

March 6, 1928.

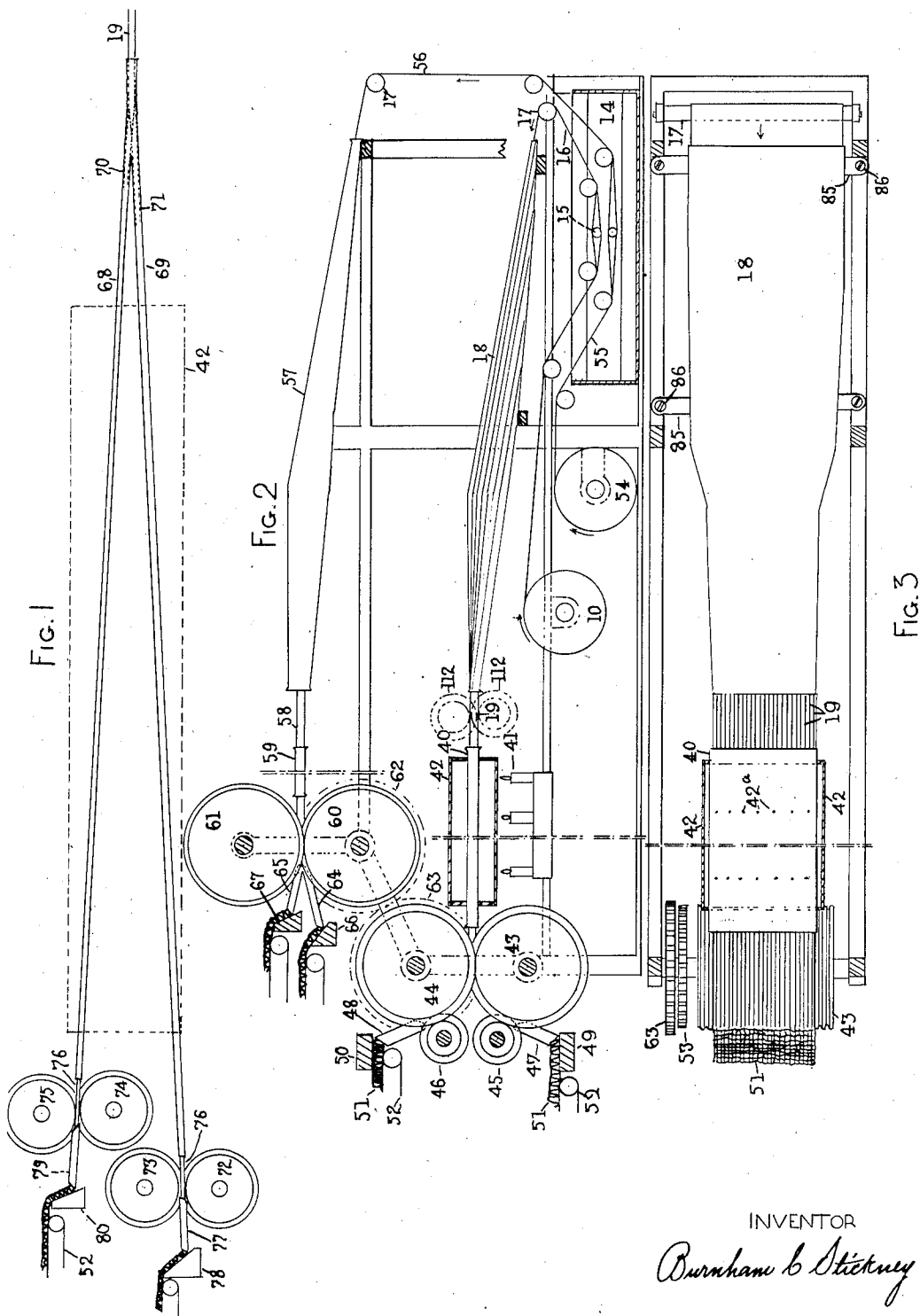
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PAPER CORRUGATING AND CRINKLING

Filed Jan. 6. 1921

4 Sheets-Sheet 1



INVENTOR

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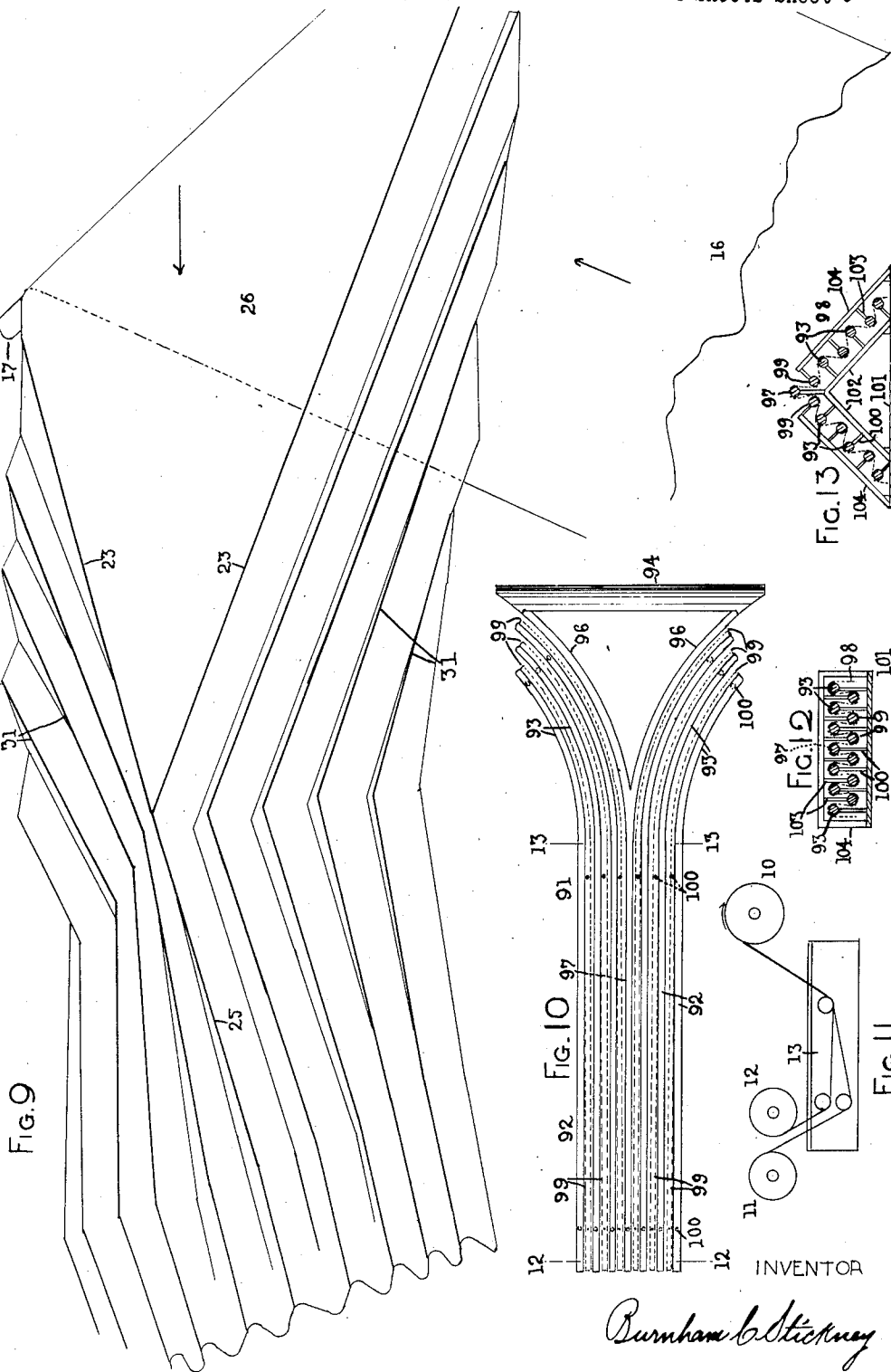
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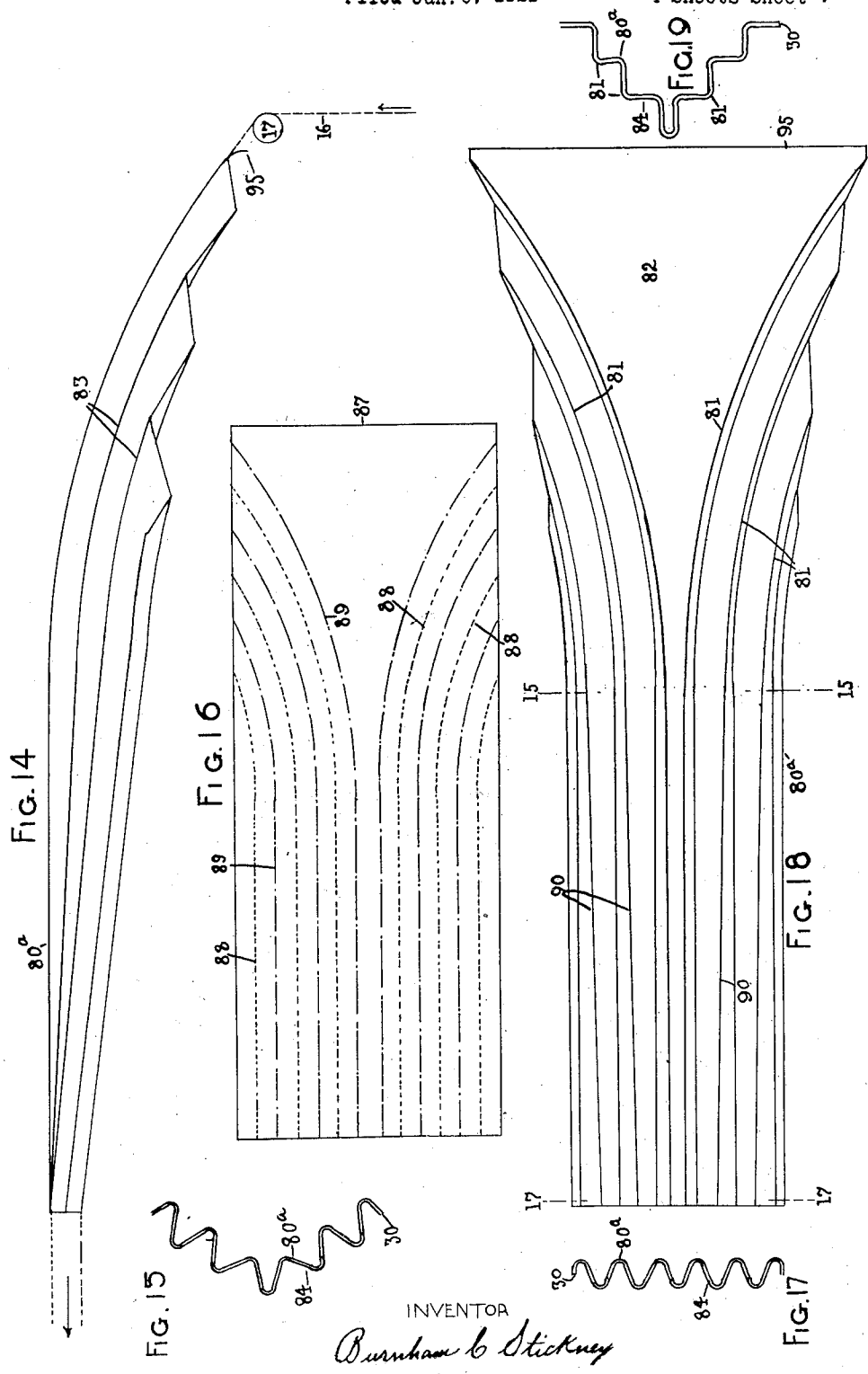
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PAPER CORRUGATING AND CRINKLING.

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This invention relates to gathering a web of paper laterally by forming longitudinal corrugations therein, and also longitudinally by forming transverse crinkles in the corrugated web.

One of the objects of the invention is to improve the method of forming the longitudinal corrugations in the web. For this purpose there is employed a novel former, one portion of which is in the nature of a triangular plate, or at least a plate having converging sides and merging at its apex into a prolonged straight blade, the plate being inclined relatively to the edge of the blade. In one form of the invention this portion of the device may somewhat resemble the former which is commonly used for providing a web with a single longitudinal fold. The device so far described forms in the web the middle one of a series of flutings or corrugations, the other corrugations being formed in about the same manner by means of ripples that run alongside of the angle plate and ribs that run alongside of the central blade or rib. These lateral ripples and ribs form all the remaining corrugations or flutes in the web, and each ripple may extend alongside of one of the side edges of the main angle plate, and merge into a rib which extends alongside of the central rib; these ripple and rib portions being disposed obliquely to each other, or in other words the ripples on one side of the plate converge substantially towards those on the other side, and the ribs run about parallel, or slightly convergent.

In one form of the invention, the converging ripples are straight, and form obtuse angles with the straight ribs into which they merge; but in the preferred form the converging ripples are curved inwardly or in a concave manner, and merge into the parallel ribs, thereby avoiding the formation of salient angles between the ripples and the ribs. Moreover the entire convergent or intake portion of the former, including both middle plate and side ripples, is arched or convexly curved, and merges into the straight ribs.

The main angle plate, the ripples and the ribs may all be formed of a single piece of sheet-metal, and this plate may be substantially duplicated, one plate to be removably fastened above the other, with a slight space between them to form a passage for the traveling web, so that the same will be

caused to conform to the ribs and thereby gathered into longitudinal corrugations. All of the angles of the former may be rounded; and after the corrugation or flutes are generated they may be modified in contour as desired as they progress through the delivery portion of the former.

The ribs at the delivery portion of the former may be approximately parallel, and hence subject the web to little or no friction. The ripples at the introductory side of the former are convergent, and the paper is subjected to negligible friction in passing over the edges of the ribs; these edges may be rounded, and the ripples may extend at slight angles to the direction of travel of the paper, so that there will be negligible opposition to the flow of the paper into and out of the ripples. The paper may be wet either before or after passing through the former. The latter may be made of polished metal or glass, or of enameled ware; and the surfaces of the former may if desired, be lubricated by means of water.

In order to increase the output of the machine, two plies of paper may be passed therethrough in superposed condition, and these may be separately cross-crinkled as they emerge from the machine. One of the features of the invention relates to the preferred preliminary moistening of the paper, which is passed through a tank containing water, the webs being led from two rolls to the tank, and then wound up into one double-ply roll. This may be allowed to set for a suitable period, say a day or more, to allow the moisture to permeate evenly throughout the roll, and thereby eliminate relatively strong or weak spots in the paper, and hence reduce liability of rupture in passing through the gathering former. It is noted that the strength of the two-ply web is double that of a single ply, whereas the frictional opposition of the web in passing through the machine is only the same as a single ply, so that a further advantage is gained in passing the web through the machine in double-ply form whether the double-ply web be wet or dry; the advantage being greater when the paper is wet and comparatively weak.

Preferably the double-ply web is led through a bath of melted paraffin before passing into the former; and while in the bath the plies may be separated so as to give

the paraffin access to both sides of each ply.

The paper as it leaves the former is in a corrugated condition, and if it is dry at this time it may be made moist and soft by any
 5 desired means. The corrugated or fluted paper then passes at a moderate speed through a long oven, and while in the oven it is guided by fluted guides, one above the web and one below, whereby the paper is
 10 heated and dried, its form being preserved by the fluted guides during the drying process, so that when the paper becomes dry it is in a permanent fluted condition, and if distorted will spring back to its fluted shape.
 15 It will be understood that the longer the oven, the more rapidly the machine may operate. Preferably the fluted guides in the oven are provided with perforations to facilitate the escape of vapor from the paper.
 20 The fluted and dried paper then passes between feed-rolls, and at this point, in one form of the invention, the plies of the web may be separated and pass separately off to devices to effect the cross-crinkling.
 25 There may be small feed-rolls running upon main rolls, and each small roll may co-operate with its main roll to feed the paper through a short corrugated sheet-metal guide, this guide open at both its receiving and delivering ends, and a doctor-blade being stationed at its delivery end to effect the cross-crinkling of the corrugated paper.
 30 This delivery guide may extend into the bite of the large and small feed-rolls, but out of contact therewith, and serves to guide the corrugated paper into engagement with the doctor-blade or other creping device.
 35

In order to further increase the output of the machine, a second forming device
 40 may be mounted above the first, and a double-ply web may be led thereto, after passing through said paraffin bath. The web after passing through the second former may be led through a drying oven and
 45 thence to feed-rolls, by which they may be delivered to cross-crinkling devices; and if desired the sheet-metal corrugated delivery guides may take the paper directly from these main feed-rolls to the doctor-blades.
 50 If desired, different kinds of corrugating may be carried on simultaneously by the use of different gathering formers.

The preferred method of handling the paper, after it leaves the gathering former,
 55 is to divide the plies at once and lead them separately through the oven or through long corrugating sheet-metal guides or tubes, which may diverge from their receiving ends and lead separately into different pairs of feed-rolls, there being provided sheet-metal corrugated delivery guides or tubes in association with the different pairs of feed-rolls to lead the paper to separate doctor-blades.
 60

65 If desired, the paper may be moistened

as it leaves the feed-rolls and while in the delivery tubes, so as to facilitate the cross-crinkling of the web by the doctor-blade.

It will further be understood that the moist corrugated paper, as it enters the
 70 corrugated tubular drying guides, may be in such a condition as to be incapable of holding its shape, but as it passes along said guides it becomes heated and dried and hardened, while the guides preserve its
 75 shape, and as it emerges from said guides it is in permanent, elastic, fluted condition.

Other features and advantages will hereinafter appear.

In the accompanying diagrammatic drawings.
 80

Figure 1 is a diagrammatic elevation of an apparatus illustrating the plies of corrugated web as being separated and transversely crinkled.
 85

Figure 2 is a sectional elevation or diagram illustrating a double-deck machine having upper and lower gathering formers, and upper and lower sets of feed-rolls and crinkling devices.
 90

Figure 3 is a sectional diagrammatic plan of the lower portion of the apparatus seen at Figure 2.

Figure 4 is a cross-section of the former, the position of the cross-section being indicated diagrammatically by the line 4—4 of Figure 8, showing the delivery end of the gathering former.
 95

Figure 4^a shows the preferred form of compound-curved web-gathering rib.
 100

Figure 5 is a cross-section whose position is indicated diagrammatically by the line 5—5 of Figure 8, showing a section of one form of the gathering former at its apex portion.
 105

Figure 5^a shows a cross-section of a former made with compound-curve ribs of the kind seen at Figure 4^a; this cross-section resembling Figure 13 except for the style of ribs.
 110

Figure 6 is a section whose position is indicated diagrammatically by the line 6—6 of Figure 8, and showing the gatherer near its intake end.
 115

Figure 7 is a diagrammatic elevation of the lower plate of the novel former.
 120

Figure 8 is a diagrammatic plan of the lower plate or frame of one form of the former.
 125

Figure 9 is a perspective to illustrate the manner in which the web gathers as it advances through the Figure 8 former; the web for the sake of clearness being gathered into fewer folds or corrugations than illustrated at Figure 8.
 130

Figure 10 shows a plan of ribs of a gathering former, these ribs consisting of round wires, the delivery end of each wire being straight, and the receiving end having a compound curvature upon the principle seen at Figure 14.
 135

Figure 11 illustrates diagrammatically a method of wetting separate webs and rolling them up together preparatory to passing them in superposed relation through either the upper or lower deck of the apparatus seen at Figure 2.

Figure 12 is a cross-section of the gathering frame, taken at about the line 12—12 of Figure 10.

Figure 13 is another cross-section, taken at about the line 13—13 of Figure 10.

Figure 14 shows in side elevation one style of the preferred arched construction of former.

Figure 15 is a diagram of the upper and lower plates of the former, at about the line 15—15 of Figure 18.

Figure 16 shows a plate of copper or other suitable metal from which the former plates seen at Figures 14 and 17 may be struck up; the markings indicating the locations of the tops and bottoms of the gathering ribs or plates.

Figure 17 is a diagram of the upper and lower former plates at about the line 17—17 of Figure 18.

Figure 18 is a plan of the arched former seen at Figure 14; Figure 18 showing the converging concave curves which are formed in the arched gathering portion of the former seen at Figure 14.

Figure 19 is a cross-section showing ribs at right-angles instead of the acute angle arrangement seen at Figure 15.

The paper to be treated may be paid off from a roll 10. Preferably the web comprises two superposed plies, although a single ply may be used. At Figure 11 the plies are seen being paid off from rolls 11 12, and passing through a water bath 13, then running in superposed relation to roll 10, whereon they are wound. The double (or single) web may, if desired, be run through a paraffin bath 14, Figure 2, the plies passing above and below a separator 15 in said bath, and then running up at 16 to a guide bar or roll 17, whence they pass to a former 18, by which the double (or single) web is gathered into longitudinal corrugations or flutes 19.

The former seen at Figures 4 to 8 comprises a triangular or three-sided ripple plate or frame 20, the paper advancing from the base of the triangle to the apex, and there folding over a central rib 21 into which the triangular plate 20 merges, the point of junction of the rib with the apex of the triangle being seen at 22, this forming the apex or highest point of the former. As so far described, this former resembles the device commonly used for longitudinally folding a web; the paper turning down at 23, Figure 9, over the converging edges 24 of the triangular plate or frame 20, and coming to a fold at 25 upon the rib 21, and the rib

extending from the triangle at a slight angle when viewed in elevation at Figure 7; the fold 25 being also at an obtuse angle to the triangular flat surface 26 of the advancing paper, Figure 9. The rib 21 makes one of the folds or corrugations, namely, the central one.

The former may comprise upper and lower plate-like forming-elements 29 and 18, between which the sheet advances, each of these elements comprising a triangular portion, as at 20 and 27, Figure 6, this triangular portion flanked with ripples, which at Figure 8 are designated as 28 and converge substantially in parallelism with the sides of the triangular plate 20. The upper plate or frame, which is designated generally as 29 in Figures 4, 5, 6 and 7, has a central rib 21 and a point of junction 22 and otherwise corresponds with frame 18, and serves to ripple the advancing sheet into conformity with the lower plate or element; a space 30 being left between the plates for the passage of the rippling paper. The advancing paper runs over (i. e. into and out of) the converging ripples 28, and flows into a shape corresponding with the straight ribs or corrugations 31, those on one side converging somewhat towards those on the other side as at Figure 9. The paper advances at a slight angle to the succession of convergent ripples 28, and is gradually brought to a fluted condition, this occurring at the time the paper reaches the apex of the triangle 20, at which point the section at Figure 5 is taken. At Figure 6 it will be seen that only small portions of the paper have entered the ripples 28, but at Figure 5 the entire width of the web is contained within the convolutions formed by upper and lower sets of ribs.

At about the line 5—5 of Figure 8, the middle rib 21 may be parallel sided or vertical, as seen at Figure 5, and the paper may fold down vertically upon the sides of said rib. The wall of the next outer rib 28 may be either vertical or nearly parallel with 21, and the succeeding ribs, stepping outwardly, may be inclined in nearly the same direction. However, the shaping of the former on line 5—5 may be substantially varied within the scope of the invention, and it is not essential that the former consist of plates, since rods or other devices (Figures 10, etc.,) may be employed for tracks over which the paper may gather as it advances. For example, all of the ribs 28 may have vertical sides and horizontal tops, in which case the sides of the former would be extended down as at Figure 19. But it is desirable to bring all of the flutes in the paper promptly into horizontal row or arrangement (Figure 4), and for this reason the side walls or portions of the ribs 28 may be inclined outwardly, somewhat as at Fig-

ure 5, in order to enable this cross-section to approximate the desired horizontal arrangement.

The fluted condition of the paper as it reaches the line 5—5 can be understood by noting the undulatory paper-space seen between the former plate 18 and the cover plate 29 at Figure 5. From this point, where the rippling motion of the paper is completed, the paper may proceed along the straight fluted delivery portion 32 of the former, the flutes being here so designed as gradually to bring the paper to the desired corrugated or fluted condition, as will be understood by reference to the paper-space 30 between the former plate 18 and the cap plate 29 at Figure 4, in which the corrugations are even and regular, making a horizontal row; this section being taken at the delivery end of the former. It will be seen that the sides of the central rib 21 may be caused to slope gradually outward at the bottom at 31^a, and that the sides of the remaining ribs are twisted or shaped at 31^b so that they are gradually brought to substantially uniform condition or shape at their delivery ends, with similar configurations and even spacing. The parallel flutings 32 in the former may form obtuse angles at 33 with the convergent ripples 28, and these may converge somewhat to their delivery ends; the configuration or cross-section gradually changing from one end to the other, so as to bring the delivery ends into the desired arrangement. As will be understood by reference to Figure 7, the central rib 21 may be horizontal, while the ribs at each side thereof may be inclined upwardly, to bring their ends to a level with the central rib 21.

A simple form of gatherer is shown at Figure 19, in which the walls of the grooves are all either horizontal or vertical, the vertical walls being parallel with the sides of the central rib 21.

As seen at Figure 7, the portion of the former extending from the apex thereof to its terminal end may be lengthened, to permit the paper to alter gradually from its step-like cross-section, as at Figures 5, 5^a, 13, 15 and 19, to its grooved condition, as at Figures 4, 12 and 17. If the former is made of sheet-metal, it may, if desired, be originally bent or shaped into the right-angle condition seen at Figure 19, and then its middle side portions may be sprung or gradually shaped up to the condition seen at Figure 5 or 15.

From the gathering former the corrugated web 19 is led to the intake end of a drying unit comprising a corrugated drier 40, the cross-section of which is the same as that at Figure 4, comprising upper and lower matching plates such as those seen at 29, 32, in Figure 4, which hold the paper

in shape while it is being dried during its travel. The plates are kept warm by any suitable heater, as, for example, burners 41 beneath an oven 42, through which the heating plates 29, 32 extend. The oven and the heating plates may be of such length as to render the paper as dry as desired when it emerges, so that it will preserve its fluted form.

From the drier the single-ply or double-ply web of corrugated paper may pass between feed-rolls 43, 44; and if the web is double-ply, one ply may be led down into the bite of roll 43 and an auxiliary feed-roll 45, while the other ply may be led up into the bite of roll 44 and auxiliary roll 46. The plies may then pass separately through stationary directrices 47, 48, against doctor-blades 49, 50, by which the corrugated paper is transversely crinkled at 51, and led off over delivery belts 52. The directrix 48 may be in the form of plates whose cross-section is also seen at Figure 4 or 14, whereby the corrugated shape of the paper is preserved while it is being urged by the rolls to the doctor-blades and crushed thereagainst. The paper is closely confined against buckling in the directrices 47, 48. By the provision of the two doctor-blades or any other desired crinkling devices, it will be seen that the output of the machine may be doubled by inexpensive means. The paper may be crinkled in a manner to render the directrices 47, 48 unnecessary; as, for example, the doctor-blades may engage directly with the rolls 43, 44.

The upper and lower plates of the drier 40, are preferably provided with numerous perforations 42^a to permit the venting of vapor escaping from the paper, and to facilitate the drying thereof. The rolls 43, 44 may be connected by power-driven gearing 53.

If desired, the apparatus may be provided with an upper deck for simultaneously treating a single or double-ply web from an additional roll 54, from which the web may be led at 55 through the paraffin bath, and then at 56 up to an upper gathering former 57, which may be similar to 18, and from this it may pass at 58 to heating plates 59 and thence to feed-rolls 60, 61; 60 having a driving gear 62 to mesh with a gear 63 on roll 44. If two plies are used they pass through the rolls 60, 61 into a forked guide comprising upper and lower directing members 64, 65, whereby the paper is led to doctor-blades 66, 67, so that the rolls 45, 46 may be omitted. Members 64 and 65 are the same in cross-section, as seen at Figure 4 or 14, but may join or substantially join at their inner ends, where they may extend into the grooves in the rolls; all of the described rolls having grooved peripheries to match the corrugations in the webs. The

stationary driers need occupy but little room vertically, thus permitting the construction of the compact double deck machine shown.

At Figure 1 is shown a method of separating the superposed plies of grooved web 19 as these plies enter the heating unit, which in this case may comprise upper and lower couples of heating plates 68, 69, each of which has the cross-section seen at Figure 4; these couples diverging and one of the plies entering the upper couple, as at 70, while the lower ply enters the lower couple, as at 71, so that the plies are heated separately and may be fed forward separately by the rolls, one pair of which is indicated at 72, 73, and the other at 74, 75; all of these rolls being power-driven and resembling the rolls 43, 44. One ply of dried corrugated paper 76 may be delivered by the rolls 72, 73, to a directrix 77, whereby it is delivered against a doctor-blade 78; and the upper directrix 79 for the other ply may lead the paper against a doctor-blade 80.

The directrices 77, 79 may be open at their ends and may extend within the grooves in the feed-rolls and may terminate a little short of the doctor-blades, or, if desired, may be carried directly against the doctor-blades, as at 64, 65, according to the character of the crinkling that it is desired to produce.

Referring to Figures 14, 15, 17 and 18, the converging ripples at the introductory end of the former 80^a have concave curves as 81, Figure 18, these being substantially concentric arcs of relatively great radius. Moreover the former, when seen in elevation at Figure 14, also has the introductory or ripple portion thereof arched, or curving upwardly and forwardly from the intake end to the intermediate region of the former, where the comparatively straight flutes begin. This arched effect is seen not only in the main triangular plate or frame 82, with its concave converging edges or corners 81, but also in the convergent ripples, which are also arched, or formed into convex arcs about concentric with the arch of the plate 82, as seen at 83, Figure 14. The radii of the arcs 83 may be about equal to those of the curves 81. The top or corner of each ripple and also the bottom of each, are struck upon both a concave curve and a convex arch, and may substantially resemble a circular arc generated upon the surface of a cylinder.

At Figures 14 and 18 is shown diagrammatically the lower of the two separable plates constituting the former; the upper plate being somewhat similar to the lower, as will be understood from examination of the cross-sections at Figures 15 and 17, in which the upper plate is designated as 84. These plates, like those at Figure 3, may be separately connected by means of arms 85

and screws 86, which hold the plates at the proper distance from each other, and also fasten the plates to the framework; the top plate being removable to permit the leading end of the web to be laid thereon, 70 whereupon the top plate is fastened in place, preparatory to beginning the advance of the web through the former.

If desired, the ribs may be formed with right-angle sides (Figure 19) from the intake end to about the line 15—15 of Figure 18; and at said line the cross-section will appear about as at Figure 19. From this point the ribs at the sides of the center line may incline upwardly to bring all the ribs into horizontal alignment at the delivery end, as at Figure 17. Preferably the ribs are so shaped and inclined that they have about the conformation seen in Figure 15 instead of Figure 19; that is, the sides of the ribs form acute angles to their tops, to bring the row of ribs nearer to a horizontal arrangement at the place where the longitudinal convergent curves merge into the straight lines.

At Figure 16 is shown a plate 87 of copper or other metal, from which either of the former plates 80^a or 84 may be struck up, by pressing grooves and ribs therein along the lines marked thereon; 88 indicating dotted lines for the bottoms of the grooves, and 89 dot-and-dash lines for the tops or corners of the ribs.

Whether the cross-section be of the style shown at Figure 15 or that shown at Figure 19, it will be understood that the straight ribs extending from the convergent ripples not only rise towards their delivery ends, but also are slightly twisted so that they gradually fall into an evenly-spaced symmetrical arrangement of similar ribs, as seen at Figure 17. At the section-line 15—15 of Figure 18, the sides of the ribs may be vertical or nearly so; but these sides may gradually twist out or in, as the case may be, as at 90, Figure 18, to bring them finally to the desired symmetrical arrangement. At Figure 17 the ribs are shown as having substantially rounded tops and bottoms; and this broad rounding may persist throughout the length of the ripples and ribs, or it may be gradually developed towards the delivery ends of the ribs. If the web is to be finally gathered into fan-fold plies or pleats, the rounding may be slight.

The paper does not travel from each side to the center, but the movement of the paper is always lengthwise of the web. There need be no drag upon the paper as it is fed into the former. The paper may creep slowly into the device; there is nothing to hold it back. The web is gradually gathered, Figure 6 showing the rippling or wave-motion as having started at the side borders of the web, while the main middle

portion of the web still remains in flat condition. The movement of the paper is not from left to right, nor from right to left, but at all stages it is in a direction wholly longitudinal of the web. Roughly, the web, in advancing say 10 inches, may contract in width only about 1 inch. The web ripples into and out of extremely shallow open convergent grooves, which form slight angles to the path of the web, putting only a negligible tension (if any) upon the web.

The middle part of the former substantially corresponds with the well-known folder of a newspaper web. As the web advances around the broad part 95 of the former, and folds down over the main corner 81, the sides of the web tend to flap together, that is, all of the paper tends to sink inwardly towards the central ridge, this tendency being similar to that in the newspaper folder, in which the sides of the web flap together as they fold. The direction of the paper movement therefore changes from parallelism to convergence, and finally to parallelism again, and there is consequently no occasion for the paper to turn over more than one corner, except some of the border portions of the web; and all the angles over which the paper bends are very obtuse, being even more so than seen at the right-hand end of Figure 14. (This will be evident when it is kept in mind that the paper at the sides is tending to run somewhat convergently as it runs over the corners, and before it takes a straight course in the straight troughs of the former.) The paper at no time travels in more than slightly convergent directions. It never follows the directions of the convergent ripples seen at Figure 18 as crossing the path of the web. The convergent course of the advancing paper is an acute angle to the shallow ripples, and almost parallel to the body of the web. The convergent steps, at the introductory end of the former, are mere shallow ripples into and out of which flow the side borders of the web, which narrows as it advances, until the same has entered the straight flutes.

The paper in passing through the device does not become straightened out after it once gathers. The gathering is completed when the paper enters into the straight flutes. Once the paper is there, no further rippling occurs. The convergent ripples are only between the open web and the introductory ends of the straight flutes. The web fits in these curved ripples of the former, Figure 18, without any puckering whatever, and without binding in the least degree at any point. This freedom is due to the shape of the curved ripples in the former. The former itself may be shaped from a metal sheet without any stretching whatsoever, and could be smoothed or flattened out into its original rectangular form and original dimensions.

Since a sheet of metal (Figure 16) falls readily into the shape seen at Figure 18, it is evident that a sheet of paper will do the same, and hence will fit the former exactly, and that the leading end of a paper web will do the same, and that as the web is pulled through the former, the successive portions thereof will fit the former just the same, and hence adapt themselves readily to the ripples and flow into the straight flutes.

No part of the paper has to take a course which is tortuous, for the reason (as will be seen at Figure 18) that, owing to the convexity of the plate, the paper enters only once into any straight flute, as, for example, the central flute or ridge; and the same is true of the remaining straight flutes. As the paper climbs up over the convexity and begins to flow into its central fold, the side portions thereof begin to ripple into the two adjoining side folds, without, however, disturbing the central fold. As the paper folds down over the central ridge, its side borders flow somewhat inwardly, so that the paper, by reason of its advancing and drawing inwardly, takes a diagonal convergent course until entering the straight flutes, whereupon the paper pursues a straight course. This is true as to the second and third flutes or ridges, and it may be stated roughly that the direction of the travel of the paper nearly follows the concave converging lines seen at Figure 18, and there is no unfolding of any part which is once definitely folded.

In starting the machine, the leading end of the web is first laid upon the device (Figure 18), and while the web is stationary it is fitted into the flutes or grooves. The paper will fit closely in the grooves. There is no trouble from stretching, wrinkling or puckering of the paper at any point. Then the web is confined to the grooves at the delivery end of the former (and it may also be loosely confined over all portions of the former), and then the web is drawn through, the drive or power being applied thereto at the delivery end. As the paper advances it always tends at every point to shape itself in conformity with the former, as just explained. In other words, the paper as it is drawn along tends at every step to be self-forming into a shape similar to that seen at Figure 18.

No stretching occurs during the fluting of the web, but the web always follows a natural tendency. There is formed substantially the same longitudinal central fold that is made in the perfecting web presses, and this is done without putting tension upon the paper. At the same time other portions of the paper are being pulled over the ripples and into the flutes in approximately the same manner, and also without putting tension thereon.

The advancing paper ripples over the corners into and out of the shallow grooves, naturally and without any difficulty, or any forcing, or any liability of rupture whatever. The corners can be rounded and the device made smooth. There is nothing to cause the paper even to become taut in rippling over these smooth obtuse corners, which are all set at slight angles to the direction of travel of the web. The mere rippling course of the paper has no tendency to injure the paper, because it has high flexibility.

At Figures 10, 12 and 13, the former is illustrated as constituting an open framework 91, consisting mainly of forming wires or rods 92, with supporting brackets therefor. Each of the rods has a compound curvature at 93 and a straight portion 92. These rods or wires are substitutes for the corners of the ribs and the bottoms of the grooves seen at Figures 14-18. The intake end of the frame comprises a curved apron 94, whose contour may correspond generally to a similar portion 95 of the former seen at Figures 14 and 18. At Figure 10 the cap plate may be omitted, and the web may advance over the apron 94 and the first pair of curved rods 96, which form an angle and merge into a single central rod or rib 97. The web turns down over the leading-in rods 96 and folds centrally over the rod 97; the web being seen dotted in the cross-sections at 98, Figures 12 and 13. The paper turns under the rods in the next pair 99, to form the bottoms of the grooves; the rods 99 being shown dotted at Figure 10. The web then turns over the next outer pair of rods 93, to form the ridges or corners of the corrugations; then under the next pair 99, and so on. The central wire or rod 97 is horizontal, and the others may all incline upwardly from about the line 13-13, Figure 10, to the delivery ends, upon the same principle as the ribs of the sheet-metal former at Figure 14. The individual rods in the inner or dotted set at Figure 10 lie nearly under individual rods 93 in the upper or outer set, at their curved portions, but converge sufficiently at their delivery portions to bring them into even upper and lower rows, the rods being evenly spaced in each row, to give the web symmetrical corrugation, as at Figure 12. Thus in their curvature and inclination the rods correspond with the tops and bottoms of the ribs in the sheet-metal former at Figure 14. At Figures 12 and 13 the rods in the upper or outer set may be supported by studs 100, either mounted directly upon a base 101 (suitably secured upon the framework) or upon brackets 102 rising from said base. The lower or inner rods may be suspended by means of studs 103 from brackets 104. By supporting the rods in this manner, the

web may pass through the former without meeting obstructions.

Another form of rod may be substituted for the round form seen at Figures 12 and 13. This is in the shape of a metal strip 105, Figures 4^a and 5^a, having one edge rounded at 106, for the paper to fold over, and at its other edge attached to supports, shown diagrammatically at 107, Figure 4^a. Figure 5^a represents diagrammatically a cross-section taken at a point in the former indicated by the line 5^a in Figure 4^a, and corresponding with the line 13-13 at Figure 10. It will be seen that the supporting studs may be dispensed with, and the square edges of the metal strips 105 may be directly attached to suitable upper and lower brackets 108, 109, erected at frequent intervals along a base plate 110, to support the strips 105 throughout their length. The rounded edges of the strips perform substantially the same functions as the cylindrical surfaces of the wires or rods at Figures 10, 12, 13; that is, the paper folds repeatedly down and out over said rounded edges, as indicated by the dotted line 98 at Figure 5^a. The apex of the central strip at Figure 5^a is seen between the adjoining strips 109^a, which are inverted, the paper passing around their bottom edges to the top edges of the next pair of strips, then down around the bottom edges of the next strips, and so on for as many strips as may be desired. From Figure 4^a it will be understood that each strip has a compound curvature, arching when seen in elevation, and diverging outwardly in a concave curve when viewed in plan. Figure 10 may therefore be taken as approximating a plan of the strip arrangement seen at Figure 5^a, the dotted lines showing nearly the positions of the curved portions of certain of the strips, which may slightly converge throughout their straight portions, to bring the paper into an evenly fluted condition, as at Figure 12.

At Figure 5^a the upper brackets 108 may be held detachably by means of screws 111, to permit them to be lifted off together with the upper strips secured thereto, thereby permitting the web to be laid upon the lower strips, whereupon the upper strips may be restored and the brackets again secured by the screws 111, preparatory to starting the web through the former. The upper side rods in Figures 10, 12 and 13 may be removed and replaced in like manner. If desired, power-driven grooved feed-rolls 112 may be employed between the former and the heating unit.

Other variations may be resorted to within the scope of the invention, and portions of the improvements may be used without others, as, for example, the web may be dry as it passes through the gathering former, and the contour of the delivery portion of

the latter at Figures 4 and 12 may be made with sharp corners in place of the rounded corners shown, and the pleats of the single-
 5 ply product may be compacted together, making a commercial "fan-fold" web, that is, a web consisting of several plies fan-folded together.

Having thus described my invention, I claim:

10 1. An element for use in gathering a web into flutes or longitudinal corrugations, comprising a three-sided plate or frame having its base at the receiving end of the former, and having two convergent sides, a central
 15 rib into which the frame merges at its apex and over which the web folds along its median line, ripples disposed alongside of the converging edges of the frame and extending in the same direction, whereby the entire web
 20 is brought to a fluted condition, continuations of said lateral ripples, said continuations extending along each side of said central rib, to gradually bring the flutings of the web to the desired configuration, and
 25 means co-operative with said element for gathering the web longitudinally thereon.

2. A former for gathering a web into flutes or longitudinal corrugations, including a
 30 three-sided plate or frame having its base at the receiving end of the former, and having convergent sides, a central rib into which the frame merges at its apex and over which the web folds along its median line, ripples
 35 disposed alongside of the converging edges of the frame and extending in the same direction, whereby the entire web is brought to a fluted condition, continuations of said lateral ripples, said continuations extending
 40 along each side of said central rib, to gradually bring the flutings of the web to the desired configuration, said frame inclined relatively to the edge of said median rib, and means for confining the web against
 said frame.

45 3. A former for gathering a web into flutes or longitudinal corrugations, including a three-sided plate or frame having its base at the receiving end of the former, and having
 50 convergent sides a central rib into which the frame merges at its apex and over which the web folds along its median line, ripples disposed alongside of the converging edges of the frame and extending in the same direction,
 55 whereby the entire web is brought to a fluted condition, and continuations of said lateral ripples, said continuations extending along each side of said central rib, to gradually bring the flutings of the web to the
 60 desired configuration, said frame inclined relatively to the edge of said median rib, and the planes of said converging ripples at the sides of said frame being also arranged at obtuse angles with reference to the
 65 ripples which extend alongside of the median rib at the delivery end of said former,

said former also including a device overlying said frame and conforming therewith and co-operative therewith to confine the web.

4. A former for gathering a web into flutes or longitudinal corrugations, including a three-sided plate or frame having its base at the receiving end of the former, and having convergent sides, a central rib into which the frame merges at its apex and over which the web folds along its median line, ripples
 disposed alongside of the converging edges of the frame and extending in the same direction, whereby the entire web is brought to a fluted condition, continuations of said lateral ripples, said continuations extending
 along each side of said central rib, to gradually bring the flutings of the web to the desired configuration, said frame and the ripples being pressed or formed from a metal plate or sheet, and means co-operative with
 said frame for confining the web thereagainst.

5. A former for gathering a web into flutes or longitudinal corrugations, including a three-sided plate or frame having its base at the receiving end of the former, and having convergent sides, a central rib into which the frame merges at its apex and over which the web folds along its median line, ripples
 disposed alongside of the converging sides of the frame and extending in the same direction, whereby the entire web is brought to a fluted condition, continuations of said lateral ripples, said continuations extending along
 each side of said central rib, to gradually bring the flutings of the web to the desired configuration, said frame, the ripples alongside thereof, and the ripples at the delivery end of the former being in the form of a single sheet-metal plate, and means co-operative with said frame for confining the web thereagainst.

6. A former for gathering a web into flutes or longitudinal corrugations, including a three-sided plate or frame having its base at the receiving end of the former, and having convergent sides, a central rib into which the frame merges at its apex and over which the web folds along its median line, ripples disposed alongside of the converging edges of the frame and extending in the same direction, whereby the entire web is brought to a fluted condition, continuations of said lateral ripples, said continuations extending along each side of said central rib, to gradually bring the flutings of the web to the desired configurations, said frame and the ripples alongside thereof being pressed or formed from a metal plate or sheet, and a cap-plate or frame having a corresponding contour or construction, and mounted to leave a slight space for the web between the cap-plate and the former, whereby the cap-plate causes the web to

follow the ripples and grooves in the former.

7. A former for gathering a web into flutes or longitudinal corrugations, including a three-sided plate or frame having its base at the receiving end of the former, and having convergent sides, a central rib into which the frame merges at its apex and over which the web folds along its median line, ripples disposed alongside of the converging edges of the frame and extending in the same direction, whereby the entire web is brought to a fluted condition, continuations of said lateral ripples, said continuations extending along each side of said central rib and converging slightly toward the delivery end of the former, and means co-operative with said frame for confining the web thereagainst.

8. A former for gathering a web into flutes or longitudinal corrugations, including a three-sided plate or frame having its base at the receiving end of the former, and having convergent sides, a central rib into which the frame merges at its apex and over which the web folds along its median line, ripples disposed alongside of the converging edges of the frame and extending in the same direction, whereby the entire web is brought to a fluted condition, continuations of said lateral ripples, said continuations extending along each side of said central rib, to gradually bring the flutings of the web to the desired configuration, said frame and the ripples being pressed or formed from a metal plate or sheet, and a cap-plate or frame having a corresponding contour or construction, and mounted to leave a slight space for the web between the cap-plate and the former, whereby the cap-plate causes the web to follow the ripples and grooves in the former, said former and said cap having glazed surfaces.

9. A former element for gathering a web into longitudinal flutes or pleats, comprising a three-sided frame, a central rib into which the frame merges at its apex, a series of ripples at each flank of said frame and of said central rib, and means co-operative with said frame for confining the web thereagainst.

10. The combination of web-corrugating means, corrugated plates through which the web is led, means for heating the corrugated plates to dry the web, and means to effect cross-crikling of the corrugated web.

11. A former for gathering a web into flutes or longitudinal corrugations, including a three-sided plate or frame having its base at the receiving end of the former, and having convergent sides, a central rib into which the frame merges at its apex and over which the web folds along its median line, ripples disposed alongside of the converging edges of the frame and converging in sub-

stantially the same direction, bringing the web to a fluted condition, continuations of said lateral ripples extending along each side of said central rib, and means cooperative with said frame for confining the web thereagainst; said frame curving convexly from its base towards the delivery end of the former, and said converging sides of the base being curved inwardly or to each other, and said ripples being correspondingly curved.

12. A former for gathering a web into flutes or longitudinal corrugations, including a three-sided plate or frame having its base at the receiving end of the former, and having convergent sides, a central rib into which the frame merges at its apex and over which the web folds along its median line, ripples disposed alongside of the converging edges of the frame and converging in substantially the same direction, bringing the web to a fluted condition, continuations of said lateral ripples extending along each side of said central rib, and means cooperative with said frame for confining the web thereagainst; said frame curving convexly from its base towards the delivery end of the former, and said converging sides of the base being curved inwardly or to each other, and said ripples being correspondingly curved, the curved ripples merging into straight parallel portions at the delivery side of the former.

13. A former for gathering a web into flutes or longitudinal corrugations, including a plate or frame having a base at the receiving end of the former and curving convexly towards the delivery end of the former, said plate or frame having ripples converging from the base towards the delivery end of the former, said ripples being at the sides of said frame and the ripples at each side curving inwardly to the ripples at the other side, said ripples extending toward the delivery end of the former sufficiently to bring the entire web to fluted condition.

14. A former for gathering a web into flutes or longitudinal corrugations, including a plate or frame having a base at the receiving end of the former and curving convexly towards the delivery end of the former, said plate or frame having ripples converging from the base towards the delivery end of the former, said ripples being at the sides of said frame and the ripples at each side curving inwardly to the ripples at the other side, said ripples extending toward the delivery end of the former sufficiently to bring the entire web to fluted condition, said ripples including a central rib into which said frame merges at its apex, and over which the web folds along its median line.

15. A former for gathering a web into flutes or longitudinal corrugations, including a plate or frame having a base at the

receiving end of the former and curving convexly towards the delivery end of the former, said plate or frame having ripples converging from the base towards the delivery end of the former, said ripples being at the sides of said frame and the ripples at each side curving inwardly to the ripples at the other side, said ripples extending toward the delivery end of the former sufficiently to bring the entire web to fluted condition, said ripples including a central rib into which said frame merges at its apex, and over which the web folds along its median line, the ripples at the delivery portion of the former being substantially parallel with said central rib.

16. A former for longitudinally fluting a paper-web, including superposed co-operative members between which the web is drawn lengthwise, and from which it is delivered in narrowed fluted condition, said former having a relatively broad intake portion and a relatively narrow rifled delivery portion, one of said superposed members having at its intake portion means for supporting the incoming web in smooth condition, each of said members having between its intake and delivery ends a set of web-fluting riffls placed diagonally of the general direction of travel of the web and extending towards the delivery portion of the former, the other of said superposed mem-

bers provided with riffls complementary to the aforesaid riffls, and means for supporting said members with the riffls of each member protruding into the corresponding depressions of the other member, and with one member slightly spaced from the other so that all of said riffls co-operate to form a constricted undulatory web-guiding passage permitting free advance of the web.

17. A former for longitudinally fluting a paper-web, including superposed co-operative members between which the web is drawn lengthwise, and from which it is delivered in narrowed fluted condition, said former having a relatively broad intake portion and a relatively narrow rifled delivery portion, one of said superposed members having at its intake portion means for supporting the incoming web in smooth condition, said former having a set of superposed interfitting diagonal riffls between its delivery end and its intake end, said diagonal riffls at their delivery ends curving gradually to the delivery riffls, and merging separately thereinto, the riffls of each of said co-operative members protruding into the corresponding depressions of the other member, and said members being slightly spaced apart so that the riffls co-operate to form a constricted undulating web-guiding passage.

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