United States Patent [19]

Watrous

[11] **3,917,254**

[45] **Nov. 4, 1975**

[54] **APPARATUS FOR FOLDING OF A WEB**

[75] Inventor: **Howard N. Watrous**, Cincinnati, Ohio

[73] Assignee: **The Procter & Gamble Company**, Cincinnati, Ohio

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[21] Appl. No.: **409,494**

Related U.S. Application Data

[62] Division of Ser. No. 203,806, Dec. 1, 1971, abandoned.

[52] **U.S. Cl.** **270/86;** 100/176

[51] **Int. Cl.**[2] **B65H 45/22**

[58] **Field of Search** ..... 156/219, 196; 264/293; 93/58 R, 58 P, 58 ST, 58.1; 270/64, 66, 86–94; 83/1, 5–12; 100/176, 155

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Primary Examiner—Melvin D. Rein
Assistant Examiner—A. Heinz
Attorney, Agent, or Firm—E. Kelly Linman; Fredrick H. Braun; John V. Gorman

[57] **ABSTRACT**

A web of material is predisposed to folding by being passed through a pair of cooperatively mounted mating rolls; i.e., a male and female roll, which roll along what become the lines of fold of the web, prior to its being manipulated into its folded position. The rolls tend to loosen bonds in the web transverse of the ultimate lines of fold, thereby facilitating folding. Because the mating rolls manipulate the web only slightly, in distinction to the action of conventional folding devices, the web maintains its alignment while passing through the mating rolls relatively well, resulting in accurately located lines along which the web is predisposed to fold. Since the lines of predisposition to folding are accurately located, the ultimate folded structure is more dimensionally consistent than heretofore possible. In the preferred embodiments, the rolls press against the web with constant pressure, rather than being fixedly mounted, thereby providing a built-in adjustment for variations in web thickness.

3 Claims, 8 Drawing Figures

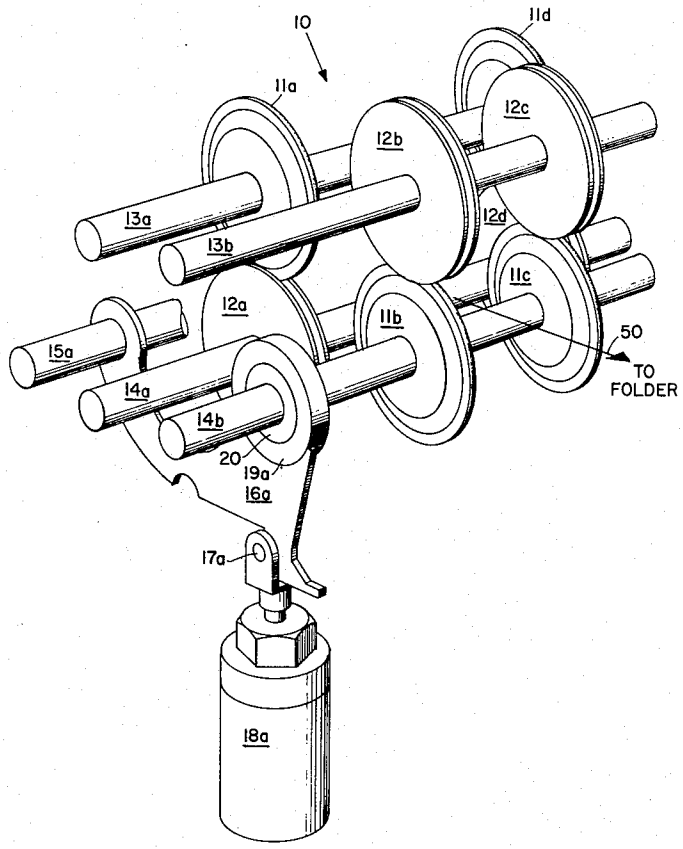


Fig. 1

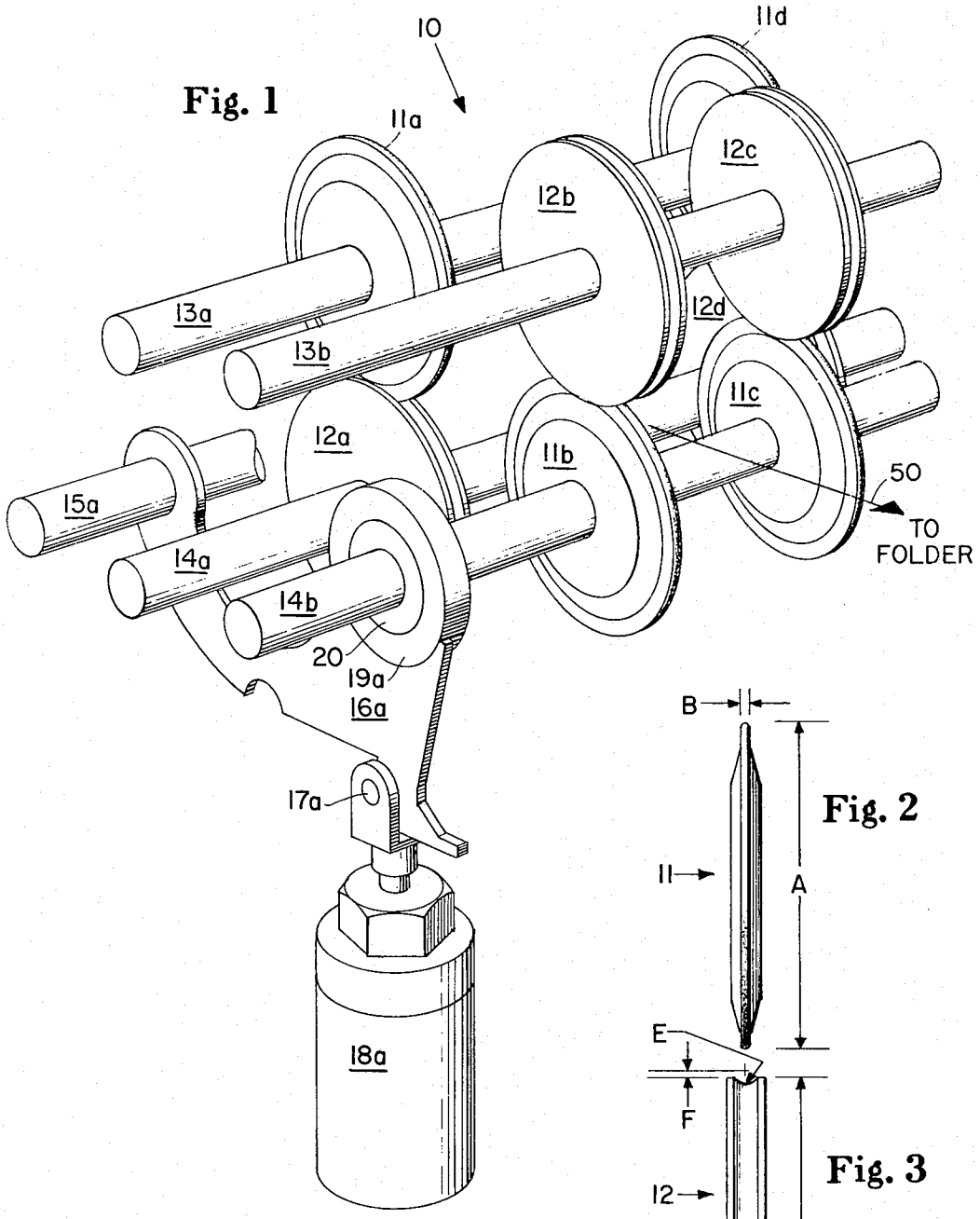


Fig. 2

Fig. 3

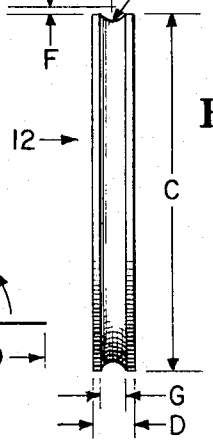
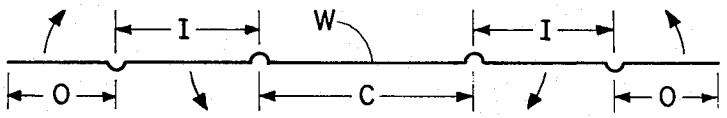


Fig. 4



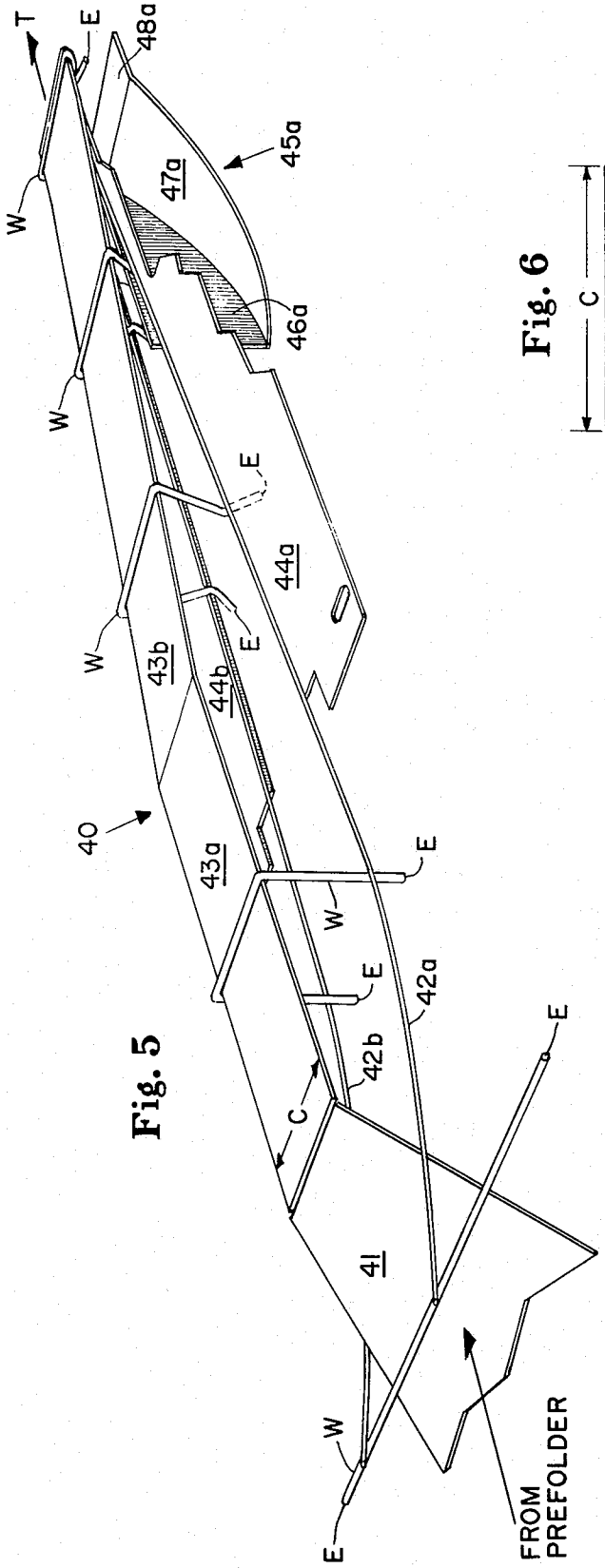

T
E
48a
45a
47a
46a
W
E
44a
43b
44b
40
43a
42a
42b
C
41
FROM PREFOLDER

Fig. 5

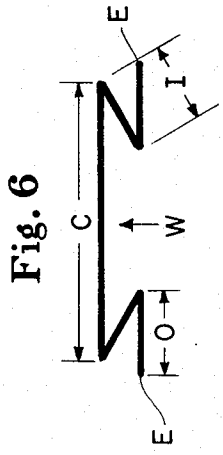

E
I
C
W
O
E

Fig. 6

Fig. 7

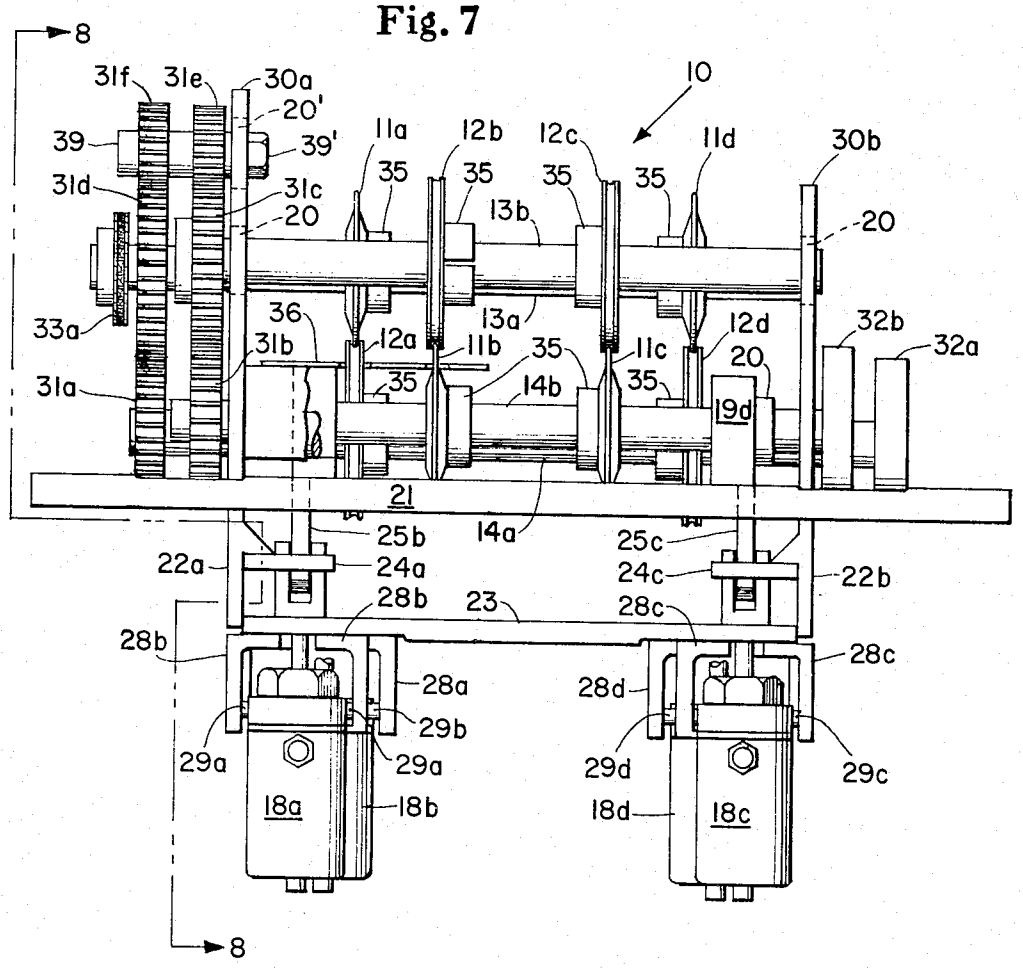
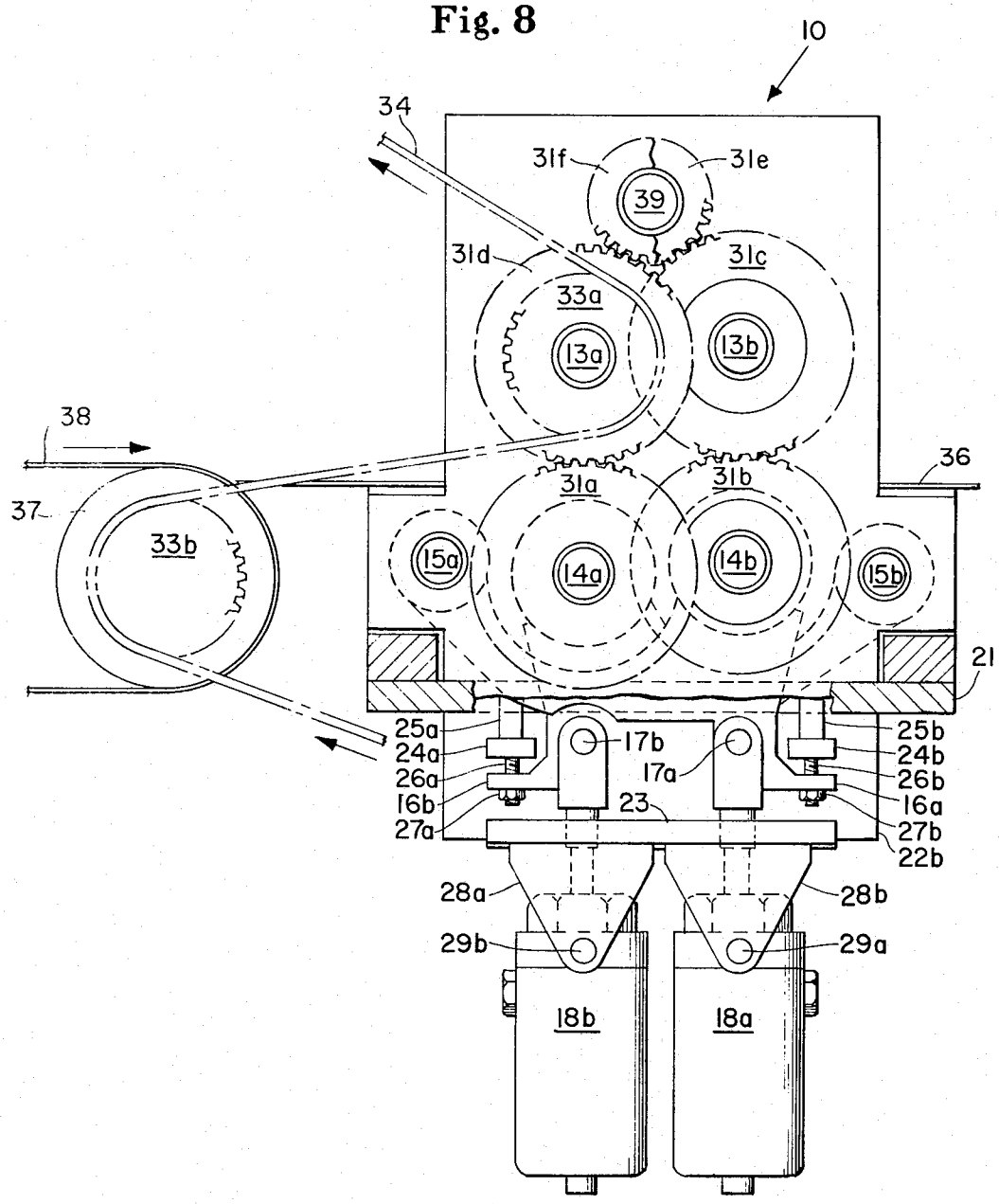

8
31f
31e
30a
20'
39
39'
31d
31c
20
10
11a
12b
12c
11d
30b
35
13b
33a
36
31b
12a
11b
13a
11c
12d
32b
32a
31a
14b
19d
21
14a
25b
25c
22a
24a
24c
22b
28b
23
28c
28a
28d
29b
29a
29d
29c
18a
18b
18d
18c
8

Fig. 8


10
34
31f
31e
39
31d
31c
33a
13a
13b
38
36
37
31a
31b
33b
15a
14a
14b
15b
21
25a
24a
26a
16b
27a
17b
17a
23
25b
24b
26b
16a
27b
22b
28a
28b
29b
29a
18b
18a

APPARATUS FOR FOLDING OF A WEB

This is a division of application Ser. No. 203,806, filed Dec. 1, 1971, and now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to the folding of webs and more particularly to the use of mated rolls to predispose a web to fold.

Webs of material are often provided with lines of fold by the use of a pair of mating male and female rolls with a generally "V" shaped periphery which crush and deform the web as it passes through them. Typical of this prior art is U.S. Pat. No. 3,570,841 issued Mar. 16, 1971 to Friedrich Rettig.

With relatively flexible webs such as facial tissues, folding is generally done with structures comprising boards around which a moving web is manipulated by means of guiding members. A folding apparatus of guides and boards has also been used with relatively heavy webs such as a disposable diaper pad with some success. Because of the relative rigidity of such a heavy web, however, control of the web position in such a folding apparatus is relatively difficult; the stiff web has a mind of its own. The result of inadequate control of web position in the folding apparatus, commonly referred to as poor tracking, is dimensional variations in the folded web. This is obviously undesirable.

It has been found that a prefolding step such as described hereinafter will predispose a web to fold along the lines of prefolding and cause the web to track more nearly uniformly on the folding apparatus, resulting in a more dimensionally consistent folded web.

Second only to the dimensional stability problem in a board and guide folder is the problem of longitudinal web stretching in the folder because of the relatively high web tensions normally required in this apparatus. This problem is especially severe with composite webs whose materials have greatly different elasticities such as the creped paper and polyethylene sheet composite web used for making disposable diapers. When such a web is tensioned both materials stretch. When the tension is released the polyethylene springs back a significant amount while the creped paper has little or no spring back. The difference in final lengths of the two components of the web, often referred to as puckering, is obviously undesirable. If the web can be predisposed to fold, and consequentially the tension used in the folding apparatus reduced, this problem may be significantly reduced.

Any solution to the above problems, to be practical, must also avoid materially weakening the web transverse of the lines of fold. This requirement means that many conventional means for folding such as embossing and scoring could not be used.

Accordingly it is an object of this invention to provide an apparatus of predisposing a web to fold along lines of fold which are accurately located.

It is another object of this invention to predispose a web to fold thereby reducing the forces required in the folding operation.

It is still another object of this invention to achieve the above objects without embossing or scoring the web and without materially affecting the strength of the web transverse of the line of fold.

SUMMARY OF THE INVENTION

In accordance with one aspect of the invention there

is provided an apparatus for predisposing a web to fold along a predetermined line of said web comprising a male roll having a convex raised periphery and a female roll having a concave peripheral groove, said groove being substantially wider than said raised periphery, said male and female rolls being cooperatively mounted and adapted to engage said web therebetween and to roll along said predetermined line and to compress said web with about 10 to about 40 pounds force.

BRIEF DESCRIPTION OF THE DRAWINGS

Although the specification concludes with claims particularly pointing out and distinctly claiming the subject matter regarded as forming the present invention, it is believed the invention will be better understood from the following description taken in connection with the accompanying drawings in which:

FIG. **1** is a fragmentary perspective view of the prefolding apparatus of this invention.

FIGS. **2** and **3** are elevation views of the preferred configuration of the prefolding rolls.

FIG. **4** is an exaggerated edge view of the web emerging from the apparatus of FIG. **1.**

FIG. **5** is a fragmentary perspective view of the board and guide folding portion of the overall folding apparatus.

FIG. **6** is an end view of the web as it is folded by the apparatus of this invention.

FIG. **7** is a front elevation view of a preferred embodiment of the prefolding apparatus of this invention, partially cut away for clarity.

FIG. **8** is a fragmentary side elevation view of the apparatus of FIG. **7** as viewed along section line **8—8.**

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FOLDER

Referring now to the drawings, FIG. **5** shows the board and guide folder designated generally as **40.** Web W enters the folder **40** at the left of the drawing as a flat sheet and is discharged at the right in its folded configuration. Although many different fold patterns may be achieved by the apparatus of this invention, the description will be limited to achieving the fold pattern shown in FIG. **6**; and in particular to achieving this fold pattern on a web of materials comprising a disposable diaper such as that shown in U.S. Pat. No. Re. 26,151 issued Jan. 31, 1967 to R. C. Duncan et al. Briefly, this web is typically comprised of about 10 plies of creped tissue having an air dry basis weight of 7–9 pounds per ream of 3,000 square feet, before creping to reduce its length by 60%, sandwiched between a .001 inch thick sheet of polyethylene and a non-woven fabric web of 1.5–3 denier rayon with 20–35% thermoplastic binder and a basis weight of 15– 19 grams per square yard. A "fluff" batt of comminution pulp as described in U.S. Pat. No. 3,612,055, issued Oct. 12, 1971 to F. K. Mesek can be used in place of the creped paper. Such a web has a typical total thickness of 0.100–0.25 inches or more.

Web W is pulled through folder **40** by tension T applied to the web W by subsequent equipment, not shown, and is shown in fragments (for clarity of illustration) at various points along folder **40.** Initially the web W is flat and horizontal. Upon reaching the elevating board **41** the web W rises and its outer edges droop downwardly over the edges of elevating board **41** under

the force of gravity and the urging of guide rails **42***a* and **42***b*. As can be seen, elevating board **41** narrows from its initial width, which is preferably the same as the width of the web, to a final width C which is substantially equal to the width of the central portion of the folded structure as shown in FIG. **6.** The horizontal board **43***a* and the descending board **43***b* are also substantially equal to C in width.

The guide rails **42***a* and **42***b* proceed downwardly and inwardly from their point of initial contact with web W and at the discharge end of horizontal board **43***a* (i.e., the right end as shown in FIG. **5**) are directly below horizontal board **43***a* and beneath it by the distance I corresponding to the intermediate section I of the folded structure as shown in FIG. **6.**

In the direction of travel of web W along the descending board **43***b* the guide rails **42***a* and **42***b* converge at points adjacent the underside of descending board **43***b* and spaced inwardly from its edges by the distance I. Members **44***a* and **44***b* provide support and lateral rigidity to guides **42***a* and **42***b*, respectively.

Normally the tension T imparted to the entire width of the web W by the subsequent equipment (not shown) will be sufficient to cause the outer edges E of the web to rise into the desired position as shown. If for some reason, the web W does not rise as desired, the plow **45***a* (and a corresponding member on the other side, not shown) will urge it into the desired position. Plow **45***a* consists of a vertical member **46***a* which prevents inwardly movement of edge E of web W and supports lifting member **47***a* which urges web W upwardly toward the discharge plate **48***a*. Since plow **45***a* serves only to redirect the web W should it go astray, it is not necessary for the discharge plate **48***a* to be in close proximity to descending board **43***b* and the two are preferably spaced about one-half inch apart as shown so as to avoid binding problems.

As mentioned previously, the board and guide folding apparatus **40** has previously served as the only means for folding a web W which is later cut into individual lengths to form disposable diapers. Tracking has been a continual problem with this arrangement, however, since there is no assurance that web W will remain centered on the folding apparatus **40.** Moreover, any misalignment tends to perpetuate itself rather than correct itself.

PREFOLDER

The prefolding apparatus shown in the fragmentary perspective view of FIG. **1,** and designated generally as **10,** located at any point upstream of the folding apparatus **40** (in the direction of web travel), has dramatically improved the tracking of web W on the folding apparatus **40.** The prefolding apparatus **10** uses mated pairs of rolls consisting of male rolls **11** and female rolls **12** to flex the web W as it passes between the mated rolls. The preferred geometry of the rolls is shown in more detail in FIGS. **2** and **3.** Each pair of rolls (*a*, *b*, *c*, and *d*) flexes the web W along predetermined lines and the result of this flexing is shown, greatly exaggerated for clarity, in FIG. **4.**

The web W of FIG. **4** is shown as it would appear emerging from the prefolding apparatus **10** of FIG. **1**; i.e., looking into the arrow **50** of FIG. **1** showing the direction of movement of the web W through the prefolding apparatus **10.** The ridges shown in FIG. **4** from left to right are formed by rolls **11***a* and **12***a*, **11***b* and **12***b*, **11***c* and **12***c*, **11***d* and **12***d* respectively. The arrows on FIG. **4** show the direction in which each portion of the web is predisposed to fold as a result of passing the prefolding apparatus **10.**

Returning to FIG. **1,** all of the rolls **11** and **12** are preferably driven in synchronism by a mechanism which will be described in connection with FIGS. **7** and **8** which show the complete assembly of the preformer **10.** Male rolls **11***a* and **11***d* are mounted on fixed rotatable shaft **13***a* and female rolls **12***b* and **12***c* are similarly mounted on fixed rotatable shaft **13***b*. Female rolls **12***a* and **12***d* which mate with male rolls **11***a* and **11***d* respectively are mounted on floating rotatable shaft **14***a*. Male rolls **11***b* and **11***c* which mate with female rolls **12***b* and **12***c* respectively are mounted on floating rotatable shaft **14***b*.

Floating rotating shafts **14***a* and **14***b* are similarly mounted, although the only mounting shown is a portion of that for shaft **14***b*. Air cylinder **18***a* is used to provide a constant upward force on shaft **14***b* via pin **17***a*, pivot linkage **16***a*, bearing block **19***a* and bearing **20.** Pivot linkage **16***a* rotates about fixed shaft **15***a*. Similar piston and linkage assemblies are used to provide constant upward force on each end of each of the floating rotatable shafts **14***a* and **14***b*.

To predispose the web of diaper material to folding on the folding apparatus **40,** the web is compressed to a point just short of embossing as will be discussed later. This can be accomplished by having a suitably adjusted fixed spacing between the male and female roll of a pair or by use of a constant force moving the male and female rolls of a pair toward one another. If the constant force approach is used, each of the four pairs of rolls should be urged together with a force of from about 10 to about 40 pounds. The use of constant force between the pairs of mating rolls is superior to the use of constant spacing between the rolls in many applications as it provides automatic adjustment for variations in web thickness. This is especially important when folding disposable diapers as they are comprised of a plurality of layers of creped paper, each layer being provide by a separate stock roll. Rolls of creped paper stock are continually being exhausted and new ones added, consequently the exact number of layers, and hence the web thickness, is continually varying. Each of the four air cylinders must therefore exert 10 to 40 pounds upward force plus whatever is required to overcome the force of gravity on the shaft, gears, rolls, bearings, etc. which it is lifting. Each of the male rolls **11** preferably has a diameter A of about 4½ inches with a width B of .188 inches and a semicircular periphery of .188 inches diameter. The female roll **12** preferably has a diameter C of about 4¾ inches and a width D of about one-half inch. The segment shaped groove in its periphery, as shown in FIG. **3,** has a radius E of 0.218 inches with an offset F of 0.083 inches. The web contacting portions of the rolls (i.e., the outside diameter of the male roll and the inside diameter of the groove) should be the same diameter, thus allowing the peripheral speed of these portions to be matched to the web speed by simple gearing as will be shown later. The otherwise sharp corners circumferentially about the female roll **12** are machined to a 0.03 radius to minimize the potential for the web hanging-up on the edges and being pulled apart.

There is some tendency for the web to be drawn inwardly by the pairs of mating rolls; i.e., to be gathered

between two pairs of mating rolls. Because of this, when four pairs of mating rolls are being used as shown the web preferably first contacts the two outermost pairs of rolls. In this way, a small, but controlled, amount of excess material is gathered between these rolls to provide some "play" at the inner two pairs of rolls.

It should be noted that it is almost imperative to mount no more than two preforming rolls on each of the floating shafts as shown. This coupled with the floating mounting of each end of each floating shaft allows each pair of preforming rolls to adjust individually.

MACHINE DETAILS

FIGS. **7** and **8** show a complete machine, cut away in places for clarity, used to perform the prefolding steps described earlier with reference to the partial perspective view of FIG. **1.**

FIG. **7** is a front elevation of the prefolding apparatus **10.** The web (not shown) is moving toward the viewer. The male rolls **11***a*, 11*b*, 11*c*, and **11***d*, and female rolls **12***a*, 12*b*, **12***c* and **12***d* each has a split collar extension **35** to allow it to be secured to one of the shafts **13***a* and **13***b* and **14***a* and **14***b* as shown. Shafts **13***a* and **13***b* and **14***a* and **14***b* are supported in bearings **20** which in turn are supported by side plates **30***a* and **30***b*. The side plates **30***a* and **30***b* are supported on base plate **21** which also supports depending support members **22***a* and **22***b*. Depending support members **22***a* and **22***b* hold the piston support plate **23** which in turn supports piston mounting yokes **28***a*, 28*b*, 28*c* and **28***d* to provide a pivoted mounting for air cylinders **18***a*, **18***b*, 18*c* and **18***d* respectively via piston mounting brackets **29***a*, 29*b*, 29*c* and **29***d* respectively.

The drive mechanism will be described subsequently with reference to FIG. **8,** however it should be noted with reference to FIG. **7** that the floating rotatable shafts **14***a* and **14***b* are driven by gears **31***a* and **31***b* respectively. As was stated earlier, the upward force exerted by the air cylinders **18** preferably equals the weight of the rolls, shafts, etc. plus about 10 to about 40 pounds. To simplify adjustment of the upward forces exerted by each air cylinder **18** counterweights **32***a* and **32***b* are provided. By making the counterweights **32***a* and **32***b* exactly like gears **31***a* and **31***b* respectively and by locating them symmetrically with respect to said gears, the air cylinders **18** may more easily be adjusted as desired.

FIG. **8** is a side elevation of the prefolding apparatus **10** taken along section line **8—8** of FIG. **7.** Gears **31***a*, **31***b*, 31*c*, 31*d*, 31*e* and **31***f* provide the requisite synchronization of the pairs of mated rolls. Sprocket **33***a* is driven by chain **34** and a suitable drive means (not shown). Chain **34** also drives sprocket **33***b* which is connected to conveyor belt roll **37.** The interconnection of the preformer **10** with the preceding conveyor belt **38** via conveyor belt roll **37,** sprockets **33***a* and **33***b*, and chain **34** allows the preformer **10** to be synchronized with the web speed on the preceding equipment as exemplified by conveyor belt **38.**

Sprocket **33***a* drives shaft **13***a*, and thereby male rolls **11***a* and **11***d*, and gear **31***d* which is also mounted on shaft **13***a*. Gear **31***d* engages gear **31***a*, thereby driving shaft **14***a* and the female rolls **12***a* and **12***d*, and gear **31***f*, thereby driving the overhung shaft **39** and gear **31***e*. The overhung shaft **39** is supported by bearing **20'** specifically suited to the overhung load and retained by shaft retainer **39.** Gear **31***e* drives gear **31***c*, thereby driving shaft **31***b* and female rolls **12***b* and **12***c*. Gear **31***c* in turn drives gear **31***b*, thereby driving shaft **14***b* and male rolls **11***b* and **11***c*.

Pivot shafts **15***a* and **15***b* are mounted between side plates **30***a* and **30***b*. Connected to pivot shaft **15***a* is pivot linkage **16***a* and **16***d* (not shown) and connected to pivot shaft **15***b* is pivot linkage **16***b* (partially shown in FIG. **8**) and **16***c* (not shown). The function of each pivot linkage **16** and the associated parts is identical; for simplicity only pivot linkage **16***a* will be described. Pivot linkage **16***a* is pivotally mounted to both pivot shaft **15***a* and, via pivot pin **17***a*, to air cylinder **18***a*. Bearing block **19***a* rests on pivot linkage **16***a* and contains bearing **20** which in turn supports one end of floating shaft **14***b*. Thus air cylinder **18***a* provides upward support for and pressure on male roll **11***b*. Pivot linkage **16***a* is tapped to accommodate stop bolt **26***b* which is held in place by lock nut **27***b*. Stop bolt **26***b* is adjusted such that, in the absence of a web, the male roll **11***b* cannot be driven against the female roll **12***b* because of the stop **24***b* which is supported by member **25***b*. Member **25***b* is in turn supported from base plate **21.**

Work table **36** is supported from side plates **30***a* and **30***b* and serves to support the web W and guide it into the nip of the mating rolls.

ROLL GEOMETRY CONSIDERATIONS

FIGS. **2** and **3** show the male roll **11** and the female roll **12** respectively in the preferred configuration for prefolding the web of a disposable diaper.

While applicant does not wish to be bound by a description of the mechanisms involved in the prefolding step described, it is believed that the prefolding step has the effect of loosening the fibrous bonds transverse of the lines of ultimate fold without materially weakening the web, thereby facilitating folding along these lines.

More specifically, two mechanisms are thought to be involved. First is the bending of the web around the male roll which is a comparatively gentle and distributed action. Second is application of a relatively high force along a narrow line where the male and female rolls meet. To separate these effects, the male roll has a smaller radius protrusion than the radius of the groove in the female. This provides a narrow line of greatest proximity thus providing a narrow line of application of the high force.

The width B of the male roll largely determines the sharpness of the ultimate fold; the narrower the roll the sharper the fold. The female roll is chosen based on the width of the male roll and the thickness of the web. In the application described above the width B of male roll is about 1.7 times the thickness of the web being prefolded and the width G of the groove in the female roll is such that there is essentially no compression of the web in the region between the sides of the male roll and the essentially vertical walls of the arcuate groove in the female roll (i.e., $G = B + 2X$ web thickness). Thus, the periphery of the male roll meets the base of the groove in the female roll along a narrow line to compress the web. Beyond the narrow line of compression, the groove in the female roll provides a means to wrap the web around the semicircular periphery of the male roll.

With the above mentioned geometries, materials, and forces, the web is compressed to a minimum thickness of about 0.004 to about 0.008 inches and it springs back after passing through the prefolder to essentially its initial thickness of about 0.100–0.250 inches. This same web could be embossed by compression with much higher pressures to about .001 to .003 inches thickness at which point it would have very limited spring back.

It can be appreciated that, while the preferred geometry for the rolls of the prefolding apparatus utilizes a male roll having an arcuate convex raised periphery and a female roll having a concave arcuate peripheral groove as described above, other roll shapes selected with the above considerations could perform satisfactorily. For example the male roll could have a "V" shaped edge portion and the female groove could be rectangular with a "V" or truncated "V" shaped bottom.

Many modifications of the invention can be made and it is not intended to limit the invention to the particular structures described, all reasonable equivalents thereof being intended to fall within the scope of this invention.

What is claimed is:

1. An apparatus for predisposing a moving web of disposable diaper material or the like having an initial thickness, prior to compression, of from about 0.100 to about 0.250 inches to fold along at least one predetermined fold line, said apparatus comprising:

a. a male roll having an arcuate convex raised periphery, said arcuate convex raised periphery having a minimum width approximately 1.7 times greater than the thickness of said web prior to compression;

b. a mating female roll having an arcuate concave peripheral groove, said groove having a minimum width approximately equal to the sum of the width of said arcuate convex raised periphery plus twice the thickness of said web prior to compression;

c. means for engaging said web between said mating rolls so that the axis of rotation of each of said rolls is perpendicularly aligned to the direction of movement of said web; and

d. means for urging said mating rolls together against said web to compress said web to a minimum thickness of between about 0.004 inches and about 0.008 inches while said web is engaged between said rolls, thereby flexing and pressing said web in the area of said web between said rolls.

2. The apparatus of claim **1,** wherein said means for urging said mating rolls together against said web is comprised of a constant force generating mechanism.

3. The apparatus of claim **1,** wherein said means for urging said mating rolls together against said web is comprised of a fixed gap spacing between said rolls, said fixed gap spacing being between about 0.004 inches and about 0.008 inches, as measured between said mating rolls at the highest point on said raised convex periphery and the lowest point on said concave peripheral groove.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,917,254
DATED : November 4, 1975
INVENTOR(S) : Howard N. Watrous

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 42, "provide" should read -- provided --.

Column 6, line 2, "39" should read -- 39' --.

Signed and Sealed this

Sixteenth Day of November 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks