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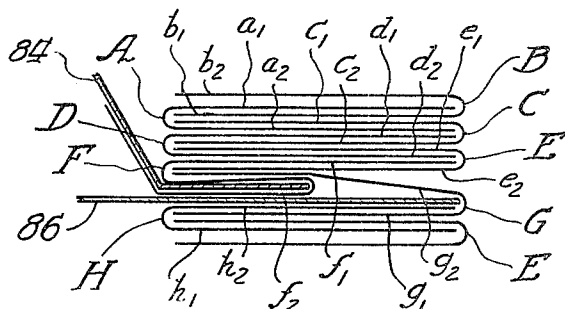
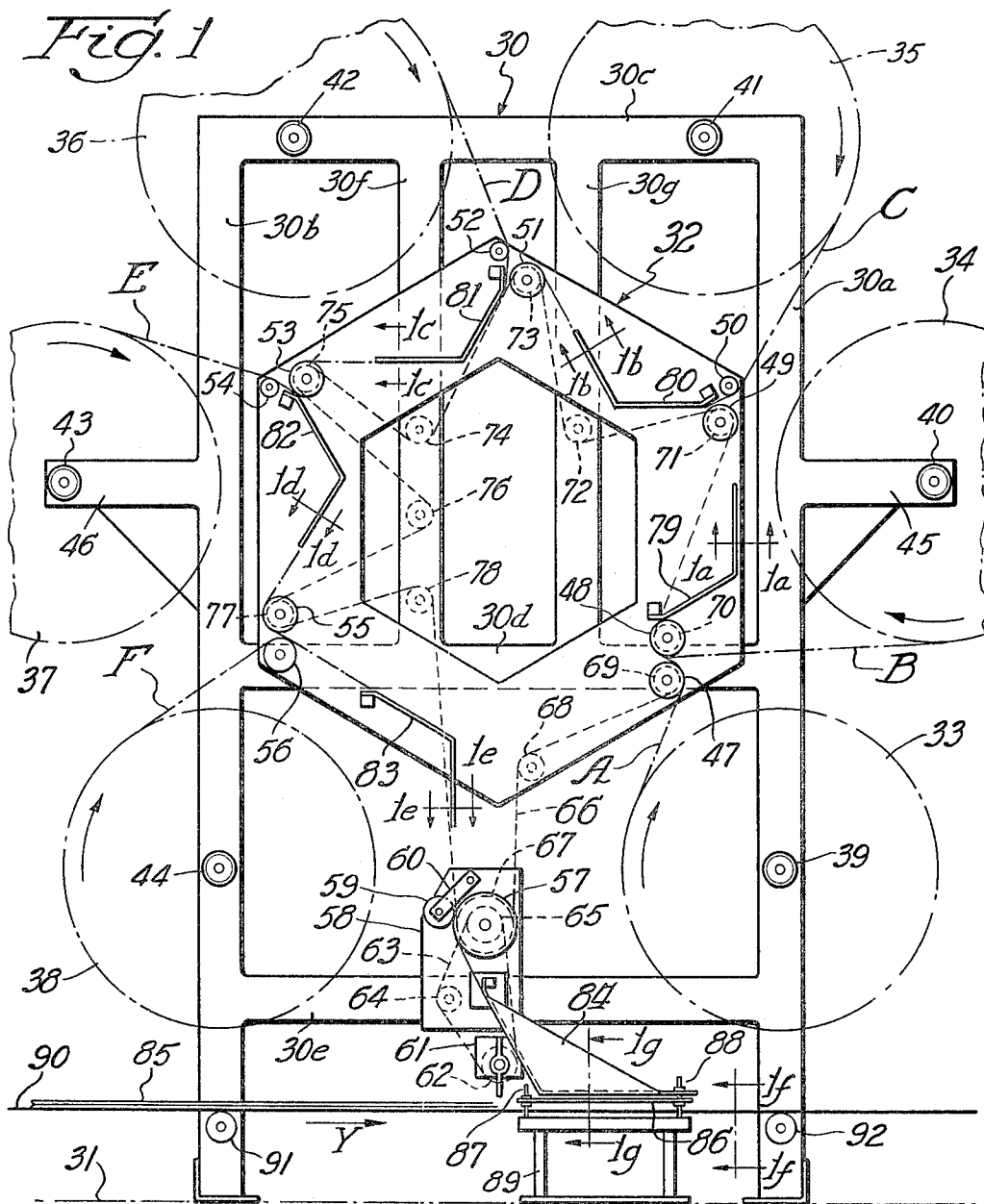
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WEB INTERFOLDING MACHINE

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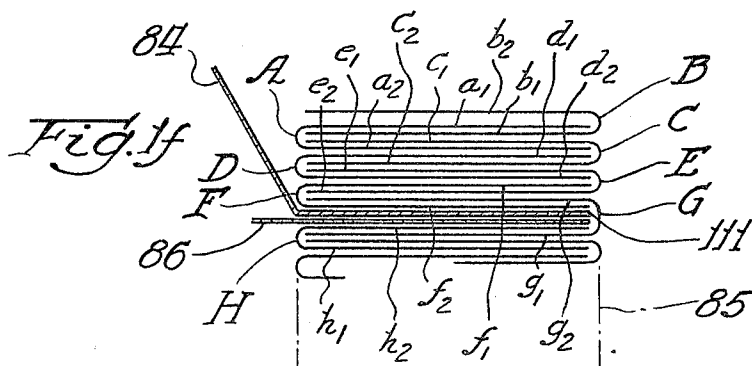
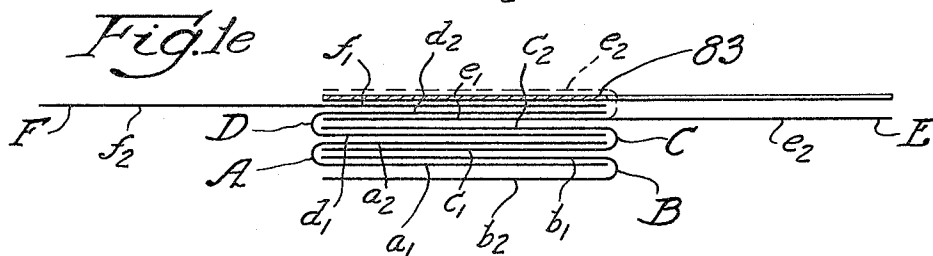
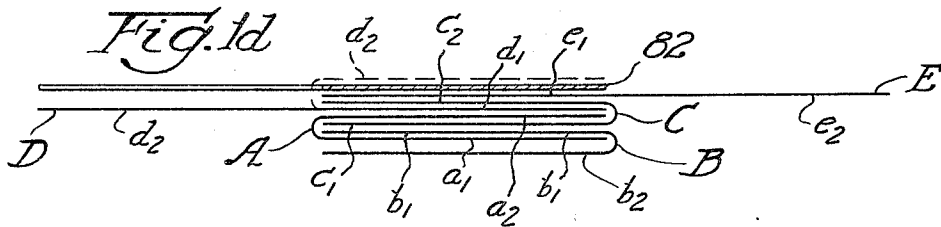
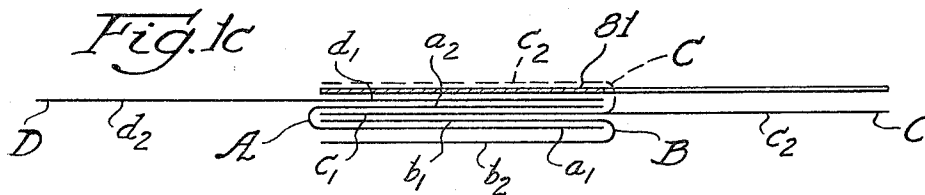
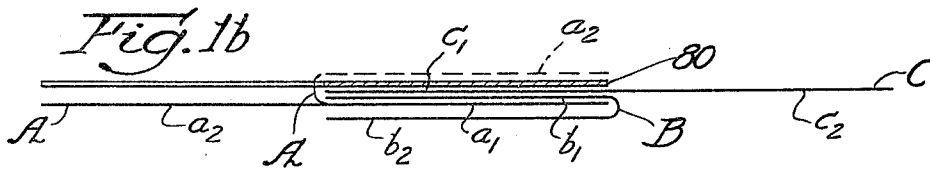
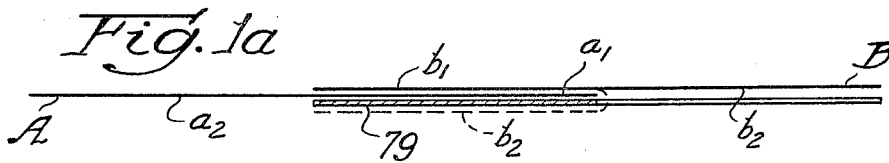
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*Fig. 2*

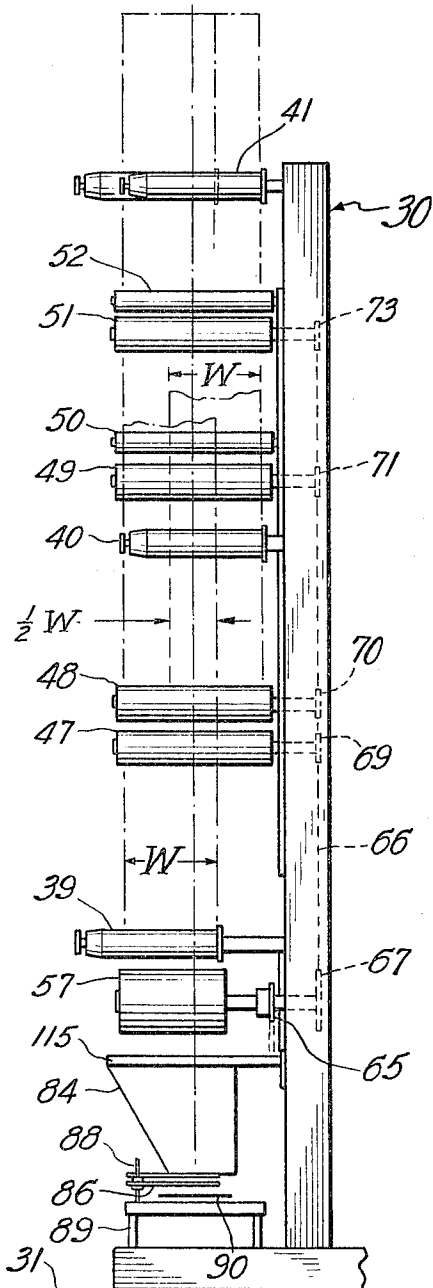
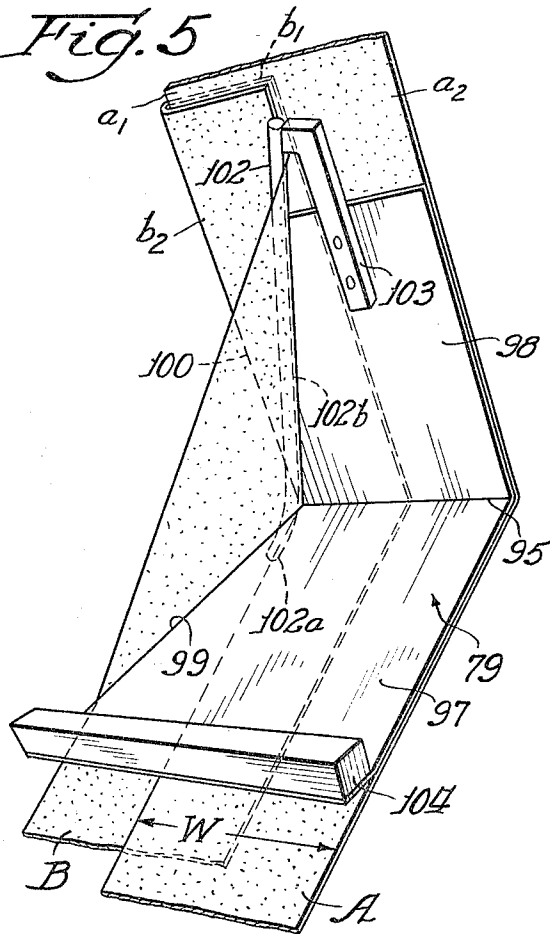
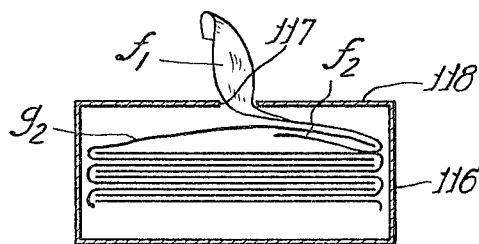


Fig. 5



*Fig. 11*



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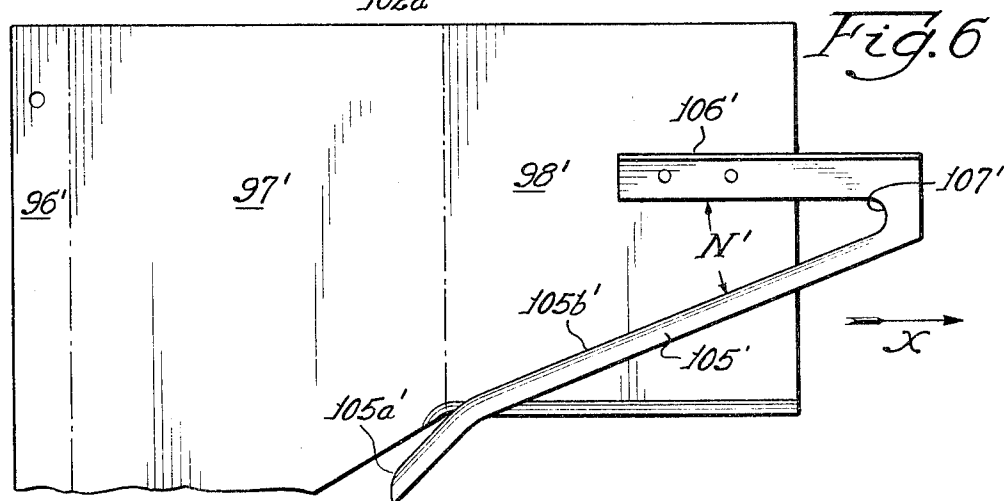
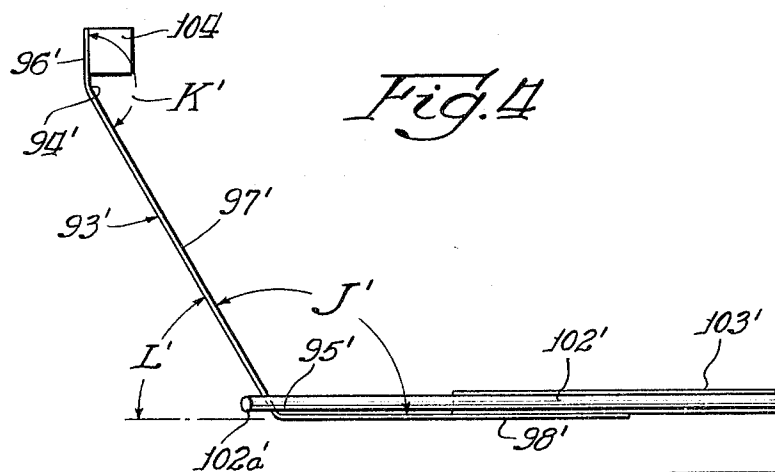
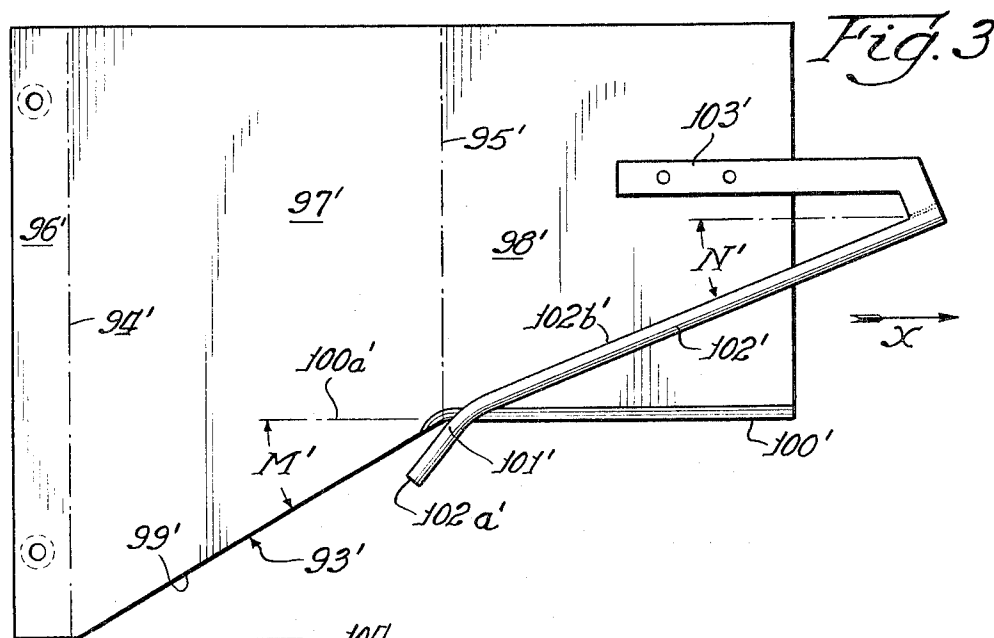
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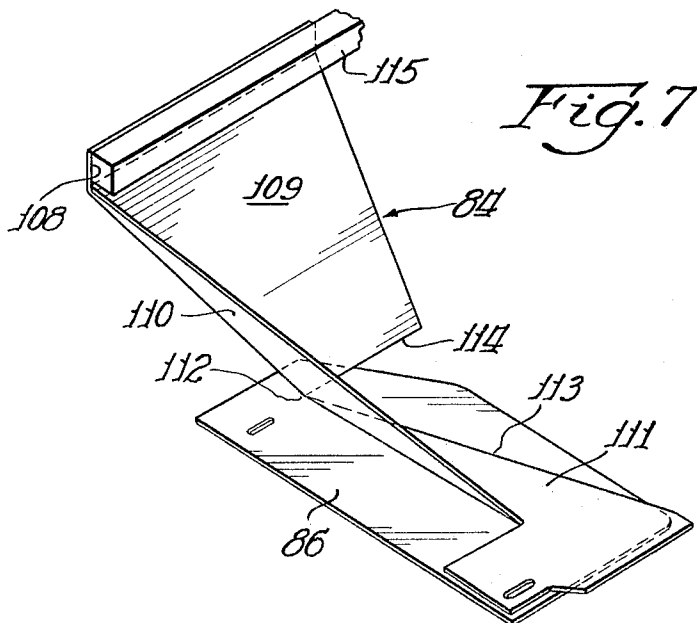


Fig. 7

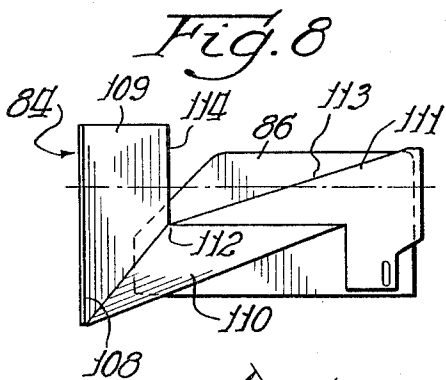


Fig. 8

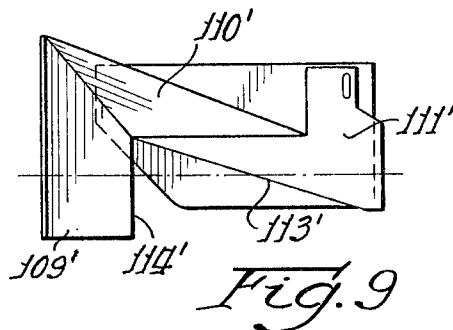


Fig. 9

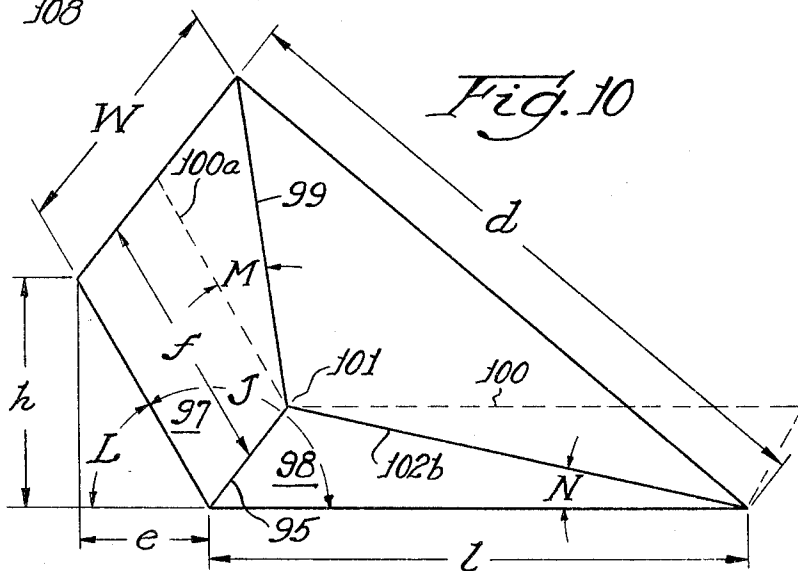


Fig. 10

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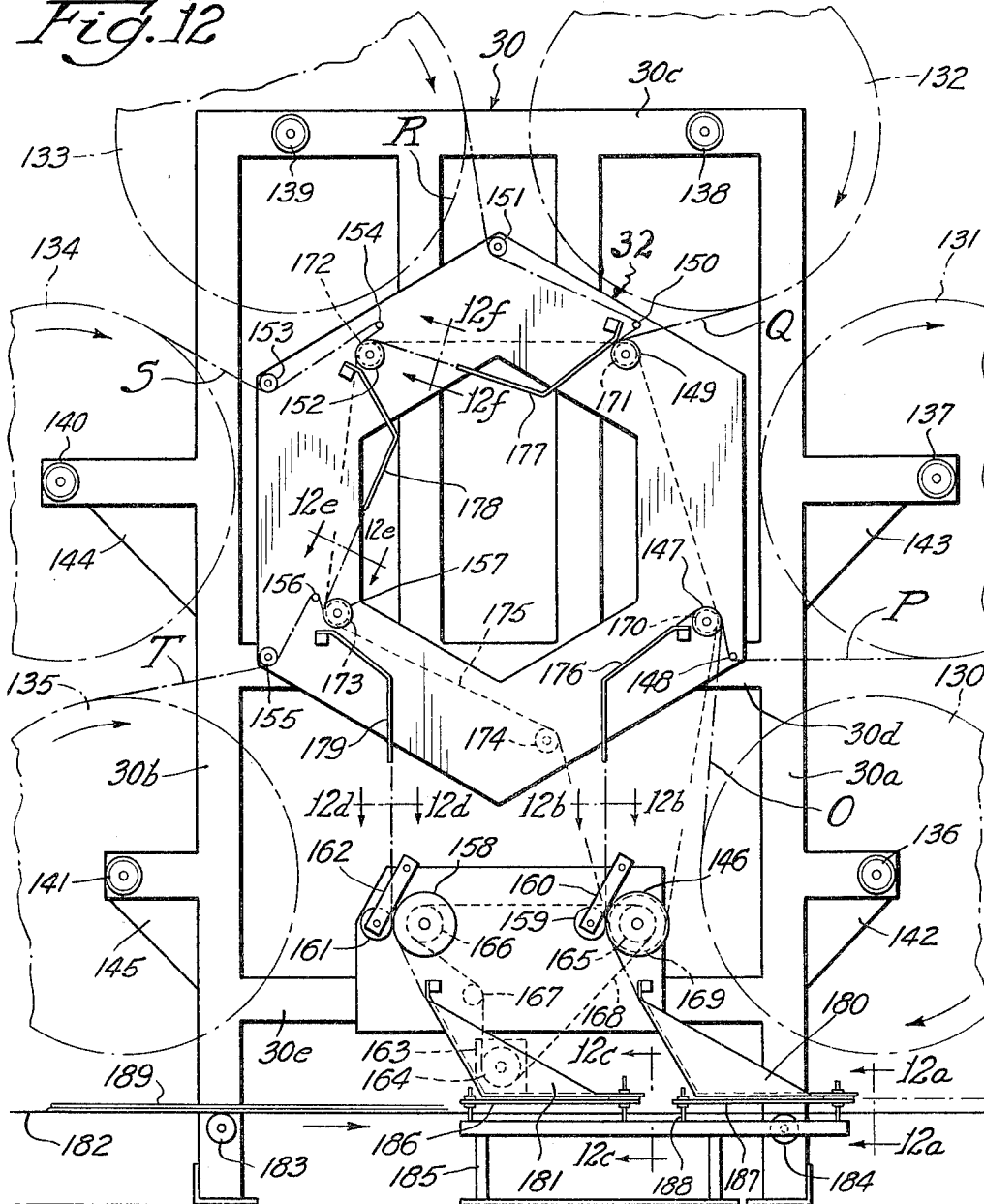
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Fig. 12



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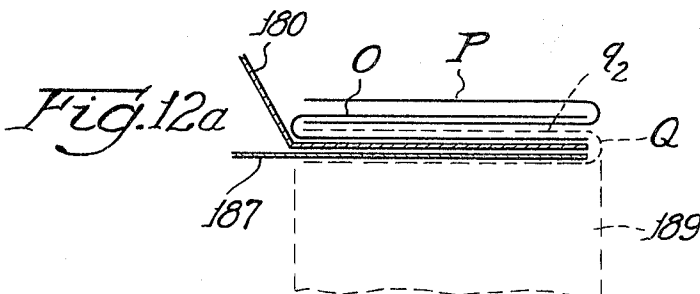
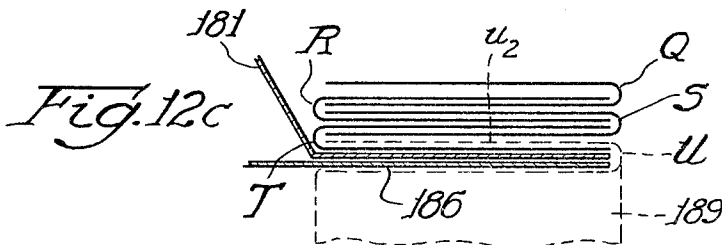
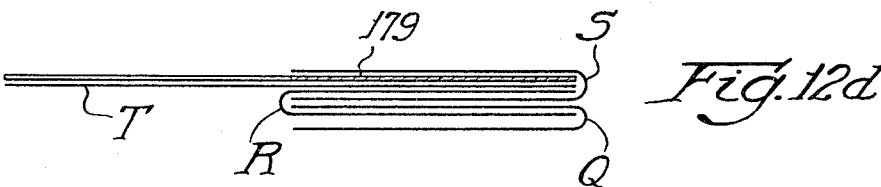
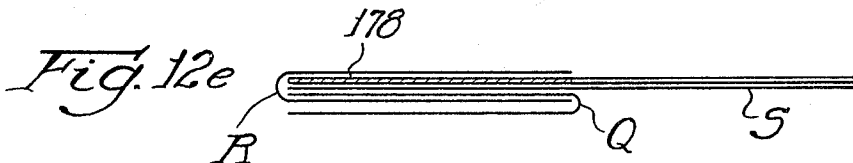
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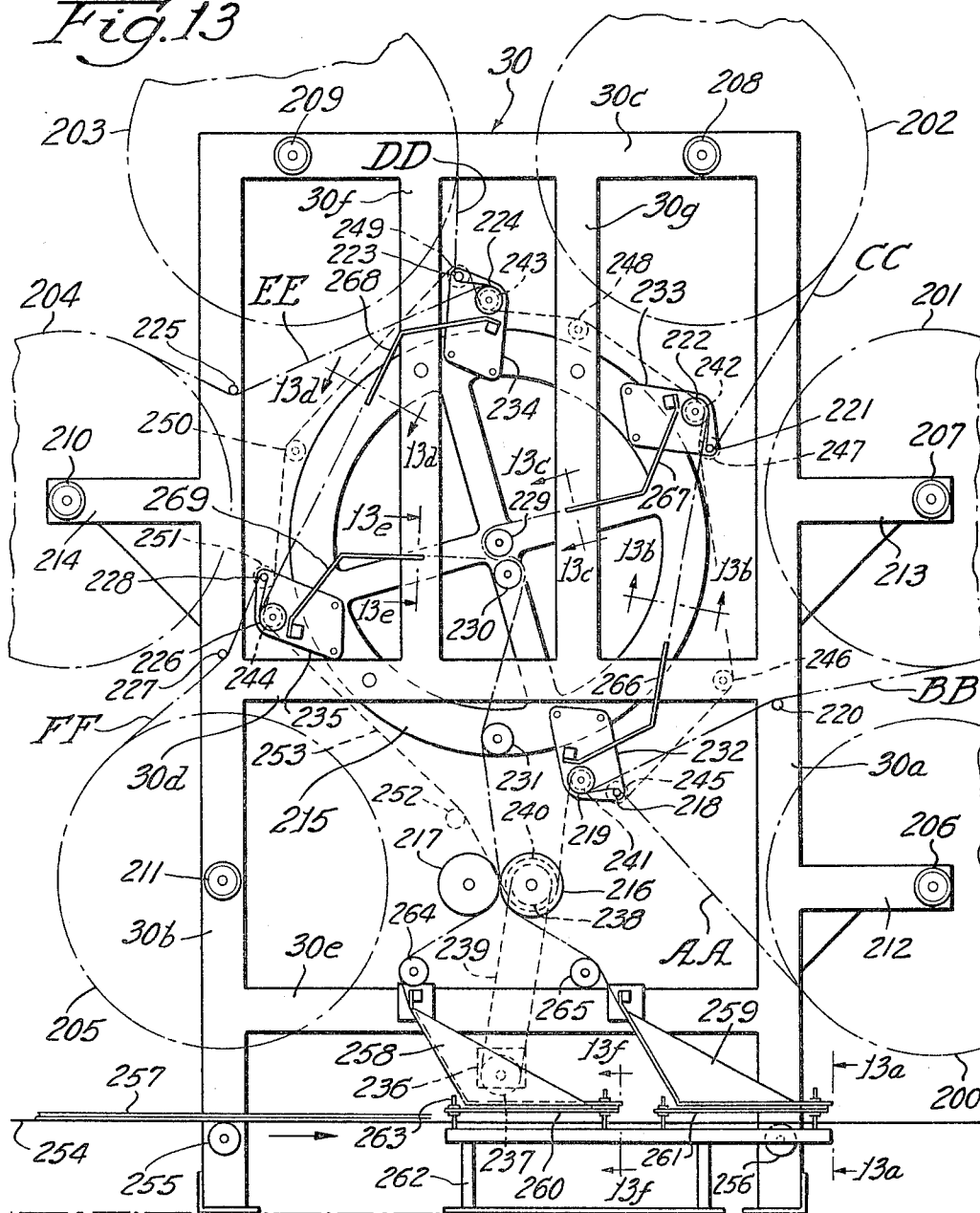
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*Fig. 13*



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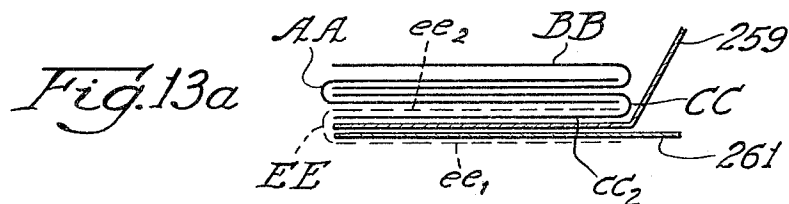
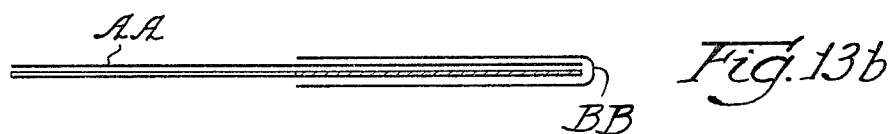
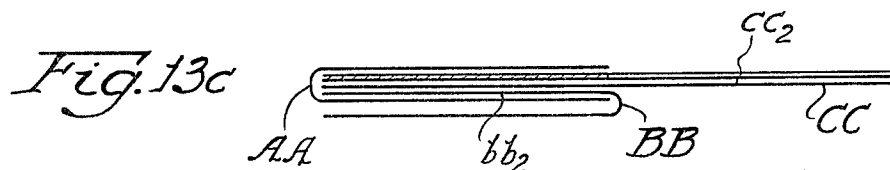
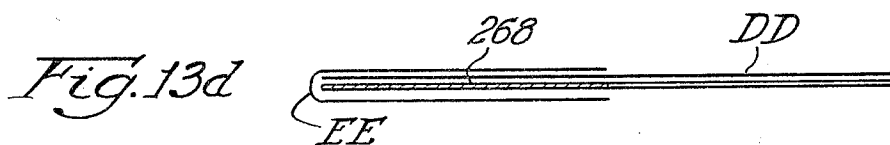
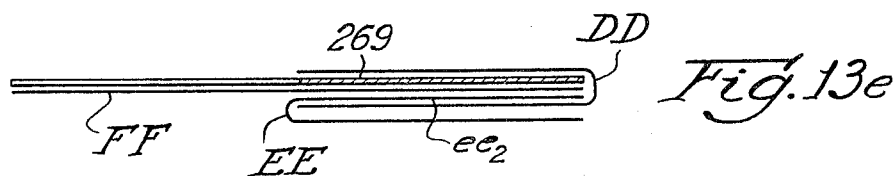
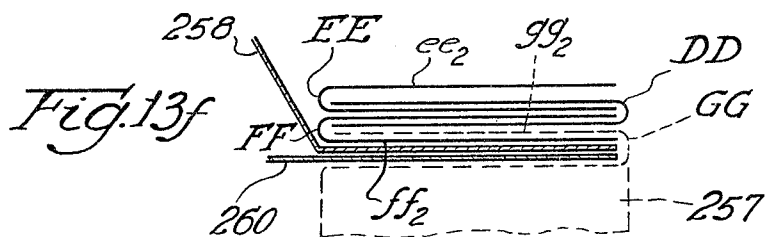
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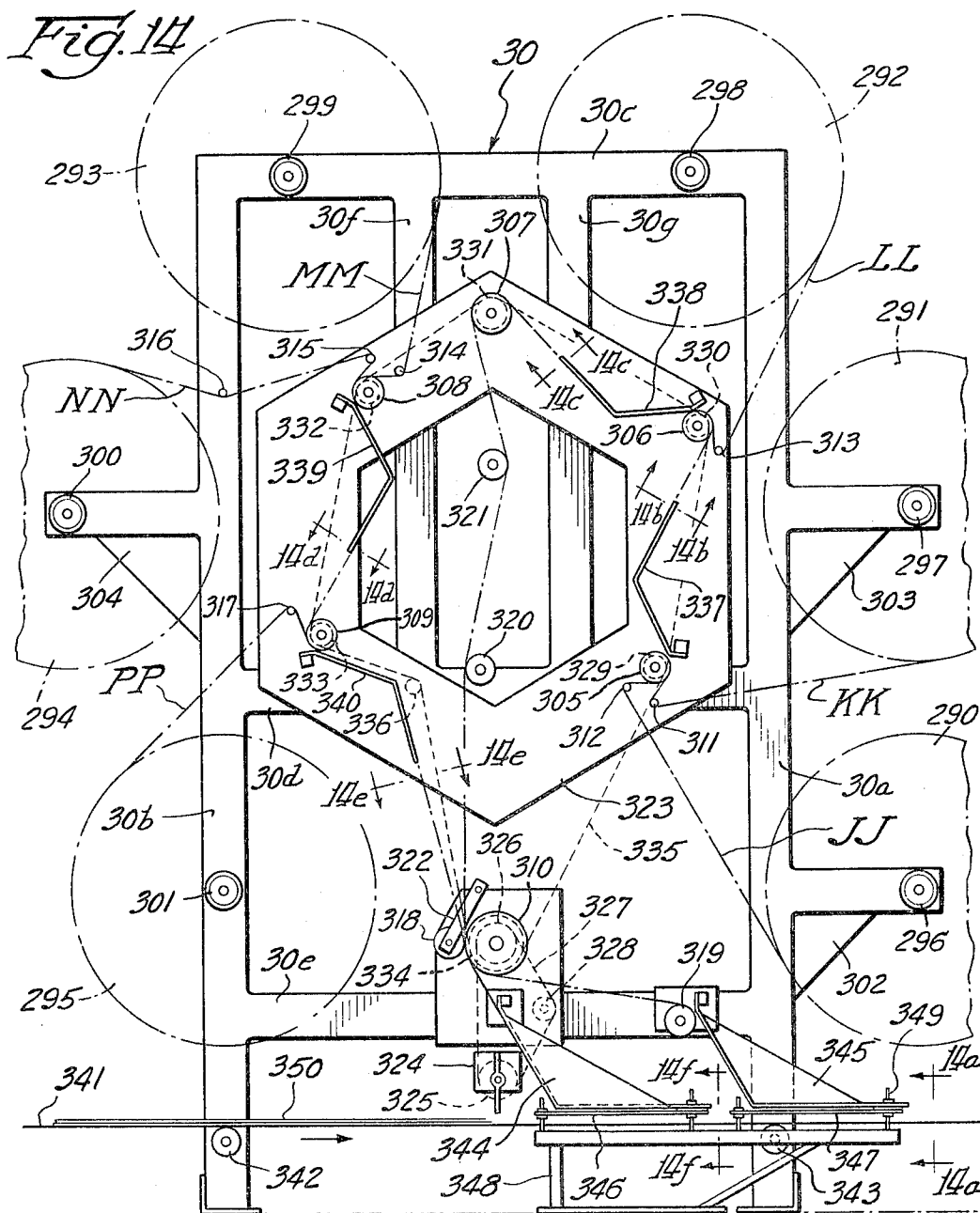
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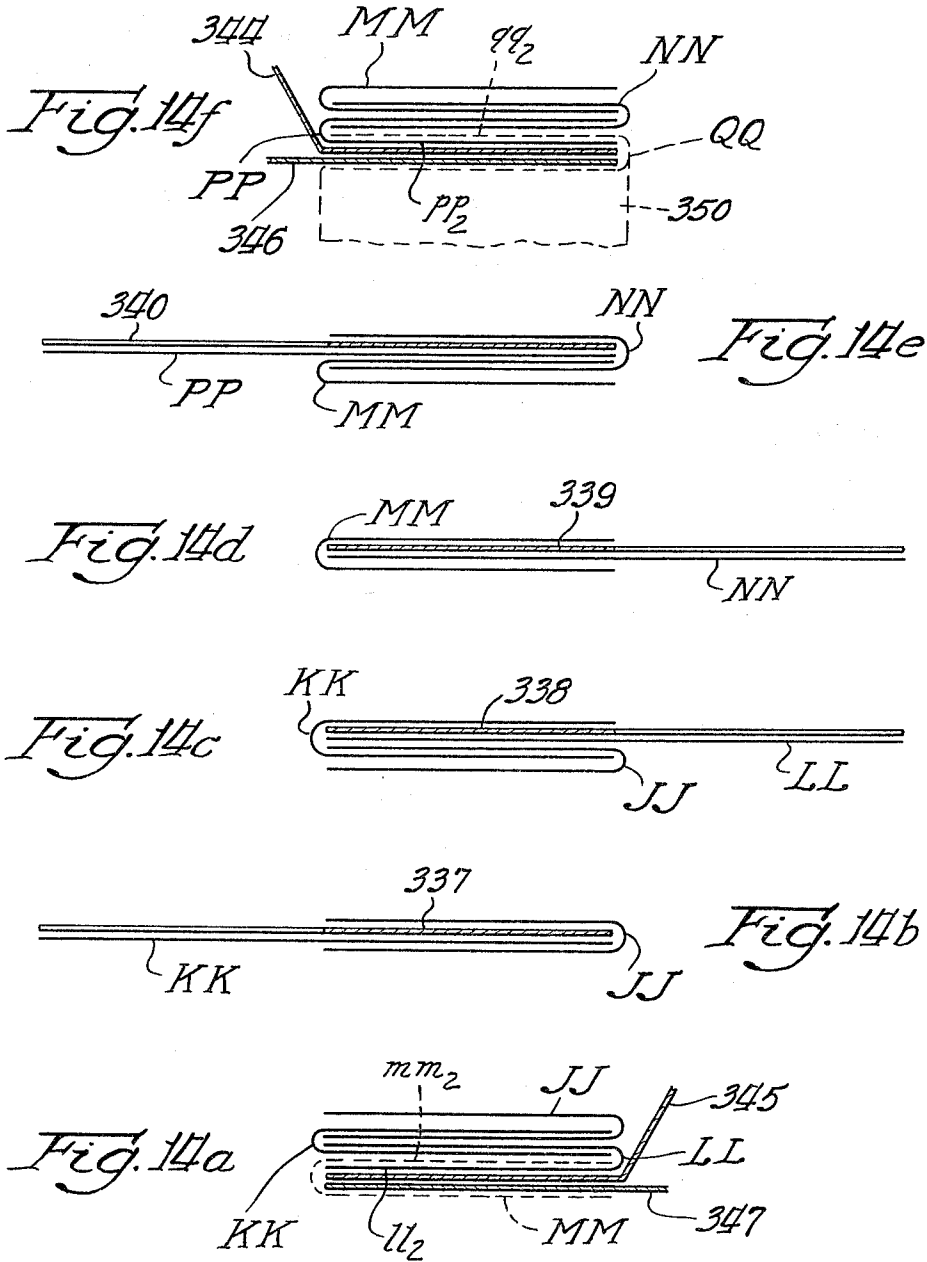
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## WEB INTERFOLDING MACHINE

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Filed June 1, 1964, Ser. No. 371,244

5 Claims. (Cl. 270-40)

Our invention relates to papermaking machines and particularly to machines for interfolding webs of paper or other sheet material.

Facial tissues composed of soft absorbent paper are generally supplied in stacks within dispensing cartons. The tissues may be interfolded, that is, folded so that portions of the top tissue on a stack overlie portions of the tissues underneath, and the cartons are generally provided with slots in their upper surfaces so that the tissues may be withdrawn from the cartons one at a time. The interfolding causes a portion of each succeeding tissue to be partially drawn through the slot, so that it is readily available, when the top tissue is drawn from the carton.

Such stacks, or multiples of two or three such stacks, which may be separated after interfolding, are generally produced individually by automatic machines. These machines fold an end portion of each individual sheet over an end portion of the preceding sheet, and due to the speed and sudden reversals of motions of parts required for such interfolding action, the machines are quite noisy. Furthermore, inasmuch as the individual stacks or multiples of two or three stacks only are produced at a time, the output of such machines is limited.

It is an object of the present invention to provide an improved apparatus for interfolding continuous webs of paper or like material, which may be cut cross-wise after interfolding is completed, in order to produce stacks of interfolded paper, such as tissues, in sizes to fit the conventional cartons above referred to.

More particularly, it is an object of the invention to provide such an improved apparatus which retains the continuous webs being folded in full control at all times during the interfolding process, so that the interfolding is accurate and fast.

Still more particularly, it is an object of the invention to provide apparatus for successively folding over a plurality of webs of paper or the like with one-half or fold of each web being folded over on the other one-half or fold of the web, and with the arrangement being such that, as each fold is formed, it not only folds over the other fold of the particular web being folded but also folds over preceding and succeeding webs so as to produce a continuous stack of interfolded webs.

It is another object of the invention to produce an improved folding board over which a web may be drawn so as to continuously fold half of the web over the other half, whereby a succession of these folding boards may be utilized for providing the interfolded continuous web stacks mentioned above.

The invention consists of the novel constructions, arrangements and devices to be hereinafter described and claimed, for carrying out the above stated objects, and such other objects, as will be apparent from the following description of preferred forms of the invention, illustrated with reference to the accompanying drawings, wherein:

FIG. 1 is a side elevational view of folding apparatus incorporating the features of the invention;

FIGS. 1a, 1b, 1c, 1d, 1e, 1f and 1g are sectional views taken respectively on lines 1a-1a, 1b-1b, 1c-1c, 1d-1d, 1e-1e, 1f-1f and 1g-1g shown in FIG. 1, and the left sides of the structures as shown in FIGS. 1a to 1g are those sides which are visible in FIG. 1.

FIG. 2 is an end view of the folding apparatus taken

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from the right side of the apparatus as illustrated in FIG. 1;

FIG. 3 is a plan view of one of the so called righthand overfolding boards incorporated in the folding apparatus illustrated in FIGS. 1 and 2 prior to bending of the folding board into its operating configuration;

FIG. 4 is a side view of the folding board of FIG. 3 after it has been so bent;

FIG. 5 is a perspective view of a so called lefthand overfolding board in the folding apparatus illustrated in FIGS. 1 and 2;

FIG. 6 is a plan view similar to FIG. 3 of a modified type of folding board useable in lieu of the FIG. 3 folding board;

FIG. 7 is a perspective view of a so called righthand underfolding board also incorporated in the machine illustrated in FIGS. 1 and 2;

FIG. 8 is a plan view of the folding board illustrated in FIG. 7;

FIG. 9 is a plan view of a folding board of the type illustrated in FIGS. 7 and 8, but which is of the lefthand type instead of the righthand type;

FIG. 10 is a diagram illustrating the various dimensions of the folding board shown in FIG. 5;

FIG. 11 is a cross sectional view of a carton containing tissues that are interfolded as by the folding apparatus illustrated in FIGS. 1 and 2;

FIG. 12 is a side elevational view of a modified form of folding apparatus incorporating the principles of the invention;

FIGS. 12a, 12b, 12c, 12d, 12e and 12f are sectional views taken respectively on lines 12a-12a, 12b-12b, 12c-12c, 12d-12d, 12e-12e and 12f-12f in FIG. 12, and the left sides of the structures as shown in FIGS. 12a to 12f are those sides which are visible in FIG. 12.

FIG. 13 is a side elevational view of another modified form of the folding apparatus;

FIGS. 13a, 13b, 13c, 13d, 13e and 13f are sectional views taken respectively on lines 13a-13a, 13b-13b, 13c-13c, 13d-13d, 13e-13e and 13f-13f in FIG. 13, and the left sides of the structures as shown in FIGS. 13a to 13f are those sides which are visible in FIG. 13;

FIG. 14 is a side elevational view of still another modified form of the folding apparatus; and

FIGS. 14a, 14b, 14c, 14d, 14e and 14f are sectional views taken respectively on lines 14a-14a, 14b-14b, 14c-14c, 14d-14d, 14e-14e and 14f-14f in FIG. 14, and the left sides of the structures as shown in FIGS. 14a to 14f are those sides which are visible in FIG. 14.

Like characters of reference designate like parts in the several views.

Referring now to FIG. 1 of the drawings, the illustrated folding mechanism may be seen to comprise a frame 30.

The frame 30 is made up of vertical beams 30a and 30b with horizontal beams 30c, 30d and 30e extending between and connecting the vertical beams 30a and 30b. Additional intermediate vertical beams 30f and 30g extend between and connect the horizontal beams 30c and 30d. The vertical beams 30a and 30b rest on a floor 31 which supports the frame 30. A hexagonal plate 32 is fixed to the frame 30, and in particular, with respect to the beams 30f, 30g and 30d as illustrated.

Paper rolls 33, 34, 35, 36, 37 and 38 are supported by the frame 30 by means of arbors 39, 40, 41, 42, 43 and 44 respectively. The arbors 39 and 44 are respectively fixed with respect to the beams 30a and 30b, and the arbors 41 and 42 are fixed on the beam 30c. The arbors 40 and 43 are carried by brackets 45 and 46, which are respectively fixed on the beams 30a and 30b.

Rolls 47, 48, 49, 50, 51, 52, 53, 54, 55 and 56 are rotatively disposed on the hexagonal plate 32 for

carrying various of the webs A, B, C, D, E and F which are respectively drawn from the paper rolls 33, 34, 35, 36, 37 and 38. A roll 57, rotatively carried by a bracket 58 disposed on the beam 30e, has the webs A through F passing over it as will be hereinafter described. A roll 59 is swingably disposed on arms 60 pivoted to the plate 58 so that the roll 59 may have a nip with the roll 57 for drawing the webs between the rolls 57 and 59.

The roll 57 is driven from a miter gear box 61, which is suitably fixed with respect to the frame 30 and is suitably driven from any appropriate power shafting (not shown). The gear box 61 has a driven pulley 62, and a belt 63 extends around the pulley 62 and around pulleys 64 and 65. The pulley 65 is fixed with respect to the roll 57, and the pulley 64 is rotatively mounted on the beam 30e, so that the pulley 65 and roll 57 are driven from the pulley 62 by means of the belt 63.

The rolls 47, 48, 49, 51, 53 and 55 are driven from the roll 57 by means of a belt 66. The belt 66 extends over pulleys 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77 and 78. The pulleys 67, 69, 70, 71, 73, 75 and 77 are respectively fixed with respect to the rolls 57, 47, 48, 49, 51, 53 and 55 so that, as will be more fully hereinafter described, the roll 57 is effective to drive the others of these rolls. The pulleys 68, 72, 74, 76 and 78 are idler pulleys and are rotatively mounted with respect to the hexagonal plate 32 and the vertical intermediate beams 30f and 30g, as illustrated.

Folding boards 79, 80, 81, 82 and 83 are fixed with respect to the hexagonal plate 32. These boards 79 to 83 are basically identical and are of a so called overfolding type and operate to interfold the webs A, B, C, D, E and F, as will be hereinafter more fully described. A folding board 84, which is of a different, so called underfolding type, is provided for receiving the webs passing between the rolls 57 and 59 and for interfolding the webs A to F with a previously interfolded endless stack 85 of webs. The folding board 84 is supported from the horizontal beam 30e, and a sheet guide plate 86 is disposed beneath the board 84, being disposed on studs 87 and 88 that are, in turn, supported by a standard 89 resting on the floor 31. The stud 88 also supports the lower end of board 84 as is apparent from FIG. 7. The web stack 85 is carried by an endless flat belt 90 that is supported by and moves on rollers 91 and 92, rotatively mounted on the vertical beams 30a and 30b.

As has been previously mentioned, the folding boards 79 to 83 are basically similar and are of a so called overfolding type; however, some of them are reversed with respect to the others for folding the webs in the opposite directions. The boards 79, 80 and 82 may be termed lefthand folding boards, and the boards 81 and 83 may be termed righthand folding boards. Briefly stated, a lefthand folding board folds a web from left to right and a righthand folding board folds a web from right to left. As will appear from the following more detailed description of each of the folding boards utilized, each of these boards has a concavity formed by at least two plane sheet metal portions; and these directions of folding are determined in looking down on the board into its concavity and in the direction of web movement. As will be apparent, a righthand folding board has the web which it folds set off to the right side of the completed stack of folded webs, and a lefthand folding board has the web which it folds set off to the left side of the completed stack of folded webs. As has been mentioned, the boards 79 to 83 are of a so called overfolding type, and the folding board 84 is a so called underfolding type of board. As will appear from the following description of these two types of boards, the overfolding boards 79 to 83 fold the web strip or fold which is set off to the side of the completed stack of folded webs on top of the other fold of the web folded by the board, and the underfolding board 84 folds the strip or fold which is set off to the side of the completed stack of folded webs underneath the other fold

of the web being folded by the folding board, looking as before, down on to each board into its concavity and in the direction of web movement. The folding board 84 is, incidentally, an underfolding board of the righthand type.

One of the righthand overfolding boards is illustrated in FIGS. 3 and 4, in which FIG. 4 shows the board in operating condition and FIG. 3 shows the board before being bent into operating condition. The board may be seen to comprise a sheet metal plate 93' bent along parallel lines 94' and 95' to have plane plate portions 96', 97' and 98'. The plate portions 97' and 98' have an angle J' between them, and the plate portions 96' and 97' have an angle K' between them. The angles J' and K' are such that the portions 96' and 98' extend at right angles with respect to each other. There is an angle L' between the plate portion 97' and an extension of the portion 98' which, as will be understood, is a supplementary angle with respect to the angle J'.

The plate portions 97' and 98' have folding edges 99' and 100' which intersect at a point 101' with the bend line 95'. It will be noted that the plate portion 98' is substantially rectangular and that the plate portion 97' broadens toward its upper edge. The folding edge 99' thus extends at an angle M' with respect to a line 100a' that in effect, constitutes an extension of the edge 100' prior to folding the board along the line 95'.

A rod 102' extends diagonally across the plate portion 98' to the intersection 101' of the edges 99' and 100', and the rod has a portion 102a' that bends outwardly with respect to the edges 99' and 100'. The rod 102' is fixed with respect to the plate portion 98' by means of a bracket 103' fixed on the upper face of the portion 98'. The rod 102' is welded onto the bracket 103' as illustrated. The arrow X indicates the direction of movement of a paper web over the folding board, and this is in substantially the same direction as the direction in which the edge 100' extends. The inside edge 102b' of the rod 102' constitutes the folding edge of the rod, and there is an angle N' between the folding edge 102b' and the direction of movement of the web indicated by the arrow X.

As will hereinafter appear, the bend line 95' may constitute a first folding edge of the board illustrated in FIGS. 3 and 4; the edge 99' may constitute a second folding edge; the inside edge 102b' of the rod 102' may constitute a third folding edge; and the edge 100' may constitute a fourth folding edge. All of these folding edges meet substantially at the point of intersection 101'. It will be observed from these figures that the angle J' between the plane plate portions 97' and 98' is an oblique angle and the supplementary angle L' is an acute angle and that the angles M' and N' are both acute angles. The angle J', for example, may be 120°; the angle N', for example, may be about 22°; and the angle M' may, for example, be about 30°. In the board illustrated in FIGS. 3 and 4, the plane portions 97' and 98', on the upper side of the board having the angle J' between the portions 97' and 98', provide the concavity mentioned above. It will be noted that the rod 102' is mounted on the upper face of the plane portion 98' that faces the portion 97' and that the rod 102' is slightly spaced from the upper surface of the portion 98' so that a web of paper may pass between the rod and the portion 98'.

A lefthand overfolding type of board is illustrated in FIG. 5 and corresponding unprimed reference numerals are used for the parts that correspond to the similarly numbered parts of the righthand folding board illustrated in FIGS. 3 and 4. It will be observed that the folding board illustrated in FIG. 5 is simply reversed with respect to the board illustrated in FIGS. 3 and 4. Looking down on the board illustrated in FIGS. 3 and 4 into its concavity formed by the plane sheet metal portions 97' and 98' and in the direction of movement of the web indicated by the reference letter X, it will be observed that the folding edges 99' and 102b' extend slantwise from

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right to left. Looking down in the same manner on the lefthand folding board illustrated in FIG. 5, it will be observed that the folding edges 99 and 102b extend slantwise in just the opposite direction, namely from left to right.

Each of the folding boards 79 to 83 has a rod 104 of rectangular cross section fixed to its plate portion 96' or 96, and the rod 104 for each of the folding boards is anchored at the end of the rod to the hexagonal plate 32 for thereby fixing the folding board with respect to the plate 32.

A relatively narrow, long, thin plate or rod 105' (see FIG. 6) may be utilized in lieu of the rod 102' for the righthand folding board illustrated in FIGS. 3 and 4. The plate 105' is formed integrally with a bracket portion 106' that is fixed on the upper face of the plate portion 98' in lieu of the bracket 103'. There is a fillet 107' between the plate 105' and the bracket portion 106', and the end of the plate 105' is rounded at 105a'. The plate has a rounded edge 105b' which is its working edge and which corresponds with the edge 102b' of the rod 102'. The bracket portion 106' is installed on the plate portion 98' to extend in the direction of web movement indicated by the arrow X, and the same angle N' exists between the bracket portion 106' and the working edge 105b' as between the working edge 102b' of the rod 102' and the bracket 103'. The plate 105' may be quite thin and may have a thickness of only  $\frac{1}{16}$  inch, if desired. The width of the plate 105' is not critical and it may be  $\frac{1}{2}$  inch wide, for example, to provide rigidity. As will be apparent, a plate similar to the plate 105', but reversed, may be substituted for the bracket 103 and folding rod 102 in the lefthand folding board illustrated in FIG. 5.

Each of the folding boards 79 to 83 is of such design that it longitudinally folds a web in half, with one-half being folded on top of the other half and also on top of a half of another web that remains unfolded. FIG. 5 illustrates the two webs A and B traveling over the board 79 and illustrates the manner in which each folding board operates on a pair of webs, folding over one of the webs with respect to itself and to the other web—in this case the web B is folded over on itself and also over the web A to embrace the latter. The webs A and B travel on to the folding board 79 in a staggered relationship so that the only half of each web overlaps the half of the other web. Web A is in direct contact with the exterior surfaces (the convex or under surfaces) remote from the included angle J of the plate portions 97 and 98, and the complete width W of the web A is in contact with the folding board 79. One-half the width of the web B is in contact with the exterior or under surface of the plate portion 97 adjacent to the upper edge of the plate portion, and this half of the web B that is not in overlapping relation with the web A travels over the diagonally extending edge 99 and from thence under the rod 102 which reverses the direction of movement of the web. The web B, along its longitudinal center, rides on the edge 100 of the plate portion 98, and the half of the web B that is not in original overlapping relation with the web A in passing over the edge 99 and over the folding edge 102b is thereby folded over, so that the web B as a whole has thereby been folded longitudinally in half to have its crease riding the edge 100 and so as to embrace a longitudinal one-half of web A.

The webs A and B before and after passage over the folding board 79 are shown in FIG. 1a. As will be observed from this figure, the webs A and B are originally staggered so that only one-half of each web is in contact with the other; and considering the overlapping halves of the webs A and B, the web A is located between the web B and the folding board 79. After the web B has been folded across the folding edges 99 and 102b, the web B has thereby been folded to have folds  $b_1$  and  $b_2$ . The folds  $b_1$  and  $b_2$  embrace ones longitudinal half of web A, or fold  $a_1$ , and the other longitudinal half  $a_2$  of

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the web A remains outside the web B. It will be noted that FIG. 1a (and FIGS. 1b to 1e, as well) is a sectional view looking in the direction of web movement and viewed from the outside of the hexagonal plate 32. FIG.

1a, therefore, is viewed from the convex sides of the surfaces 97 and 98, while FIGS. 1b to 1e, as will hereafter appear, are figures viewed from the concave sides of the folding boards 80 to 83. Thus, the web B has its fold  $b_2$  folded downwardly as seen in FIG. 1a, rather than upwardly. It will be noted that with all of the sectional views 1a to 1g, the left sides of these views are toward the outer side of the machine which is the side from which FIG. 1 is viewed, the inner side of the machine being that part on the other sides of the folding boards adjacent the frame 30.

It is very desirable that the web that is being folded over by each of the folding boards 79 to 83 be maintained uniformly taut throughout its passage over the folding board. In order to attain this result, the distance that each part of the web travels must stay the same throughout the travel of the web over the folding board; and the folding board is provided with angles L, M, and N (the angles for a lefthand overfolding board that correspond with angles L', M' and N' for a righthand overfolding board) which have a certain relationship with respect to the linear dimensions of the board for this purpose.

The preferred relationship between the angles L, M and N and the dimensions of the folding board will now be described in connection with FIG. 10. This figure diagrammatically shows the portions of the lefthand overfolding board 79 and the plate portions 97 and 98 that are in contact with or lie between various of the interleaved folds  $a_1$ ,  $b_1$  and  $b_2$  leaving the board. The FIG. 10 diagram does not include a showing of the marginal portions of the board 79 which are not in contact with or do not support portions of the web B being folded by the board, since these marginal portions have no effect insofar as folding the web B is concerned. The web B passes on to the portion 97 across the full width of the upper edge of the portion 97, as it is shown in FIG. 10, and the width of the web being folded is indicated by the distance W as is indicated in FIG. 10. The longitudinal half of the web B, which passes over the board portion 97, across the fold line 95, and over the board portion 98, lies between the line 100a and the folding edge 100 and the outermost edges of the portions 97 and 98 as seen in FIG. 10. The folding line 95, as illustrated in FIG. 10, thus is equal to one-half of the width W of the web. The distance  $f$  is the length of the plate portion 97 or the distance from the fold line 95 along the plate portion 97 to the end of the folding edge 99. The distance  $d$  is the distance measured from the end of the folding line 99 directly to the intersection of the folding edge 102b and the edge of the web being folded, and  $l$  is the distance between the fold line 95 to the intersection of the folding edge 102b and the edge of the web being folded, the edge of the web being folded traveling along the dimension  $l$ . It will be apparent that a rectangle is formed having the folding edge 102b as a diagonal, with one end of the rectangle being the fold line 95 and with a side of the rectangle being the dimension  $l$ . The dimension  $h$  is the vertical height of the slanted folding board portion 97 (the portion 98 in FIG. 10 is assumed to be horizontal), and the dimension  $e$  is the length along the horizontal of the slanted board portion 97. The angles L, M and N correspond with the angles L', M' and N', which have been previously mentioned.

The distance traveled by the marginal edge of the web that passes over the folding edges 99 and 102b is equal to the distance  $d$ , and the distance traveled by the other marginal edge of the web is  $l+f$ , as is apparent, if there is no stretching of the web being folded. Therefore:

$$d=l+f \quad (1)$$

as is apparent.

Since  $d$  is the space diagonal of the rectangular box, whose dimensions are: width= $W$ , height= $h$  and length= $e+l$  where  $e$  and  $h$  are those dimensions illustrated in FIG. 10, which are the horizontal and vertical components of the distance  $f$ ; therefore,

$$d^2 = W^2 + h^2 + (e+l)^2 \quad (2)$$

or

$$d^2 = W^2 + h^2 + e^2 + 2el + l^2 \quad (3)$$

or

$$d^2 = W^2 + f^2 + 2el + l^2 \quad (4)$$

since

$$f^2 = h^2 + e^2 \quad (5)$$

using the theorem of Pythagoras.

Since

$$d = f + l \quad (1)$$

if the marginal edges of the web are not stretched in passing over the folding board, therefore,

$$d^2 = (f+l)^2 \quad (6)$$

or

$$d^2 = f^2 + 2fl + l^2 \quad (7)$$

Equating Equations 4 and 7 gives

$$W^2 + 2el = 2fl \quad (8)$$

In the right triangle containing the angle  $L$ , the hypotenuse is  $f$ , and the side adjacent to angle  $L$  is  $e$ , therefore,

$$e = f \cos L \quad (9)$$

Substituting the quantity  $e$  from Equation 9 into Equation 8 gives

$$W + 2lf \cos L = 2lf \quad (10)$$

or

$$2lf \cos L = 2fl - W^2 \quad (11)$$

Solving the latter equation for  $\cos L$ , the following equation appears:

$$\cos L = \text{One} - W^2/2fl \quad (12)$$

The following equations are apparent from the right triangle on the plate portion 98 having the subtended angle  $N$  and the right triangle on the plate portion 97 which has the subtended angle  $M$  and the base 100a in the same vertical plane as the folding edge 100:

$$\tan N = W/2e \quad (13)$$

$$\tan M = W/2f \quad (14)$$

Therefore, the angles  $L$ ,  $M$  and  $N$  may be determined from the quantities  $l$ ,  $f$  and  $W$  so as to assure that there is substantially no wrinkling of the web passing over the folding board as it is being folded.

The fact that the folding edge 102b is on the edge of a round bar or rod 102 (or the edge 102b' on bar 102') and the fact that there is a substantial thickness of the bar bring in a small discrepancy in the above equations, so that in this case the angles  $L$ ,  $M$  and  $N$  are within a few degrees of providing substantially perfect folding of a web. If the plate 105', as for a righthand board, is used in lieu of a round bar 102', the angles as given by the above formulae are even more accurate, since the folding edge 102a' is very thin. It has been mathematically proved above that, using the angles set forth in Equations 12, 13 and 14, no stretching or laxity results on the marginal edges of a web being folded. It can also be mathematically shown that, along intermediate longitudinal lines in the web, there is likewise no stretching or laxity of the web if the above Equations 12, 13 and 14 are used.

The folding board 84 is of a type which receives a web on its external or convex surface and folds the longitudinal half of the web under the other half, as distinguished from folding it over, as do the folding boards 79 to 83. The folding board 84 is made of a piece of sheet metal and comprises plane surfaces 108, 109, 110 and 111 (see FIGS. 7 and 8). The surfaces 109, 110 and 111 meet at a

common point 112, and the surface 111 has a folding edge 113. The surface 109 has a lower edge 114 over which webs pass on to a folded web stack, as will be hereinafter described. The surface 108 is for attachment purposes only, and a bar 115 is fixed to this surface and is suitably attached at its end with respect to the cross beam 30e. The folding board 84 is so designed that the web being folded by the board 84 is not stretched and does not become lax, either along its marginal edges or intermediate its marginal edges, and is made substantially in accordance with the teachings of U.S. Patent No. 3,066,932, issued on December 4, 1962, to C. J. Greiner et al. The folding board 84 is substantially like the folding board illustrated in FIGS. 5 and 6 of this patent. No further detailed explanation of the board 84 is, therefore, deemed necessary herein.

As above described, the boards 79, 80 and 82 are lefthand boards, as shown in FIG. 5, for example; and the boards 81 and 83 are righthand boards, as shown in FIGS. 3 and 4, for example. The web rolls 33 to 38 are disposed in a generally circular configuration on the frame 30, and the folding boards 79 to 83 are disposed within this circular disposition on the hexagonal plate 32, as may be seen from this figure. All of these boards have their concavities defined by the angle  $J$  or  $J'$  between portions 97 and 98 or 97' and 98', facing outwardly except for the board 79, which is disposed in the opposite manner. The boards are so disposed that the folding edges 99 or 99' of the boards 79, 81 and 83 face inwardly (toward the hexagonal plate 32) and the lefthand boards 80 and 82 have their corresponding folding edges 99 facing outwardly (toward the viewer in FIG. 1). As will hereafter appear, the webs A and D that are being folded by the boards 80 and 82 are staggered by a half web width outwardly toward the outer side of the machine with respect to the webs B, C and E, which are folded by the boards 79, 81 and 83. The interfolded webs produced by the boards 79 to 83, as will hereafter appear, include a web F which remains unfolded by these boards but is inserted within the folds of the other webs; and the protruding portion of web F is staggered toward the outer side of the machine and passes downwardly across the unfolding board 84 with its protruding portion passing across the obliquely extending surface 110 of the board 84. Therefore, the portion 110 of the board 84 is disposed toward the outer side of the machine with respect to the path of interfolded web folds.

In operation, the belt 90 moves in the direction indicated by the arrow Y as seen in FIG. 1, carrying with it a stack of webs 85 which have been interfolded by previous interfolding mechanism, such as, for example, a duplicate of the folding mechanism shown in FIG. 1. The gear box 61 is driven in synchronism with the belt 90, and the roll 57 is driven from the gear box 61 through the pulleys 62 and 65 and the belt 63. The rolls 47, 48, 49, 51, 53 and 55 are driven in synchronism with the roll 57 by means of the belt 66 and the pulleys 69, 70, 71, 73, 75, and 77. The belt 66 extends around these pulleys and also around the pulleys 68, 72, 74, 76 and 78, which are simply idler pulleys. Web A is drawn from the roll 33 and passes over the roll 47 on to the roll 48; the web B is drawn from the roll 34 and also passes on to the roll 48. The two webs A and B pass over the first folding board 79 and then on to the roll 49. The web C is drawn from the roll 35 and passes over the roll 50 on to the folding board 80; and the webs A and B also pass on to the folding board 80 from the roll 49. The webs A, B and C pass from the folding board 80 on to the roll 51 and from thence on to the folding board 81. The web D is drawn from the paper roll 36 and passes over the roll 52 on to the folding board 81, along with the webs A, B and C. The webs A, B, and C and D pass from the board 81 over the roll 75 and on to the folding board 82. The web E from the paper roll 37 passes over the roll 54 and on to the board 82, along with the webs A, B, C and D.

The webs A, B, C, D and E pass over the folding board 82 and over the roll 55 on to folding board 83, and the web F is combined with these webs on the folding board 83, passing over the roll 56 on to the board 83. The webs A, B, C, D, E and F pass downwardly from the board 83 and between the rolls 57 and 59 on to the folding board 84, which combines these webs with the prior folded stack 85.

The webs A, B, C, D, E and F are staggered with respect to each other. The webs A, D and F and the corresponding rolls 33, 36 and 38 are located closer to the front of the machine (looking at the machine as illustrated in FIG. 1) than are the webs B, C and E and the corresponding rolls 34, 35 and 37, by a distance equal to one-half the width  $W$  of each of the webs. Such staggering causes webs coming in contact with each other to contact for only one-half the width of the webs. The arrangement of the rolls 47 and 48 and the folding board 79 is such that the full width of the web A is in direct contact with the external, convex surface of the folding board 79, and the web B lies for half of its width on top of the web A (see FIGS. 1 and 5). The web B passes over the folding edges 99 and 102b and thus has one-half of its longitudinal width folded over the web A so that its folds  $b_1$  and  $b_2$  embrace and are on opposite sides of the web A. The web C passes over the roll 50 into direct contact with the convex surface of the lefthand board 80, and the webs A and B pass over the roll 49 and are disposed on top of the web C. The web A passes over the folding edges 99' and 102' of the board 80 and is folded over the webs B and C and the board 80. The folds  $a_1$  and  $a_2$  of the web A then embrace the folds  $b_1$  and  $c_1$  of the webs B and C as shown in FIG. 1b.

The web D is drawn from the roll 36 into direct contact with the convex surface of the righthand folding board 81, passing over the roll 52. The sandwich of webs A, B and C from the board 80 pass over the roll 51 and on to the board 81 along with the web D, and the web C is folded over by the folding edges of the board 81 so that the folds  $c_1$  and  $c_2$  embrace the fold  $a_2$  of the web A and the fold  $d_1$  of the web D as shown in FIG. 1c.

The folding board 82 operates similarly to the preceding folding boards. The web E is drawn over the roll 54 from the paper roll 37 into direct contact with the convex surface of the board 82. The sandwich of previously interfolded webs A, B, C and D pass over the roll 53 and on to the convex surface of the folding board 82, on top of the web E; and the web D is folded over by the board 82 so that its folds  $d_1$  and  $d_2$  embrace the fold  $c_2$  of the web C and the fold  $e_1$  of the new web E as illustrated in FIG. 1d.

The righthand folding board 83 operates similarly to the preceding boards, and a new web F passes over the roll 56 on to the convex surface of the board 83. The previously folded sausage of webs A, B, C, D and E pass over the roll 55 on to the exterior surface of the board 83, on top of the web F; and the board 83 folds the web E over by means of the board's folding edges. The folds  $e_1$  and  $e_2$  of the web E then embrace the fold  $d_2$  and the fold  $f_1$  of the new web as seen in FIG. 1e.

The webs, which are in their folded condition as illustrated in FIG. 1e, travel from the folding board 83 between the rolls 59 and 57 on to the folding board 84. The stack 85 of previously interfolded webs is traveling on the belt 90 beneath the folding board 84. The stack 85 includes top webs G and H, respectively having folds  $g_1$  and  $g_2$  for the web G and folds  $h_1$  and  $h_2$  for the web H. The stack 85 travels underneath the plate portion 111 of the folding board 84, except for the uppermost fold  $g_2$ , which is trained to pass over the plate portion 111 of the board 84. The interfolded stack of webs A, B, C, D, E and F passes downwardly over the exterior surface of the plate portion 109 on top of the previously folded stack 85, except for the fold  $f_2$ , which extends to the side of the folded stack. The fold  $f_2$  travels over the exterior

surface of the plate portion 110, underneath the plate portion 111 and around the folding edge 113 (see FIG. 1g), so that the fold  $f_2$  is folded underneath the fold  $g_2$  of the previously completed stack 85. The webs are now in the condition illustrated in FIG. 1f. It will be noted that the fold of each of the webs embraces a fold of the web beneath it in the stack. For example, the folds  $b_1$  and  $b_2$  embrace the fold  $a_1$ ; the folds  $a_1$  and  $a_2$  embrace the fold  $c_1$ ; the folds  $c_1$  and  $c_2$  embrace the fold  $d_1$ , etc. The purpose of the sheet guide plate 86 is to prevent the fold  $f_2$  as it travels beneath the horizontal portion 111 of the folding board 84 from disturbing the previously interfolded stack 85 and pushing it sidewardly.

Assuming that the completed sausage of webs is cut into segments, it will be apparent that stacks of interfolded web segments have been provided, so that, when the uppermost web segment or fold is withdrawn from the stack, it automatically pulls upwardly the uppermost fold of the next succeeding web segment below it in the stack. Therefore, if these web segments are utilized in cartons having slots in their tops in accordance with present practice, the uppermost web segment or fold, when removed through the slot in the top of the carton, automatically pulls the uppermost fold of the next succeeding web in the stack up through the slot in the top of the carton for easy grasping by the user. Such an arrangement is illustrated in FIG. 11. This figure illustrates a paperboard carton 116 having a slot 117 in its upper panel 118. The fold segment  $f_1$  of the web F is shown as being withdrawn through the slot 117, and the fold  $f_1$  protrudes through the slot 117. The fold  $f_2$  lies underneath the fold  $g_2$  of the next succeeding web in the stack; and, as the web F is completely withdrawn from the slot 117, it will raise the fold  $g_2$  and cause it to partially protrude through the slot 117 for easy grasp by the user.

The modified folding apparatus illustrated in FIG. 12 uses the same types of folding boards as does the above described apparatus; however, two of the same type as the board 84 (the underfolding type) are used, while only four of the type of the boards 79 to 83 (the overfolding type) are used. The same frame 30 having the hexagonal plate 32 fixed thereon is used; and the frame, as has been previously mentioned, comprises the horizontal beams 30c, 30d and 30e and the vertical beams 30a and 30b.

Paper web rolls 130, 131, 132, 133, 134 and 135 are rotatively disposed on the frame 30. The rolls fit on cores 136, 137, 138, 139, 140 and 141. The cores 138 and 139 are rotatively mounted on the beam 30c, and the cores 136, 137, 140 and 141 are respectively mounted on the frame 30 by means of brackets 142, 143, 144 and 145. The rolls 131, 132 and 134 are mounted quite close to the frame 30 and the other rolls 130 and 135 are mounted farther outwardly with respect to the frame by a distance equal to half the width of the paper web on the rolls 130 to 135.

Rolls 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157 and 158 are rotatively mounted with respect to the frame 30. A roll 159 is provided on a swinging arm 160 and has a nip with the roll 146, and a roll 161 is mounted on a swinging arm 162 so that the roll 161 has a nip with the roll 158.

The rolls 146, 147, 149, 152, 157 and 158 are driven so as to pull the paper webs which pass over these rolls. The roll driving mechanism includes a gear box 163 having an output pulley 164, a pulley 165 fixed with respect to the roll 146, a pulley 166 fixed with respect to the roll 158, and an idler pulley 167. An endless belt 168 passes over the pulleys 164, 165, 166 and 167 for driving these pulleys and the rolls 146 and 158. A pulley 169 is fixed, along with the pulley 165, with respect to the roll 146. Pulleys 170, 171, 172 and 173 are respectively fixed with respect to the rolls 147, 149, 152 and 157 respectively, and an idler pulley 174 is also provided. A belt 175 extends around the pulleys 170 and 174 and thereby drives the rolls 147, 149, 152 and 157.

Folding boards 176, 177, 178 and 179, of the overfolding type illustrated in FIGS. 3, 4 and 5 and previously described, are fixed with respect to the hexagonal plate 32 in the positions illustrated. The boards 176 and 178 are lefthand boards of the FIG. 5 type, and the boards 177 and 179 are righthand boards as shown in FIGS. 3 and 4.

Two folding boards 180 and 181 are fixed with respect to the horizontal beam 30e. A belt 182 travels below the folding boards 180 and 181 and is supported by means of rolls 183 and 184 rotatively disposed on the vertical beams 30a and 30b. A standard 185 supports guide plates 186 and 187 disposed beneath the folding boards 180 and 181, and studs 188 are fixed on the standard 185 for the purpose of supporting two ends of each of the guide plates 186 and 187 for supporting the lower end of each of the following 180 and 181. Both folding boards 180 and 181, incidentally, are similar to the board 84 and are of the righthand underfolding type.

In operation, the web O is drawn from the roll 130 and the web P is drawn from the roll 131. The webs O and P both pass over the roll 147, the web P preliminarily passing over the idler roll 148. The folding board 176 is of the lefthand type and folds the web P over the web O as shown in FIG. 12b. The web Q is drawn from the roll 132 on to the roll 149, and the web R is drawn from the roll 133 and passes over the idler rolls 151 and 150 so that it also passes over the roll 149; and the two webs Q and R both pass over the folding board 177, which is of the righthand type. The web Q is folded over the web R by the board 177 as illustrated in FIG. 12f.

The webs Q and R as so folded pass over the roll 152 and on to the folding board 178. The web S passes from the roll 134 over the idler rolls 153 and 154 on to the roll 152, and the web S passes along with webs Q and R on to the folding board 178. The folding board 178 is of the lefthand type and folds the web R over the web S as shown in FIG. 12e.

The webs Q, R and S, are so folded, pass on to the roll 157; and the web T is drawn from the roll 135 over the idler rolls 155 and 156 on to the roll 157. The webs Q, R, S and T then pass on to the folding board 179, which is of the righthand type; and the board 179 folds the web S over the web T as illustrated in FIG. 12d.

The webs Q, R, S and T then pass between the rolls 158 and 161 and downwardly over the folding board 181, which functions to fold the portion of the web T protruding from the stack of folds produced by the boards 177, 178 and 179 underneath a top fold  $u_2$  of a web U, which is the uppermost web of the stack 189 of webs being carried by the belt 182 and produced by previous interfolding apparatus.

The webs O and P pass from the folding board 176 downwardly and between the rolls 145 and 159 to the convex surface of the folding board 180. A longitudinal half of the web O travels over the side plane surface 110 and over the folding edge 113 of the board 180, and this fold of the web O is folded underneath the top fold  $q_2$  of the web Q, which is the uppermost web of the stack 189 as it travels to the folding board 180.

The modified folding apparatus illustrated in FIG. 13 also includes four of the overfolding boards and two of the underfolding boards. The frame 30, including its beams 30a to 30e, is utilized for the apparatus. Paper webs AA, BB, CC, DD, EE and FF from rolls 200, 201, 202, 203, 204 and 205 are interfolded by means of the apparatus. The rolls 200 to 205 are respectively mounted on cores 206, 207, 208, 209, 210 and 211. The cores 206, 207 and 210 are respectively supported by means of brackets 212, 213 and 214 fixed to the frame 30; and the cores 208, 209 and 211 are directly mounted on the frame 30. The cores 207, 208 and 209 are so arranged as to hold their respective paper rolls quite close to the frame 30; and the cores 206, 210 and 211 are arranged to hold the rolls carried by the latter cores farther spaced from

the frame 30 by the distances of half the width of the paper webs. A support ring 215 is fixed to the frame 30, particularly being mounted on the horizontal beam 30d and on the vertical beams 30f and 30g.

Webb-carrying rolls 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230 and 231 are rotatively mounted with respect to the frame 30, either being mounted directly on to the frame or to the circular plate 215 or on plate extensions 232, 233, 234 and 235. Various of these rolls are driven for the purpose of propelling the webs from the rolls 200 to 205. The power is derived from a gear box 236 carrying an output pulley 237. The roll 216 has a pulley 238 fixed to it, and a belt 239 extends around the pulleys 237 and 238, thereby driving the roll 216. The roll 216 has another pulley 240 fixed to it, and the rolls 219, 222, 224 and 226 respectively have pulleys 241, 242, 243 and 244 fixed to them. The frame 30 also either directly or by means of extensions on the circular plate 215 carries idler pulleys 245, 246, 247, 248, 249, 250, 251 and 252. A belt 253 extends around the pulleys 241, 245, 246, 247, 242, 248, 243, 249, 250, 251, 244, 252 and 240 for driving the rolls 219, 222, 224 and 226.

A belt 254 is movably supported from the frame 30 by means of rollers 255 and 256. The belt carries a continuous stack 257 of previously interfolded tissue webs.

A pair of underfolding boards 258 and 259 are disposed above the belt 254. The board 258 is of the righthand type similar to the board 84 shown in FIGS. 1, 7 and 8, and the board 259 is of the lefthand type. Guide plates 260 and 261 are disposed beneath the boards 258 and 259. A standard 262 supports the guide plates 260 and 261 and the lower ends of the folding boards 258 and 259 by means of studs 263.

The lefthand board 259 is substantially the same as the righthand type, except that the parts are reversed. A plan view of the lefthand type of underfolding board is shown in FIG. 9, and it will be noted that the board has folding edges 114' and 113' and plate portions 109', 110' and 111' corresponding to the folding edges 114 and 113 and the plate portions 109, 110 and 111 of the righthand board illustrated in FIGS. 7 and 8. Since the FIG. 9 board, however, is reversed, the diagonal folding edge 113' extends from left to right instead of vice versa, looking in the direction of web travel, which is from right to left as seen in both FIGS. 8 and 9. A board of the FIG. 9 type is illustrated and described in greater detail in the above mentioned C. J. Greiner et al. Patent, 3,066,932, referring to FIG. 8, in particular, of the patent.

Auxiliary guide rolls 264 and 265 are disposed above the folding boards 258 and 259 and are suitably supported from the cross frame member 30e.

Folding boards 266, 267, 268 and 269 are respectively fixed to the extensions 232, 233, 234 and 235. The folding board 266 extends generally upwardly; the folding board 268 extends generally downwardly; and the folding boards 267 and 269 extend generally sidewardly and inwardly toward the rolls 229 and 230. The folding boards 266 and 267 are of the lefthand overfolding type as shown in FIG. 5, and the boards 268 and 269 are of the righthand overfolding type as shown in FIGS. 3 and 4.

In operation, the webs AA and BB are drawn from the rolls 200 and 201 on to the driven roll 219, with the web AA being on the outside. The web AA passes over the idler roll 218, and the web BB passes over the idler roll 220. The two webs AA and BB pass on to the exterior or convex surface of the lefthand folding board 266, and the folding board 266 folds the web BB over the web AA as illustrated in FIG. 13b.

The webs AA and BB as so folded pass on to the driven roller 222. The web CC passes over the idler roll 221 and on to the roller 222 along with the webs AA and BB. The three webs AA, BB and CC then pass on to the convex surface of the lefthand folding

board 267, and the board 267 folds the web AA over so that it embraces the fold  $bb_2$  of the web BB and also embraces the web CC as shown in FIG. 13c. The webs AA, BB and CC as so folded have fold  $cc_2$  protruding from the folded stack as illustrated in FIG. 13c, and they then pass over the rolls 229, 230 and 231 to the rolls 216 and 217 and from thence on to the folding board 259.

The webs DD and EE are drawn from the rolls 203 and 204 on to the driven roll 224. The web DD passes over the idler roll 223, and the web EE passes over the idler roll 225. The two webs DD and EE pass from the roll 224 over the convex surface of the righthand folding board 268, and the folding board 268 functions to fold the web EE over the web DD as illustrated in FIG. 13d.

The webs DD and EE as so folded pass on to the driven roll 226. The web FF from the roll 205 is added to the webs DD and EE on the roll 226, passing over the idler rolls 227 and 228 on to the roll 226. The webs DD, EE and FF pass from the roll 226 on to the convex surface of the righthand folding board 269, and the board 269 functions to fold the web DD over, so that the web DD embraces the fold  $ee_2$  of the web EE and also embraces the web FF as illustrated in FIG. 13e which protrudes from the stack. The webs DD, EE and FF from the board 269 then pass over the roll 230, underneath the webs AA, BB and CC, and over the roll 231 to the rolls 216 and 217, and from thence to the folding board 258 over the roll 264.

The stack 257 of previously folded webs includes an uppermost web GG, and the uppermost fold  $gg_2$  of the web GG passes over the horizontal plate portion 111 of the board 258 (see FIGS. 7 and 8); and the board 258 functions to fold the web FF, in particular, to move the fold  $ff_2$  of the web FF beneath the fold  $gg_2$ . The webs DD, EE and FF have thus been interfolded with the previously interfolded web stack 257.

The webs AA, BB and CC pass from the roll 265 on to the convex surface of the folding board 259 with the fold  $cc_2$  of the web CC protruding from the stack, and the folding board 259 folds the web CC downwardly and inwardly so that the fold  $cc_2$  of the web CC lies between the fold  $ee_2$  of the web EE and the fold  $ee_1$  of the web EE. The webs AA, BB and CC have thus been interfolded with the previously interfolded webs, the uppermost one of which is the web EE with its upper fold  $ee_2$ .

The modified folding apparatus disclosed in FIG. 14 also utilizes the frame 30 with its vertical beams 30a, 30b, 30f and 30g and its horizontal beams 30c, 30d and 30e. A plurality of paper rolls 290, 291, 292, 293, 294 and 295 are supported on the frame 30. Cores 296, 297, 298, 299, 300 and 301 are respectively provided for these rolls. The cores 296, 297 and 300 are respectively supported by means of brackets 302, 303 and 304 from the frame 30, and the cores 298, 299 and 301 are rotatively mounted directly on the frame 30 as shown. The cores support the rolls so that the rolls 291, 292 and 294 are located quite close to the frame 30, while the other rolls 290, 293 and 295 are located farther outwardly from the frame 30 by a distance equal to half the width of the webs carried by the rolls 290 to 295.

The apparatus includes rotatable web-carrying driven rolls 305, 306, 307, 308, 309 and 310; and it also includes idler web-carrying rolls or rollers 311, 312, 313, 314, 315, 316, 317, 318, 319, 320 and 321. The roll 318 is supported on a swingable arm 322 so that the rolls 318 and 319 have a nip between them, and the other rolls are rotatively supported on a hexagonal plate 323 or on other parts fixed with respect to the frame 30.

The driven rolls 310, 305, 306, 307, 308 and 309 are driven from a gear box 324 having an output pulley 325. A pulley 326 is fixed with respect to the roll 310, and a belt 327 extends around the pulleys 325 and 326 and also around an idler pulley 328 so as to drive the

roll 310 from the gear box 324. Pulleys 329, 330, 331, 332, 333 and 334 are fixed respectively with respect to rolls 305, 306, 307, 308, 309 and 310, and a belt 335 extends around these pulleys and also around an idler pulley 336 for driving the driven rolls 305 to 309 with respect to the roll 310.

Folding boards 337, 338, 339 and 340 are fixed on the hexagonal plate 323. The folding boards 337 and 340 are righthand folding boards as shown in FIGS. 3 and 4, and the boards 338 and 339 are lefthand folding boards as shown in FIG. 5.

A belt 341 travels across the frame 30, being supported by rolls 342 and 343 rotatively disposed on the vertical beams 30a and 30b. A pair of the underfolding boards 344 and 345 are fixed with respect to the horizontal beam 30e as illustrated, and web guide plates 346 and 347 are disposed beneath the folding boards. A standard 348 is provided for supporting the guide plates 346 and 347 and also for supporting the lower end of the folding boards 344 and 345 by means of studs 349 fixed to the standard 348. The board 344 is a righthand board as shown in FIGS. 7 and 8, and the board 345 is a lefthand board as shown in FIG. 9.

In operation, the web JJ and KK are drawn from the rolls 290 and 291, respectively, and both of these webs pass on to the driven roll 305. The web JJ passes over the idler roll 312 and the web KK passes over the idler roll 311 to the roll 305. The webs JJ and KK pass from the roll 305 on to the convex surface of the righthand overfolding board 337, and the board 337 folds the web JJ over the web KK as illustrated in FIG. 14b.

The webs JJ and KK pass from the board 337 on to the roll 306, and the web LL is drawn from the roll 292 and is added to the webs JJ and KK on the roll 306, the web LL passing over the preliminary guide roll 313. The webs JJ, KK and LL pass on to the convex exterior surface of the lefthand board 338, and the board 338 folds the web KK over the web LL as shown in FIG. 14c. The webs JJ, KK and LL as so interfolded pass from the folding board 338 over the driven roll 307 and downwardly over the idler rolls 321 and 320 to the rolls 310 and 318. The webs pass between the rolls 310 and 318 on to the idler roll 319 and from thence on to the convex surface of the underfolding board 345.

Webs MM and NN are respectively drawn from rolls 293 and 294 on to the driven roll 308. The web MM passes over the idler roll 314, and the web NN passes over the idler roll 315 prior to the roll 308. The webs MM and NN pass on to the convex surface of the lefthand folding board 339 from the roll 308, and the folding board 339 folds the web MM over the web NN as shown in FIG. 14d.

The webs MM and NN as so folded pass from the board 339 on to the driven roll 309, and the web PP is added to the webs MM and NN on the surface of the roll 309. The web PP is drawn from the roll 295 over the idler roll 317 on to the roll 309. The webs MM, NN and PP pass from the roll 309 on to the convex surface of the folding board 340, and the board 340 functions to fold the web NN over the web PP as shown in FIG. 14e. The webs NN and PP pass from the board 340 between the rolls 318 and 310 to the underfolding board 344.

A stack 350 of previously interfolded tissues is carried by the belt 341 beneath the folding board 344. The stack 350 has a web QQ on its upper surface, and the upper fold  $qq_2$  of the web QQ passes over the plate portion 111 of the underfolding board 344 which is of the righthand type. The folding board 344 functions to fold the fold  $pp_2$  beneath the fold  $qq_2$  so as to complete the interfolding of the stack 350 with the webs NN and PP as shown in FIG. 14f.

The interfolded web stack 350 travels from the folding board 344 to the folding board 345, and the upper fold  $mm_2$  of the stack 350 at this point is trained over the lower plane surface 111' of the folding board 345. The

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folding board 345 functions to fold the fold  $ll_2$  of the web LL beneath the fold  $mm_2$  so as to complete the interfolding of the webs JJ, KK, and LL with respect to the stack 350, which includes the webs MM, NN and QQ (see FIG. 14a).

The embodiments of the invention illustrated and described advantageously include mechanism for inter-folding webs from a plurality of rolls that are disposed in generally circular configuration. It will be observed that in all illustrated forms of the invention the rolls are disposed on the frame 30 in this manner, two rolls being rotatably mounted on the top of the frame and two rolls each being mounted on opposite sides of the frame. A plurality of these frames, each carrying a plurality of paper rolls, may be advantageously utilized for providing a continuous stack or sausage of interfolded webs of substantial thickness, in view of the inclusion of the under-folding boards for interfolding together previously interfolded stacks of webs and the webs produced on the frames 30. The forms of the invention illustrated in FIGS. 12, 13 and 14 cause interfolding of previously formed stacks and webs from the rolls carried on the frames 30 in two steps so that there is less tendency for the webs to become misaligned.

Each of the overfolding boards, particularly if they utilize the mathematical equations given above and in connection with FIG. 10, advantageously assure that the web is passing over the overfolding board is not stretched or does not become relaxed along any longitudinal line in the web, so that the web is overfolded accurately. It will be apparent that each of the folding boards has a path for folded webs which emerge from the board, the path for the board illustrated in FIG. 5 being defined as the portion of the plane part 98 which is embraced by the folds  $b_1$  and  $b_2$ , and the longitudinal halves of the webs being folded over or under are staggered inwardly or outwardly with respect to these paths. Each of the overfolding boards utilizes an active and an inactive web, both of which are unfolded as they enter on the board—the active web is, for example, the web B on the board 79 illustrated in FIG. 5 which is being folded over by the board, and the inactive web is the web A which simply passes along the exterior or convex surface of the board without being folded so that the folds of the web B may be folded over the web A to embrace the web A.

We wish it to be understood that the invention is not to be limited to the specific constructions, arrangements and devices shown and described, except only insofar as the claims may be so limited, as it will be apparent to those skilled in the art that changes may be made without departing from the principles of the invention.

What is claimed is:

1. A folding device for folding a web of sheet material which is drawn over the device and emerges from the device in a longitudinally folded condition in a predetermined path, comprising a first folding edge extending from a point at an edge of the path transversely of the path and to the other edge of the path and half the width (W) of the web, a second folding edge extending from said point outwardly with respect to the path and at an obtuse angle ( $90^\circ + M$ ) with respect to said first folding edge and at an obtuse angle ( $180^\circ - L$ ) with respect to the direction of movement of said web in said path, and a third folding edge extending from said point obliquely of said path to the other edge of the path to have an acute angle (N) with respect to the other edge of the path, whereby a longitudinal fold of the web may be drawn over said first folding edge in said path and another fold of the web may be drawn over said second and third folding edges to be thereby folded over said first named fold to provide a folded web, wherein the sizes of the angles L, N and M are substantially as follows:

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$$\cos L = \text{one} - W^2/2fl$$

and

$$\tan N = W/2e$$

and

$$\tan M = W/2f$$

wherein  $f$  is the distance from said first folding edge to a line intersecting with said second folding edge and parallel with said first folding edge and having the length (W) and overlying said path,  $e$  is the component of said distance  $f$  along said path, and  $l$  is the distance from said first folding edge to the point at which said third folding edge crosses said other edge of said path.

2. A folding device for folding a web of sheet material which is drawn over the device and emerges from the device in a longitudinally folded condition in a predetermined path, comprising a folding board of sheet material bent along a first folding edge extending from a point at an edge of the path transversely of the path to the other edge of the path and half the width (W) of the web to provide first and second plane portions that have an obtuse angle ( $180^\circ - L$ ) with respect to each other, said second plane portion being disposed in said path and said first plane portion providing a second folding edge extending from said point at an obtuse angle ( $90^\circ + M$ ) with respect to said first folding edge, a rod fixed to the surface of said second plane portion facing said first plane portion, said rod extending at an acute angle (N) from the other edge of said path to said point and forming a third folding edge whereby a longitudinal fold of the web may be drawn over the folding device and across said first folding edge in said path and another fold of the web may be drawn over said first plane portion and over said second and third folding edges to be thereby folded over said first named fold to provide a longitudinally folded web, wherein the sizes of said angles L, M and N are substantially as follows:

$$\cos L = \text{one} - W^2/2fl$$

and

$$\tan N = W/2e$$

and

$$\tan M = W/2f$$

wherein  $f$  is the distance in said first plane portion from said first folding edge to a line intersecting with said second folding edge and parallel with said first folding edge and having the length W and overlying said path,  $e$  is the component of said distance  $f$  along said path and  $l$  is the distance in said second plane portion from said first folding edge to the point at which said third folding edge crosses said other edge of said path.

3. A machine for interfolding webs of sheet material to produce a continuous stack of webs traveling in a predetermined path, comprising a plurality of successive over-folding devices, and mechanism for drawing webs from web supply rolls over said devices and along said path, each of said devices having a first folding edge extending directly across the path over which a longitudinal fold of an active web which is being folded by the device may travel, and a second folding edge, and a third folding edge extending diagonally across the path, said second folding edge being positioned to transfer the other longitudinal fold of the active web on to said third folding edge over which the latter fold is reversed so that the device produces one fold of the active web above the other, said first folding edge of each of said devices being adapted to have an inactive web from one of said supply rolls passing over it and underlying the active web of the device and the first of said devices drawing an active web from one of said rolls and folding the active web over its inactive web and each of said devices after the first device being adapted to receive and fold the inactive web from the previous device over its own inactive web so as to produce a continuous stack of interfolded webs traveling along said path and a folding device of an underfolding type and receiving the webs as folded by said first named devices, said under-

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folding device comprising a part for lifting the uppermost fold of the previously interfolded stack of webs and to underfold the inactive web of the interfolded webs received from said first named devices underneath the top fold of the previously interfolded stack of webs to further complete the previously interfolded web stack.

4. A machine for interfolding webs of sheet material to produce a continuous stack of webs traveling in a predetermined path, comprising a plurality of successive folding devices, a frame, a plurality of arbors mounted on said frame in such positions as to hold a plurality of web supply rolls in a generally circular disposition, a plurality of folding devices mounted on said frame within said circular disposition, and mechanism for drawing webs from the web supply rolls over said devices and along said path, each of said devices having a first folding edge extending directly across the path over which a longitudinal fold of an active web which is being folded by the device may travel, and a second folding edge, and a third folding edge extending diagonally across the path, said second folding edge being positioned to transfer the other longitudinal fold of the active web on to said third folding edge on which the latter fold is reversed so that the device produces one fold of the active web above the other, said first folding edge of each of said devices being adapted to have an inactive web from one of said supply rolls passing over it and underlying the active web of the device and the first of said devices drawing an active web from one of said rolls and folding the active web over its inactive web, and each of said devices after the first device being adapted to receive and fold the inactive web from the previous device over its own inactive web so as to produce a continuous stack of interfolded webs traveling along said path.

5. A machine for interfolding webs of sheet material to produce a continuous stack of webs traveling in a predetermined path, comprising five successive overfolding devices, mechanism for drawing webs from web supply rolls over said devices and along said path, each of said devices having a first folding edge extending directly across the path over which a longitudinal fold of an active web which

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is being folded by the device may travel, and a second folding edge, and a third folding edge extending diagonally across the path, said second folding edge being positioned to transfer the other longitudinal fold of the active web on to said third folding edge over which the latter fold is reversed so that the device produces one fold of the active web above the other, said first folding edge of each of said devices being adapted to have an inactive web from one of said supply rolls passing over it and underlying the active web of the device, and the first of said devices drawing an active web from one of said rolls and folding the active web over its inactive web and each of said devices after the first device being adapted to receive and fold over the inactive web from the previous device over its own inactive web so as to produce a continuous stack of interfolded webs traveling along said path, means for conveying a previously interfolded continuous stack of webs, and a folding device of an underfolding type and receiving the webs as folded by said first-named devices, said underfolding device comprising a part for lifting the uppermost fold of the previously interfolded stack of webs and to underfold the inactive web of the interfolded webs received from said first-named devices underneath the top fold of the previous interfolded stack of webs to further complete the previously interfolded web stack, said overfolding devices and said underfolding device being so aligned with each other and with the webs supplied to them that each of these devices longitudinally folds a web substantially along the longitudinal center line of the web and so that all internal folds of the webs in the resulting stack are substantially completely inserted between the folds of adjacent webs in the resulting stack.

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