Feb. 10, 1970 D. R. MIDDOUR 3,494,265

PACKAGE FORMER WITH MULTIPLE ELLIPTICAL CURVE

Filed Feb. 1, 1968 3 Sheets-Sheet 1

FIG. 1

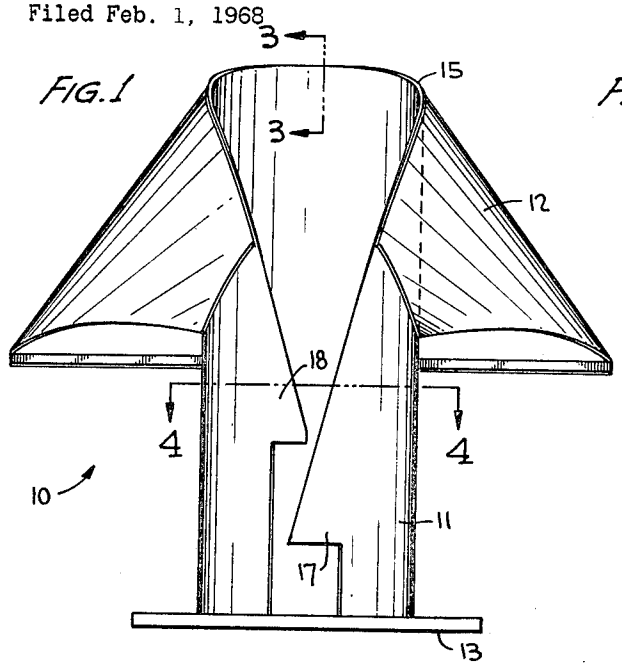


FIG. 2

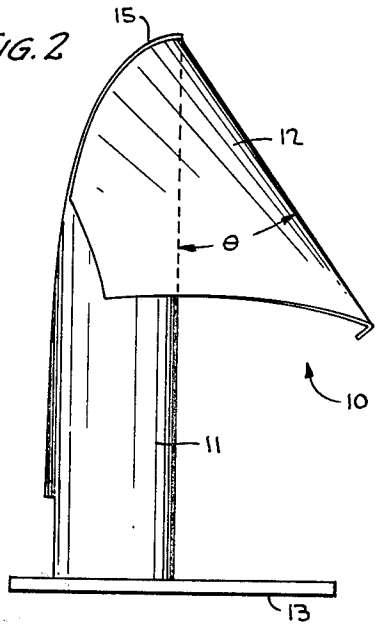
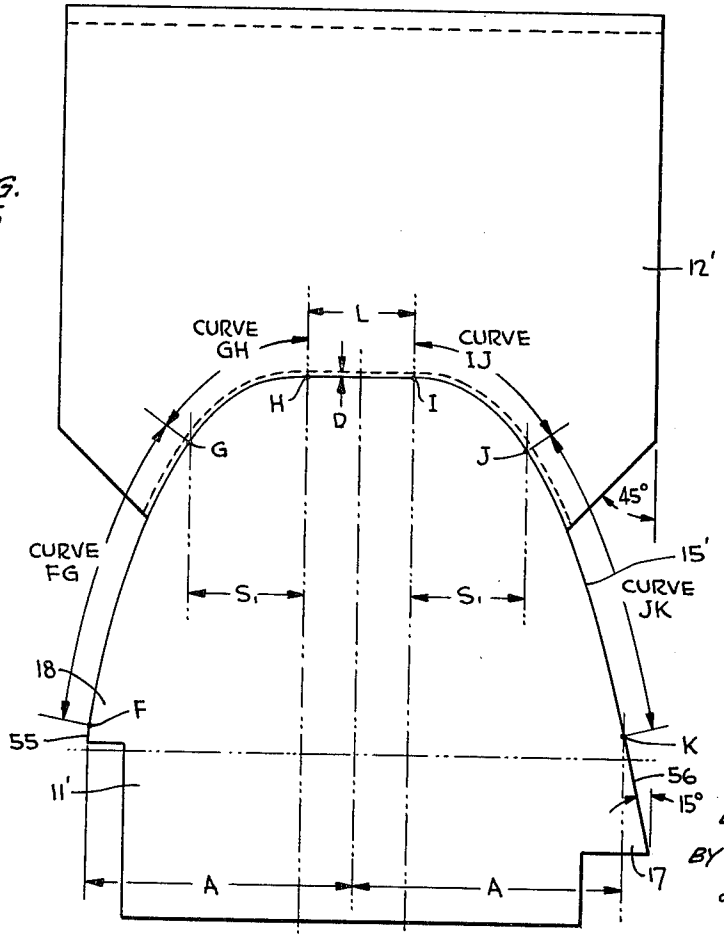


FIG. 5



INVENTOR,
DONALD R. MIDDOUR

BY Lowe & Kuig

ATTORNEYS

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PACKAGE FORMER WITH MULTIPLE ELLIPTICAL CURVE

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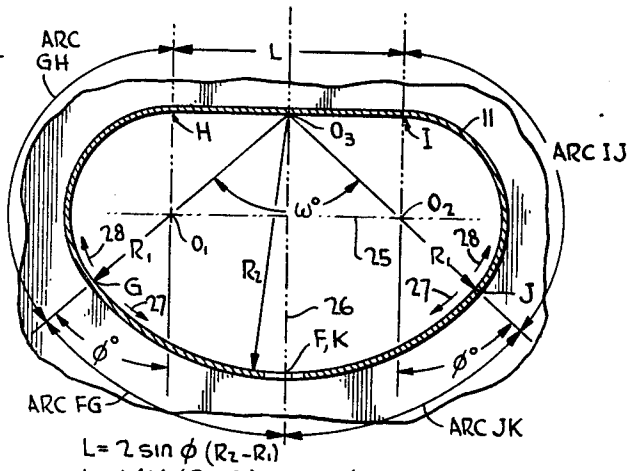
FIG. 4



$L = 2 \sin \phi\,(R_2 - R_1)$

$L = 1.414\,(R_2 - R_1)$, WHEN $\phi = 45°$

$CIRC. = 2A = 2 \sin \phi\,(R_2 - R_1) + 2\left[\left(\frac{180° - \phi}{180°} \pi R_1\right)\right] + \left[\left(\frac{\omega}{180°}\right) \pi R_2\right]$

$CIRC. = 2.984\,R_2 + 3.306\,R_1$, WHEN $\phi = 45°$

$L = .450 \times$ BAG WIDTH (APPROX.)

MAX. WIDTH LABEL = .475 BAG WIDTH

FIG. 3

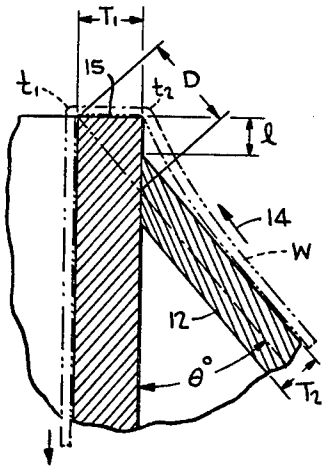
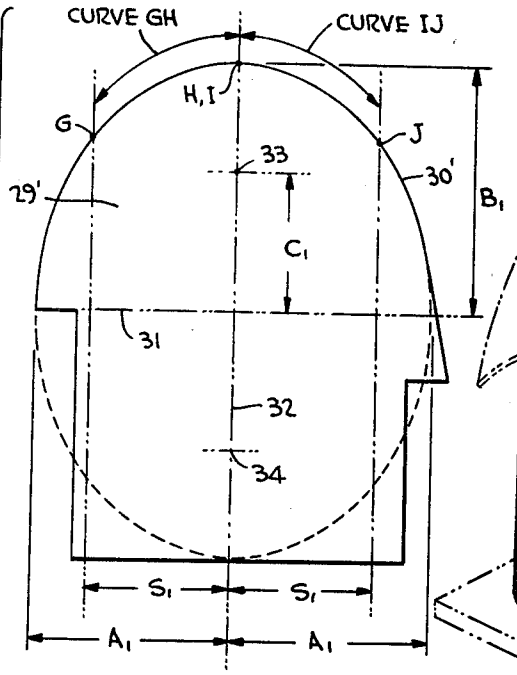


FIG. 6



ELLIPTICAL LAYOUT FOR CIRCULAR FORMER

$\frac{X^2}{A^2} + \frac{Y^2}{B^2} = 1$ (BASIC EQUATION)

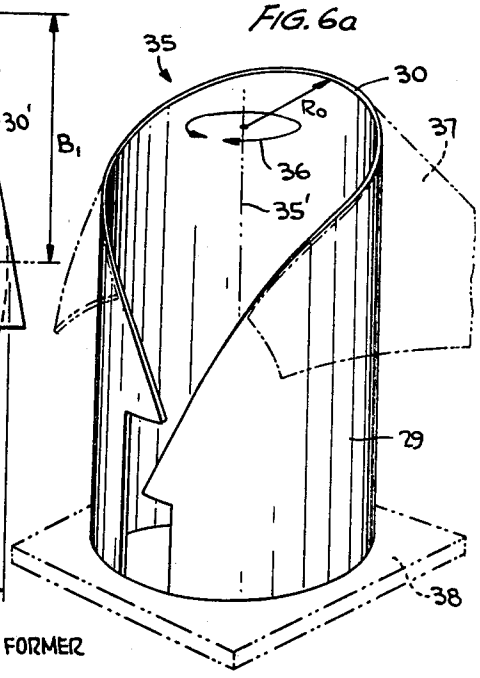
A_1 = BAG WIDTH

$B_1 = 1.286 \times A_1$

$C_1 = \sqrt{B_1^2 - A_1^2}$

$S_1 = \left(\frac{180° - \phi}{180°}\right) A_1$

FIG. 6a



INVENTOR,
DONALD R. MIDDOUR

BY

Lowe & King
ATTORNEYS

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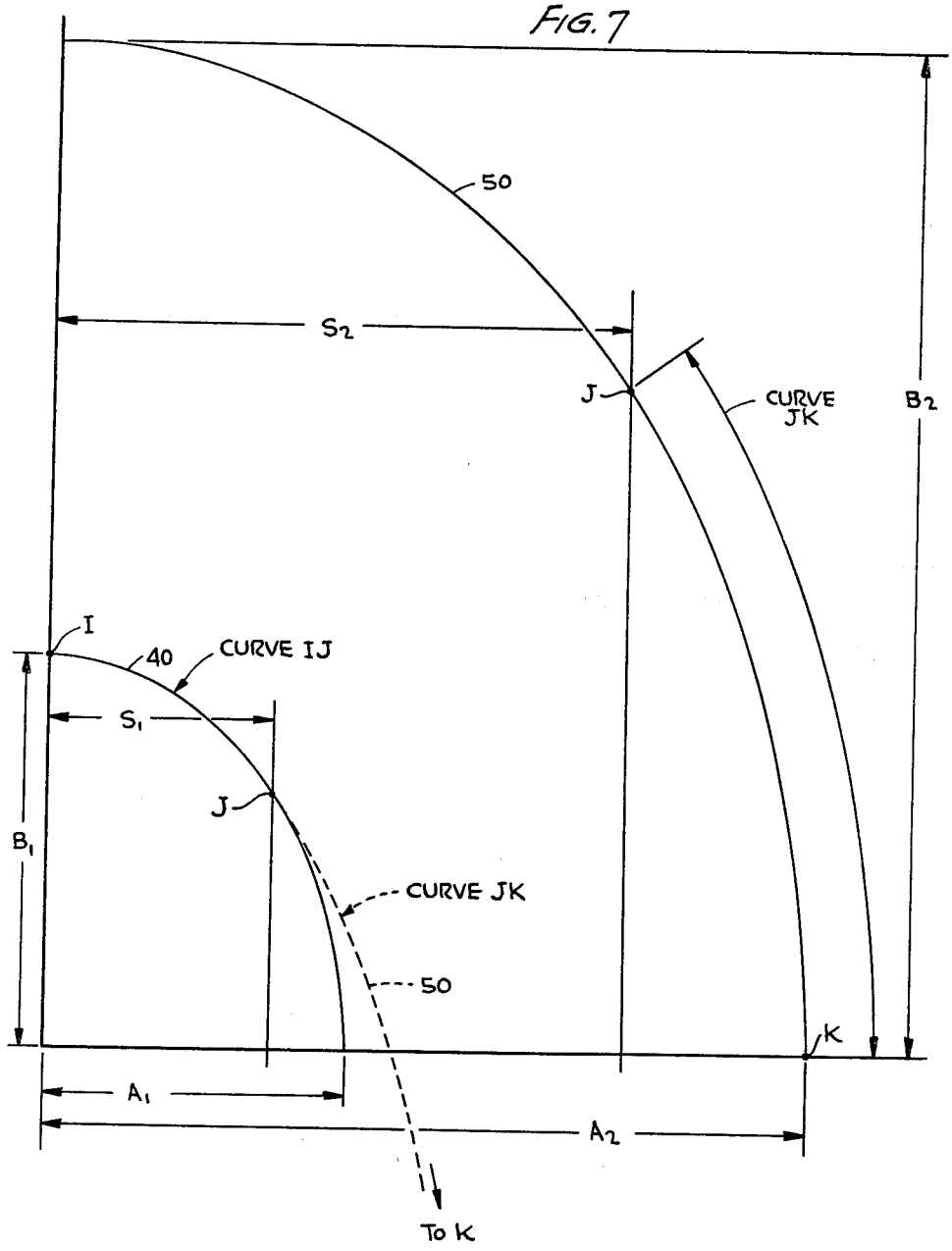
FIG. 7



INVENTOR,
DONALD R. MIDDOUR
BY
Lowe & Kuig
ATTORNEYS

United States Patent Office 3,494,265
Patented Feb. 10, 1970

3,494,265

PACKAGE FORMER WITH MULTIPLE ELLIPTICAL CURVE

Donald R. Middour, Decatur, Ga., assignor to The Woodman Company, Inc., Decatur, Ga., a corporation of Georgia

Filed Feb. 1, 1968, Ser. No. 702,314
Int. Cl. B31b 1/38
U.S. Cl. 93—82 20 Claims

ABSTRACT OF THE DISCLOSURE

Former for forming a web of flexible sheet material into a tube having an edge at the line of transformation which is an elliptical curve. Circular arcs of different radii are smoothly merged and symmetrically arranged on each side of the minor axis of the ellipse.

The present invention relates to form and fill packaging machines and, more particularly, to an improved device for forming a web of flexible sheet material into a continuous tube for use in forming successive packages.

In the field of form and fill packaging machines, it is conventional to pass a web of sheet material over a specially designed former that reversely directs the sheet material down through an upstanding tubular portion to form the same into a tube with overlapping opposite side edges. The tube is completed by continuously heat sealing the edges together with the product being packaged being introduced in weighed batches through the upper mouth of the formed tube and allowed to drop by gravity to the bottom of said tube. A transverse heat seal is formed across the tube above the batch of material to thus complete the top of the bag and form the bottom of the next succeeding bag.

To successfully form the tube in the rapid fashion required for high speed packaging, it has been found that the former must be designed and manufactured with the utmost of care to maintain the proper tracking of the web over the former and to prevent web fracture and wrinkling due to uneven tension along the line of transformation of the web. It has been proven that one of the most successful of the designs in gaining these objectives is the standard circular former, that is, a former having a tubular portion of circular cross section that forms a circular tube. In these prior art circular formers, the layout of the upper end or operative edge of the tubular portion which forms the line of transformation of the web is the most critical step since a line of transformation which properly shapes the web into the tube to form a smooth wrinkle-free bag must be provided; it having been proven by experience that too much tension at any given point along said line tends to cause a longitudinal fracture in the web, whereas too little tension tends to allow the web to pucker and thus form an equally deleterious longitudinal wrinkle.

It has been discovered that a highly efficient circular web former is produced when the operative edge of the tubular portion is laid out so that the resultant line of transformation is a basic elliptical curve with the transverse axis of the ellipse (that is, the axis through the foci) extending parallel to the central axis of the finished tubular portion, and thus in the same direction as the tube being formed. The success of this specific elliptical line of transformation is thought to lie in having reached a particularly favorable compromise between the two extremes of paper tension, both of which cause problems as noted above. Also, the use of an elliptical curve allows the preformer, which shapes the web just prior to the transformation, to approach the tubular portion at a

moderate, relatively constant angle at all points around the tubular portion at which it is employed. Finally, the ellipse is a familiar, relatively uncomplicated curve which can be easily laid out by the pattern maker for any size tube desired so that the cost of production is also favorable.

While the former with the circular cross section has thus been proven to be successful and allows efficient formation of any desired size tube of sheet material as just described, there has been a recognition in the art that a noncircular former would be an advantage in certain machines, and in particular, in machines adapted to package relatively thin, disc-like products, such as potato chips, which are most conveniently fed to the mouth of the tube for packaging in an integral batch or charge, that is as near to the final shape that the chips assume in the finished bag as possible. Specifically, potato chips are fed from a vibratory conveyor in a relatively thin stream for accuracy into a weighing hopper; however, for transfer from the weighing hopper into the tube it is desirable to maintain the chips in an oblong cross-sectional shape since the final bag is this shape rather than circular. This concept greatly shortens the transfer time and prevents breakage of the chips since the chips need not be strung out as much as has been previously required for passing through a circular tube. Furthermore, with a noncircular or flattened tube cross section, the wide or larger potato chips may be handled with ease and are not required to be broken to enter the tube, which fact is of great importance to the ultimate satisfaction of the customer. Also of course, with a cross section that better suits the wide shape of the potato chips, the problem of jamming of chips in the tube is alleviated.

Furthermore, with a tube of circular cross section, the front-to-back dimension is increased over that which would be required with the use of a flattened cross section as proposed by the present invention. This is a needless waste of space thus making the machine bulkier than necessary since in the past after the tube has been sealed transversely, it is then transformed into a flattened or generally oblong shape, as is well known. A preflattened bag further adds to the efficiency of the operation in that the transverse sealing dies that perform the sealing operation do not have to be withdrawn the extra distance that is required with a tube of circular cross section. In other words, the front and back of the bag are closer together so that the in and out travel of the transverse sealing dies is substantially reduced, sometimes as much as one-half the distance, which greatly adds to the speed and operating efficiency of the form and fill packaging operation.

Other considerations in the packaging industry have also pointed to the need for a successful noncircular tube former. Of these, the most obvious is the case wherein the product being packaged has a definite oblong rather than circular cross-sectional configuration. For example, in the same potato chip packaging field the recent popularity of the twin pack of chips which includes two inner packs of chips in side-by-side relationship has pointed to a need for a former wherein the inner packs are easily inserted together without difficulty.

Thus, it is one object of the present invention to provide a former with a noncircular cross section for efficiently transforming a web of flexible sheet material into a continuous tube with a wide mouth.

It is another object of the present invention to provide a former of the type described wherein recognized and proven principles are utilized in a novel manner to prevent the possibility of fracture and wrinkling of the sheet material during formation.

It is still another object of the present invention to provide a noncircular former with the stated favorable forming

characteristics, which former may be laid out and fabricated without the use of special complicated formulae or templates.

Briefly, the apparatus of the present invention comprises a former that includes a noncircular upstanding tubular portion with a curved wing preformer extending at an acute angle to the back of the former for guiding the web up and over the operative end of said tubular portion. The tubular portion, the upper edge of which defines the line of transformation of the web into a tube, being of noncircular cross section has a major axis along which the filling operation takes place to gain the benefits of the wide mouth design. The cross section of the tubular portion includes a plurality of substantially circular arcs of different radii symmetrically arranged on each side of the minor axis giving the cross section the required shape. In accordance with the invention, the critical line of transformation is divided into a plurality of segments, each with a curvature corresponding to the arcs rather than being a single continuous curve as in the past and as shown, for example, in the U.S. patent to Dreeben No. 2,872,762, issued Feb. 10, 1959. In accordance with this teaching, the former may be made so that the tension of the web along the line of transformation is substantially constant thus giving the desired results mentioned above.

In accordance with the preferred embodiment of the invention, the rate of change of the slope of the multiple curves is continuously variable and inversely proportional to the corresponding radii of the circular arc of the cross section. That is, the rate of change of the slope of the line of transformation defined by the segments positioned adjacent the major axis of the cross section is greater than that defined by the segments adjacent the minor axis. Furthermore, in accordance with more specific aspects of the invention, I have been able to successfully utilize multiple ellipses for forming the composite transformation curve, it being remembered that elliptical curves have been found to be highly successful in the formation of successful circular formers. Thus, for convenience for any one segment a flat layout that is suitable for a standard circular former is selected, and the line of transformation is thus defined by the basic equation

$$\frac{X^2}{A^2}+\frac{Y^2}{B^2}=1$$

wherein A is equal to one-half the circumference of such circular former.

To best insure a smooth transition of the web in the area between the multiple segments of the line of transformation, the present invention contemplates the use of elliptical layouts which have the same eccentricity. Further, it has been found that an eccentricity wherein B is equal to approximately 1.25 to 1.3 times the dimension A is desirable; this particular range of values determinative of the eccentricity of the ellipse serving to give a former wherein the preformer approaches the lip of the tubular portion at an acute angle of approximately 30°, thus insuring adequate frictional contact between the web and the former around the line of transformation to obtain a positive stretching of the web around the tubular portion to prevent wrinkling and collapse of the tube while at the same time preventing fracture of the web due to excessive tension.

Another feature of the present invention is concerned with the provision of the tubular portion of the inventive former with a flat back whereby the line of transformation includes a straight segment corresponding to the same. The provision of this straight segment means not only that the front-to-back dimension of the tubular portion is reduced to a minimum, but also that the height of the tubular portion is a minimum since the transformation of the web can take place in this area without any curvature. Preferably, this flat segment is approximately .450 times one-half of the circumference of the tubular portion or the bag width,

and this means that the curved portion is no greater than necessary and that the front-to-back thickness and height of the former is minimized for the advantages pointed out above. The winged preformer is preferably positioned so that the guide edge of the tubular portion extends above the same and is squared off to form a protruding lip that forms successive transitory creases across said web to induce lateral stretching and longitudinal smoothing of the web.

Still other objects and advantages of the present invention will become readily apparent to those skilled in this art from the following detailed description, wherein I have shown and described only the perferred embodiment of the invention, simply by way of illustration of the best mode contemplated by me of carrying out my invention. As will be realized, the invention is capable of other and different embodiments, and its several details are capable of modification in various obvious respects, all without departing from the invention. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not as restrictive.

In the drawings:

FIGURE 1 is a front view of a former constructed in accordance with the teachings of the present invention;

FIGURE 2 is a side view of the former illustrated in FIGURE 1;

FIGURE 3 is a cross-sectional view taken along line **3—3** of FIGURE 1 showing a magnified cross section along the longitudinal axis of the former;

FIGURE 4 is a cross-sectional view of the tubular portion taken along line **4—4** of FIGURE 1 showing the noncircular cross section of the former;

FIGURE 5 is a flat layout utilized in constructing the former with a multiple elliptical curve as shown in FIGURES 1 and 2;

FIGURE 6 is a flat layout of the tubular portion of a standard circular former utilizing an elliptical line of transformation;

FIGURE 6*a* is an illustration of the manner in which the flat layout of FIGURE 6 might be utilized to construct a circular tubular portion to be combined with other standard parts to make a standard circular former; and

FIGURE 7 is a graphical layout of one quadrant of two elliptical curves which can be utilized in the former of the present invention.

With specific reference now to FIGURES 1 and 2 of the drawings, a more complete description of the specific structure of a preferred embodiment of the apparatus of the present invention can be given. In these figures it will be recognized by those skilled in the art that a former, generally represented by the reference numeral **10**, is provided which comprises an upstanding tubular portion **11**, a winged preformer **12** and a base **13**. In general, these several parts that make up the former **10** are well known and can be interconnected in the conventional manner shown in these figures. For example, the winged preformer **12** may be suitably welded to the upper end of the tubular portion **11** so as to extend at an acute angle θ required to properly support the material just prior to being transformed, which in the present case is shown as approximately 30°, and the lower end of the tube portion may be suitably welded to the base **13**, which simply consists of a suitable plate having an aperture for receiving said tubular portion **11**.

As is well known in the art, the web to be transformed into a tube is received by the winged preformer **12** from below, which serves to guide and preliminarily shape the web prior to its being reversely directed down through the tubular portion **11**. Since such basic action is conventional in this art, as shown for example in the above mentioned patent, a detailed description of the same is deemed not to be necessary; however, to insure completeness of the present disclosure there is illustrated in

FIGURE 3 such a web W of flexible sheet material being fed in the direction of the arrow **14** from supportive contact with the winged preformer **12** to a contoured guide edge **15** of the tubular portion **11**, and thence being reversely directed down along the interior of the tubular portion **11** in the manner required.

As will be clear from viewing FIGURE 3 and comparing the same with FIGURES 1 and 2, the line of transformation of the web, or to put it another way, the locus of points at which the web W is changed from a curved or upwardly bowed web on the preformer **12** to a tube within the tubular portion **11**, is defined by the guide edge **15** of said tubular portion **11**. The edge **15** is positioned slightly above (by a distance **1**, FIGURE 3) the point of juncture between the upper surface of the winged preformer **12** and the tubular portion **11** so that the web W is actually slightly spaced from the preformer **12** just prior to being transformed, as shown in FIGURE 3.

The lowermost ends of the contoured guide edge **15** are formed by a pair of opposed guide ears **17, 18** which extend into the open front of the former **10**. These guide ears **17, 18** perform the final laying of the side edges of the web W together for heat sealing which completes the formation of the sheet material tube.

The guide edge **15**, as shown in FIGURE 3, is squared off along its full length so as to provide a pair of sharp edges over which the web W must pass to thereby create a corresponding pair of pronounced transitory creases in said web W, as has been denoted by the reference numerals t_1, t_2 in this figure. The provision of these creases t_1, t_2 in the web W is made possible by the elevated position of the edge **15** as noted above, and said creases t_1, t_2 induce both a longitudinal smoothing and lateral stretching of the web W due to the distortion of the web material. Specifically, the longitudinal smoothing action occurs as a result of the differential stretching across the thickness of the web W; whereas, the lateral stretching action occurs as a result of an outwardly directed component force being induced in the web W at the line of transformation, which component force is caused by the web W meeting the sharp edges of the curved segments of the guide edge **15** at an acute angle with respect to a horizontal plane. This action is of particular importance in the present instance since with the noncircular cross section the front portion of the critical guide edge **15** is relatively flat, as will be seen later, so that this aid to stretching and smoothing of the web W is needed to insure against wrinkling and to take the curl out of the material in this area.

As can be noted in FIGURE 3, the thickness of the tubular portion **11**, as indicated by the dimension T_1, is greater than the thickness of the preformer **12**, as denoted by the dimension T_2. This indicates that the composite former **10** can be constructed from two separate sheets of material which is desirable for optimum economy. In other words, the tubular portion **11**, which must resist the tension in the web and remain substantially rigid so as to prevent bodily deflection and resultant mistracking of said web W, is preferably fabricated from relatively thick stock; whereas, the preformer **12** since it encounters very little deflecting force is thus from substantially thinner stock material. To properly position the preformer **12** at its juncture or interface with the tubular porion **11**, an arcuate strip of material from the prefomer **12** of average thickness D (see FIGURE 3), which it will be seen is equal to sin θ times T_1, has been removed subsequent to its having been laid out by the pattern shown in FIGURE 5 (note dashed line outline in this figure).

As has been noted above, one of the most important features of the former **10** of the present invention is to construct the guide edge **15** with a contour so that the tension in the web W along its line of transformation is maintained substantially constant; this being necessary to prevent fracture in the sheet material from too much tension and to prevent wrinkling or puckering of the sheet material due to too little tension. Thus, the structure of the design contour of this guide edge **15** that determines the line of transformation of the web W is a result of a novel combination of a plurality of curves which can best be seen in the composite flat layout of FIGURE 5. As will be realized, in this figure a pattern **11'** of the tubular portion **11** is shown in the flat or prerolled condition. Likewise, a pattern **12'** for the preformer **12** is shown prior to being shaped into the proper bowed condition and for clarity is shown in mating position with said pattern **11'** of said tubular portion **11** with a composite curve outline **15'** being illustrated as forming the interface between the same. Particularly, the flat layout of the guide edge **15** or the line of transformation of the web W is represented by the outline **15'** and includes the composite curve FGHIJK, as shown in this figure. This composite curve outline **15'** may be further described as including a plurality of segments or individual curves FG, GH, HI, IJ, and JK, which are selected in accordance with the invention by a procedure that begins with reference to the cross section of the former **10** as shown in FIGURE 4, in a manner which will now be explained.

Accordingly, the cross section of the tubular portion **11** noncircular to present a wide mouth for receipt of the product being packaged, and is formed of a plurality of arcs FG, GH, IJ, JK which correspond to the multiple curves or segments of the same designations explained with reference to FIGURE 5. The tubular portion **11** thus being generally oblong in shape can be said to have a major axis **25** extending through centers O_1, O_2 at the sides thereof and a minor axis **26** perpendicular to said major axis **25** extending through the center of the former **10** from the front to the back thereof. As can be noted from this figure, the back of the tubular portion **11** is formed so as to be flat between the point H and I and its length is represented by the dimension L. Corresponding to this flat or noncurved portion of the cross section, the edge **15** of the tubular portion **11** is formed with a straight segment HI, as defined by the center portion of the outline **15'** (note FIGURE 5). The arcs GH and IJ and the corresponding segments thus form the sides of the tubular portion **11** by smoothly merging with the opposite ends (points H and I) of the straight back HI and the corresponding straight segment, respectively; whereas the arcs FG and JK and the corresponding segments form the front of the former **10** by smoothly merging with the outer ends (points G and J) of the arcs and curved segments GH and IJ. These arcs FG, GH and IJ, JK are circular and the centers of the first two are O_1, O_2 along the major axis **25** with designated radii R_1. The centers O_1, O_2 are aligned with the points H and I so that the tangent to said arcs at these points is coextensive with the straight segment HI to give a perfect merger. The center of the innermost arcs FG, JK is at a common point O_3 along the minor axis **26** with a designated radius R_2 also so as to give common tangency at the points G and J.

In the embodiment shown for purposes of illustrating the invention, the radii R_1 of arcs GH and IJ are selected to be equal to ½ L and since the centers O_1, O_2 are positioned so as to be aligned with the merging points H, I of said arcs with the flat back HI, equilateral right triangles O_1HO_3 and O_2IO_3 are formed. Extending the lines HO_1, O_3O_1 and IO_2, O_3O_2 forwardly, an included angle ϕ is formed which thus equals 45°; the lines HO_1 and IO_2 being parallel to the minor axis **26** so that the included angle ω being thus equal to 90°. The arcs GH and IJ are then selectively determined by movement of the radii R_1 from the points H and I to the points G and J, respectively; the latter points G, J necessarily from the above being 45° past the major axis **25** so that the total radial expanse of arcs GH and IJ is 90°+45° or 135°. To complete the circumference of the preferred cross

section, since lines O_3G and O_3J which are equal to the radius R_2 pass through the centers O_1, O_2, respectively, the common center at O_3 falls at the midpoint of the straight back HI and the curves FG and JK have common tangency with the respective adjacent arcs GH and IJ.

In accordance with an important aspect of the invention, the configuration of the noncircular cross section can be easily varied by merely selecting a substitute angle ϕ to thereby reposition the merger points G and J. In such a case, the proper radius R_2 for common tangency merger is conveniently determined by drawing a line from said selected points G and J through the centers O_1, O_2 to the intersection with the minor axis **26**. It will be realized that this is so since the angle ϕ of the adjacent circular arcs is the same. This feature is important in adjusting the cross section of the tubular portion **11** to give the proper circumferential length required for the bag size being formed, as will be seen in detail in the discussion that follows.

Before proceeding with the detailed analytical study of the cross section, it should be noted that since the bag is transversely sealed across its width so as to assume a flat condition, the circumference of said cross section must be equal to two times the nominal width of the bag measured at the seal area. Accordingly, in the flat layout of FIGURE 5, dimension A represents the width bag desired to be formed so that the width of the pattern **11'** in a flat condition is equal to 2A.

Keeping this in mind, the first step is to set up the formula for the circumference in terms of the bag size, as follows:

$$\text{Circ.}=2A \tag{1}$$

Now, breaking the cross section down into its component parts, the length of the dimension L of the flat back HI is determined by the following equation:

$$L=2 \sin \phi \ (R_2-R_1) \tag{2}$$

When ϕ equals 45° as in the preferred embodiment shown, then the equation becomes:

$$L=1.414 \ (R_2-R_1) \tag{3}$$

The combined length of the sides or arcs GH and IJ can be represented by the formula:

$$L_1=2\left[\left(\frac{180°-\phi}{180°}\pi R_1\right)\right] \tag{4}$$

and similarly the front or combined length of the arcs FG and JK can be written as:

$$L_2=\left(\frac{\omega}{180°}\right)\pi R_2 \tag{5}$$

Then, in turn, the circumference can be set out in terms of the sum of these several parts whereupon the formula is:

$$\text{Circ.}=2 \sin \phi \ (R_2-R_1)+\left[\left(\frac{180°-\phi}{180°}\pi R_1\right)\right]+\left[\left(\frac{\omega}{180°}\right)\pi R_2\right] \tag{6}$$

Placing the equation in the terms of R_2 and R_1 where ϕ equals the 45° of the preferred embodiment, it becomes:

$$\text{Circ.}=2.984R_2+3.306R_1 \tag{7}$$

Accordingly, knowing the width of the bag desired and thus the circumference of the tubular portion to be used and with $\phi=45°$, in accordance with the present invention the designer of the former **10** need only select an appropriate dimension for the radius R_1 of the sides of the tubular portion **11** then the raduis R_2 is immediately known by solving the above equation.

Alternatively, it has been found to be particularly advantageous to first determine the length of the flat portion L by the following relationship:

$$L=.450\times\text{bag width} \tag{8}$$

This equation thus giving a substantial portion of the circumference by eliminating the first term of Equation 6 allows for easier selection of the radius R_1.

Once the rough selection of R_1 has been made and solving for R_2 has been accomplished, the final fine adjustment of the length of the circumference can easily be made by varying the location of the points G and J slightly in the required direction. Thus, if a slightly shorter circumference is needed for the final bag dimension, the points G and J would be moved toward each other as noted by arrows **27** thereby creating an inward movement of the front GFKJ and thus a reduction in the length of the arcs FG, JK. As this takes place it will be remembered that the center O_3 moves outwardly along the minor axis **26** so that the radius R_2 is extended through the centers O_1, O_2 and common tangency between the adjacent arcs FG, GH and IJ, JK is thereby maintained.

Conversely, if it is found to be necessary to increase the circumference of the cross section, the points G, J are moved away from each other, or in the direction of arrows **28**, whereupon the front GFKJ of the tubular portion **11** is extended outwardly thus slightly increasing the circumference. In this case, the center O_3 of the radius R_2 moves inwardly along the minor axis **26** and the radius R_2 is extended through the centers O_1, O_2 to the respective points G, J so that the adjacent arcs again merge at a common tangency.

The description of the cross section of the tubular portion having been given, the manner in which the critical composite curve FGHIJK is determined and its relationship to said cross seciton will now be described. With regard to the curves GH and IJ at the upper part of the pattern **11'** which it will be remembered correspond to the arcs of the same designation in the cross section, the designer is first provided with a flat layout pattern **29'** illustrated in FIGURE 6. As mentioned above, it has been discovered that an efficient transformation of the web W into a tube occurs when the line of transformation is in the form of an ellipse so that composite curve outline **30'** of the pattern **29'** has been drawn in accordance with the basic equation for an ellipse, as follows:

$$\frac{X^2}{A^2}+\frac{Y^2}{B^2}=1 \tag{9}$$

wherein:

X=the distance along conjugate axis **31**, and
Y=the length of traverse axis **32** which extends through foci **33**, **34**.

It will be recognized that the ellipse or layout of the pattern **29'** is in the nonstandard position, that is, with the positions of the conjugate axis **31** and the transverse axis **32** being reversed from the standard position.

To further understand the significance of the pattern **29'**, it is pointed out that it can as shown be a layout for tubular portion **29** having a guide edge **30** of a standard circular former **35** illustrated in FIGURE 6*a*. That is, after being laid out from the pattern **29'**, the tubular portion **29** could be rolled into a cylinder about central axis **35'** with a radius R_0, as indicated by the double arrow **36** in this figure. The usual preformer **37** and base **38** could be added as shown in dash-dot lines to complete the assembly. It is emphasized that the standard circular former **36** per se of FIGURE 6*a* does not form a part of the present invention but is important to illustrate the novel manner in which only the parts or segments GH and IJ of the composite curve outline **30'** are used in the layout of the composite curve outline **15'** of the pattern **11'** of the inventive

former **10**. To put it another way, the radius R_0 of the standard former **35** is selected to be equal to the radius R_1 of the arcs GH and IJ of the tubular portion **11** so that the curves or segments of the same designations are determinable by simple transposition of said curves from the outline **29'** of the standard former **35** to the outline **15'** of the present former **10**.

To determine the above analytically by solving the ellipsoidal equations derived from the basic Equation 9 for the outline **30'** of the pattern **29'**, A_1 or half the width of said pattern **29'** is selected to be equal to the bag width that would be formed by the standard former **35**. In terms of the radius of the standard fromer **35** of FIGURE 6*a*, it follows the A_1 thus equals pi times R_0. B_1 is then selected to be a multiple of A_1 and, in particular, is selected to be approximately 1.25 to 1.30 times A_1, which it will be remembered gives efficient tube forming action. Having done this, the eccentricity of the ellipse can be solved from the equation:

$$e_1=\sqrt{1-\left(\frac{A_1}{B_1}\right)} \tag{10}$$

wherein A_1 is taken along the conjugate axis and B_1 along the transverse axis since the ellipse is in the non-standard position. When B_1 of the pattern **29'** is selected so as to equal a number within the preferred range of about 1.25 to 1.30 times A_1 given above, and is substituted into Equation 10, the eccentricity e_1 is found to be approximately 0.6.

Knowing the relationship between A_1 and B_1 or the eccentricity of the elliptical pattern **29'** the position of the foci **33**, **34** and then determinable, for example, by the equation:

$$C_1=B_1^2-A_1^2 \tag{11}$$

this completing the formation of the pattern **29'** and determination of the layout of the outline **30'**.

Since each side of the former **10** must complete the turning of the web W through 180°, a distance S_1 (FIG. 6) to locate the termination points G, J along the outline **30'** can be solved by multiplying the dimension A_1 by the proportion of the corresponding arcs GH, IJ in the cross section (FIGURE 4). Thus, the equation is as follows:

$$S_1=\left(\frac{180°-\phi}{180°}\right)A_1 \tag{12}$$

When $\phi=45°$ of the preferred embodiment, then S_1 equals three-fourths of A_1 thereby locating the points G and J three-quarters of the way out along the conjugate axis **31** which has been shown in FIGURE 6.

With the final determination of the layout and length of the upper curves GH and IJ of the outline **30'** and since R_0 is equal to R_1 as pointed out above, the layout of curves GH and IJ of outline **15'** is now complete. In other words, the curves GH and IJ for the pattern **30** of FIGURE 6 are those curves which will correspond with the arcs GH and IJ of a radius R_1 and thus they may be directly transposed to the composite layout pattern **11'** of the noncircular former **10** of the present invention shown in FIGURE 5.

Using the same basic Equation 9, the lower curves or segments FG and JK can be solved and, as best shown in FIGURE 5, these curves are relatively flat as compared to the upper curves GH and IJ. To explain, in FIGURE 7 a graphical illustration of one quadrant curve **40** of the ellipse based on the radius R_1 including the curve or segment IJ as just described, has been shown in conjunction with one quadrant curve **50** of another ellipse based on the larger radius R_2, which it will be remembered is the radius of the arcs FG and JK. Of importance to the present invention is that the curve JK as a part of the quadrant curve **50** is thus based on the same Equations 9–12 given above in relation to the curve IJ. Furthermore, the dimensions A_2, B_2 of the ellipse of which the quadrant curve **50** is a part have the same relationship to each other as the dimensions A_1, B_1. It follows that the eccentricity of the quadrant curves **40**, **50** is the same and that the slopes of the two curves at any radial position are the same, as can be seen from the comparison in this figure. S_2 of the elliptical quadrant **50** being determined in the same manner as S_1 is found to be equal to three-fourths of A_2 and the curve JK can then easily be selected as illustrated in FIGURE 7.

Overlaying the curve JK of the quadrant curve **50** on the quadrant curve **40**, as shown by the dashed line in this figure, it will be realized that the necessary common tangency is present to form a smoothly merging line of transformation for the web W of sheet material. Thus, proceeding to transpose this multiple curve IJK of FIGURE 7 to the outline **15'** of FIGURE 5 and forming the mirror image for the curve HGF on the opposite side of said outline **15'**, the composite curve FGHIJK is formed.

As shown in this figure, the provision of the guide ears **17**, **18** necessitates a special treatment of the portion of the outline **15'** below the curves FG and JK. To explain, the guide ear **18** terminates in a short straight segment **55** that is substantially parallel to the longitudinal axis of the pattern **11'**. The guide ear **17** on the other hand, extends substantially further down so that a longer straight segment **56** is employed, which segment **56** can be positioned at approximately 15° for tangency to the curve JK. Thus, while the positions of the points F and K are substantially as shown in FIGURE 5, it will be realized that the location may vary in certain embodiments and sizes without departing from the invention.

It is noted that the rate of change of the slope of the multiple elliptical curves HGF and IJK of FIGURE 5 is continuously variable from a maximum to a minimum, that is from a substantially tight curve to a relatively flat curve, in accordance with Equation 10. Further, it is evident that the average rates of change of the slope of the curves GH or IJ and the curves FG or JK are inversely proportional to the corresponding radii of the circular arcs of the same designation; i.e. the curves adjacent the major axis of the ellipse are selected for the cross-sectional arcs of small radius while the curves adjacent the minor axis of the ellipse are selected for the large radius arcs. As a result, the flat layout of the pattern **11'** is generally eccentric in shape and, more particularly, has the general configuration of an ellipse in a nonstandard position as in the successful standard former **35** (FIGURE 6*a*). Thus, the passage of the web W over the former **10** is effective to provide a wide mouth tube with the important characteristic of maintaining the same amount of tension along the entire line of transformation thus insuring against the possibility of wrinkling or other malfunctions which have been problems in the past.

Furthermore, from the foregoing description with reference to the drawings and the other objects of the present invention, it will be realized that the former **10** lends itself to efficient fabrication while at the same time making use of established principles rather than trial and error. Specifically, with the provision of a direct relationship between the circular arcs of the cross section (FIGURE 4) and the configuration of the operative edge **15** which determines the line of transformation of the web W, the former **10** can be easily constructed for any size bag with assurance of successful operation in each case. Furthermore, with the provision of multiple circular arcs in the cross section goes the advantage of being able to relocate the point of merger between the circular arcs of the cross section while maintaining common tangency so that the final circumference of the former **10** can be varied within a fine range with ease. Also, since the back HI of the former **10** is provided as a straight segment, the distance from the front to back of the former as well as the height of the tubular portion **11** is held to a minimum for maximum space efficiency in the packaging machine.

In this disclosure, there is shown and described only the preferred embodiment of the invention, but, as aforementioned, it is to be understood that the invention is capable of various changes or modifications within the scope of the inventive concept as expressed by the accompanying claims.

I claim:

1. A former for transforming a web of flexible sheet material into a continuous tube with a wide mouth comprising a tubular portion having an operative guide edge defining a line of transformation of said web, said tubular portion having a back, a front and opposite sides, and a curved wing preformer extending at an acute angle to the back and sides of said tubular portion for guiding said web up and over said edge with the side edges of said web being brought together at said front, said tubular portion having a noncircular cross section with a major axis and with a minor axis extending perpendicular thereto, said cross section of said tubular portion including a plurality of smoothly merging substantially circular arcs of different radii symmetrically arranged on each side of said minor axis, said edge of said tubular portion being generally eccentrically shaped in flat layout and divided into a plurality of smoothly merging segments corresponding to said arcs, each segment being defined by a selected curve in flat layout in accordance with the radius of the corresponding arc such that the tension in said web along said line of transformation is maintained substantially constant whereby fracture and wrinkling of said sheet material are prevented.

2. The combination of claim 1 wherein the rates of change of slope of the selected curves are substantially continuously variable and the average rate of change for each curve being inversely proportional to the corresponding radii of the circular arcs so that the rate of change of the segments positioned adjacent the major axis of said cross section is greater than adjacent said minor axis.

3. The combination of claim 2 wherein each of said curves is taken from a corresponding portion of a different flat layout defining an elliptical line of transformation suitable for a standard circular former, the radius of the corresponding arc being equal to the radius of said standard circular former and each curve being determined in accordance with the basic equation:

$$\frac{X^2}{A^2}+\frac{Y^2}{B^2}=1$$

wherein A is equal to one-half the circumference of said standard circular former and B is greater than A.

4. The combination of claim 3 wherein the elliptical layouts have the same eccentricity and B is equal to approximately from 1.25 to 1.30 times A.

5. The combination of claim 1 wherein the back of said tubular portion is flat and wherein said end of said tubular portion includes a straight segment corresponding to said back whereby the distance from said front to said back and the height of said tubular portion are both held to a minimum.

6. The combination of claim 5 wherein said straight segment is equal to substantially one-half the circumference of said tubular portion times .450.

7. The combination of claim 1 wherein the sides of said tubular portion are formed by a first pair of said circular arcs, and the front of said tubular portion is formed by a second pair of said arcs having radii substantially larger than said first pair whereby said major axis of the cross section of said tubular portion extends parallel to said back.

8. The combination of claim 7 wherein said first pair of arcs each has a center located on said major axis and said second pair of arcs has a common center located along said minor axis, said common center being determined by the intersection of a line with said minor axis passing through the point of merger of one of said second pair of arcs and one of said first pair of arcs and the center of the latter whereby said arcs have common tangency at the point of merger.

9. The combination of claim 1 wherein the segments of said edge are defined by different elliptical curves, each curve being determined in accordance with the basic equation:

$$\frac{X^2}{A^2}+\frac{Y^2}{B^2}=1$$

wherein A is equal to pi times the radius of the corresponding arc and B is greater than A.

10. The combination of claim 1 wherein said guide edge of said tubular portion extends slightly above said preformer and is squared off to present a pair of sharp edges over which said web passes to form successively pronounced transitory creases across said web at said line of transformation to induce longitudinal smoothing and lateral stretching of said web.

11. The combination of claim 1 wherein the length of each segment is proportional to the corresponding circular arc in accordance with the relationship:

$$S=\frac{180°-\phi}{180°}A$$

wherein S equals the distance across the flat layout to the merging points of the arcs and A substantially equals pi times the radius of the arc defined by $180°-\theta$.

12. A former for transforming a web of flexible sheet material into a continuous tube with a wide mouth comprising a tubular portion having an operative guide edge defining a line of transformation of said web, said tubular portion having a cross section comprising a plurality of smoothly merging substantially circular arcs of different radii, said guide edge having a flat layout outline including a plurality of smoothly merging segments corresponding to said arcs, each segment being related to its respective arc such that the tension in said web along said line of transformation is maintained substantially constant whereby fracture and wrinkling of said sheet material are prevented.

13. The combination of claim 12 wherein each of said segments includes a segment of an elliptical curve, each different segment being selected from different ellipses in accordance with the basic equation:

$$\frac{X^2}{A^2}+\frac{Y^2}{B^2}=1$$

wherein A is equal to pi times the radius of the corresponding arc and B is greater than A.

14. The combination of claim 13 wherein the different ellipses have the same eccentricity and B is equal to approximately from 1.25 to 1.30 times A.

15. A former for transforming a web of flexible sheet material into a continuous tube with a wide mouth comprising a tubular portion having an operative guide edge defining a line of transformation of said web, a curved wing preformer extending at an acute angle to the back of said tubular portion, said tubular portion having a noncircular cross section including a plurality of smoothly merging substantially circular arcs of different radii, said arcs including a first pair forming the sides of said tubular portion and a second pair of substantially greater radius with a common center forming the front of said tubular portion whereby a generally flattened cross section is presented, said guide edge having a flat layout outline including a plurality of smoothly merging segments corresponding to said arcs, each segment being related to its respective arc such that the tension in said web along said line of transformation is maintained substantially constant whereby fracture and wrinkling of said sheet material are prevented.

16. The combination of claim 15 wherein the back of said tubular portion is flat, a flat segment being provided

to correspond to said back, all of said segments merging at common tangency.

17. The combination of claim **16** wherein said guide edge of said tubular portion extends slightly above said preformer and is squared off to present a pair of sharp edges over which said web passes to form successively pronounced transitory creases across said web at said line of transformation to induce longitudinal smoothing and lateral stretching of said web.

18. The combination of claim **15** wherein the segments of said edge are defined by different elliptical curves, each curve being determined in accordance with the basic equation:

$$\frac{X^2}{A^2}+\frac{Y^2}{B^2}=1$$

wherein A is equal to pi times the radius of the corresponding arc and B is greater than A.

19. The combination of claim **15** wherein said tubular portion is constructed of material greater in thickness than said preformer for rigidity.

20. The combination of claim **19** wherein said preformer is attached to said tubular portion at an angle θ with an average dimension of sin θ times the thickness of said tubular portion being removed from said preformer as defined by the flat layout prior to attachment for accuracy in fit.

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