United States Patent [19]

Imaizjmi et al.

[11] **3,873,082**

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[54] **SYNTHETIC PAPER FOLDING DEVICE**

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[73] Assignee: **Kabushiki Kaisha Oji Yuka Goseiski Kenkyusho**

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[21] Appl. No.: **317,534**

[30] **Foreign Application Priority Data**

Dec. 25, 1971 Japan 47-1810

[52] **U.S. Cl.** ..... **270/68 A**

[51] **Int. Cl.** **B65h 45/14**

[58] **Field of Search** ..... 270/68, 68 A, 61; 93/DIG. 1; 425/384; 223/51; 72/176, 200

[56] **References Cited**

UNITED STATES PATENTS

1,961,000	5/1934	Kleinschmit et al.	270/68 R
2,015,445	9/1935	Bierer et al.	425/384
2,080,505	5/1937	Rader	270/68 R
3,577,665	5/1971	Kamberg	270/66
3,602,944	9/1971	Szabo et al.	425/384

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Assistant Examiner—A. J. Heinz
Attorney, Agent, or Firm—Martin Smolowitz

[57] **ABSTRACT**

A paper folding apparatus for use with a supply of synthetic paper, making use of an array of rollers disposed in proximity to such supply. The rollers are in communication with one another to form a series of corresponding roller nips for pressing and guiding the paper in a predetermined manner to impart folds thereon. A plurality of paper turn-up passages disposed in alternate offset relation with respect to said roller nips receive the paper prior to its travel to the next respective nip. Heating means, i.e., electric coil, etc. are disposed in proximity to the underside of the folding rollers in order to heat such rollers during the folding operation. A conveyor belt receives the folded paper and transfers such paper to a pair of rollers where a suitable knife blade cuts the paper to size. Heating means disposed beneath such pair of rollers also provide a source of heat for the rollers as the blade acts upon the paper.

5 Claims, 8 Drawing Figures

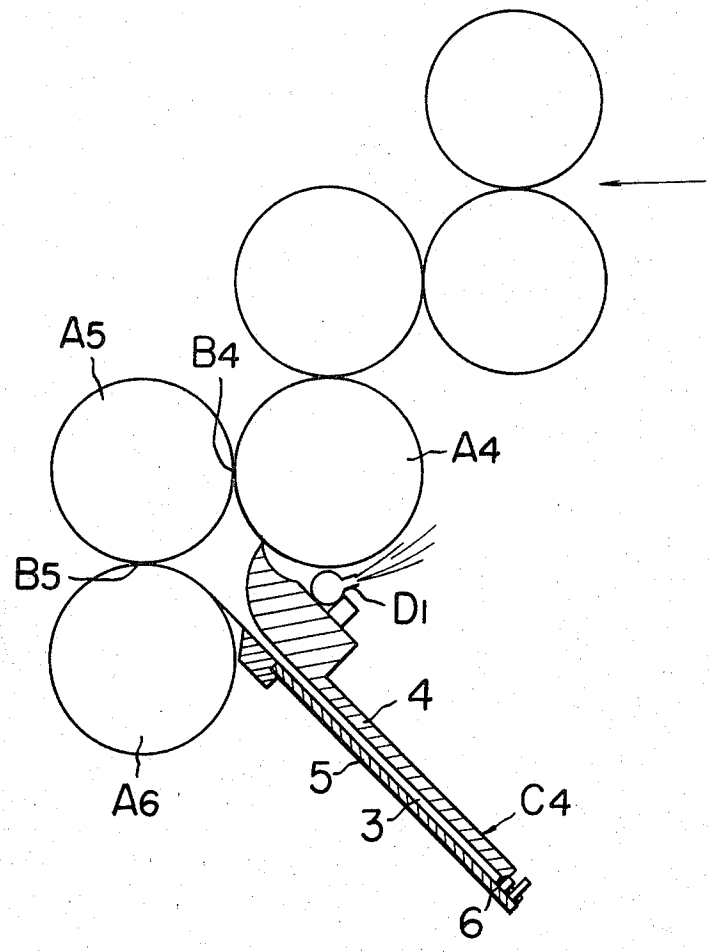


FIG. 1(a)

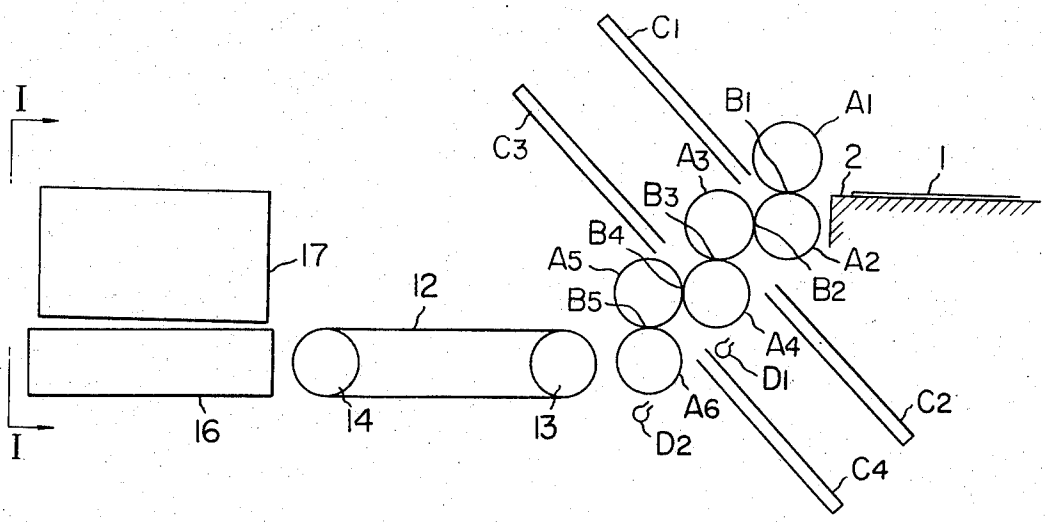


FIG. 1(b)

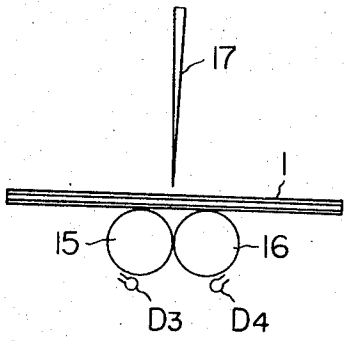


FIG. 4

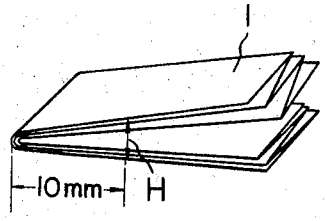


FIG. 2

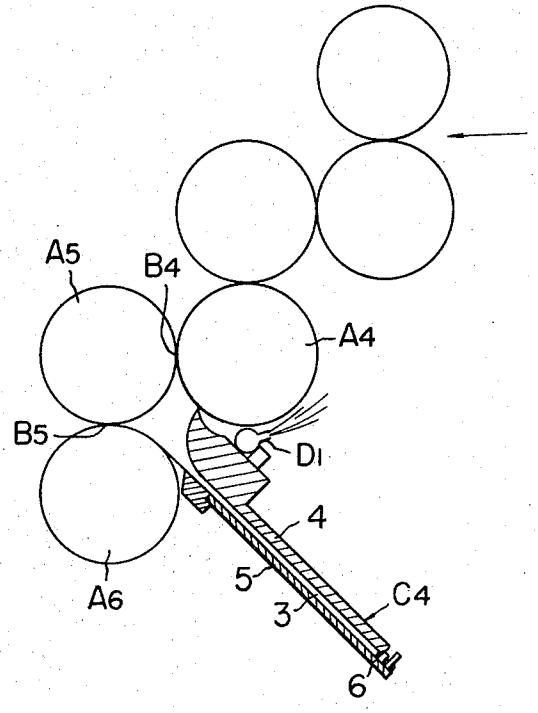


FIG. 3(a)

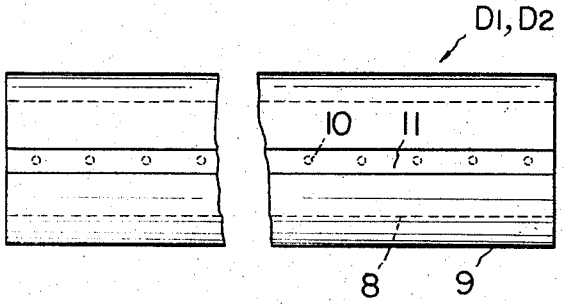


FIG. 3(b)

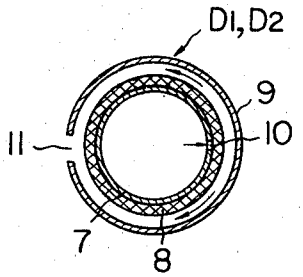


FIG. 5

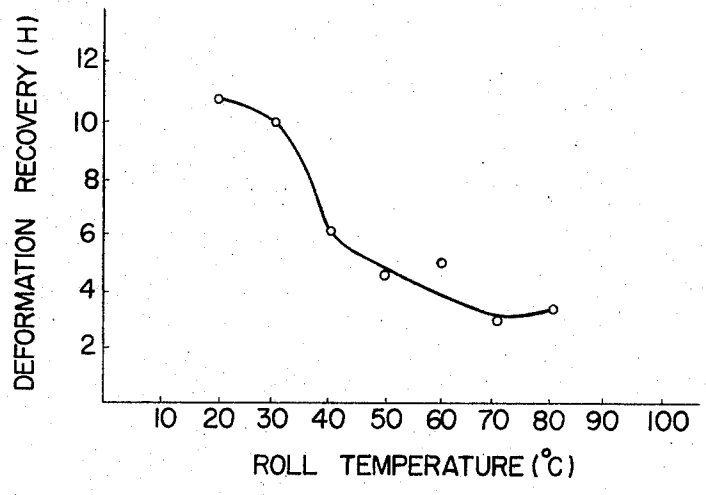
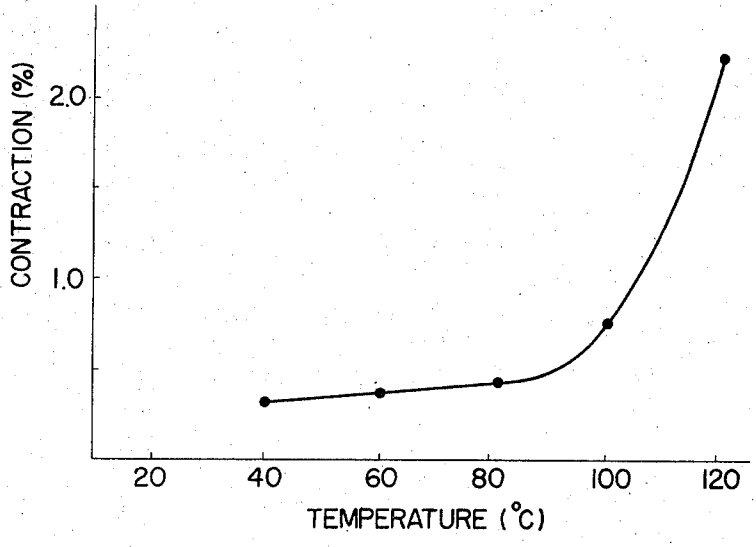

DEFORMATION RECOVERY (H)
12
10
8
6
4
2
10 20 30 40 50 60 70 80 90 100
ROLL TEMPERATURE (°C)

FIG. 6


CONTRACTION (%)
2.0
1.0
20 40 60 80 100 120
TEMPERATURE (°C)

SYNTHETIC PAPER FOLDING DEVICE

The present invention is directed to an apparatus suitable for use in the folding of synthetic paper. More particularly, the present invention relates to an apparatus adapted to fold synthetic paper of the type which will be more fully described hereinafter, in a manner such that the tendency of the paper as folded exhibits physical characteristics similar to that normally found in natural paper.

By way of background, it has recently been found that synthetic paper has been developed, that is material made from stretched plastic resin film such as: polyolphin (single component or mixture of homo or copolymer) polypropylene, polyethylene, polybutane, etc., which exhibits physical properties similar to natural paper, i.e., retaining printed or written matter thereon. Empirical methods and testing have indicated that such synthetic papers manifest a high resistance against folding, with the result that such synthetic paper does not lend itself in the manufacture of such articles as books, bags, maps to be folded, etc. Presently available conventional folding machines which are employed in the manufacture of these articles with natural paper have not worked out well with synthetic paper. For an example, if the synthetic papers of the type mentioned above are to be folded by conventional folding machines, the deformation recovery of any fold is quite great, and in the event that a plurality of folding operations are to be performed continuously as within the manufacture of a book or a folded map, the fold deformation of preceding folds tends to recover so that the article is not in its proper form for further travel in the manufacturing operation. As a result, the article cannot be smoothly fed from one sequence into the next. Furthermore, problems arise in maintaining proper folds in order to assure that subsequent folds are in proper registration. Another problem that has been found is the tendency of such synthetic folded papers to expand from their intended shape by the recovery of folding deformation. Once this occurs, any stacking or wrapping process is disturbed and the paper is no longer within the parameters of the manufacturing operation.

On the other hand, if pressure between the paper folding rolls increases, the position of the folding line tends to remain within its predetermined position, and fold recovery and alignment is consequently improved. However, once this pressure increases beyond a predetermined amount, a rupture of the paper can occur or the printed matter on such synthetic paper will tend to come off; an obvious result is that it is difficult to fold such synthetic papers to the same degree as with natural papers. This problem is further compounded as the number of steps in the folding operation are increased, since there is a direct relationship between the number of folds on such synthetic paper and the difficulty in maintaining the fold in place.

A principal feature of the present invention is provided with a synthetic paper folding machine for use with a supply of synthetic paper, including: a series of alternately disposed folding rollers in cooperative relation with respect to one another, said rollers forming an array where mutually associated rollers form paper contact nips with respect to each other; said rollers being disposed in proximity to a passage provided for said paper to enter into said series of folding rollers;

one of more paper fold-directing means in offset relation with respect to said nips of said rollers; and heating means for heating said folding rollers to a predetermined temperature.

Also within the scope of the present invention is a fold-directing means having a turned up portion extending away from about the nip of the respective folding rollers at an off-setting angle, wherein such means urges said paper passing therethrough from said nips to be formed by folding and returned to the next set of roller nips.

Accordingly, it is the main object of the present invention to provide an apparatus adapted to overcome the defects of the prior art.

Still another object of the present invention is to provide an apparatus for folding synthetic paper free of any defects after such folding operation.

Still another object of the present invention is to provide a synthetic paper folding apparatus which employs a heated folding roller yielding a folded synthetic paper exhibiting the characteristics of that of natural paper.

A further object of the present invention is to provide a synthetic paper folding apparatus which is able to perfectly execute a multitude of paper folds suitable for use in the manufacture of articles requiring numerous folds.

Still another object of the present invention is to provide a synthetic paper folding device effective for multi-step folding.

The aforementioned objects will be best understood with respect to the specification, claims and accompanying drawings.

FIG. 1*a* is a side view illustrating the present invention.

FIG. 1*b* is an end elevation along a line I—I shown in FIG. 1.

FIG. 2 is an enlarged side elevation of the turned-up portion of the present invention.

FIG. 3 is a front elevation of a heated air nozzle of the present invention.

FIG. 3*b* is a cross-section of the heated air nozzle of FIG. 3*a*.

FIG. 4 is a perspective elevation of the folded paper.

FIG. 5 is a graphical representation showing the relation of roll temperature and deformation recovery.

FIG. 6 is a graphical representation of roll temperature and contraction of synthetic paper.

FIG. 1 shows a side view of one embodiment of the present invention. In accordance with the operation of the present invention, the paper 1 enters through a supply passage 2 into a sequence of cooperating rollers A_1, A_2, A_3, A_4, and A_6, where such rollers are disposed in cooperating relationship and in communication with one another. For an example, the even numbered rollers such as A_2, A_4, A_6, are each disposed to communicate with two adjacent rollers; one in front and one to the rear, i.e., roller A_2 communicates with roller A_3 and A_1; roller A_4 communicates with roller A_3 and A_5 and roller A_6 communicates only with roller A_5. The points or nips at which the even-numbered rollers communicate with the odd numbered rollers have been identified with the indication B. Therefore, A_2 roller communicates with A_1 at point B_1 and with roller A_3 at point B_2; A_4 roller communicates with roller A_3 at nip B_3 and with A_5 roller at nip B_4. Lastly, the A_6 roller communicates with roller A_5 at point B_5. The rollers A_1 through A_6 are adjustable by suitable means such as by spring

means (not shown). The rollers A_1 through A_6 are intended to rotate in counter-direction with respect to each other so as to engage and urge the paper **1** to travel in a select course of travel where folds on paper **1** are completed in, for example, four steps. An alternating array of turned-up passages or buckles iddentified as C_1, C_2, C_3, C_4 are provided at an angle (slanting) with respect to the previously identified nips B_1, B_2, B_3, B_4, B_5. More specifically, this array of buckles or passages are offset with respect to the roller nips and extend alternately to the left and to the right of the indicated points B_1 through B_5. For an example, the buckle C_1 extends in a slanting direction from the upper direction of contacting points B_1, B_2; buckle C_2 for example, extends from the rear or the lower portions of contacts of B_2, B_3 and so on for the remainder of the buckles, C_3 C_4, etc.

FIG. **2** shows an enlarged side elevation of the turned-up passage or buckle C_4. This configuration comprises a pair of upper grid frames **4** and lower frames **5** which oppose one another through a nominal clearance **3** which corresponds to the thickness of the folded paper **1.** The leading part of the upper frame **4** forms a smooth curved surface so as to guide the paper **1** from the nip B_4 and the upper face of the lower frame **5** extends to the direction of the tangent under roll A_6 of the nip B_5. At the lower end of the clearance **3,** stopper **6** is provided which is intended for adjustment corresponding to the length of the folding paper. The other buckles or turned up passages C_1, C_2, C_3, are of similar construction to that shown in FIG. **2.**

Disposed beneath the folding rollers A2 and A4 are thin tubes D_1, D_2, which eject heated air to the folding rollers A_4, A_6. As shown in FIGS. *3a* and *3b* the thin tube comprises an inner pipe **7,** a coil heater **8,** wound on the outer face of the inner pipe **7** and an outer pipe **9.** The inner pipe **7** is communication with an air compressor of a conventional type (not shown) and includes nozzles **10** disposed in one direction and with corresponding nozzles **11** oriented in a direction opposite to that of nozzles **10** disposed on outer pipe **9.** The outer pipe **9** is closed at both ends and is adjustable, by rotating about its axis for proper positioning, so that nozzles **11** can be positioned to eject heated air in the direction of rotation of the folding roller A_4, A_6. In so doing, the heated air does not in any way interfere to adversely affect the movement of the paper through the rollers. More particularly, the position of the thin tube D_1, $D_2$is selected to most advantageously provide for efficient movement of the folded paper and to provide heat to the roller. In the case where a buckle or turned-up passage type of folding machine is employed, it is desirable to dispose the tube D_1, D_2 under the folding roller so as to provide for effective heating and to thereby permit ease modification of the apparatus in the event additional folding steps are required. The direction of the stream of air heating the rollers must be the same as that of the folding roller. At the outset of the folding operation, the paper is usually pressed several times and by subsequent treatment via rollers, the fold is made firm. In such subsequent steps, the latter folding requires a lesser amount of pressing; however, it follows that the resultant folds are not very satisfactory. In an endeavor to overcome the aforementioned problem, it has been found desirable to provide heat underneath such folding rollers.

A conveyor belt **12** disposed in front of the last in the series of contact edges or nips, namely B_5 is governed by a pair of rollers **13, 14,** such belt **12** conveys the folded paper in the longitudinal direction to a pair of folding rollers **15, 16** which are disposed in the line of travel of such conveyor belt **12.** A paper folding blade in the form of a knife **17** is provided above the nip formed by the rollers **15, 16** and is adapted to adjustably be positioned upwardly and downwardly with respect thereto. Furthermore, thin tubes D_3, D_4 disposed beneath rollers **15, 16** eject heated air to the folds of the paper **1** with a high level of heat emmission; to achieve this, ejected air from the thin tube D_3, D_4 travels in a direction consistent with a rotation of rollers **15, 16.**

By way of further explanation, the apparatus of the instant invention is intended to operate as follows:

Air is supplied to the inner pipe **7** by a compressor and such air is urged to pass through nozzles **10** to the space between the inner pipe **7** and the outer pipe **9,** and is then heated by the heating coil wire **8;** thereafter, the heated air is ejected from the nozzle **11** and impinges upon the rollers A_4, A_6 to heat them, as well as the synthetic paper **1** as such paper travels therethrough. The temperature of the rollers A_4, A_6 is regulated to a level in order to maintain it below that point where the synthetic paper can deform and contract. The synthetic paper **1** is cut to a predetermined length and passes from the supply passage **2** to contacting nip B_1 which is that point between folding rollers A_1, A_2 and in turn enters and travels up the buckle C_1. Subsequently, the end of paper **1** contacts a stop portion **6** on C_1 and then the paper is urged to bend and travel toward the nip B_2 and is retained in the nip B_2 between the folding roller A_2, A_3 such that the paper is folded. Then the folded paper in turn is urged to travel and enter into the next turned up passage or buckle C_2 and contacts a stop portion **6** on the buckle C_2. Next, the paper begins to bend and travels toward the nip B_3 between rollers A_3, A_4 and is in turn folded again. As hereinbefore explained, the paper is folded successively by passing contacting points or nips $B_1 \ldots B_5$ for example, at least four times, and is then in turn urged to travel onto the conveyor belt **12** from whence the folded paper rides on rollers **15, 16.** The cutting blade **17** is urged to descend and makes an appropriate cut, and the paper is then folded in a longitudinal direction as shown in FIG. **4.** At this moment, the folding rollers A_4, A_6 are heated and the paper **1** is heated at the nips B_4, B_5. In this connection, the folded portions of the paper thus exhibit a lower Young modulus and in turn exhibits the properties of: readily achieving plastic deformation, minimization for deformation to recover, and a tendency on the part of the synthetic paper to remain in its folded state.

In the aforementioned arrangement, the nozzle which is ejecting heated air for heating the folding rollers can include: heating means such as electronic heating wire, steam ducts or other suitable means. Furthermore, it is also within the contemplation of the present invention to employ an infra-red lamps or other heating means instead of a nozzle arrangement as described above.

By way of example, the following are illustrations of the operation of the instant invention.

EXAMPLE I

A folding machine of the type hereinbefore described was constructed in a manner to fold the synthetic paper in four stages or steps as was provided with thin tubes of the type identified as D_1, D_2 which were 16 mm in diameter and provided with an array of spaced nozzles 4 mm in diameter disposed under the folding rollers A_4, A_6. Heated air at a temperature of 150° C was ejected from nozzles in the direction identical to that of the direction of the rollers A_4, A_6 and the heated roller **15, 16**. The pressure at the nips B_1B_2 was set at 0.7 kg/cm and the rotating velocity of the folding roller A_1, A_2 was 900 rpm. The paper being folded in the machine was a synthetic paper of a polypropylene with a thickness of 110μ and a weight of 88 gr/m^2. The results were most satisfactory; the synthetic paper folded to the same degree of responsiveness as the folds in natural paper and the folds maintained their position at a predetermined point in a precise manner.

EXAMPLE II

Utilizing the same machine as indicated above, the temperature and volume of the heated air were adjusted and the temperature of the heated folding rollers A_4, A_6 was adjusted to vary from 20° C to 90° C. Furthermore, the data reflects the ease in gathering and arranging 25 sheets of folded synthetic paper. (0 = good; Δ = less than good; X = bad). The results are tabulated in Table A hereinbelow.

TABLE A

Roller Temperature	Yield Rate	Operation
20° C	35%	X
30° C	40%	X
35° C	86%	Δ
50° C	98%	Δ
60° C	98%	0
70° C	97%	0
80° C	97%	0
90° C	55%	X

From the Table it is apparent that if the temperature of the folded roller is set at from 35° to 80° C, the yield rate and the overall gathering and wrapping operation are as good as with natural paper.

EXAMPLE III

A further test utilizing the same machine as above, had the synthetic paper folded under a roller pressure of 0.5 kg/cm. at various roller temperatures. Deformation recovery of the fold was measured (the term deformation recovery, that is the height, H at 10 cm. from the fold after a period of 30 seconds after the folding operation) and is shown in FIG. **4**. The relationship between roller temperature and deformation is shown in FIG. **5** and roller temperature and contraction is shown in FIG. **6**. It is apparent from the graphs in FIGS. **5** and **6** that the deformation recovery is quite substantial under 30° C. However, if the roller temperature is above 90° C deformation recovery is less, but contraction is large.

In the aforementioned embodiment, the turned-up passages buckles C_1, C_2 were employed for deflecting the paper into the nips B_1, B_2 etc. However, instead of such buckles C_1, C_2 etc. it is possible to employ one or more folding blades disposed in parallelism with the axis of the rollers A_1, A_2 as a means for folding paper into such nips. In the same sense the invention can employ a pair of folding rollers **15, 16** in the paper supply passage at a point prior to the folding rollers A_1, A_2 instead of as mentioned above.

It will be understood that the foregoing relates only to a preferred embodiment of the invention and it is not intended to cover changes and modifications of the invention which do not represent a departure from the spirit and scope of the invention.

What is claimed is:

1. A synthetic paper folding apparatus for successively folding paper sheet material advancing through said apparatus, comprising: a buckle chute folder having a plurality of adjacent paper folding rollers forming corresponding nips at the respective interface surfaces of said rollers; alternately disposed buckle chutes and paper folding roller heating means disposed in proximity to said folding rollers, said roller heating means being provided with an inner cylindrical chamber having a series of nozzle passages disposed along its longitudinal axis, an outer generally cylindrical member surrounding said chamber thusly defining a channel therebetween, said outer member being further defined by an integrally formed elongated slot means, heating element means positioned within said channel for heating a heat transfer fluid being fed into said chamber from a source of supply, said outer cylindrical member being rotatable relative to said chamber for orientation of said elongated slot means with respect to adjacent roller undersurfaces to enable heated fluid travelling from said nozzle passages in said channel to exit through said elongated slot means and impinge tangentially upon said undersurfaces in the direction of roller rotation as folded paper is drawn through said nips.

2. An apparatus as claimed in claim **1** wherein: said elongated slot means being an integrally formed slotted nozzle disposed in the axial direction of said outer cylindrical member for directing a heat fluid stream out of said channel into said ambient atmosphere.

3. An apparatus as claimed in claim **1** wherein: said heating element means is an electrical heating element disposed about said inner cylindrical member.

4. An apparatus as claimed in claim **1**, wherein: said heat transfer medium supplied to said inner cylindrical chamber is pressurized air.

5. An apparatus as claimed in claim **1**, wherein: said paper folding rollers are heated to a temperature varying from 50° to 90° C.

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