Sept. 11, 1962 H. W. WILSON ETAL 3,053,309

CORRUGATING FLUTE CONTOUR

Filed July 21, 1958 2 Sheets-Sheet 1

FIG. 1

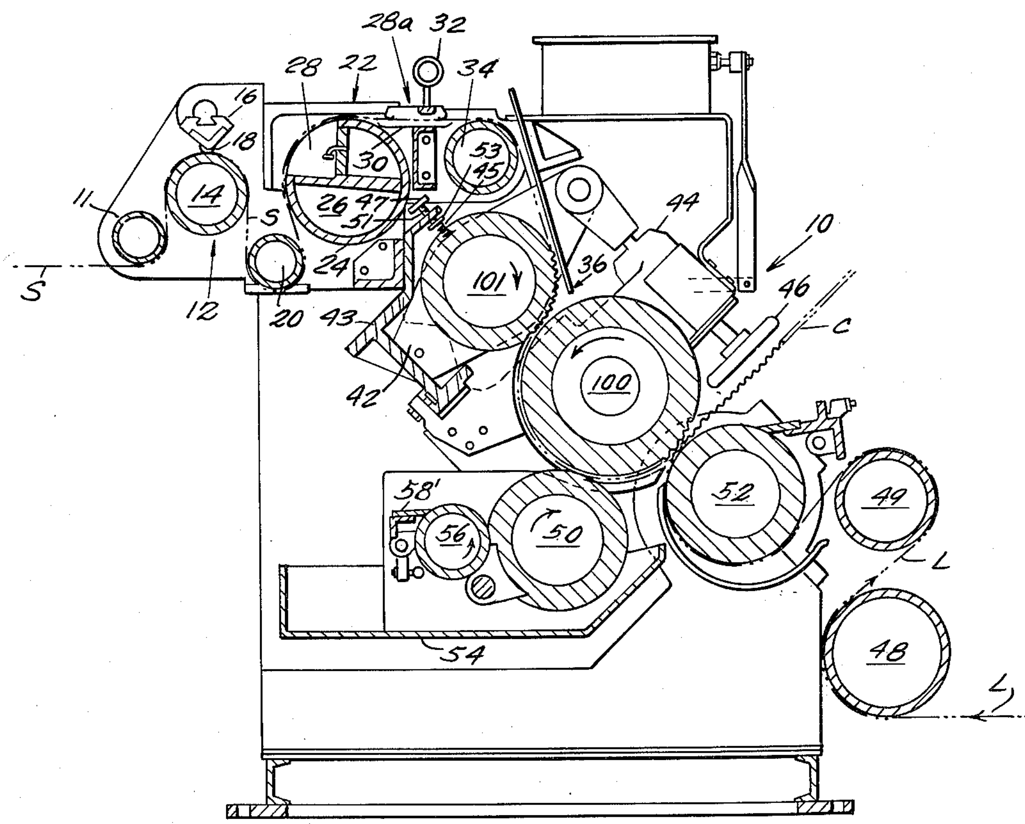
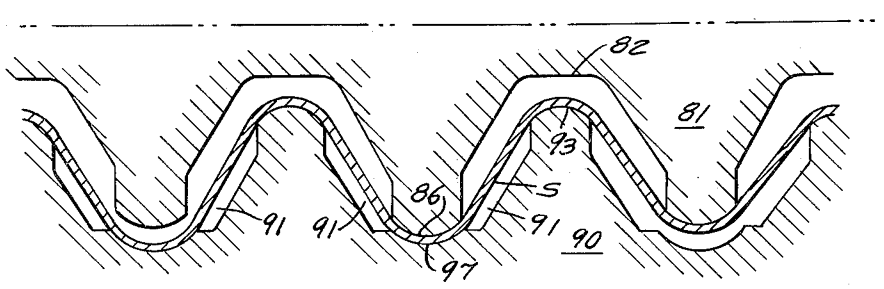


FIG. 5



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Filed July 21, 1958 2 Sheets-Sheet 2

FIG. 2

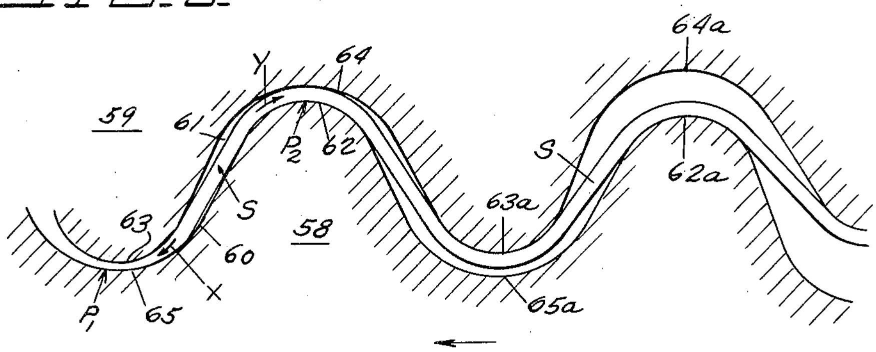


FIG. 3

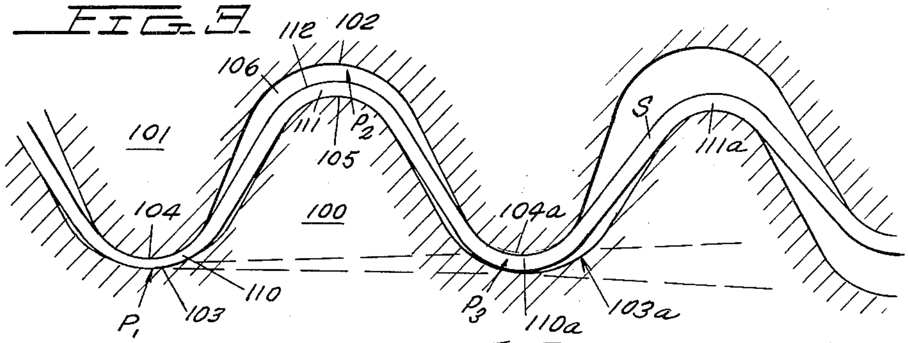
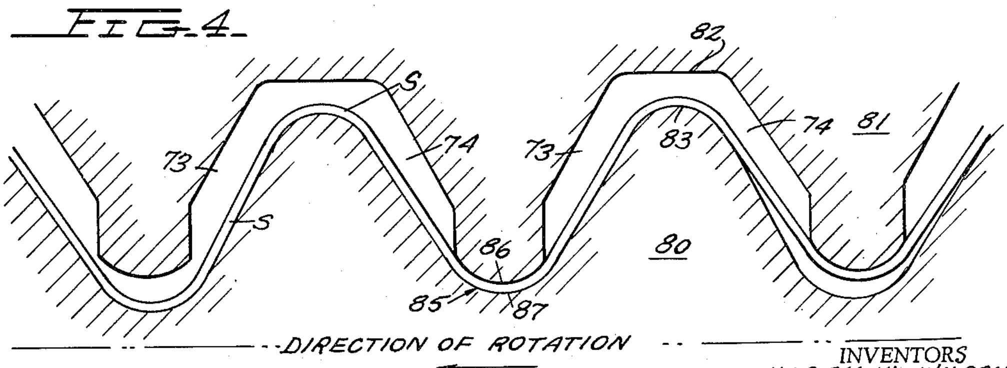


FIG. 4



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1

3,053,309
CORRUGATING FLUTE CONTOUR

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6 Claims. (Cl. 156—471)

This application is a continuation-in-part of our co-pending application Serial No. 666,863, filed June 20, 1957, and assigned to the assignee of the instant invention, now abandoned.

The instant invention relates to high speed corrugating rollers for corrugating cardboard and more particularly to the flute contours of said rollers whereby a corrugated medium is produced and which is free of fractures as well as free of low and leaning flutes.

In a corrugating single facer the corrugating medium, usually flat paper, passes between two toothed rolls and is then glued to one side of a flat sheet of paper, known as the liner. The resultant product at this stage is known as single face board. One roll, which we shall designate the "contour roll," is always driven, while the other roll, which we shall designate the "forming roll," is loaded by spring, pneumatic, or hydraulic pressure, toward the contour roll and is often not driven separately but only through the paper by the matrix roll by engagement of the very tips and valleys of both rolls.

Corrugating rolls thus do not act like embossers, in which both members are driven or are always connected together by gears, or like gears, in which the gear teeth maintain contact with each other at all times along their side walls in between their points of full mesh. In fact, in a corrugating single facer side wall contact results in placing stresses on the paper that could fracture it so it is important that there not be any contact along the side walls, but only at the point of full mesh where the tip of a tooth in the forming roll rests in a valley of the contour roll, when that tooth is in the diametric center line and, in the prior art, alternately, when the tip of a tooth of the contour roll engaged a valley of the forming roll.

In this invention the contour roll is driven, while the forming roll, although forced toward the matrix roll with a pressure normally between 75 and 150 pounds per line inch, or between 2500 and 5000 p.s.i. of contact, is driven only through the paper by the contour roll and is driven only at the point of engagement of one of its teeth in a valley of the contour roll.

Very severe problems in corrugating single facers have arisen in recent years when the roll size was increased in order to increase production speed, for this has led to impairment of paper flow and compression of the paper at a second position. To explain what this means and why it is bad, definitions are required. In corrugating single facers the position where a tooth of the forming roll fully engages into the valley of the contour roll along the diametric centerline shall be designated as the "first position." The next prior position where the paper touches the forming roll shall be designated as the "second position." In typical prior art machines the teeth and valleys of the forming and contour rolls have been cut identically, and at the second position the tooth tip on the contour roll engages a valley in the forming roll at a point not on the diametric center line. At this point there has been "impairment," which means that the paper has actually been gripped and even squeezed between the two rolls at the second position before the first position has completed drawing all the paper it needs.

One bad effect of impairment at the prior art second

2

position is to stretch the paper by simultaneously gripping it at two places and pulling it in opposite directions, a fact which will be illustrated later in discussing one of the drawings herein showing the prior art. This stretching has a tendency to weaken the paper and even to fracture it, and, therefore, is a very serious matter. The present invention solves that problem by eliminating impairment prior to the first position, so that, in preferred forms of the invention, the paper is never gripped prior to its compression at the full mesh position.

Another, possibly even more important injurious effect of compressing of the paper at the prior art second position is its effect on the glue bond, for the corrugated medium is immediately glued to one side of the liner. This gluing operation is done as soon as possible after corrugation, while the corrugations are maintained by the matrix roll, and, as a result, very little time elapses between application of the glue to the corrugated tips and their engagement with the flat facing sheet and the subsequent compression of the two together. Hence, there is very little time for glue to penetrate the paper fibers of the corrugated medium and secure a good bond there. Penetration is necessary for a good bond, and penetration is greatly lessened by the compression of the paper fibers that result when the forming roll is driven by the contour roll at a second position so that the paper is indented and its fibers compacted. It is much more difficult for glue to penetrate compacted fibers than to penetrate uncompacted fibers.

It may be pointed out that the indentation which is still functionally necessary at the first position, the point of full mesh, is a different matter, because those indented tips are glued to the second face liner, if glued at all, and second face gluing is done while the corrugated medium is carried for a substantial distance along a flat path with presses holding it to the second face liner for sufficient time for the glue to penetrate even highly compacted fibers, whereas only a short time interval is permitted for such penetration in the single facing operation, where the liner is applied to the corrugating medium within a fraction of a second.

Another very serious problem attendant with the use of prior art single facers was wearing of the tips with resultant reduction in flute height, so that the corrugated board they produced became weaker as time went on. It should first be recalled that the teeth and valleys of the forming roll and the teeth and valleys of the contour roll were shaped identically in the prior art. Since the tips lie at a greater radius from their roll's axis than the valleys, the speed at the tips is necessarily greater than the speed at the valleys. Since the forming roll was being driven alternately by one of its tips engaging a contour roll valley and then one of its valleys being engaged by a contour roll tip, this meant that there was engagement of each tip with each valley and also that the tip had to slide in the valley in order to compensate for the difference between tip velocity and valley velocity. This sliding, of course, took place, through the paper and tended to fracture it. But, more important, the sliding of the tip meant that the tip wear was considerably greater than the wear of the valley, especially since the small surface of the tip was sliding across a large surface of the valley.

As the tip wore, its height was necessarily reduced, and since the tip height controlled the flute height in prior art machines, the flute height became lower as the machine got older. A reduction in flute height greatly reduces the strength of the finished corrugated box formed of either single face or double face board, because the corrugating medium acts like a column and the strength of a column is proportional to the cube of its width.

Thus, small reductions in flute height reduce the strength in order of the cube of the height reduction. Hence, the board produced by such single facers became weaker the older the machine got.

This last recited problem is not encountered by the device of the instant invention since the forming roller is driven only through the engagement of its teeth tips with the valleys of the contour roll. There is no driving obtained by an engagement between the tips and valleys of the contour and forming rolls, respectively, since no engagement of this type ever exists. Thus, the rolling diameter is essentially at the tips of the forming roll and the valleys of the contour roll where the linear speeds are maintained equal to each other thereby preventing excessive rubbing and subsequent wear.

In prior art devices the diameter of the corrugating rolls was limited since with a larger diameter roll impairment at the second position is more severe than with a smaller diameter roll. In the device of the instant invention there is no impairment at the second position, hence the diameter of the rolls may be increased so that for a given speed of rotation the output of the machine may be increased.

Accordingly, a primary object of the present invention is to provide novel corrugating rollers for paper to provide increased production for a combiner than heretofore possible and still produce corrugated material free of low or leaning flutes as well as being free of fractures.

Another object of the present invention is to provide corrugating rolls that will not compact the fibers at crowns of the corrugating medium to which the first facing is to be applied.

Still another object is to provide corrugating rolls that will stretch the fibers at the crowns of the corrugating medium to which the first facing is to be applied thereby conditioning these crowns for the ready absorption of glue.

A further object of the present invention is to provide corrugating rolls which will not impair the corrugating medium at the second position.

A still further object of this invention is to provide corrugating roll construction in which wear is minimized.

Yet another object is to provide a pair of meshing corrugating rollers in which meshing clearance is furnished by providing clearance notches in the flute sidewalls of one or both of the rollers.

These and other objects of this invention will become more apparent after reading the following description of the drawings in which:

FIGURE 1 is a side elevation of a single face corrugator wherein our novel corrugating rollers are incorporated.

FIGURE 2 is an enlarged fragmentary view at the point of mesh between corrugating rollers of the prior art.

FIGURE 3 is an enlarged fragmentary view at the point of mesh between corrugating rollers of a first embodiment of this invention.

FIGURE 4 is an enlarged fragmentary view at the point of mesh between corrugating rollers of a second embodiment of this invention.

FIGURE 5 is an enlarged fragmentary view at the point of mesh between corrugating rollers of a third embodiment of this invention.

Referring to the figures, there is illustrated a machine **10** for the manufacture of single faced corrugated paper board C which may be the final product or may be delivered to a further machine for applying a second face. The sheet S to be corrugated is passed over a tensioning roller **11** and into a straw or sheet trimming assembly **12** including a trimmer roll **14** and a trimming head **16** having a cutting roller **18**. Thereupon the sheet S is passed over an idler roller **20** to a sheet moistener assembly **22**. The sheet moistener assembly embodies a steaming roll **24** including a steam chest **26** having a segmental cutout

28 over which the sheet S passes. The steam chest **26** is supplied with steam at a proper temperature whereby as the sheet S passes over the steam roll **24** it is preheated and prepared for the corrugating operation. After passing over the steam roll **24**, the sheet S is fed through a guideway **28*a*** including a plate **30** and a shield **32** whereupon the sheet is passed over a suitable feed roller **34** positioned above the corrugating unit generally designated by numeral **36**.

The corrugating unit **36** includes a pair of intermeshing corrugating rollers **100**, **101** each of which has its external peripheral surface provided with flutes which, when in engagement along a line of intermeshing, impart corrugations to the sheet S passing therethrough. The corrugating roller **101** is mounted on suitable bearings and is preferably supported for adjustment toward and away from the corrugating roller **100**, for example by means of a pivoted supporting bracket **42** and an adjusting coupling **44** operated from a hand wheel **46** accessible exteriorly of the machine.

Compression spring **45**, arranged between member **53** and supporting bracket **42**, acts on a line through the centers of corrugating roller **100** and **101** to bias roller **101** toward roller **100** for a purpose to be hereinafter explained. The force exerted by spring **45** is adjustable by means of handwheel **47** secured to threaded shaft **51** which passes through a threaded opening in the frame **43** to abut member **53**. Suitable provision may likewise be made for adjusting the corrugating rollers **100**, **101** axially relative to each other. In many applications the axial adjustment of the rollers may be essential to assure that the corrugating rollers have their respective axes in perfect parallelism and with the teeth in exact intermesh to thereby avoid cutting or crushing of the sheet S during high speed operation.

The facing sheet or liner L is fed toward the corrugating roller **100** for assembly with the corrugated sheet S by suitable pre-heat rollers **48**, **49** arranged one above the other. The liner L passes over these rollers prior to being extending about the liner applying or pressure roller **52** arranged in cooperating relation with the corrugating roller **100** along a line of tangency substantially coplanar with the line of intermesh and the respective axes of the rollers **100**, **101**, **52**.

Below the corrugating roller **100** and along the feed path prior to the liner applying roller **52** is a silicate or adhesive transfer roller **50** fed with adhesive from a suitable pan **54**, provision being made for application of a uniform coating of the adhesive or silicate by means of a doctoring roller **56** and a scraper assembly **58'**. The silicate or transfer roller **50** applies the adhesive to the crowns of the corrugated sheet as it passes from the line of intermesh between the corrugated rollers **100**, **101** and the line of tangency of the corrugating roller **100** and the liner applying roller **52**.

As is apparent to those skilled in the art, the described arrangement is capable of corrugating the sheet S and adhesively securing to one face of the corrugated sheet a liner L, the resultant product being accessible beyond the corrugating rollers **100** and the liner applying roller **52** for further processing as and, for example, by providing a liner on the corrugated face opposite the liner L, or for cutting into appropriate lengths.

Referring more particularly to FIGURE 2, in corrugating machines of the prior art both corrugating rollers **58**, **59** were usually driven and the flutes of both rollers **58**, **59** were of essentially the same contour. In order to prevent tooth interference when rollers **58**, **59** run into mesh, clearance is designed into the flute contour. Side clearances **60**, **61** are formed by relying on the difference in radii between the tips **62**, **63** and their cooperating valleys **64**, **65**, respectively, together with the offsetting of their respective centers. This method of forming side clearances **60**, **61** does not allow the sheet S to be completely supported by either roller **58**, **59** at any time.

The lack of complete support even in the region, generally designated as P_1, where the rolls **58, 59** are fully meshed, results in corrugated sheet having leaning and short flutes. Further, the corrugating medium S is simultaneously being compressed at a first and a second position P_1, P_2.

In the typical prior art design shown in FIGURE 2, the indentation of the sheet S at the point P_1 of full mesh runs in the neighborhood of .0045″ and the rollers **58, 59** are probably actually closer together than this. This design is for paper of a caliper of approximately .009″. However, when plotting out a typical curve, it is normally found that there is also impairment of this paper at the second position P_2, where the distance between the tip of the tooth **62** and the valley **64** is no more than .0085″ and is probably less, for this distance assumes that the clearance at the first position P_1 between members **63** and **65** is .0045″, and it is probably somewhat smaller. The same thing holds true when a valley **65*a*** and tip **63*a*** engage after moving a circular pitch distance beyond that illustrated in FIGURE 2.

The impairment at the second position P_2, may be greater, but universally there has heretofore been impairment in this position. Thus, the paper is compressed at the second position P_2 and its fibers are compacted, leading to difficulty in the subsequent gluing operation because the glue cannot penetrate this packed fiber.

Moreover, the dual impairment in compression of the paper at both points **62, 64** and **63, 65** means that the paper S is stretched in between those points because forces in opposite directions are pulling on the paper, as shown by the arrows X and Y, and, therefore, tearing stresses are urged on the paper from those two points. As a result, the paper has sometimes been fractured and it has often been weakened here at its flute walls. Further, the tips **62, 63** are moving faster than the valleys **64, 65** and so they slide in the valleys **64, 65** as they engage in the first position P, causing the tips **62, 63** to wear, thereby shortening the flute height.

FIGURE 3 illustrates corrugating rollers **100, 101** constructed in accordance with the instant invention and illustrates the point that there is no impairment of sheet S prior to its arrival at the first position P_1. Contour roll **100** and form roll **101** are constructed with approximately identical radii for their valleys **102** and **103**. However, the tooth depth in the forming roll **101** from the chord is greater than the tooth depth of the contour roll **100**, and the radius of the tip **104** of the forming roll **101** is only slightly smaller than the radius of the valley **103** of the contour roll **100** while the radius of the tip **105** of the contour roll **100** is considerably less than that of the valley **102** it engages. As a result, the relieved area **106** shown in the drawings extends from one tip **104** to the next tip **104*a***. It will be noted that not only is there no impairment as in the prior art second position P_2, but that the actual second position is shifted to a new location P_3, where the paper leaves the forming roll **101**, coming in contact with it next at the first position P_1. At the second position P_2 the clearance is greater than the thickness of the paper, a typical instance being .0105″ in this instance for .009 caliper paper in an instance where the first position clearance is only .0045″.

There is clearance everywhere except at the actual tip portion of the first position P_1, where the paper is necessarily compressed, and there is no impairment before or after the first position P_1. Thus, the corrugation is made by alternate impressions at every other corrugation tip **110, 110*a***, etc. and a gentle rounded folding occurs at the other corrugations **111, 111*a***, etc. The outer surface **112** of the tip **111** is the one that is glued to the liner L, and this is uncompacted, in fact, as will be seen from the drawing, it tends to be somewhat stretched as it passes over the tip **105** of the contour roll **100**, so that its outer fibers tend to be opened rather than closed and certainly are not compacted, at the time glue is applied thereto by glue roller **50**.

Therefore, they take glue much better. However, the glue receiving areas of the corrugated sheet are subsequently compacted by the force exerted thereon as liner L is applied to the corrugated sheet. While the glue receiving areas are compacted, they are probably not compacted to the extent that the glue free crowns are compacted. This results in a substantially symmetrical flute contour in the single faced board.

According to the present invention contour roll **100** is driven by the means which drives the sheet feeding rolls while forming roll **101** is caused to rotate merely by the meshing of its flutes with the flutes of contour roll **100**. Thus, it will be said that the forming roll **101** merely idles.

In order to understand the effect of impairment at the prior art second position, it will be necessary first to consider what happens during the actual corrugation of the corrugating medium. Since the forming roll **101** is not driven and since its pitch centers are not fixed because of the resilient mounting, the tendency is for the axis thereof to move up and down as it rotates instead of remaining level as it would with gears, where the pitch centers are fixed. This is overcome partly by the spring force urging it toward the contour roll **100**, but mostly because the roll **101** rotates at fast speed with a high momentum or rotational kinetic force. Thus, it tends to stay on a single level, compressing the sheet S instead of moving up and down. Therefore, the paper S tends to be compressed a distance equal to or greater than what the forming roll **101** would have had to move if it were not for the paper S absorbing this tendency of the axis to become displaced.

The paper S is somewhat elastic so that it recovers somewhat and does not remain as thin as its initial compression, but this compression is considerable and recovery is not complete. Thus, when the forming roll **101** comes into its full meshing position with the contour roll **100** at the first position P_1, the paper is compressed between the two rolls **100, 101** at a pressure usually between about 2500 to about 5000 p.s.i. and sometimes greater. Since the sheet S has been steamed, it is soft and the paper fibers are compressed into a permanent set or indentation. Actual measurement of the paper caliper indicates a typical reduction in the thickness of the paper of about 0.0045″, which may be ½ to ⅓ of the original thickness of the paper. This indentation is functionally necessary in order to effect the corrugation. In contrast, impairment in the prior art second position is functionally unnecessary and is undesirable.

Since only contour roll **100** is driven this results in a rolling diameter which falls at the center of sheet S at the fully meshed position P_1. This is so because the tips of forming roll **101** engage the contour roll valleys, but there is no engagement between the contour roll teeth and the forming roll valleys. The forming roll valleys are, in effect, recessed so that they are not even closely approached by the contour roll tips. This makes it possible to construct the rolls **100, 101** so that the effective radius of corrugation is at or near the actual point of engagement of the forming roll tips and with the contour roll valleys. Consequently, these two can be of the same effective radius and can rotate at a substantially the same speed. Thus, any wear that takes place will wear equally on the forming roll tip and the contour roll valley.

There is no sliding of the tips in the valleys in the single facer of the present invention. Moreover, such wear as occurs tends to increase the flute height and, therefore, makes the board stronger. This is so because the wear on the forming roll teeth is unimportant, since they must always bottom in contour roll valleys due to the biasing force acting on forming roller **101** and wear of the contor valleys increases the distance between the contour valleys and the contour teeth tips, and that distance determines the flute height. So in the present invention the board becomes stronger as the machine wears, whereas in the prior art the board became weaker. Also, due to the contour described, it is possible to prevent impairment at the second position on rolls twice as large as those now in use.

In single facing corrugators the flute height and spacing have to be held constant so the number of flutes on a roll are determined by the diameter of the roll. However, the larger a roll is made, the flatter becomes any arcuate portion of its surface, i.e. its radius of curvature is greater, and, therefore, the likelihood of impairment becomes greater. Rolls can easily be made so large that impairment in the second position P_2 becomes inevitable, and may even occur at a third or fourth position. This impairment due to the flattening of the roll by its increase in diameter of corrugating rolls that can be used and still maintain all the strength and other physical characteristics of the product, and, therefore, has limited the speed and production of single face stock.

The present invention, by a novel structure of the valleys of the rolls, particularly those of the forming roll **101**, makes it possible to avoid such impairment completely in corrugating rolls up to twice the diameter of the largest ones now being used satisfactorily, without causing impairment at more than a single point at any given time. Therefore, with the same speed of rotation and only slightly greater rotational inertia, production can be doubled.

In a second embodiment of this invention, illustrated in FIG. 4, contour roller **80** is of identical design as contour roller **100** while the contour of guide roller **81** differs from that of guide roller **101** in that no attempt is made to conform the contours of valleys **82** of roller **81** to the contours of tips **83** of roller **80** and generous side clearance notches **73** and **74** are provided in the flute walls of forming roller **81** to prevent the possibility of interference between the rollers **80**, **81** as they run into mesh.

When a tip of forming roller **81** is fully meshed, as at **85**, with a valley **87** of contour roller **80**, valley **82** and tip **83** will be spaced by a distance greater than the thickness of cardboard sheet S. The cooperation of forming roller **81**, and contour roller **80** will also produce symmetrically corrugated sheets without short or leaning flutes as well as being free of fractures.

FIGURE 5 illustrates a third embodiment of this invention which utilizes forming roller **81**, of FIGURE 4, intermeshed with contour roller **90**. Tips **93** and valleys **97** of contour roller **90** are identical with tips **83** and valleys **87**, respectively, of contour roller **80**. However, depressions **91** are formed in the walls joining the valleys **97** and tips **93** of contour roller **90** to provide clearance notches which prevent the possibility of interference between rollers **81** and **90** as they run into mesh.

The embodiments of FIGURES 4 and 5 are constructed to be especially adapted for large diameter rollers and exceptionally high speed operation. When tips **86**, **86** are centered in valleys **87**, **97**, respectively, large support areas are provided for the corrugating medium thus preventing fracturing thereof. With the last two embodiments, both corrugating rollers may be driven, if so desired.

In the foregoing, the invention has been described only in connection with preferred embodiments thereof. Many variations and modifications of the principles of this invention within the scope of the description herein are obvious. Accordingly, it is preferred that we be bound not by the specific disclosure herein, but only by the appending claims.

We claim:

1. A corrugating machine for paper comprising a driven contour roll and a forming roll being driven through the paper corrugating medium by the contour roll, said forming roll being yieldingly forced toward said contour roll and caused by its rotational inertia to rotate in a stationary axis by compressing the paper at a point of full mesh lying along the diametric centerline of said rolls, said forming roller having a tooth and valley contour differing from the tooth and valley contour of the contour roll by having continuous clearance between its valleys and the teeth of the contour roll while having engagement between its teeth and the valleys of the contour roll at the point of full mesh.

2. The machine of claim 1 wherein there is no position other than the point of full mesh where the paper corrugating medium is compressed, all clearances except at the point of full mesh being greater than paper thickness.

3. In a corrugating machine having a driven contour roll and a forming roll yieldingly urged toward said contour roll and driven by it through the corrugating medium, a tooth structure wherein teeth of the forming roll mesh in valleys of the contour roll and compress the corrugating medium there in a first position while in a second position, the last position preceding the first position where the corrugating medium engages the forming roll, there is no impairment of said medium because there is clearance between the forming roll and the contour roll exceeding the thickness of the medium except at said first position, so that the corrugating medium is compressed between said rolls only at the point of formation.

4. The machine of claim 3 wherein there is a glue applicator for applying glue to the outside tips of the corrugations that alternate with the tips formed at said first position, and means for applying a liner against the glued tips, so that the glue is applied to uncompressed fibers of said tips.

5. A corrugating machine for paper comprising a lower driven contour roll and an upper forming roll having its axis higher than said contour roll and being driven through the paper corrugating medium by the contour roll, said rolls having corrugating teeth in fixed relationship with respect to the rotational axes of the respective rolls, said forming roll being yieldingly forced toward said corrugating roll and caused by its rotational inertia to rotate in a stationary axis by compressing the paper at a point of full mesh, said forming roll and contour roll having different tooth and valley contours providing continuous clearance between the forming roll valleys and the teeth of the contour roll while having engagement between its teeth and the valleys of the contour roll at the point of full mesh.

6. The machine of claim 5 wherein the rolling radii of said forming roll tips and of said contour roll valleys are substantially identical, so that they move at substantially identical speeds without sliding and without causing excessive tip wear.

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