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(54) **RIGID PAPERBOARD CONTAINER AND METHOD AND APPARATUS FOR PRODUCING THE SAME.**

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(73) Proprietor: **JAMES RIVER-DIXIE/NORTHERN INC.**
**P.O. Box 2260
Greenwich Connecticut 06830 (US)**

(72) Inventor: **WNEK, Patrick H.**
**Route No. 1, Box 294F
Menasha, WI 54952 (US)**
Inventor: **PETIT, John L.**
**2100 South Telulah Avenue
Appleton, WI 54911 (US)**
Inventor: **VAN HANDEL, Gerald J.**
**762 West Cecil Street
Neenah, WI 54956 (US)**

(74) Representative: **Senior, Alan Murray et al**
**J.A. KEMP & CO 14 South Square Gray's Inn
London WC1R 5EU (GB)**

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Description

This invention pertains generally to the field of processes and apparatus for forming pressed paperboard products such as paper trays and plates and to the products formed by such processes.

Formed fiberboard containers, such as paper plates and trays, are commonly produced either by molding fibers from a pulp slurry into the desired form of the container or by pressing a paperboard blank between forming dies into the desired shape. The molded pulp articles, after drying, are fairly strong and rigid but generally have rough surface characteristics and are not usually coated so that they are susceptible to penetration by water, oil and other liquids. Pressed paperboard containers, on the other hand, can be decorated and coated with a liquid-proof coating before being stamped by the forming dies into the desired shape. Large numbers of paper plates and similar products are produced by each of these methods every year at relatively low unit cost. These products come in many different shapes, rectangular or polygonal as well as round, and in multicompartment configurations.

Pressed paperboard containers tend to have somewhat less strength and rigidity than do comparable containers made by the pulp molding processes. Much of the strength and resistance to bending of a plate-like container made by either process lies in the side wall and rim areas which surround the center or bottom portion of the container. In plate-like structures made by the pulp molding process, the side wall and overturned rim of the plate are unitary, cohesive structures which have good resistance to bending as long as they are not damaged or split. In contrast, when a container is made by pressing a paperboard blank, the flat blank must be distorted and changed in area in order to form the blank into the desired three dimensional shape. Score lines are sometimes placed around the periphery of blanks being formed into deep pressed products to allow the paperboard to fold or yield at the score lines to accommodate the reduction in area that takes place during pressing. However, the provision of score lines, flutes, or corrugations in the blank may result in a formed product with natural fault lines about which the product will bend more readily, under less force, than if the product were unflawed. Shallow containers, such as paper plates, may also be formed from paperboard blanks which are not scored or fluted, but the pressing operation will cause wrinkles or folds to form in the paperboard material at the rim and side walls of the container at more or less random positions; these folds, again, act as natural lines of weakness within the container about which bending can occur.

In the common process for pressing paperboard containers from flat blanks, a sheet or web of paperboard is cut to form the blank—a

circular shape for a plate—and the blank is then pressed firmly between upper and lower dies which have die surfaces conforming to the desired shape of the finished container. The paperboard web stock is usually coated with a liquid-proof material on one surface and may also have decorative designs printed under the coating. The surfaces of the upper and lower dies have typically been machined such that, when they begin to compress the shaped paperboard blank between them, the die surfaces will be generally spaced uniformly apart over the entire surface of the formed paperboard. The lower die is spring mounted to limit the maximum force applied to the paperboard between the dies; and this force is distributed over the entire area of the paperboard if the spacing between the dies is uniform. In practice, the machining of the dies is such that random high and low spots are commonly formed on the die surfaces, resulting in random, localized areas of the paperboard which are highly pressed while other areas are unpressed. The dies are also generally heated to aid in the forming and pressing operation. Paperboard plates produced in this manner have good decoration quality and liquid resistance because of the surface coating, and are suited to high production volume with resulting relatively low unit cost. However, as noted above, the plates suffer from a lower than desired level of rigidity and are subject to greater bending during normal household use than is perhaps most desirable.

While problems with the rigidity of pressed paperboard containers have long been known, there has heretofore been limited success in improving the rigidity qualities of these products in a commercially practical manner. One example of a process intended to increase the rigidity of pressed paper plates is shown in the patent to *Bernier, et al*, 3,305,434. A process is disclosed therein in which paperboard having very high moisture content, in the range of 15% to 35% by weight, is pressed between heated forming dies which are specially designed to allow escape of the water vapors driven off during the pressing operation. The paperboard blank stock is thus relatively soft and easily formed into shape. Distortion of the shape of the soft and flowable fiberboard is prevented by driving the forming dies to a stop at which the surfaces of the dies are uniformly spaced apart a distance approximately equal to or slightly less than the desired thickness of the formed container. The shaped fiberboard material dries under the heat and pressure applied by the dies and the fibers within the material build up internal bonds upon drying which help to maintain the strength and rigidity of the deformed portions of the paperboard material. The apparent limitations of such a process are the complex dies required to allow release of the water vapours from the pressed fibreboard, handling problems with high moisture fibreboard and slower production times required because of the

time necessary to allow removal of the water vapour from the paperboard during the pressing operation, thereby all contributing to increased production costs.

US—A—2 832 522 discloses a container in accordance with the prior art portion of claim 1.

The container of the present invention is characterised as specified in claim 1. Particular embodiments of the invention are indicated in dependant claims 2 to 5. With this construction an extremely rigid container is formed in that densified regions are provided in the rim in which three layers of paperboard have been reformed into an integrated fibrous structure. There is no suggestion of such compacted reformed layers in US—A—2 832 522. In GB—A—981 667 there is simply disclosed compression at the rim area and the provision of existing corrugations to assist deformation of the side wall area.

The paperboard container of the present invention is formed from fibrous substrate stock in such a way that the raised areas of the container are substantially free of the type of fault lines which are found in paperboard containers pressed in a conventional manner. The container has a bottom wall, an upturned side wall extending from the bottom wall, and a rim extending from the side wall. The bottom wall of the formed container is substantially equal in thickness and density to the blank, whereas the rim is preferably somewhat denser generally than the blank and is substantially denser in those areas where folds are formed in the rim during initial shaping. Those portions of the paperboard which are folded up during forming are substantially the same thickness as the rest of the container, although containing more fibrous material, and the entire surface of the rim area is essentially smooth. The upturned side wall, or a portion thereof, may also be densified, particularly in the areas of the folds formed therein. The container may be formed in the various geometric shapes used for pressed paperboard products. The rim preferably has a downturned edge portion, compressed and densified, which is found to particularly enhance the rigidity of the container structure. The paperboard stock may be coated in a conventional manner to provide decoration and liquid-proofing. Because of the lack of voids and other fault lines, the container of the invention will have a rigidity at least 40% and often 100% greater than conventional containers pressed from the same paperboard stock.

US—A—2 832 522 discloses a method in accordance with the prior art portion of claim 6. This prior method will not provide the improved rigidified construction of the present invention in that there is no reforming of the fibrous structure of the container and there is not obtained the reformed rigidified structure of the rim of the container as made by the method of the present invention as characterised in claim 6. Thus, the method of the present invention requires the reforming of the rim portion of the container using heat, pressure and a required moisture

content so as to provide radially extending areas of densified material. There is no suggestion or requirement for such radially extending reformed dense areas in US—A—2 832 522.

Particular embodiments of the invention are indicated in dependent claims 7 to 14.

In the preferred method of forming a paperboard blank into the container described above, the blank material is selected to have a moisture content before forming in the range of preferably 9.5% to 10.5% by weight. The blank is then pressed between a pair of mating dies having die surfaces generally conforming to the shape of the formed plate, but with the adjacent surfaces of the dies at the rim area being closer together than at the bottom wall area as the die surfaces approach. During the forming operation, the surfaces of the two dies engage the paperboard blank between them and distort the blank into the general shape of the formed product. However, as the die surfaces continue to approach, the more closely spaced die surfaces at the rim engage the paperboard in the area of the rim between them before the paperboard in the bottom wall portion of the blank is firmly engaged; as a result, extremely high compression forces are applied in the rim area and, in particular, at any downwardly extending portions of the rim. Compression force may also be applied to the upturned side wall to press out wrinkles and voids created therein during initial shaping of the container. The moisture in the paperboard helps to weaken the fibre bonds within the paperboard, thereby allowing the fibres to disengage from one another and flow under the intense compression force applied to the rim area, particularly at the folds. The flowing of the fibres within the fibreboard under pressure causes the wrinkles and other fault lines within the rim to be substantially eliminated so that, after the dies are removed from the paperboard and the bonds between fibres are reformed, the rim area of the formed container is a substantially integral structure.

Under preferred conditions, the dies are maintained at a temperature between 121°C and 160°C (250°F and 320°F). These temperatures are found to yield the best conditions of fibre flow and distortion under the intense pressures applied by the dies without overheating the blank and causing surface blisters or scorching of the paperboard. As moisture is driven out of the heated paperboard, bonds between fibres are reformed in their compressed positions. The dies are mounted in a conventional manner, such that the motion of the die surfaces toward one another is stopped only by the compression of the paperboard material between them. The force applied to the dies is limited by the spring mounting of the lower die, typically at a force of at least 26688N (6000 lbs) and preferably 35590 N (8000 lbs) or more for containers in the common 22.86 to 25.4 cm (9 to 10 inch) diameter range. Most of the force between the dies is applied to the rim area of the formed plate, yielding typically pressures in the rim area of at least 1379 Kpa (200

lbs per in²) and even greater localised pressures at the areas where the paperboard is initially folded.

A further aspect of the invention provides apparatus in the prior art portion of claim 14 disclosed by GB—A—981 667 characterised with the additional features as specified in claim 15 to provide the utility to make the container of claim 1.

In the drawings:

Figure 1 is a perspective view of a plate-like paperboard container in accordance with the invention.

Figure 2 is a cross-section of the container of Figure 1 taken generally along the lines 2—2 of Figure 1.

Figure 3 is a cross-section of the upper and lower dies used to press the container of Figure 1, showing a flat blank in position between the dies.

Figure 4 is a simplified schematic view illustrating the clearances between the upper and lower die surfaces of Figure 3 when they are adjacent and pressing the paperboard blank between them.

Figure 5 is a photomicrograph (140X) of a cross-section through the bottom wall portion of a prior commercially produced paperboard plate.

Fig. 6 is a photomicrograph (80X) of a cross-section through the center of the rim portion of a prior commercial paperboard plate.

Fig. 7 is a photomicrograph (80X) of a cross-section at a position adjacent the edge of the rim portion of a prior commercial paperboard plate.

Fig. 8 is a photomicrograph (140X) of a cross-section through the bottom wall portion of a paperboard plate formed in accordance with the invention.

Fig. 9 is a photomicrograph (140X) of a cross-section through the center of the rim portion of a paperboard plate formed in accordance with the invention.

Fig. 10 is a photomicrograph (110X) of a cross-section at a position adjacent the edge of the rim portion of a paperboard plate formed in accordance with the invention.

Best mode for carrying out the invention

With reference to the drawings, a paperboard container in the form of a plate is shown in perspective at 10 in Fig. 1. This container structure will be described to illustrate the invention, although it will be readily apparent that the invention can be incorporated in many other container geometries being in accordance with the claims. The form of the plate 10 is typical of commercially produced plates now distributed in the mass market: it has a substantially flat, circular bottom wall portion 11, an upturned side wall portion 12 which serves to contain food and particularly juices on the plate, and an overturned rim portion 13 extending from the side wall. The plate portions 11, 12, and 13 are formed integrally with one another. The distinctions between the portions may be best illustrated with respect to the cross-sectional view of Fig. 2. The flat bottom wall 11 of the plate extends to about the position in the plate denoted at 15, at which the side wall 12 begins rising upwardly; the upturned side wall 12

terminates at about the position marked 16 in Fig. 2, at which the paperboard begins to curve over and down about a smaller radius to form the overturned rim 13 which terminates at a peripheral rim edge 17.

The rim 13 serves a number of purposes in the paper plate product. It provides a more aesthetically pleasing appearance than would a plate which simply has an upturned side wall terminating in an edge, and it provides a generally lateral area which can be gripped by a user when carrying the plate. From the standpoint of the structural integrity of the plate, the most important function of the rim 13 is to make the plate rigid and resistant to bending when held by a user. As is apparent from an examination of the cross-sectional view of Fig. 2, the vaulted shape of the overturned rim 13 provides a structure which is naturally resistant to bending about any radial axis extending from the center of the plate. If the paperboard forming the rim portion 13 is unitary and cohesive, the plate will resist bending in the hand of a user until the plate is loaded so heavily that the paperboard in the rim 13 is under tensile stress sufficient to cause the paperboard to yield and buckle. The maximum tensile stress in the plate under normal loading will lie across a generally radial cross-section through the rim area.

While the theoretical maximum load carrying capabilities of a paper plate are related to the tensile strength of the paperboard of which the plate is made, plates made by the conventional blank pressing process are found to have much lower load carrying capabilities than might be expected, due to folds and wrinkles formed in the rim. These folds and wrinkles naturally occur in the incipient rim during forming to accommodate the decrease in area of the rim as it is being drawn radially inwardly during formation of the upwardly turned wall 12. The wrinkles or folds extend radially over the rim and usually extend through a portion of the upwardly turned side wall 12, which is also somewhat shrunk in surface area. The wrinkling or folding of the rim material produces a disruption of the fiberboard material at the fold, breaking many bonds between fibers, and results in a radial fault line in the rim—a natural hinge—which is much less resistant to stresses produced by loads on the plate than the original paperboard. Since such wrinkling is inevitable in normal pressing processes, it has heretofore not been considered feasible to significantly increase the rigidity of plates pressed from flat paperboard blanks. Paperboard blanks, especially those to be deep pressed, are commonly provided with a plurality of radial score lines to control the number and position of the wrinkles in the formed product, but such score lines do not increase the rigidity of the final product and, in fact, usually tend to decrease rigidity in shallow pressed products compared to containers which are not scored.

The paperboard plate 10 of the invention is also formed from a unitary flat blank of paperboard stock, either scored or unscored, and thus must also undergo folding in the side wall 12 and rim 13.

The resulting fold lines are shown for illustrative purposes at 20 in Fig. 1. However, the plate 10 is produced in such a way that the paperboard in the vicinity of the rim portions of the folds 20 is tightly compressed and essentially bonded together so that the folds 20 in the rim do not present natural hinge lines or lines of weakness and, in fact, have a tensile strength substantially similar to that of the integral paperboard. As described further below, the paperboard material in the rim 13 is densified at the folds, and any voids or disruptions formed in the rim areas of the folds 20 during the pressing operation are compressed out and new bonds are formed between the tightly compacted fibers in these areas. The entire rim is preferably densified and slightly reduced in thickness compared with the bottom of the plate. As shown in the cross-sectional view of Fig. 2, in which the dimensions are exaggerated for purposes of illustration, the thickness of the plate 10 at the flat bottom wall 11 and the upturned side wall 12 is essentially the same as that of the nominal thickness of the unpressed blank from which the plate is made. However, beginning at about the point denoted in 16—the intersection between the side wall portion 12 and the rim portion 13—the paperboard density increases and the thickness of the paperboard decreases out to the rim edge 17. In particular, the entire downwardly extending portion of the rim—the portion of the rim from the top 21 to the edge 17—is thus preferably compressed to a thickness somewhat less than the thickness of the bottom wall. The material of the rim is commensurately denser than the paperboard material in the remainder of the plate, and the areas of the folds 20 are substantially denser than the bottom wall. Generally, the paperboard of the blank preferably has a nominal caliper in the range of 0.025 to 0.1 cm (0.010 inch to 0.040 inch) with a basis weight in the range of approximately 0.163 to 0.65 Kg/m (100 pounds to 400 pounds per 3,000 square feet). The density of the paperboard in the bottom wall and side wall portions is preferably approximately 660 Kg/m³ (10.3 pounds per 0.001 inch caliper per ream (3,000 square feet)).

Containers formed in accordance with the invention have much greater rigidity than comparable containers formed of similar paperboard blank material in accordance with the prior art processes. To provide a comparison of the rigidity of various plates formed in the configuration of the plate 10, a test procedure has been used which measures the force that the plate exerts in resistance to a standard amount of deflection. The test fixture utilized, a Marks II Plate Rigidity Tester, has a wedge shaped support platform on which the plate rests. A pair of plate guide posts are mounted to the support platform at positions approximately equal to the radius of the plate from the apex of the wedge shaped platform. The paper plate is laid on the support platform with its edges abutting the two guide posts so that the platform extends out to the center of the plate. A straight leveling bar, mounted for up and down

movement parallel to the support platform, is then moved downwardly until it contacts the top of the rim on either side of the plate so that the plate is lightly held between the platform and the horizontal leveling bar. The probe of a movable force gauge, such as a Hunter Force Gauge, is then moved into position to just contact the top of the rim under the leveling bar at the unsupported side of the plate. The probe is lowered to deflect the rim downwardly one-half inch, and the force exerted by the deflected plate on the test probe is measured. For typical prior commercially produced 9 inch paper plates similar in shape to the plate 10, rigidity readings made as described above generally averaged about 60 grams or less (using the Hunter Force Gauge), whereas the plate 10 as shown in Figs. 1 and 2, and formed in the manner described below, can be produced with average rigidity readings of at least 90 grams and generally over 100 grams.

Fig. 3 shows a cross-section of the upper die 25 and lower die 26 which are utilized to press a flat, circular paperboard blank 27 into the shape of the plate 10. The construction of the dies 25 and 26, and the equipment on which they are mounted is substantially conventional; for example, as utilized on presses manufactured by the Peerless Manufacturing Company. To facilitate the holding and shaping of the blank 27, the dies are segmented in the manner shown. The lower die 26 has a circular base portion 29 and a central circular platform 30 which is mounted to be movable with respect to the base 29. The platform 30 is cam operated in a conventional manner and urged toward a normal position such that its flat top forming surface 31 is initially above the forming surfaces 32 of the base 29. The platform 30 is mounted for sliding movement to the base 29, with the entire base 29 itself being mounted in a conventional manner on springs (not shown). Because the blank is very tightly pressed at the peripheral rim area, moisture in the paperboard which is driven therefrom during pressing in the heated dies cannot readily escape. To allow the release of this moisture, at least one circular groove 33 is provided in the surface 32 of the base, which vents to the atmosphere through a passageway 34.

Similarly, the top die 25 is segmented into an outer ring portion 35, a base portion 36, and a central platform 37 having a flat forming surface 38. The base portion has curved, symmetrical forming surfaces 39 and the outer ring 35 has curved forming surfaces 40. The central platform 37 and the outer ring 35 are slidably mounted to the base 39 and biased by springs (not shown) to their normal position shown in Fig. 3 in a commercially conventional manner. The die 25 is mounted to reciprocate toward and away from the lower die 26. In the pressing operation, the blank 27 is first laid upon the flat forming surface 31, generally underlying the bottom wall portion 11 of the plate to be formed, and the forming surface 38 makes first contact with the top of the blank 27 to hold the blank in place as the forming

operation begins. Further downward movement of the die 25 brings the spring biased forming surfaces 40 of the outer ring 35 into contact with the edges of the blank 27 to begin to shape the edges of the blank over the underlying surfaces 32 in the areas which will define the overturned rim 13 of the finished plate. However, because the ring 40 is spring biased, the paperboard material in the rim area is not substantially compressed or distorted by the initial shaping since the force applied by the forming surfaces 40 is relatively light and limited to the spring force applied to the die segment 35. Eventually, the die 25 moves sufficiently far down so that the platform segments 30 and 37 and the ring segment 35 are fully compressed such that the adjacent portions of forming surfaces 38 and 39 are coplanar and the adjacent portions of surfaces 39 and 40 are coplanar, and similarly, that the forming surface 31 is coplanar with the adjacent portion of the forming surfaces 32. The upper die 25 continues to move downwardly and thus drives the entire lower die 26 downwardly against the force of the springs (not shown) which support the die 26. At the full extent of the downward stroke of the upper die 25, the dies exert a force on each other, through the formed blank 27 which separates them, which is equal to the force applied by the compressed springs supporting the die 26. Thus, the amount of force applied to the formed blank 27, and distributed over its area, can be adjusted by changing the length of the stroke of the upper die 25.

In a conventional manner, the dies 25 and 26 are heated with electrical resistance heaters (not shown), and the temperature of the dies is controlled to a selected level by monitoring the temperature of the dies with thermistors (not shown) mounted in the dies as close as possible to the forming surfaces.

In the standard prior paper plate pressing operations, the dies 25 and 26 were machined such that the forming surfaces 38, 39 and 40 of the die 25 were nominally substantially parallel to the forming surfaces 31 and 32 of the lower die 26 at a selected spacing approximately equal to the thickness of the blank being pressed. From a consideration of the geometry of the die surfaces, it can be seen that the upturned sidewall and any downturn on the rim would receive the greatest compressive forces initially if the selected spacing at which the die surfaces are parallel is less than the blank thickness; whereas the top of the rim and the bottom wall would receive substantially all the compressive force if the selected parallel spacing is greater than or equal to the blank thickness. In either case, the force between the dies will be distributed over the entire area of the paperboard between the dies, including the bottom wall which comprises more than half the area of the pressed plate, except where irregularities in the machining of the die surfaces cause high or low spots. As indicated above, plates pressed utilizing uniform die forming surface clearances had relatively low rigidity, primarily

due to the severe disruption of the fibers at the wrinkles in the rim of the plate.

The forming surfaces 38, 39 and 40 of the upper die 25 are not entirely parallel to the forming surfaces 31 and 32 of the lower die 26 at any spacing. The preferred spacing of the die surfaces is shown in the view of Fig. 4, which illustrates a cross-section of the two dies closely adjacent to one another—substantially in the position that they would be in with a paperboard blank between them during the pressing operation. Of course, the relative spacing between the die surfaces will depend upon the thickness of the paperboard blank being formed. However, the topography of the die surfaces can be specified, in general, by assuming that at the circumferential position 41 in the die surfaces at which the side wall of the plate ends and the rim begins, the die surfaces are spaced apart a thickness substantially equal to the nominal thickness of the paperboard blank. The die surfaces are preferably formed such that the spacing between the surfaces decreases gradually and continuously from such reference position toward the rim edge of the paperboard plate formed between the dies. The location in the die surfaces which corresponds to the rim edge is denoted at 42 in Fig. 4, and the location in the die surfaces corresponding to the top of the rim in the formed plate is denoted at 43 in Fig. 4. For paperboard plate stock of conventional thicknesses, i.e., in the range of 0.025 to 0.1 cms (0.010 to 0.040 inch), it is preferred that the spacing between the upper die surface and the lower die surface decline continuously from the nominal paperboard thickness at the location 41 to at least 0.0051 cms (0.002 inch) less than the nominal thickness at the location 43 and to at least 0.0076 cms (0.003 inch) less than the nominal thickness at the rim edge location 42. The spacings between the upper and lower dies at other points not on the rim, such as the mid-point 44 of the side wall area, at the middle 45 of the bend between the bottom wall and the side wall, at the beginning 46 of the side wall, and at the bottom wall 47, are preferably at least as great as the nominal thickness of the paperboard blank. In particular, the spacing between the die surfaces at the bottom wall is substantially greater than the thickness of the paperboard blank so that the bottom wall area receives little pressure. As an example, for a paperboard blank having a nominal thickness of 0.41 mm (0.016 inch), satisfactory die surface spacings are: position 42, 0.33 mm (0.013 inch); position 43, 0.36 mm (0.014 inch); position 41, 0.41 mm (0.016 inch); position 44, 0.48 mm (0.019 inch); and at positions 46, 47, and 48, at least 0.51 mm (0.02 inch). The actual die clearances can be measured by laying strips of solder radially across the surface of the bottom die, pressing the dies together, and measuring the height of the solder at various positions on the die surface after pressing.

It will be apparent from the consideration of the die clearances discussed above that, as the dies

25 and 26 engaged the paperboard blank between them, all or substantially all of the force between the two dies will be exerted on the rim area of the pressed blank, which lies generally between the positions labeled 41 and 42 in Fig. 4. The springs upon which the lower die 26 is mounted are typically constructed such that the full stroke of the upper die 25 results in a force applied between the dies of 26.690 to 35.590 N (6,000 to 8,000 pounds). For the common 22.9 cm (9 inch) diameter (after forming) paper plate, a force between the dies of, e.g., 31140 N (7,000 pounds), would, if uniformly distributed over the area of the plate, result in a pressure of about 758 KPa (110 pounds per square inch) over the entire plate area. However, the die shapes of the invention, as shown in Fig. 4, wherein the rim areas of the die surfaces are spaced more closely together, concentrate most of the force on the plate at the rim. A typical width for the rim—the distance between the lines 41 and 42—for a 22.9 cm (9 inch) plate would be approximately 1.27 cms (1/2 inch). As an example, if 31140 N (7,000 pounds) of force applied to the dies were concentrated in the rim area, the pressure applied to the paperboard in the rim would be approximately 3620 KPa (525 pounds per square inch). Because of the inevitable slight misalignments between the upper and lower dies, high and low spots in the dies, and variations in the paperboard thickness, the pressure applied to the paperboard at some points on the rim will be less than this maximum amount but almost certainly at least 1379 KPa (200 pounds per square inch), twice the pressure that would be placed upon the rim if the compressive force were distributed uniformly over the area of the pressed plate, as has nominally been the case in prior paperboard pressing operations.

The compressive forces should be even greater at the folds in the paperboard, since these areas are raised above the rest of the paperboard and contain more fibrous material. These folded areas will comprise a small percentage of the area of the rim, e.g., 4 to 5 percent, so that the compressive force concentrated in these areas may attain many millions of Pa (thousands of pounds per square inch). This tremendous pressure serves to greatly densify the fibrous material at the folds in the rim.

The ideal die surface configurations given above would preferably be maintained around the entire circumference of the dies, so that all the die surfaces were perfectly symmetrical. Of course, in the practical machining of the die surfaces, it will not be possible to maintain perfect symmetry nor will it be possible to achieve, at any radial cross-section through a practical die, the exact, preferred die surface spacings specified above. The most critical tolerances are those within the rim area from the position 41 to the position 42. It is highly preferred that the die clearances in the rim be uniform along any circumferential line around the rim so that all folded areas in the rim receive the intense compressive forces. A satisfactory radial gradient of

die surface spacing is for nominal paperboard thickness "N" at position 41, $N-0.05$ mm (0.002 inch) at position 43, and $N-0.076$ mm (0.003 inch) at position 42. Satisfactory results have been obtained with dies that have been measured to conform to this gradient within plus or minus 0.05 mm (0.002 inch), with best results obtained with dies maintained within 0.025 mm (0.001 inch), provided that the spacing between the dies at the positions 45—47 is at least as great as the nominal paperboard thickness N and preferably 0.075 to 0.203 mm (0.003 to 0.008 inch) greater than the nominal thickness N.

By utilizing the die surface configurations described above, it is possible to apply compressive forces to the rim at a magnitude capable of causing plastic deformation of the rim area of the plate when the other conditions of the process are satisfied, in particular, the moisture content of the blank being formed and the temperatures of the dies. Under the proper process conditions, the fibers in the rim area, particularly at the folds, apparently can break interfiber bonds, compress together under the very high applied stresses, and reform interfiber bonds. The use of these die spacings, with high die forces (e.g. 26690 to 35590 N (6,000 to 8,000 pounds)), results in compression of the rim area of 15% to 20% or more of the blank thickness, although the fibrous material will tend to spring back toward the unpressed thickness after the pressure is released. Although such high stresses might be expected to cause ripping or localized tearing of the paperboard in the rim area, such does not occur; rather, the plate stock under the rim behaves as if it were a ductile, compressible material. It is found that proper moisture levels within the paperboard are a condition for such ductility or plastic behavior within the paperboard. In addition, the dies are maintained at high, though not excessive temperatures to aid in the pressing process.

The paperboard which is formed into the blanks 27 is conventionally produced by a wet laid papermaking process and is typically available in the form of a continuous web on a roll. The paperboard stock is preferred to have a basis weight in the range of 0.163 to 0.65 Kg/m² (100 to 400 pounds per ream (3,000 square feet)) and a thickness or caliper in the range of about 0.25 to 1 cm (0.010 inch to 0.040 inch). Lower basis weight and caliper paperboard is preferred for ease of forming and economic reasons. Paperboard stock utilized for forming paper plates is typically formed from bleached pulp furnish, and is usually double clay coated on one side. Such paperboard stock commonly has a moisture (water) content varying from 4.0% to 8.0% by weight.

The effect of the compressive forces at the rim is greatest when proper moisture conditions are maintained within the paperboard: at least 8% and less than 12% water by weight, and preferably 9.5% to 10.5%. Paperboard in this range has sufficient moisture to deform under pressure, but not such excessive moisture that water vapor interferes with the forming operation or that the

paperboard is too weak to withstand the high compressive forces applied. To achieve the desired moisture levels within the paperboard stock as it comes off the roll, the paperboard is treated by spraying or rolling on a moistening solution, primarily water, although other components such as lubricants may be added. The moisture content may be monitored with a hand held capacitive-type moisture meter to verify that the desired moisture conditions are being maintained. It is preferred that the plate stock not be formed for at least 6 hours after the moistening operation to allow the moisture within the paperboard to reach equilibrium.

Because of the intended end use of paper plates, the paperboard stock is typically coated on one side with a liquid-proof layer or layers. In addition, for aesthetic purposes, the plate stock is often initially printed before being coated. As an example of a typical coating material, a first layer of polyvinyl acetate emulsion may be applied over the printed paperboard with a second layer of nitrocellulose lacquer applied over the first layer. The plate stock is moistened on the uncoated side after all of the printing and coating steps have been completed.

In the typical forming operation, the web of paperboard stock is fed continuously from a roll through a cutting die (not shown) to form the circular blanks 27, which are then fed into position between the upper and lower dies 25 and 26. The dies are heated, as described above, to aid in the forming process. It has been found that best results are obtained if the upper die 25 and lower die 26—particularly the surfaces thereof—are maintained at a temperature in the range of 121°C to 160°C (250°F. to 320°F.) and most preferably 149°C (300°F.) plus or minus 5.6°C (10°F). These die temperatures have been found to facilitate the plastic deformation of paperboard in the rim areas if the paperboard has the preferred moisture levels. At these preferred die temperatures, the amount of heat applied to the blank is apparently sufficient to liberate the moisture within the blank under the rim and thereby facilitate the deformation of the fibers without overheating the blank and causing blisters from liberation of steam or scorching the blank material. It is apparent that the amount of heat applied to the paperboard will vary with the amount of time that the dies dwell in a position pressing the paperboard together. The preferred die temperatures are based on the usual dwell times encountered for normal production speeds of 40 to 60 pressings a minute, and commensurately higher or lower temperatures in the dies would generally be required for higher or lower production speeds, respectively.

A paper container produced in accordance with the present invention may best be compared with prior paperboard containers formed of similar materials by examining the photomicrographs of Figs. 5—10. Figs. 5—7 show various cross-sections through a paperboard plate made in accordance with the prior commercial practice in which

the die surfaces are uniformly spaced; whereas Figs. 8—10 are cross-sections through a paper plate made in accordance with the present invention. Both paper plates were formed of 0.28 Kg/m² (170 pound per ream (3,000 square feet)), 0.41 mm (0.016 inch) caliper, low density bleached plate stock, clay coated on one side, printed on one surface with standard inks, coated with a first layer of polyvinyl acetate emulsion and overcoated with a nitrocellulose lacquer. The density of the paperboard stock averages about 660 Kg/m³ (about 10.3 pounds per 0.001 inch of thickness per ream), and the Taber Stiffness of the paperboard ranges, with the grain, from about 110 to 300, and across the grain, from about 55 to 165.

The view of Fig. 5 (140X) is through the center portion of the prior plate structure. It may be observed that there are numerous voids within the fiber structure, indicating that the board is not substantially compacted, although the fiber distribution is relatively uniform. The thickness of the cross-section is about 0.41 mm (0.016 inch). Fig. 6 (80X) is a cross-sectional view through the rim area of the prior plate, generally cut along a circumferential line at about the top of the rim. The particular view of Fig. 6 is through one of the areas in the rim which has a fold or wrinkle in it. As is graphically apparent from an examination of Fig. 6, the paperboard at the wrinkle has been badly disrupted, leaving large voids between the fibers, with adjacent fibers ripped apart, so that a fault line or very weak area exists within the paperboard at the fold. In addition, it is clear that the surface of the paperboard at the wrinkle is discontinuous, with a large gap existing between adjacent portions. The thickness of the cross-section at the fold is about 0.66 mm (0.026 inch) and is greater than the original thickness for some distance away from the fold. Fig. 7 (80X) is a cut through the rim, generally along a circumferential line at a position very close to the edge of the rim. This cut shows the termination of the one of the wrinkles running through the rim in the prior plate. Again, in the area of the wrinkle there are wide voids and a rough discontinuous surface structure. The thickness is about 0.51 mm (0.020 inch) maximum, at the fold.

The view of Fig. 8 (140X) is a cross-section through the approximate center of a plate made in accordance with the present invention. A comparison of Fig. 8 with Fig. 5 shows that the structure of the paperboard at the center of the pressed plates is substantially similar in both cases; both have relatively even surfaces and substantial voids distributed throughout the matrix of fibers within the board which is characteristic of the unpressed, low density paperboard stock material from which the pressed plates are made. The average thickness is about 0.41 mm (0.016 inch). Fig. 9 (140X) is a photomicrograph taken along a cut through the top of the rim portion of a plate made in accordance with the invention, with the cut lying along a circumferential line through one of the folded or wrinkled areas of the pressed plate. The contrast

between Fig. 9 and Fig. 6 is significant. The paperboard in the area through which the section of Fig. 9 was taken is highly compacted, leaving very little empty space between the fibers; the structure of this folded region is in marked contrast to the folded regions of Fig. 6 in which there are gapping voids between fiberboard which account for the badly weakened condition of the rim in this area. The paperboard in the rim shown in Fig. 9 has been compacted and its density increased so that the paperboard is clearly denser than at the center region shown in Fig. 8. The maximum thickness of this cross-section, occurring at the two folds shown, is about 0.43 mm (0.017 inch), substantially the same as the bottom wall. Away from the folded areas, the thickness of the rim is about the same as or somewhat thinner than the bottom wall. Since the folded-over areas contain substantially more solid fibrous material than the rest of the paperboard; perhaps 40 to 100% more, the density of the folded areas is substantially greater than the remainder of the paperboard.

The surfaces of the paperboard of Fig. 9 are essentially smooth and continuous, in contrast again to the discontinuity of surfaces shown in the view of Fig. 6, and the folds within the paperboard of Fig. 9 have been turned back upon themselves and the folded-over surfaces have been squeezed tightly together. The bottom surface, in particular, of the slice shown in Fig. 9 is smooth and continuous, rather than being disrupted at the wrinkle lines as shown in Fig. 6. The coating which covers the top surface of the plate is clearly visible in the view of Fig. 9, and this coating well illustrates where the folds began to occur in the rim of the plate as the plate was being formed. However, the extreme high pressure applied to the rim of the plate has caused virtually all traces of the fold to disappear at the bottom portion of the paperboard where the fibers of the paper have been essentially bonded together, leaving only the vestigial traces of the fold remaining in the top of the paperboard where the coating on the surface prevents the intermingling of fibers. The heat and pressure applied during the forming process may be sufficient to cause some melting and surface adhesion between the abutting coated surfaces which lie along the fold lines, although the nitrocellulose outer coating is resistant to heat and pressure.

A cross-section through a plate of the invention taken just inside of the rim edge is shown in Fig. 10 (110X). Here again, it is seen that the fibers within the plate are substantially compacted, and virtually all evidence of the folds that existed in the rim area during the forming operation had disappeared, except for small areas where the overcoated tops of the folded regions have been laid back upon themselves. The bottom of the paperboard surface is again smooth and unbroken, in sharp contrast to the section through the prior art plate shown in Fig. 7. As well illustrated in Fig. 10, the fibers are tightly and closely compressed together, leaving very few

voids or air spaces, and the overall structure is densified so that even though the rim of the plate becomes progressively thinner as the edge is approached, as illustrated in Fig. 2, the basis weight of the paperboard in this region is substantially uniform because of the compaction of the fibers. The thickness of the paperboard shown in Fig. 10 is about 0.389 mm (0.0153 inch), about 4 to 5% thinner than the bottom wall. The densification of the plate in the rim area and the laying back of the folded surface areas on themselves to reform the rim into a substantially integral structure results in the marked increases in plate rigidity that have been described above.

Of course, the successful manufacture of pressed containers in accordance with the present process requires attention to the details of the pressing processes in accordance with good manufacturing techniques. In particular, it is necessary to insure that the upper and lower dies 25 and 26 are properly aligned so that they engage the blank between them in the desired manner. Such alignment techniques are a normal part of press maintenance. Observations of plates pressed with the dies can be made to ensure that the dies are properly aligned, which is evidenced by a uniformity in the appearance of the down-turned edge at the rim of the plate.

Claims

1. A paperboard container (10) integrally press-formed from a paperboard blank (27) to include a bottom wall (11), an upturned sidewall (12) extending from the periphery (15) of the bottom wall (11), and a rim (13) extending from the periphery (16) of the sidewall (12), a series of radial folds having been provided in part of that portion of the container which is radially outwardly located with respect to the bottom wall, the folds having been formed into a plurality of circumferentially-spaced densified regions (20) extending through annular portions of the rim (13), said densified regions (20) including the fibres of at least three layers of paperboard, characterised in that the rim (13) has been compressed to a thickness less than that of the bottom wall, that said rim (13) and said densified regions extend radially, and in that said at least three layers of paperboard are reformed into substantially integrated fibrous structures having virtually no trace of the original constituent layers, the rim having a substantially smooth and continuous surface.

2. A paperboard container according to claim 1, characterised in that the densified regions have a thickness generally equal to circumferentially adjacent areas of the rim.

3. A paperboard container according to claim 1 or 2, characterised in that the thickness of the sidewall (12) and bottom wall (11) is generally equal to the nominal thickness of the blank (27).

4. A paperboard container according to claim 1, 2 or 3, characterised in that the densified regions (20) also radially extend through a part of the

sidewall (12), the sidewall portions of the densified regions having a thickness generally equal to the circumferentially adjacent areas of the sidewall.

5. A paperboard container according to claim 1, 2, 3 or 4, characterised in that the rim (13) is downwardly curved to a peripheral lip (17), the thickness of the rim (13) decreasing progressively from the periphery (16) of the sidewall (11) to the lip (17).

6. A method of forming a container from a flat blank (27) of fibrous material wherein the blank (27) is compressed, heated and shaped to form a container (10) having a bottom wall (11) and an upturned portion comprising a sidewall (12) and a rim (13) extending from the periphery (15) of the bottom wall (11), there being included in said portion (12 and 13) a plurality of axially-extending, circumferentially-spaced folds (20) each including at least three layers of the blank to accommodate the decrease in area of the rim during shaping of the container, characterised in that the container to be formed is in accordance with claim 1; in that before compression the blank (27) has a moisture content of between 8% and 12% by weight; and in that compression and heat are applied to the rim (13) to break the bonds of the fibre in the constituent layers of the folds (20) and to bond the fibres in the fold areas into substantially integrated fibrous structures having virtually no trace of the original constituent layers with the rim (13) and fold areas (20) being compressed and plastically deformed to a generally uniform thickness less than that of the blank (27).

7. A method according to claim 6, characterised in that the blank has a moisture content of between 9.5% and 10.5% by weight prior to compression.

8. A method according to claim 6 or 7, characterised in that the rim (13) is heated during compression by applying heated surfaces at a temperature between approximately 121°C and 160°C (250°F and 320°F) to the opposite surfaces of the rim.

9. A method according to claim 6, 7 or 8, characterised in that pressure is applied to the rim at a magnitude of at least 1379 KPa (200 psi).

10. A method according to claim 6, 7, 8 or 9, characterised in that the rim (13) is formed to have a downturned portion extending to a peripheral lip (17) and wherein the thickness of the rim (13) is formed to decrease progressively from the sidewall periphery (16) to the lip (17).

11. A method according to any one of claims 6 to 10, characterised in that the flat blank of fibrous material has a thickness of about 0.025 to 0.1 cms (0.010 to 0.040 inches) and a basis weight of about 0.163 to 0.65 Kg/m² (100 to about 400 lbs per 3000 ft²).

12. A method according to any one of claims 6 to 11, characterised in that the blank is shaped and formed between upper and lower dies (25, 26) having mating die surfaces (31, 32, 38, 39 and 40) to define the desired form of the finished container therebetween, such die surface for each

die including a bottom wall portion (31, 38), an upturned sidewall portion (32, 39) extending from the periphery of the bottom wall portion, and an overturned rim portion (32, 39, 40) extending from the periphery of the sidewall portion, the die surfaces being formed such that when the bottom wall portions (31, 38) of the die surfaces are spaced apart a distance (47) approximately equal to the thickness of the blank, the spacing (41, 42, 43) between the rim portions of the die surfaces are less than the thickness of the blank (27).

13. A method according to claim 12, characterised in that the rim portions (32, 39, 40) of the dies (25, 26) are curved and the surfaces of the upper and lower dies are formed such that when the die surfaces are so spaced that the points on the die surfaces corresponding to the intersection (41) of the rim portion and sidewall portion are separated a distance substantially equal to the unpressed thickness of the blank, the spacing between the upper and lower die surfaces at the top (43) of the rim portions is approximately 0.05 mm (0.002 inches) less than the thickness of the blank, and the spacing between the upper and lower die surfaces at the edge (42) of the rim is approximately 0.075 mm (0.003 inches) less than the thickness of the blank, and wherein the spacing between the upper and lower die surfaces at the bottom wall (46) and the sidewall (44) is equal to or greater than the thickness of the blank.

14. A method according to claim 12 or 13, characterised in that during the step of pressing the rim a force of at least 26688 N (6000 lbs) is applied between the upper and lower dies (25, 26).

15. Apparatus for forming a plate-like container in accordance with claim 1 from a paperboard blank having a selected thickness, the apparatus including upper and lower dies (25, 26) having mating die surfaces (31, 32, 38, 39, 40) generally shaped to the desired form of a finished container which has a substantially flat, bottom portion (11), an upturned sidewall portion (12) extending from the bottom wall portion and a curved, overturned rim portion (13) extending from and concentric with the sidewall portion, characterised in that the surfaces of the upper and lower dies (25, 26) are formed such that when such surfaces are spaced apart at the position of the intersection (16, 41) of the sidewall portion and rim portion a distance substantially equal to the selected thickness of the paperboard blank, the spacing between the upper and lower die surfaces decreases substantially continuously outwardly along the rim portion (13) at a rate such that the die surfaces are spaced approximately 0.05 mm (0.002 inches) closer together at the top (43) of the rim portion (13) and 0.075 mm (0.003 inches) closer together at the edge (42) of the rim portion (13) and wherein the spacing between the die surfaces at the sidewall and bottom wall portions (44, 46) is equal to or greater than the spacing between the die surfaces at the intersection (41) of the sidewall and rim portions.

16. Apparatus according to claim 15, charac-

terised in that the spacings (44, 46) between the die surfaces at the sidewall and bottom wall portion are at least 0.05 mm (0.002 inches) greater than the spacing (41) between the die surfaces at the intersection of the sidewall and rim portions.

17. Apparatus according to claim 15 or 16, characterised in that the upper die (25) is segmented and has an outer ring portion (35) which contacts the blank (27) first to roll over the rim edge of the blank and to hold the blank at the rim as the remainder of the upper die (25) descends into and presses the blank.

Patentansprüche

1. Papierkartonbehälter (10), der aus einem Papierkartonzuschnitt (27) derart vollständig formgepreßt ist, daß er einen Boden (11), eine sich von der Peripherie (15) des Bodens (11) aus nach oben erstreckende Seitenwand (12) und einen sich von der Peripherie (16) der Seitenwand (12) aus erstreckenden Rand (13) aufweist, wobei der sich vom Boden in radialer Richtung nach außen erstreckende Teil des Behälters teilweise mit radialen Falzen versehen ist und die Falze zu einer Anzahl von verdichteten, mit Abstand in Umfangsrichtung angeordneten, sich durch ringförmige Teile des Randes (13) erstreckenden und die Fasern von mindestens drei Lagen des Papierkartons enthaltenden Bereichen (20) ausgebildet sind, dadurch gekennzeichnet, daß der Rand (13) zu einer Dicke verdichtet ist, die geringer ist als die des Bodens, sich der Rand (13) und die genannten verdichteten Bereiche in radialer Richtung erstrecken und die genannten mindestens drei Lagen des Papierkartons zu im wesentlichen einheitlichen, praktisch keine Verformungsspur (trace) von den ursprünglichen Lagen aufweisenden Faserstrukturen umgeformt sind, wodurch der Rand eine im wesentlichen glatte und ununterbrochene Oberfläche aufweist.

2. Papierkartonbehälter nach Anspruch 1, dadurch gekennzeichnet, daß die verdichteten Bereiche im allgemeinen die gleiche Dicke aufweisen wie die in Umfangsrichtung angrenzenden Bereiche des Randes.

3. Papierkartonbehälter nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Dicke der Seitenwand (12) und des Bodens (11) im allgemeinen gleich der Nenndicke des Zuschnitts (27) ist.

4. Papierkartonbehälter nach den Ansprüchen 1, 2 oder 3, dadurch gekennzeichnet, daß die verdichteten Bereiche (20) sich auch durch einen Teil der Seitenwand (12) in radialer Richtung hindurch erstrecken, wobei die Seitenwandabschnitte der verdichteten Bereiche im allgemeinen die gleiche Dicke aufweisen wie die in Umfangsrichtung angrenzenden Bereiche der Seitenwand.

5. Papierkartonbehälter nach Anspruch 1, 2, 3 oder 4, dadurch gekennzeichnet, daß der Rand (13) zu einer peripheren Lippe (17) nach unten gebogen ist, wobei die Dicke des Randes (13) von der Peripherie (16) der Seitenwand (11) zur Lippe (17) hin allmählich abnimmt.

6. Verfahren zum Formen eines Behälters aus

einem flachen, aus Fasermaterial bestehenden Zuschnitt (27), wobei der Zuschnitt (27) derart zusammengepreßt, erhitzt und geformt wird, daß der gebildete Behälter (10) einen Boden (11) und einen nach oben gekehrten, aus einer Seitenwand (12) und einem Rand (13) bestehenden, sich von der Peripherie (15) des Bodens (11) aus erstreckenden Teil aufweist, und der genannte Teil (12, 13) eine Anzahl von sich in axialer Richtung erstreckenden, in Umfangsrichtung mit Abstand angeordneten Falzen (20) enthält, die mindestens drei Lagen des Zuschnitts enthalten, um die Abnahme der Fläche des Randes während der Formung des Behälters auszugleichen, dadurch gekennzeichnet, daß der zu formende Behälter mit Anspruch 1 übereinstimmt, der Zuschnitt (27) vor der Pressung einen Feuchtigkeitsgehalt zwischen 8 Gew.% und 12 Gew.% aufweist und Druck und Hitze auf den Rand (13) angewendet werden, um die Bindungen der Fasern in den die Falze (20) bildenden Lagen aufzusprengen und die Fasern in den Falzbereichen zu im wesentlichen einheitlichen, praktisch keine Verformungsspur (trace) der ursprünglichen Lagen aufweisenden Faserstrukturen zu verbinden, wobei der Rand (13) und die Falzbereiche (20) zu einer im allgemeinen gleichmäßigen und geringeren Dicke als die des Zuschnitts (27) zusammengepreßt und plastisch verformt werden.

7. Verfahren nach Anspruch 6, dadurch gekennzeichnet, daß der Zuschnitt vor dem Pressen einen Feuchtigkeitsgehalt zwischen 9,5 Gew.% und 10,5 Gew.% aufweist.

8. Verfahren nach Anspruch 6 oder 7, dadurch gekennzeichnet, daß der Rand (13) während des Pressens erhitzt wird, indem die gegenüberliegenden Oberflächen des Randes mit erhitzten Oberflächen mit einer Temperatur zwischen etwa 121°C und 160°C (250°F und 320°F) beaufschlagt werden.

9. Verfahren nach Anspruch 6, 7 oder 8, dadurch gekennzeichnet, daß der Rand mit einem Druck von mindestens 1379 KPa (200 psi) beaufschlagt wird.

10. Verfahren nach Anspruch 6, 7, 8 oder 9, dadurch gekennzeichnet, daß der Rand (13) derart geformt wird, daß er einen nach unten gekehrten, sich zu einer peripheren Lippe (17) hin erstreckenden Teil aufweist, wobei die Dicke des Randes von der Peripherie (16) der Seitenwand zur Lippe (17) hin fortschreitend abnimmt.

11. Verfahren nach einem der Ansprüche 6 bis 10, dadurch gekennzeichnet, daß der flache, aus Fasermaterial bestehende Zuschnitt eine Dicke von etwa 0,025 cm bis 0,1 cm (0,010 inch bis 0,040 inch) und ein Flächengewicht von ungefähr 0,163 Kg/m² bis 0,65 Kg/m² (100 lbs/3000 ft² bis etwa 400 lbs/3000 ft²) aufweist.

12. Verfahren nach einem der Ansprüche 6 bis 11, dadurch gekennzeichnet, daß der Zuschnitt zwischen unteren und oberen Gesenken (25, 26) geformt wird, die mit aufeinanderpassenden Gesenkoberflächen (31, 32, 38, 39 und 40) die gewünschte Form des fertigen Behälters umgrenzen, wobei die Gesenkoberfläche eines jeden Gesenks einen Bodenteil (31, 38), einen nach oben

gekehrten, sich von der Peripherie des Bodenteils aus erstreckenden Seitenwandteil (32, 39) und einen umgestülpten, sich von der Peripherie des Seitenwandteils aus erstreckenden Randteil (32, 39, 40) beinhaltet und die Gesenkoberflächen derart geformt sind, daß wenn sich die Bodenteile (31, 38) der Gesenkoberflächen in einem der Dicke des Zuschnitts ungefähr entsprechenden Abstand (47) voneinander befinden, der Abstand (41, 42, 43) zwischen den Randteilen der Gesenkoberflächen geringer ist als die Dicke des Zuschnitts (27).

13. Verfahren nach Anspruch 12, dadurch gekennzeichnet, daß die Randteile (32, 39, 40) der Gesenkoberflächen gekrümmt sind und die Oberflächen der oberen und unteren Gesenke so geformt sind, daß wenn sich die Gesenkoberflächen in einem Abstand voneinander befinden, bei dem die der Grenzlinie (41) zwischen Rand- und Seitenteil entsprechenden Punkte auf den Gesenkoberflächen eine der ungepreßten Dicke des Zuschnitts im wesentlichen entsprechende Distanz zueinander aufweisen, der Abstand (43) zwischen der oberen und unteren Gesenkoberfläche am höchsten Punkt des Randteiles etwa 0,05 mm (0,002 inch) geringer ist als die Dicke des Zuschnitts, der Abstand (42) zwischen der oberen und unteren Gesenkoberfläche an der Kante des Randes etwa 0,075 mm (0,003 inch) geringer ist als die Dicke des Zuschnitts und der Abstand (46) zwischen der oberen und unteren Gesenkoberfläche am Boden und an der Seitenwand gleich oder größer ist als die Dicke des Zuschnitts.

14. Verfahren nach Anspruch 12 oder 13, dadurch gekennzeichnet, daß während der Pressing des Randes eine Kraft von mindestens 26688 N (6000 lbs) zwischen den oberen und unteren Gesenken (25, 26) zur Anwendung kommt.

15. Apparat zum Formen eines tellerähnlichen, mit Anspruch 1 übereinstimmenden Behälters aus einem Zuschnitt ausgewählter Dicke, mit oberen und unteren Gesenken (25, 26), die aufeinanderpassende, der gewünschten Form des fertigen Behälters annähernd angepaßte Oberflächen (31, 32, 38, 39, 40) aufweisen, wobei der Behälter einen im wesentlichen flachen Bodenteil (11), einen nach oben gekehrten, sich vom Bodenteil aus erstreckenden Seitenwandteil (12) und einen gekrümmten, umgestülpten, sich konzentrisch vom Seitenwandteil aus erstreckenden Randteil (13) aufweist, dadurch gekennzeichnet, daß die Oberfläche der oberen und unteren Gesenke (25, 26) derart geformt sind, daß wenn diese Oberflächen an der Position der Grenzlinie (16, 41) zwischen Seitenwand- und Randteil in einem im wesentlichen der gewählten Dicke des Papierkartonzuschnitts entsprechenden Abstand zueinander stehen, der Abstand zwischen den oberen und unteren Gesenkoberflächen entlang dem Randteil (13) nach außen zu im wesentlichen kontinuierlich mit einer solchen Rate abnimmt, daß die Gesenkoberflächen am höchsten Punkt (43) des Randteiles (13) umgefähr 0,05 mm (0,002 inch) näher zusammenstehen und an der Kante (42) des Randteiles (13) 0,075 mm (0,003 inch) näher zusammenstehen und der Abstand zwischen den Gesenkoberflä-

chen an den Seitenwand- und Bodenteilen (44, 46) gleich oder größer ist als der Abstand zwischen den Gesenkoberflächen an der Grenzlinie (41) zwischen den Seitenwand- und Randteilen.

16. Apparat nach Anspruch 15, dadurch gekennzeichnet, daß die Abstände (44, 46) zwischen den Gesenkoberflächen am Seitenwand- und Bodenteil mindestens 0,05 mm (0,002 inch) größer sind als der Abstand (41) zwischen den Gesenkoberflächen an der Grenzlinie zwischen den Seitenwand- und Randteilen.

17. Apparat nach Anspruch 15 oder 16, dadurch gekennzeichnet, daß das obere Gesenk (25) in Segmente aufgeteilt ist und einen äußeren Ringteil (35) aufweist, der zuerst auf den Zuschnitt (27) aufsetzt, um die Randkante des Zuschnitts umzustülpen und den Zuschnitt am Rand festzuhalten, während der restliche ober Gesenk herunterfährt und den Zuschnitt preßt.

Revendications

1. Récipient en carton (10) formé d'une seule pièce, par emboutissage à partir d'un flan de carton (27) de manière à comprendre une paroi de fond (11), une paroi latérale redressée (12) qui part de la périphérie (15) de la paroi de fond (15) et un rebord (13) qui part de la périphérie (16) de la paroi latérale (12), une série de plis radiaux ayant été formés dans une partie de la portion du récipient qui est située radialement à l'extérieur par rapport à la paroi de fond, les plis ayant été transformés en une pluralité de régions densifiées (20) espacées circonférentiellement, qui s'étendent dans des portions annulaires du rebord (13), lesdites régions densifiées (20) comprenant les fibres d'au moins trois couches du carton, caractérisé en ce que le rebord (13) a été comprimé à une épaisseur inférieure à celle de la paroi de fond, en ce que ledit rebord (13) et lesdites régions densifiées s'étendent radialement, et en ce que lesdites au moins trois couches de carton sont reformées en structures fibreuses sensiblement monoblocs qui ne présentent pratiquement aucune trace des couches constitutives initiales, le rebord ayant une surface sensiblement lisse et continue.

2. Récipient en carton selon la revendication 1, caractérisé en ce que les régions densifiées ont une épaisseur généralement égale à celle des zones du rebord qui leur sont circonférentiellement adjacentes.

3. Récipient en carton selon la revendication 1 ou 2, caractérisé en ce que l'épaisseur de la paroi latérale (12) et de la paroi de fond (11) est généralement égale à l'épaisseur nominale du flan (27).

4. Récipient en carton selon la revendication 1, 2 ou 3, caractérisé en ce que les régions densifiées (20) s'étendent aussi radialement dans une partie de la paroi latérale (12), les portions des régions densifiées situées dans la paroi latérale ayant une épaisseur généralement égale à celle des zones de la paroi latérale qui leur sont circonférentiellement adjacentes.

5. Récipient en carton selon la revendication 1, 2,

3 ou 4, caractérisé en ce que le rebord (13) est incurvé vers le bas jusqu'à une lèvre circonferentielle (17), l'épaisseur du rebord (13) diminuant progressivement de la périphérie (16) de la paroi latérale (11) jusqu'à la lèvre (17).

6. Procédé de formage d'un récipient à partir d'un flan plat (27) de matière fibreuse, dans lequel le flan (27) est comprimé, chauffé et mis en forme pour former un récipient (10) possédant une paroi de fond (11) et une portion redressée comprenant une paroi latérale (12) et un rebord (13) qui part de la périphérie (15) de la paroi de fond (11), récipient dans lequel ladite portion (12 et 13) présente une pluralité de plis (20) s'étendant axialement, espacés circonferentiellement, dont chacun comprend au moins trois couches du flan pour absorber la diminution de surface du rebord qui se produit pendant la mise en forme du récipient, caractérisé en ce que le récipient à former est conforme à la revendication 1, en ce que, avant la compression, le flan (27) possède une teneur en humidité comprise entre 8% et 12% en poids et en ce qu'une compression et un apport de chaleur sont appliquées au rebord (13) pour briser les liaisons entre fibres dans les couches qui constituent les plis (20) et pour lier les fibres dans les régions des plis pour former des structures fibreuses sensiblement monoblocs qui ne présentent pratiquement aucune trace des couches constitutives initiales, le rebord (13) et les zones de plis (20) étant comprimés et déformés plastiquement pour prendre une épaisseur sensiblement uniforme inférieure à celle du flan (27).

7. Procédé selon la revendication 6, caractérisé en ce que le flan a une teneur en humidité d'entre 9,5% et 10,5% en poids avant la compression.

8. Procédé selon la revendication 6 ou 7, caractérisé en ce que le rebord (13) est chauffé pendant la compression par application de surfaces chauffées à une température entre environ 121°C et 160°C 250°F et 320°F sur les surfaces opposées du rebord.

9. Procédé selon la revendication 6, 7 ou 8, caractérisé en ce que la pression est appliquée au rebord à une valeur d'au moins 1 379 kPa (200 psi).

10. Procédé selon la revendication 6, 7, 8 ou 9, caractérisé en ce que le rebord (13) est formé de manière à posséder une portion retournée vers le bas, qui s'étend jusqu'à une lèvre périphérique (17) et dans lequel l'épaisseur du rebord (13) est formée de manière à diminuer progressivement à partir de la périphérie (16) de la paroi latérale jusqu'à la lèvre (17).

11. Procédé selon l'une quelconque des revendications 6 à 10, caractérisé en ce que le flan plat de matière fibreuse possède une épaisseur d'environ 0,025 à 0,1 cm (0,010 à 0,040 pouce) et un poids de base d'environ 0,163 à 0,65 kg/m² (100 à environ 400 livres par 3 000 pieds carrés).

12. Procédé selon l'une quelconque des revendications 6 à 11, caractérisé en ce que le flan est façonné et formé entre des outils supérieur et inférieur (25, 26) qui possèdent des surfaces travaillantes complémentaires (31, 32, 38, 39 et

40) pour définir entre elles la forme désirée du récipient fini, la surface travaillante de chaque outil comprenant une portion paroi de fond (31, 38), une portion paroi latérale redressée (32, 39) qui part de la périphérie de la paroi de fond, et une portion rebord retournée vers le bas (32, 39, 40) qui s'étend à partir de la périphérie de la portion paroi latérale, les surfaces travaillantes des outils étant formées de telle manière que, lorsque les portions paroi de fond (31, 38) des surfaces travaillantes des outils sont espacées d'une distance (47) approximativement égale à l'épaisseur du flan, l'espacement (41, 42, 43) entre les portions rebord des surfaces travaillantes des outils soit inférieur à l'épaisseur du flan (27).

13. Procédé selon la revendication 12, caractérisé en ce que les portions rebord (32, 39, 40) des outils (25, 26) sont incurvées et les surfaces travaillantes des outils supérieur et inférieur sont conformées de telle manière que, lorsque les surfaces travaillantes des outils sont espacées de telle manière les points des surfaces travaillantes des outils qui correspondent à l'intersection (41) de la portion rebord et de la portion paroi latérale sont séparés d'une distance sensiblement égale à l'épaisseur non emboutie du flan, l'espacement entre les surfaces de l'outil supérieur et de l'outil inférieur au sommet (43) des portions rebord soit inférieur d'environ 0,05 mm (0,002 pouce) à l'épaisseur du flan, et l'espacement entre les surfaces travaillantes des outils supérieur et inférieur au niveau du bord (42) du rebord est inférieur d'environ 0,075 mm (0,03 pouce) à l'épaisseur du flan, et dans lequel l'espacement entre les surfaces travaillantes des outils supérieur et inférieur à l'endroit de la paroi de fond (46) et de la paroi latérale (44) est égale ou supérieure à l'épaisseur du flan.

14. Procédé selon la revendication 12 ou 13, caractérisé en ce que, pendant la phase d'emboutissage du rebord, une force d'au moins 26 688 N (6 000 livres) est appliquée entre l'outil supérieur et l'outil inférieur (25, 26).

15. Appareil pour former un récipient en forme d'assiette selon la revendication 1 à partir d'un flan de carton ayant une épaisseur choisie, l'appareil comprenant des outils supérieur et inférieur (25, 26) qui présentent des surfaces travaillantes complémentaires (31, 32, 38, 39, 40) de configuration générale conforme à la forme désirée d'un récipient fini qui possède une portion paroi de fond (11) sensiblement plate, une portion paroi latérale redressée (12) qui part de la portion paroi de fond, et une portion rebord incurvée, retournée vers le bas (13) qui part de la portion paroi latérale et est concentrique à cette paroi, caractérisé en ce que les surfaces travaillantes des outils supérieur et inférieur (25, 26) sont formées de telle manière que, lorsque ces surfaces sont espacées, à la position de l'intersection (16, 41) de la portion paroi latérale et de la portion rebord, d'une distance sensiblement égale à l'épaisseur choisie du flan de carton, l'espacement entre les surfaces travaillantes des outils supérieur et inférieur décroisse de façon sensiblement continue

vers l'extérieur, le long de la portion rebord (13), à un taux tel que les surfaces des outils soient plus rapprochées d'environ 0,05 mm (0,002 pouce) au sommet (43) de la portion rebord (13) et de 0,075 mm (0,003 pouce) au bord (42) de la portion rebord (13), et dans lequel l'espacement entre les surfaces travaillantes des outils dans les portions paroi latérale et paroi de fond (44, 46) est égal ou supérieur à l'espacement entre les surfaces travaillantes des outils qui existe à l'intersection (41) des portions parois latérales et rebord.

16. Appareil selon la revendication 15, caractérisé en ce que les espacements (44, 46) entre les

surfaces travaillantes des outils dans les portions paroi latérale et paroi de fond sont supérieurs d'au moins 0.05 mm (0,002 pouce) à l'espacement (41) entre les surfaces des outils à l'intersection entre les portions paroi latérale et rebord.

17. Appareil selon la revendication 15 ou 16, caractérisé en ce que l'outil supérieur (25) est segmenté et possède une portion annulaire extérieure (35) qui entre en contact avec le flan (27), tout d'abord pour rouler le bord du rebord du flan et maintenir le flan au niveau du rebord pendant que le reste de l'outil supérieur (25) descend dans le flan et emboutit le flan.

15

20

25

30

35

40

45

50

55

60

65

14

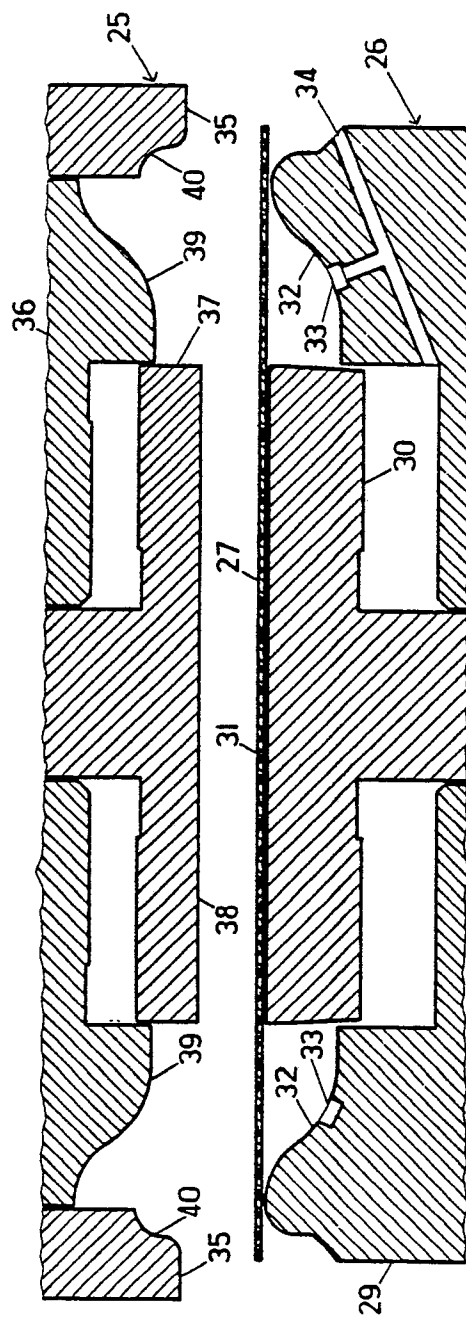


FIG. 3

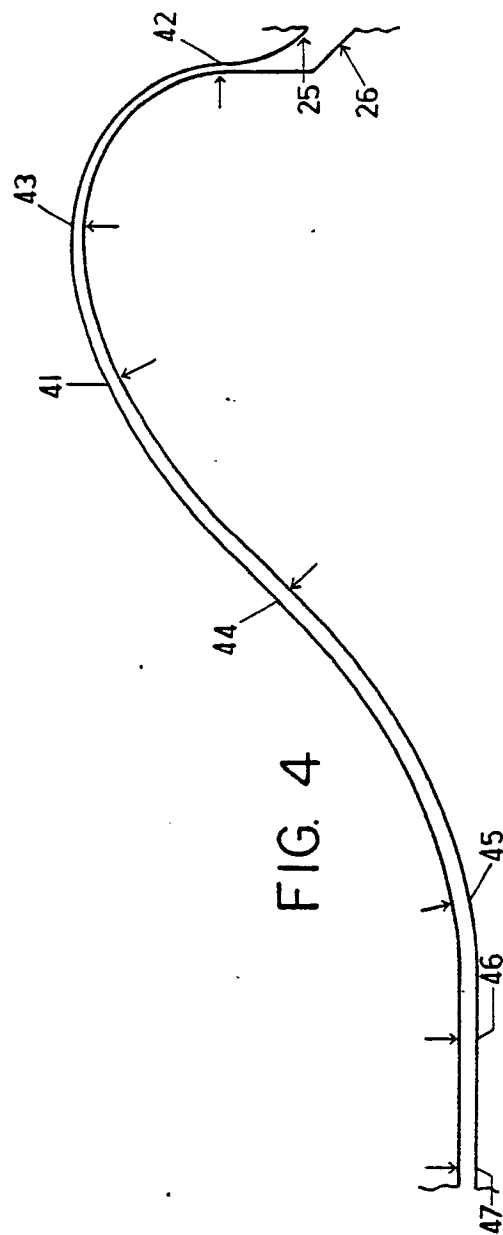


FIG. 4

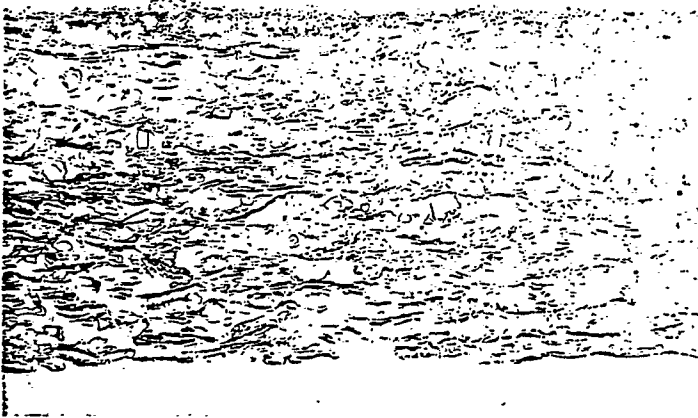


FIG. 5
(Prior Art)



FIG. 6
(Prior Art)



FIG. 7
(Prior Art)



FIG. 8



FIG. 10

FIG. 9

