaldehyde, the epoxy resins which are based upon the polymerization of prepolymers having a plurality of oxirane groups, such as the diglycidyl ether of bisphenol, under the influence of cross-linking agents or catalysts such as acids or amines, the urethane resins which are based upon the polymerizing reaction of polyisocyanates with compounds having a plurality of active hydrogens such as the polyhydroxy polymers of ethylene or propylene glycol or of polyhydroxy and polybasic acidic compounds, the polyester resins including the oil modified polyesters generally referred to as alkyd resins, which are based upon the crosslinking of copolymers, formed by the reaction of a polybasic acid and a polyhydric alcohol, through unsaturated groups in the copolymer generally by vinyl compounds, the phenolic resins which are based upon the reaction of a phenolic compound with an aldehyde such as formaldehyde, those thermosetting polycarbonate resins (as contrasted to the thermoplastic polycarbonate plastics) which are based upon the reaction between unsaturated and aliphatic dehydroxy compounds with phosgene or appropriate phosgene-derived precursors, and the organo polysiloxane based silicone resins.

For practical purposes, the selection of a thermosetting resin for use in this invention will be based primarily upon economic consideration of the current cost of the resins and the quantity of resin needed to impart the necessary properties to the cellulose web. Based upon current costs and knowledge, the preferred resins for use in this invention are the phenolic resins which are relatively inexpensive and can be employed at reasonably low levels. These phenolic resins may be employed at levels as low as 15% while still producing satisfactory cans, depending upon the service intended. (As employed herein the percentage of resin is the weight percent of the cured resin solids based upon the total weight of the cured resin solids and the cellulose web.) Below 15% the moisture resistance is inadequate to withstand the rigorous conditions of thermal processing. Levels of up to about 60% phenolic resin may be employed satisfactorily; however, above about the 35% level improvement of properties is generally insufficient to justify the added cost. A level of between 20% and 30% phenolic resin has been found to be preferred. The other thermosetting resins should be employed within the same broad range as the phenolic resins, i.e., between 15% and 60%, although the preferred range away be somewhat different.

The resin-impregnated web stock may be constructed of a single ply or a plurality of plies laminated together into a unified coherent sheet having no sharply defined planes of demarcation throughout its thickness of either properties or composition. Such a laminated structure does not necessarily have to be homogeneous, and may have gradual gradations both in composition and properties throughout its thickness. This is true also of impregnated web stock made from a single ply.

In order to achieve the necessary properties for withstanding the conditions of thermal processing, it is desirable that the resin be distributed throughout the cellulose web. The necessity of such distribution of the resin will be quite evident when it is recalled that both the heat and moisture conditions encountered in thermal processing

cause severe deterioration of cellulose fiber-to-fiber bonding. Such deterioration of the bond; although it may be in only a relatively small portion of the web could result in functional failure of the whole structure. The fact that the resin must be dispersed throughout the web does not mean that the resin distribution must be uniform throughout. It is quite possible to vary the type of resin or to employ reduced amounts of resin in the interior of the web where the fibers are not subjected to the effects of heat and moisture to as great a degree as on the surfaces of the web.

It is essential, in order to obtain web stock capable of withstanding the thermal processing operation, to cure the thermosetting resin under sufficient pressure to compact the web structure into a substantially void-free contiguous structure. The pressures necessary to achieve this type of dense structure, which should have a dry specific gravity greater than about 1.05, is greatly dependent upon the flow and cure characteristics of the resin. Pressures as low as 50 p.s.i. are marginal although they may be employed with some of the resins at rather high resin percentages. Preferably much higher pressures should be employed, in the neighborhood of 500-1500 p.s.i., especially for phenolic resins. Maximum pressures are listed to those at which compressive degradation of the fibers occurs. The pressures specified need not necessarily be employed on a constant basis throughout the curing of the resin as it is possible to reduce the pressure to a much lower level after the initial high pressure has caused flow of the resin and has compacted the web. While this second phase lower pressure can be considerably lower than the initial pressure, it should be sufficient to prevent any substantial spring-back of the fibers from their compressed state and should be continuously applied until the curing of the resin has proceeded to the stage wherein the resin bonding is strong enough to restrain the tendency of the fibers to assume their original configuration in the non-compressed web.

The temperature employed for curing the resin-impregnated webs will, of course, be dependent upon the specific type of resin employed. Some few resins, such as the resorcinol-resins and certain of the epoxy and polyester resins, can be cured at or near room temperature. However, these resins will present obvious problems in preventing precuring of the resin during impregnation of the web and subsequent removal of solvent. Most of the thermosetting resins will require curing at temperatures from about 100° to 400° F., as recommended by the resin supplier.

A relatively simple test has been developed to determine the utility of cured resin-impregnated web materials in cans subject to thermal processing. This test consists of cutting 1" x 3" strips of web stock, subjecting them to saturated steam at 212° F. for 5 minutes in a closed container, and immediately determining the modulus of elasticity in flexure of the material according to ASTM 790-61. Because of economical considerations and performance criterion it has been found that the web stock, after the aforementioned steam treatment, must retain at least 65% of its original modulus of elasticity (as measured after conditioning for 3 days in an atmosphere of 50% relative humidity at 73° F.) and after such steam treatment the modulus of elasticity should not be less than 500,000 p.s.i. Web stocks which do not retain at least 65% of their original modulus of elasticity do not possess adequate water resistance properties to perform satisfactorily in thermal processing applications. Likewise, those web stocks which do not have a minimum modulus of elasticity of 500,000 p.s.i. after the aforementioned steam treatment, lack adequate rigidity to withstand the vacuums encountered in thermal processing applications. It could be pointed out that the 65% retention of the original modulus of elasticity and the minimum 500,000 p.s.i. modulus of elasticity after steam treatment are minimum requirements for the web stock; such as for use in the canning of fruit juices, and that web stocks which barely

meet these requirements will not, in general, be satisfactory under more severe conditions of thermal processing such as encountered in the canning of meats when a temperature of 260° F. is employed for an extended period of time, and pressure differential as high as 20 p.s.i.g. are involved. To operate satisfactorily under the more severe conditions it would be desirable for the web stock to retain at least 90% of the modulus which should not be less than 1,000,000 p.s.i. after the steam treatment.

Due to the anisotropic nature of the properties of non-woven cellulose fiber webs and the cured resin-impregnated web stock obtained therefrom, the modulus of elasticity in flexure as used herein is the average of moduli taken at right angles to one another, preferably in the machine direction and cross machine direction in the case of paper and paperboard.

While the impregnated web materials of this invention are capable of withstanding the effects of steam, water and temperature without loss of utility, they are not necessarily completely impervious to water, particularly where the resin content is at the lower end of the range set forth hereinabove. Water consequently can be transmitted through the can walls by wicking action of the cellulose fibers. This permeability to water is unrelated to the fact that the impregnated web material is at the same time essentially impermeable to atmospheric gases. This problem, of water permeability, however, is readily solved by providing a thin water impermeable coating on the side of the impregnated web material that is to be in contact with the aqueous content of the can. This coating may be composed of any of the wide variety of water-impermeable materials available, such as polyvinylidene, epoxy, polyester, oleo, and alkyd resins and metal foil, which would be suitable for use in contact with food. Preferably, a thin layer of aluminum foil is used. This can be easily applied by laminating it to the impregnated web material during the pressure curing of the resin impregnated web. By use of this method the foil can be intergally laminated to the resin impregnated web without the need for a separate adhesive.

The conversion of the cured resin impregnated web stock into cans presents certain problems which are not encountered in making of cans from the presently employed tinplate. Forming these webs into the desired shapes for can bodies is much more difficult due to the facts that (1) the impregnated web stock is considerably thicker, on the order of 1.5 to 3 times as thick as the tinplate, and that (2) the stress strain relationship of the impregnated webs is entirely different from that of tinplate. The modulus of elasticity of tin-plate is on the order of 25,000,000 to 30,000,000 while that of impregnated web stock suitable for this invention ranges from about 500,000 to 2,500,000. As compared to the resin-impregnated web stock of this invention then, tinplate requires a much higher stress to produce a given deflection in the area of non-deformable flexure. The stress-strain curve of tinplate, moreover, has a broad area from the point at which deformable flexure begins until rupture occurs. This broad area of deformable flexure permits flat tinplate to be easily bent into the can body shape and permanently deformed into that shape. This region of deformable flexure, however, is very limited in the stress strain-relationship of the resin-impregnated web stock at room temperature and permanent deformation of the web stock is much more difficult to achieve without rupturing the stock.

Due to the limited deformability of the impregnated web material at room temperature and to the interrelated factor of physical properties to withstand pressure forces, it has been found that the thickness of the impregnated web material must be controlled in its relation to the diameter of the can being made. The thickness of the can wall should be less than $\frac{1}{45}$ of the can diameter and preferably in the range of $\frac{1}{100}$ to $\frac{1}{200}$. Web thickness greater than $\frac{1}{45}$ of the can diameter will cause problems in forming the can shape and in providing an economic package.

This invention may be better understood by referring to the drawings wherein

FIGURES 1-4 are top cross-sectional views of cans illustrating methods of forming a side seam.

FIGURES 5-8 are partial front elevations taken in section of methods of fastening the can end.

Production of cured resin-impregnated web stock satisfactory for use in this invention can be prepared by a number of methods well known in the prior art. One method is to employ the current techniques used in the laminating industry to produce flat sheets of material which can then be cut and formed into the can body. Obviously, it would greatly reduce costs to form a convolute or spiral tube from a non-cured resin-impregnated web and cure the resin during the tube formation. However, such methods, except for those wherein the tube is subsequently cured in a tube press for considerable time under substantial pressure, will not yield products which possess the necessary properties specified hereinabove. As currently available tube pressing methods are incapable of the large scale economical production needed for cans, forming of can bodies from flat pressed sheets is the preferred method.

In making the can body from flat, cured, resin-impregnated web stock, it is necessary that the stock be cut into the appropriate size for the can body, the cut section formed into the cylindrical shape of the can body, and the edges permanently joined together creating a side seam 20.

The methods of forming side seams in tin cans are quite obviously not applicable to the material of this invention since this material can not be soldered. Joining the edges together may be simply accomplished, however, by applying an adhesive to the edges, bringing the edges into contact with one another, and maintaining this contact until the adhesive is set. It will be obvious that the adhesive employed must be able to withstand the heat and moisture conditions of thermal processing without failure. Consequently, it is generally preferable to employ an adhesive of the thermosetting type. The melamine and epoxy resins have been found to be especially well suited for this use.

Simple butt glueing of the edges together will generally not provide sufficient side seam strength in the can. It is consequently necessary to employ other methods of glueing. Several satisfactory methods are shown in FIGURES 1 through 4 of the drawings. In FIGURE 1, a simple overlap seam is illustrated when the inner surface of one edge is glued to the outer surface of the opposite edge of the can body. In FIGURE 2 a modified butt joint is shown which has a reinforcing strip 22 glued over the butt joint. This particular joint may be further modified by use of a tear string 24 which can be pulled to separate the reinforcing strip along the seam line to provide for easy opening. The seams illustrated in FIGURES 1 and 2 have the undesirable characteristic of causing a protrusion in the area of the seam due to the multiple thickness of material. This protrusion, which is also characteristic of the common tin can, often causes difficulty in the opening of cans with the common types of can-openers and creates difficulties in providing a hermetic seal. This protrusion can easily be eliminated, however, by use of the constructions shown in FIGURES 3 and 4 employing a beveled joint and a ship lap joint respectively. As the beveled joint is more easily prepared, and better controlled, it is the preferred type for use in this invention.

Once the can body 21 has been formed, the completed can ready for filling, is formed by attaching one or more end closures 25, 25. These end closures may be formed of metal, plastic or cured impregnated web stock similar to that employed in the can body. Many different expedients may be employed for attaching the end closures; a few of which are illustrated in FIGURES 5 through 8. The presently preferred methods of attaching the end closure 25 are shown in FIGURES 5 and 6 employing a standard can end of tinplate or aluminum. Either of these closures can

be made on double seaming equipment currently employed in manufacturing tin cans.

In FIGURE 5 the gasket material employed on the standard can ends of ordinary tin cans is replaced by an adhesive 26 such as a thermosetting epoxy resin. The end is placed on the can body and a so called "false double seam" made by folding the edges of the end under adjacent portions without distributing the edge of the can body. While it is not necessary to make the false seam, this provides several distinct advantages. The false double seam not only maintains the closure in place during setting of the adhesives but also permits the use of presently available closing machinery without major modification.

The method of attaching the can end shown in FIGURE 6 is similar to that in FIGURE 5 except that the terminal edge portion of the can body is flanged prior to attachment of the lid and is mechanically interlocked with the can end during double seaming in the same manner as is commonly used on standard tin cans. Utilizing this method of attaching the can end, an adhesive need not be employed although it is preferable to do so or to employ a gasketing material similar to that employed in metal cans. It will be obviously that the bending of the edge of the can body through 180° at the very small radius involved places a severe strain on the cured resin-impregnated web stock employed in the can body. In fact, it is very interesting that, due to the high rigidity and limited deformability of the can body stock of this invention, such an interlocking arrangement can be made without ultimate failure of the can body along the bend. This is particularly true when it is considered that this bending involves compound curvature of the material. However, it has been found that some cured resin-impregnated paper webs will undergo such compound curvatures without detrimental results by properly controlling the manufacture of the cured resin-impregnated web stock. Of primary importance in accomplishing the flanging of the can body is the type of resin employed. For satisfactory flanging without cracking at the fold line, it is necessary to use either a highly plasticized resin or one having relatively high distortion characteristics at elevated temperatures above the temperature to be employed in thermal processing. In the latter case flanging is easily accomplished at an elevated temperature of about 300° to 350° F. The plasticizers used to develop the necessary bending characteristics may be either external, i.e., those which do not actually enter the resin reaction, or internal, i.e., those which are integrally reactive parts of the resin. Preferably internal plasticization should be employed due to the detrimental effects on strength and moisture resistance generally caused by the commonly employed external plasticizers.

A method of internal plasticization which has proved to be extremely effective with phenolic resins has been to utilize a phenol having an alkyl group attached in the manufacture of the phenolic resin. It is generally preferable not to employ such modified phenols as the sole source of phenolic materials due to the increase in cost without substantial improvement in plasticity after a level of 50% alkylated phenol has been reached. To achieve significant improvement in plasticity at least 10% of the phenolic material used in making the resin should be of the alkylated type. Suitable alkylated phenols are those which contain a side chain of from about 4 to 15 carbon atoms. Particularly suitable have been those having side chains in the middle of this range namely octyl or nonylphenol.

An additional factor which influences the ability of the can stock to withstand the deformation during interlocking with the can end is quantity of resin employed. Contrary to expectation, the greater the quantity of resin employed in the cured web stock, the easier it will be to form such an interlock. Consequently, it is preferred practice when employing the closure shown in FIGURE 6 that the resin loading be increased to a level between about 30 to 50%. Other well known methods of securing the can

end 25 to the body such as those in FIGURES 7 and 8 may be employed.

The following examples illustrate the methods of manufacturing cured resin-impregnated web stock and the conversion thereof into cans.

Example 1

A 195 lb./3000 sq. ft. paper web was impregnated with a resin varnish and dried to provide a ratio of 100:28:8 parts by weight of paper, phenolic resin, and volatiles, respectively. The phenolic resin was prepared from phenols, formaldehyde, and sodium hydroxide at a mole ratio of 1:1.845:0.04. In preparing this resin a kettle was charged with the following:

	Pounds
Nonyl phenol	17.25
Phenol, 92% U.S.P.	75.00
Flake paraformaldehyde, 91%	49.41
Water	14.25

This mixture was preheated to 160° at which time 2.60 lbs. of 50% sodium hydroxide was added in six equal portions at 5-minute intervals. After an additional 14 minutes of cooking, the kettle temperature was raised from 160° F. to 180° F. in 3 minutes and kept at 180° F. for 22 minutes. The kettle was then cooled to room temperature. The prepared resin contained 5.4% free formaldehyde and 63.4% solids.

The resin was then diluted to 47% solids with methanol, and the pH was adjusted to 8.3 with the use of concentrated HCl.

The paper web was passed through a trough containing the above resin varnish. A series of scraper bars and a set of squeeze rolls were used to provide uniformity of impregnation. The amount of resin pickup was controlled by adjusting the web speed and scraper bars. The impregnated web was dried to the desired volatile content with the use of two sequential drying cabinets, the temperature of which was controlled at 275° F.

The continuous dried resin-impregnated paper was cut into flat sheets. Two of these sheets faced on one side with a thin sheet of aluminum foil were pressed together to provide stock for the making of can bodies.

Pressing was accomplished at a temperature of 320° F. for 7.5 minutes employing a pressure of 1500 p.s.i.

This laminated web stock was used in the fabrication of cans in the following manner:

The laminated stock was cut into a rectangle of appropriate size for can body construction. The two opposite sides of the can body blank which form the side seam of the can were beveled with parallel slopes so that the width of the bevel was approximately 12 times the thickness of the laminate.

An adhesive, which was composed of a melamine formaldehyde resin dissolved in water, was applied to both of the beveled edges.

The can body was formed by curling the body blank into a cylinder with the aluminum foil surface on the inside and aligning the beveled edges so that when bonded the thickness of the side seam was essentially the same as that of the body material. The side seam was bonded by elevating the temperature to 320° F. while applying a pressure of 150 p.s.i. to the overlapping beveled area. This combination of heat and pressure effected cure of the adhesive, permanently bonding the side seam.

A double seamer was used to attached the metal ends to the unflanged cylinder by a false double seam. The same adhesive used for the side seam was used to bond the metal end to the can body. This adhesive was applied inside the lip of the can end in place of the conventionally used gasketing compound.

Size 303 x 406 cans fabricated in the above manner were pressure tested and easily withstood internal pressures up to 70 p.s.i.g. and external pressures up to 20 p.s.i.g. with no structural failure. Cans were also employed for the thermal processing of diced carrots and performed

satisfactorily with no failures occurring. The conditions employed in this thermal processing operation consisted of filling and sealing of the cans at 180° F. and steam retorting at 240° F. for 20 minutes.

Flexure test run in accordance to ASTM 790-61 on samples of web stock prepared in the above manner, and conditioned in a standard atmosphere, revealed an average modulus of elasticity of 1,960,000 p.s.i. After steam treatment, the average modulus of elasticity was found to be 1,340,000 p.s.i.

Example 2

A 195 lb./3000 sq. ft. paper web was impregnated with a resin varnish to provide a ratio of 100:28:8 parts paper, resin, and volatiles, respectively.

A phenolic resin was prepared which was prepared from phenol, formaldehyde and sodium hydroxide at a mole ratio of 1:1.845:0.04. In preparing this resin a kettle was charged with the following:

	Pounds
Phenol, 92% U.S.P. -----	89.7
Flake paraformaldehyde, 91% -----	53.4
Water -----	12.6

This mixture was preheated to 160° F. at which time 2.81 lbs. of 50% sodium hydroxide was added in six equal portions at 5 minute intervals. After an additional 14 minutes of cooking, the temperature of the kettle was raised to 180° F. in 2 minutes and kept at this temperature for 16 minutes. The kettle was then cooled to room temperature. The resulting resin varnish contained 6.7% free formaldehyde and 61.2% solids.

This resin was mixed at a solids weight ratio of 1:1 with a kraft pine lignin. This varnish was then diluted with methanol to a solids content of 50% and the pH adjusted to 6.0 with the use of concentrated HCl.

The same method as described in Example 1 was used to impregnate the paper web, press the laminate, and fabricate the can.

Flexure tests conducted on web stock prepared in the above manner revealed an average modulus of elasticity after standard conditioning of 1,700,000 p.s.i. and, after steam treatment, an average modulus of elasticity of 1,420,000 p.s.i.

Example 3

A 150 lb./3000 sq. ft. paper web was impregnated with a resin varnish to provide a ratio of 100:40:10 parts paper, epoxy resin, and volatiles, respectively. The epoxy resin varnish was prepared by combining 100 parts of a diglycidyl ether of bisphenol type epoxy resin prepared by reacting bisphenol and epichlorohydrin having an epoxide equivalent of 185-192, and 43 parts of a reactive polyamide resin. These components were diluted to 30% solids with methyl-ethyl ketone before treating.

Two sheets of the above impregnated paper web and a sheet of aluminum foil were pressed in the same manner as described in Example 1 with the exception that the press time was extended to 15 minutes instead of 7.5 minutes.

Cans were fabricated from this high pressure epoxy laminate in the same manner as described in Example 1.

Tests conducted on these cans revealed that internal and external pressures of 50 p.s.i.g. and 12 p.s.i.g., respectively, were withstood without failure. No difficulty was encountered in retorting diced carrots in these cans.

Flexure tests conducted on web stock prepared in the above manner revealed an average modulus of elasticity after standard conditioning of 1,340,000 p.s.i. and, after steam treatment, an average modulus of elasticity of 1,000,000 p.s.i.

We claim:

1. A can suitable for use in thermal processing of foods which comprises a pre-stressed thin-wall cylindrical

body member having a thickness equal to from 1/100 to 1/200 of the diameter of said can and an end closure hermetically sealed to one end of said body member, said body member being composed of a cylindrically formed single unitary web whose opposite edges are adhesively secured together at an axially oriented seam extending from one end of the body member to the opposite end, said web comprising a non-woven cellulose fiber sheet impregnated with from 15 to 60% by weight of a thermoset resin which has been cured under pressure in said sheet while said sheet is flat and being characterized by its ability to retain at least 65% of its modulus of elasticity in flexure following conditioning in saturated steam at 212° F. for 5 minutes and by having a residual modulus of elasticity in flexure after such conditioning of at least 500,000 p.s.i.

2. The can of claim 1 wherein said web retains at least 90% of its modulus of elasticity in flexure after said conditioning and the residual modulus of elasticity in flexure is at least 1,000,000 p.s.i.

3. The can of claim 1 wherein the interior surface of said body member is coated with a continuous water-impervious coating.

4. The can of claim 3 wherein the water-impervious coating is aluminum foil integrally laminated to the resin-impregnated web.

5. The can of claim 3 wherein the thickness of the can body at the seam formed by adhesively securing the opposite edges of the web together is substantially the same as the thickness of said web.

6. A can suitable for use in thermal processing of foods which comprises a pre-stressed thin-wall cylindrical body member and an end closure hermetically sealed to one end of said body member, said body member being composed of a cylindrically formed single unitary web whose opposite edges are adhesively secured together at an axially oriented seam extending from one end of the body member to the opposite end, said web comprising a non-woven cellulose fiber sheet impregnated with from 15 to 60% by weight of a phenolic resin in which from 10 to 50% of the phenolic component is an alkylated phenol the alkyl group of which contains from 4 to 15 carbon atoms, said resin having been cured under pressure in said sheet while said sheet is flat; said web being characterized by its ability to retain at least 65% of its modulus of elasticity in flexure following conditioning in saturated steam at 212° F. for 5 minutes and by having a residual modulus of elasticity in flexure after such conditioning of at least 500,000 p.s.i.

References Cited

UNITED STATES PATENTS

1,520,996	12/1924	Bastian.	
1,920,529	8/1933	Sidebotham.	
2,237,048	4/1941	Carter.	
2,285,220	6/1942	Morrell.	
2,319,267	5/1943	Sawyer.	
2,385,398	9/1945	Blum.	
2,633,095	3/1953	Magill et al.	
2,658,663	11/1953	Reese.	
2,722,311	11/1955	Morrison.	
2,775,384	12/1956	Bergstrom.	
2,988,528	6/1961	Tench et al	229-3.1
2,989,218	6/1961	Bergstrom.	
3,039,371	6/1962	Leibreich	93-55.1
3,093,287	6/1963	Stark.	
3,104,599	9/1963	Carpenter	93-55.1

JOSEPH R. LECLAIR, Primary Examiner.

FRANKLIN T. GARRETT, Examiner.

V. A. TOMPSON, R. PESHOCK, Assistant Examiners.