

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
3 January 2008 (03.01.2008)

PCT

(10) International Publication Number
WO 2008/003015 A2

(51) International Patent Classification: Not classified

(21) International Application Number:
PCT/US2007/072309

(22) International Filing Date: 28 June 2007 (28.06.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
11/476,474 28 June 2006 (28.06.2006) US

(71) Applicant and

(72) Inventor: **MARSCHKE, Carl, R.** [US/US]; W5718
County Road H, Phillips, WI 54555 (US).

(74) Agents: **WOZNY, Thomas, M.** et al.; Andrus, Sceales,
Starke & Sawall, LLP, 100 East Wisconsin Avenue, Suite
1100, Milwaukee, WI 53202-4178 (US).

(81) Designated States (*unless otherwise indicated, for every
kind of national protection available*): AE, AG, AL, AM,
AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH,

CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG,
ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL,
IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK,
LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW,
MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL,
PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY,
TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA,
ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every
kind of regional protection available*): ARIPO (BW, GH,
GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,
ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,
FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL,
PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM,
GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished
upon receipt of that report*

*For two-letter codes and other abbreviations, refer to the "Guid-
ance Notes on Codes and Abbreviations" appearing at the begin-
ning of each regular issue of the PCT Gazette.*

(54) Title: METHOD AND APPARATUS FOR MANUFACTURING OPEN CORE ELEMENTS FROM WEB MATERIAL

(57) Abstract: A continuous, fully automated and highly productive system for the production of open core elements utilizes various formations of fluted input webs which are cut into strips, glued, cross-transferred, and serially upended for placement against preceding strips to build up an open core element. The open core elements are useful in the manufacture of structural members such as doors, floor panels and to all panels. Also disclosed is a fluting apparatus effective for providing large pitch flutes for the input webs used in forming the core elements. A glue machine that utilizes a glue roll as the only moving part operates in conjunction with the ganged positive displacement adhesive pump to supply liquid adhesive for application to the flute tips to any of the various glue application stations in the system.



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METHOD AND APPARATUS FOR MANUFACTURING OPEN CORE
ELEMENTS FROM WEB MATERIAL
BACKGROUND OF THE INVENTION

[0001] The present invention pertains light weight open core materials having a honeycomb-like structure useful in a number of applications where light weight core elements are desirable or necessary.

[0002] It has long been known to utilize honeycomb core materials in the manufacture of structural members such as doors, wall panels and floor panels. The honeycomb core material may be made from paper, metal or even plastic web material. Conventional honeycomb construction may utilize paper strips laid together in a stack and connected to one another with intermittent lengths of adhesive, and then expanded or opened to form a hexagonal honeycomb core element. It is also known to use corrugated paper or metal webs either with or without smooth facing webs which are stacked and glued together, again resulting in an open core structure.

[0003] Although honeycomb-type core elements have long been proposed for use in structural panels, one reason for the lack of significant development of this use is the absence of a high speed process for making and assembling multi-layer honeycomb core elements. Also, when open core elements are made with conventional corrugated paper webs, conventional corrugating techniques and machinery are typically limited to flute sizes that are unnecessarily small for making open core elements for use in structural members. The inability to control thickness as well as the width of the expanded core material has been a problem.

SUMMARY OF THE INVENTION

[0004] The present invention comprises a fully automated and highly productive method and apparatus for the continuous manufacture of open core elements using fluted web material of various kinds and with or without intermediate smooth web materials.

[0005] In one embodiment, the method of the present invention includes the steps of (1) forming two composite web halves, each comprising a smooth web and

a fluted web, (2) orienting the composite web halves with the exposed fluted web flutes facing up, (3) applying an adhesive to the exposed flute tips of one of the web halves, (4) adhering the other web half by its smooth web to the glued flute tips of the one web half to form an open face double wall web, (5) slitting the open face double wall web longitudinally to form a plurality of adjacent equal width open face double wall strips, (6) applying an adhesive to the exposed flute tips of the strips, (7) cutting the strips transversely to a selected common length, and (8) upending the strips onto common lateral strip edges and adhering the adhesively glued flutes of each strip to the smooth web of the next adjacent strip to form the open core element.

[0006] The foregoing method preferably includes, prior to the step of adhering the two web halves, the step aligning the flute tips of the web halves tip-to-tip. The method may also include, after the step of adhering the two web halves, the step of heating the open face double wall web to cure the adhesive. Preferably, the method includes, prior to the upending step, the steps of (1) accelerating the strips to form a gap between said strips and the next following plurality of strips, and (2) cross-transferring the strips out of the path of the next following plurality of strips. The method also preferably includes the additional step of applying a normal force to the upended and adhered strips.

[0007] The method may also include the step of cutting the completed open core element to a selected size. The cutting comprises one or both of the steps of (1) cutting one edge of the core element in the longitudinal direction of the strips, and (2) cutting one end of the core element in a direction transverse to the strips.

[0008] In one embodiment of the method of the present invention each of the composite web halves is formed separately. In this embodiment, the webs are formed with the fluted web flutes facing downwardly and the webs are reoriented before applying the adhesive to position the flutes to face upwardly. In a variation of the basic method the composite web halves are formed by (1) forming a double width composite web, and (2) slitting the double width web to form the two composite web halves.

[0009] A somewhat more basic method of the present invention includes the steps of (1) forming a composite web from at least one smooth web and a fluted web, (2) orienting the composite web with the flutes facing up, (3) slitting the web longitudinally to form a plurality of adjacent equal width strips, (4) applying an adhesive to the exposed flute tips of the strips, (5) cutting the strips transversely to a common selected length, and (6) upending the strips onto common lateral edges and adhering the adhesively glued flutes of each strip to the smooth web of the next adjacent strip to form the open core element.

[0010] In a variation of the foregoing method, there are performed the steps of (1) eliminating the application of adhesive to a lead strip for a strip group of a selected number of strips, (2) supporting the upended lead strip on its unglued face, and (3) pressing the subsequent upended strips of the group against the lead strip. The method may also include the step of orienting the upended strips to form a downwardly directed core element. The method may also include the step of inserting a weighted strip on the upper end strip of each core element. Prior to the upending step, method may include the step of aligning the flute tips on adjacent strips tip-to-tip.

[0011] The forming step may comprise forming two composite webs, and joining said webs to form an open face double wall web. In this variation, the method includes the preliminary steps of (1) forming a double width composite web, and (2) slitting the double width web to form the two composite webs. Alternately, said composite webs may be formed separately. When formed separately, the webs are formed with the fluted web flutes facing downwardly, and the method includes the step of reorienting the webs before joining to position the flutes to face upwardly.

[0012] An apparatus for forming large pitch fluted web uses a rigid fluted rotary roll that has flute teeth defined by adjacent tips and gullets and spaced circumferentially at the desired flute pitch. A counterroll uses parallel fluting bars that are circumferentially spaced at the flute pitch and have fluting tips that extend into the gullets of the fluting roll teeth for fluting engagement with the fluting roll.

The counterroll has a rigid cylindrical core and an outer elastomer sleeve in which the fluting bars are embedded and held to permit individual fluting tips to move in response to cyclically burying force as a result of fluting tip contact with the teeth of the fluting roll. The fluting roll teeth are generally V-shaped in cross section and the tooth gullets and tips have a circular cross section and are interconnected by flat tooth flanks. Fluting tips of the counterroll fluting bars have a radius slightly less than the radius of fluting roll tooth gullets and, preferably, the radius of the fluting tips is less than the radius of the tooth gullets by an amount approximately equal to the thickness of the web being processed.

[0013] With the narrow construction of the fluting bars, contact with the formed web flutes occurs only in the flute gullets of the fluting roll. Correspondingly, there is no contact between the fluting roll flute tips and the flute flanks of the counterroll teeth.

[0014] The corrugating roll, which is typically larger in diameter than the counterroll, has a cylindrical tubular body in which is formed a series of circumferentially spaced axial bores which may be used to supply vacuum and/or heat to the roll. The vacuum system helps bring the fluted web into full contact with the corrugating roll tooth gullets and the heat which is preferably derived from steam assists in web conditioning, flute formation and drying.

[0015] Counterroll fluting bars preferably are made from hollow aluminum extrusions. The bars have a tear drop cross sectional shape to includes a wide base which is embedded in the elastomer and opposite converging sides that terminate in the fluting tips.

[0016] In a presently preferred apparatus for applying liquid adhesive to any one of the fluted web components used in the system of the present invention, a ganged positive displacement pump has an array of laterally spaced flexible adhesive supply tubes that have inlet ends for receipt of the adhesive from a supply and outlet ends for delivery of the adhesive. An adhesive glue applicator roll is mounted to receive the streams of adhesive form the outlet ends of the tubes directly on the roll surface. A flexible adhesive spreading tongue is mounted

adjacent the glue roll and has a downstream end that is shaped to conform to the cylindrical roll surface to spread the beads of adhesive into a uniform layer on the rotating glue roll. A web delivery mechanism brings the web into tangent contact with the roll downstream of the end of the tongue to pick up adhesive from the roll surface on the glue tips of the web.

[0017] Preferably, the adhesive supply pump is a peristaltic pump and includes a pump housing that has a semicylindrical backing surface and a driven rotating roller assembly that has an axis of rotation coincident with the axis of the backing surface. The rotating roller assembly operates to intermittently press the tubes against the backing surface to deliver laterally spaced uniform streams of adhesive for application to the new roll.

[0018] An upstream glue supply provides the proper volume of adhesive to the inlet ends of the pump, calculated to be the precise volume desired to be applied to the web. In this manner, the need to recycle excess adhesive from the glue machine is obviated. In one presently preferred embodiment, the adhesive comprises an aqueous starch-based glue and apparatus includes means for calculating the volume of adhesive based on pump rotational speed, web speed and web width to control supply of the proper volume of adhesive to the pump.

[0019] The outlet ends of the adhesive supply tubes are mounted adjacent the applicator roll with an apparatus that provides adjustable lateral spacing. In one embodiment, the adjustable spacing is provided by attaching the tube ends to an elastic band at a selected uniform spacing when the band is in a partially stretched condition. The tube spacing may be increased by stretching the band in opposite directions by equal amounts, thereby providing the ability to supply adhesive to webs of varying widths.

[0020] The glue machine also includes laterally adjustable adhesive layer width controls that are operative to contact the roll surface and to remove therefrom any applied adhesive that lies laterally beyond the width of the web being processed. The width controls preferably comprise vacuum assisted doctor blades.

[0021] A roll cleaning doctor blade extends the full width of the glue roll and is movable vertically into reverse angle contact with the roll surface downstream of the end of the tongue for facilitating cleaning. Cleaning solution may be circulated through the pump tubes over the glue roll, the tongue, the vacuum assisted doctor blades and the roll cleaning doctor blade for simplified cleaning of the glue. The adhesive supply tubes are mounted in the pump for axial adjustment to vary the positions of the portions of the tubes pressed by the roller assembly, thereby presenting fresh unstressed portions to contact by the rollers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] Fig. 1 is a perspective view of a system for the continuous manufacture of open core elements utilizing one embodiment of the method of the present invention.

[0023] Fig. 2 is a top plan view of the system shown in Fig. 1.

[0024] Fig. 3 is a perspective view of an upstream portion of the Fig. 1 system showing one embodiment of an apparatus for forming the composite web.

[0025] Fig. 4 is a perspective view of an intermediate downstream portion of the system showing the incremental formation of core elements.

[0026] Fig. 5 is a perspective view of the downstream portion of the system shown in Fig. 1.

[0027] Fig. 6 is a perspective view of an apparatus for forming an all-fluted composite web.

[0028] Fig. 7 is a side elevation detail of an alternate flute forming apparatus of a presently preferred construction.

[0029] Fig. 8 is a perspective view of an alternate system for the manufacture of open core elements.

[0030] Fig. 9 is a perspective detail of a portion of the system shown in Fig. 8.

[0031] Fig. 10 is a further perspective detail of the system shown in Fig. 8.

[0032] Fig. 11 is a side elevation detail of a preferred embodiment of an upender used in the method of the present invention.

[0033] Figs. 12-14 are cross sectional details of the progressive formation of an open core element from its component webs.

[0034] Fig. 15 is an end view of the web fluting apparatus of a presently preferred embodiment.

[0035] Fig. 16 is an enlarged view of a portion of Fig. 15.

[0036] Fig. 17 is a view similar to Fig. 16 showing the progression of the interacting fluting rolls.

[0037] Fig. 18 is a perspective view of a glue machine for applying a liquid adhesive to a fluted web.

[0038] Fig. 19 is a schematic top plan view of the glue machine of Fig. 18.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0039] Referring initially to Figs. 1 and 3, a core element lay up system 10 utilizes core element components made from a composite web 11 which is converted to form strip like elements (28) which are, in turn, joined to form a core element 13. In the embodiment of the invention shown, a double width composite web 11 is formed by joining a smooth web 14 and a fluted web 15 utilizing any of a number of prior art techniques. For example, the webs 14 and 15 could be formed and glued together in a single facer 16 in a manner well known in the corrugating industry. A smooth web from a supply roll 17 is fluted under heat and pressure in the single facer 16, glue is applied to the flute tips on one side of the fluted web 15, and the fluted web is then joined to the smooth web 14 from the supply roll 18.

[0040] The composite web 11 is formed (or reoriented after forming) with the fluted web component 15 facing upwardly. As the composite web 11 exits the single facer 16, it is slit longitudinally on its centerline by a slitting blade 20 to form two web halves 21 and 22. A suitable glue or adhesive is applied to the flute tips of the lower web half 21 by a glue roll 23. The other web half 21 is directed onto an angled turning bar 24 around which it is wrapped and displaced laterally to bring it into contact with the glued web half 21 where the smooth web face of the web half 22 is laid onto the glued flute tips of the other web half 21 to form an open face double wall web 25. The double wall web 25 is directed over a heating plate

26 or other heating device to cure the adhesive and permanently join the two web halves 21 and 22. As will be described in greater detail below with respect to the presently preferred embodiment, the flutes of the two component webs forming the open face double wall web 25 are brought together and joined so that the flutes of the two component webs are in flute tip-to-flute tip alignment.

[0041] The open face double wall web 25 is then slit longitudinally with a multi-blade slitter 27 to form a plurality of equal width open face double wall strips 28. The open face double wall web 25 has an upper exposed fluted face and, therefore, the strips 28 also have laterally extending flutes. The strips then pass beneath a second glue roll 30 which applies a suitable adhesive to the exposed flute tips. When the plurality of strips 28 reaches a selected length in the machine direction, a cut-off knife 31 downstream of the glue roll cuts the strips 28 to a common length. The strips are preferably cut at the bottom of the next flute which will provide a core element just slightly larger than the desired length. The plurality of glued and cut strips 32 is accelerated on a transport conveyor 33 to form a gap between the strips and the next-following uncut strips.

[0042] The plurality of glued and cut strips 32 is then cross-transferred out of the machine direction path of the next following plurality of strips and onto a lateral feed conveyor 34 to a strip upender 35. As is best seen in Fig. 4, an upender roll 36 has a series of circumferentially spaced vacuum headers 37 that serially capture each glued and cut strip to reorient the strip from a horizontal to a vertical position such that succeeding strips are deposited on common lateral strip edges and in face to face relation with each strip that precedes it. In this orientation, the glued flutes of each strip face the smooth web face of the preceding strip and, when deposited on the element forming conveyor 38, are brought into adhesive contact. As can be seen in Fig. 4, the flutes on the strips extend vertically and together comprise a core element 13. To facilitate removal of each strip 28 from the vacuum header 37 on the upender roll 36, each vacuum header includes a series of laterally spaced vacuum ports between which the tines of a discharge fork 40 extend. The fork is operable to engage the unglued smooth face of each strip and push it into contact

with the preceding strip on the element forming conveyor as the vacuum is released. The discharge fork is then returned to its discharge position for the next following strip.

[0043] In this embodiment, as the core element 13 is being formed, a set of conveyor belts 41, positioned over the top of the core element, applies a normal force to assist in compacting the core element and press the glued flute tips of each strip to the smooth face of the preceding strip by running slightly faster than the advancing core block which is held back by downstream holding rolls.

[0044] When a core element 13 comprising a desired number of strips has been formed, the core element 13 is accelerated into a trim and cut station where it can be cut into any number of smaller core elements. In the example shown in Fig. 5, the large formed core element 13 is trimmed longitudinally (in the longitudinal direction of the strips 28) with a trim blade 42 to a selected edge dimension. The trimmed element 13 is then moved to a cutting position where a series of cutting blades 43, including an edge trim blade, cuts the long core element into final element sizes. For example, if the final core elements are to be used in the manufacture of hollow-core doors, the strips 28 could be cut to lengths of 240", upended and stacked to a core width of 30" and finally trimmed and cut to provide three door pieces each 80" x 30".

[0045] The height or thickness of the core element 13 depends on the width to which the strips 28 are slit. The length of the core element 13 can be varied as desired. Thus, the system has the capability of continuously and rapidly forming core elements of widely varying dimensions.

[0046] Composite fluted webs, useful in forming core elements, can be made in a number of different ways, can utilize different kinds of web materials, and the fluted web can be formed in various ways. As indicated above, it is preferable to utilize a flute size for the fluted web that is larger than flutes commonly made on a typical single facer. A larger flute size will provide adequate strength for the core element, but utilize significantly less paper or other web material in the formation of the fluted web.

[0047] Referring to Fig. 6, an alternate apparatus utilizing an alternate flute forming method is shown. In the embodiment shown, a composite web is made by simultaneously fluting two incoming webs which may be made of the same or different materials. If, for example, two paper webs are utilized, an upper web 44 has a layer of glue, such as a starch adhesive, applied to its lower face upstream of a fluting nip 45. A lower web 46 is also fed with the glued upper web 44 into the nip 45 formed at the upper and lower tail sprockets 47 and 48 carrying a pair of intermeshing fluting conveyors 50 and 51. Each of the fluting conveyors 50 or 51 includes a continuous series of fluting bars 52 made, for example, from aluminum extrusions and extending the full width of the incoming webs 44 and 46 (e.g. 96" or about 2440 mm). The fluting bars may be carried on a series of laterally spaced $\frac{3}{4}$ " pitch roller chains with the fluting bars 52 attached thereto with conventional K-1 attachments. The roller chains may, for example, be laterally spaced 16" or about 406 mm apart. Each fluting bar has an exposed flute forming tip 53 that is shaped to form a flute one $\frac{1}{2}$ " (about 13 mm) deep and with a pitch of $\frac{3}{4}$ " (about 19 mm) corresponding to the pitch of the carrying roller chains.

[0048] As the webs 44 and 46 come into the fluting nip 45, they are simultaneously fluted, one flute at a time, and joined by the adhesive previously applied to the contacting face of one of the webs. The joined webs are held together in a straight fluting run 54 of the fluting conveyors 50 and 51 to which heat is applied by upper and lower heating elements 50 and 51 to bond and cure the adhesive. Each of the fluting conveyors 50 and 51 may include flute pre-heaters 57 to help maintain the temperature of the fluting bars 52. A composite fluted web 58 exits the fluting conveyors 50 and 51 at their head ends where, preferably, the conveyor flights are separated gradually on a much larger radius arc than that of the tail sprockets 47 and 48. The resulting composite fluted web 58 is substantially cured and rigid enough for further processing with or without the addition of a smooth facing web.

[0049] A composite fluted web 58 of the foregoing type could, for example, be glued to a smooth web and the web processed to form core elements in the

manner previously described. However, the composite fluted web 58 also has utility for other applications, such as a substitute for the ubiquitous styrofoam peanuts used as packaging filler and cushioning material.

[0050] An alternate and presently preferred apparatus for forming a fluted web is shown schematically in Fig. 7. In this embodiment, a lower fluting conveyor 75 is similar to the fluting conveyor 51 of the Fig. 6 embodiment. The flute bars 76 are heated and, in addition, are provided with a vacuum system enabling the formed flutes to be drawn into the valleys between the flute bars. In lieu of an upper fluting conveyor, a spoked fluting roll 77 is used. The fluting roll is provided with a plurality of circumferentially spaced spokes 78 which press the incoming web one flute at a time into the fluting conveyor 75 where the applied vacuum holds the web in position. If two webs of paper or other materials are joined as described with respect to the Fig. 6 embodiment, the vacuum and heat applied to the web downstream of the fluting roll 77 will cure the composite web resulting in a composite fluted web cured and rigid enough for further processing. the exposed flutes of the upper web may have an adhesive applied by a downstream glue roll 80 for the addition of a smooth facing web.

[0051] Although a single wall composite web, having one fluted web and one smooth web, can be utilized in the overall process of the present invention, it is preferable to use an open face double wall web such as web 25 used in the process described with respect to Figs. 1-5. In that process, a full width single face web is slit on its center line and one of the slit halves is turned and moved laterally on a turning bar to be joined with the other web half. However, an open face double wall web may also be formed by joining two full width single face webs each formed on a separate single facer, as will be described in the following preferred embodiment. Regardless of how an open face double wall web is formed, it is important in order to maximize the strength of the core elements to be formed to align the flutes in the joined single face webs so that they are in alignment flute tip-to-flute tip in the double wall web. On the other hand, if a more springy cushioning effect is desired in a core element, the flutes in the two component single face webs

may be aligned one half pitch from flute-to-flute alignment or such that the flutes of one composite single face web align with the valleys of the other composite single face web.

[0052] Another embodiment of a system for carrying out the process for the continuous manufacture of open core elements is shown in Figs. 8-11. The incoming web 60 from the upstream single facer or single facers 59 and 61 may be open face single wall or open face double wall, the later being either full width or half width. Preferably, however, for the reasons stated above, the incoming web 60 is an open face double wall web. A pair of single facers 59 and 61 (or fluted web forming apparatus of Figs. 6 or 7) provide an upper fluted single face web 81 (see the Fig. 12 detail) with its smooth web on the bottom and is joined to a lower fluted single face web 82 (Fig. 12 detail) to the exposed flute tips of which an adhesive has been applied with a glue roll 83. The resulting composite open face double wall web 60 (see the Fig. 13 detail) is heated and cured and brought into the lay-up portion of the system for further processing.

[0053] The web 60 is slit in a multi-blade slitting knife 62 into open face double wall strips 63 with the flutes oriented upwardly. As with the previously described process and methods, the width of the strips 63 determines the height or thickness of the finished open core elements. The strips 63 move from the slitting knife under a glue roll 64 where glue is applied to the exposed flute tips. However, in this embodiment one strip is left unglued. The unglued strip 65 may be provided in a number of ways, such as using a laterally movable scraper blade operatively engaging the glue roll to prevent glue from being applied to the unglued strip 65. Successive unglued strips 65 are placed among the strips exiting the glue roll to space between them a selected number of glued strips 63 desired in the finally formed core element. Thus, the unglued strips 65 may not always be in the same lateral position on the strips exiting the glue roll 64 because the desired core element may utilize more or less than the total number strips 63 slit from the incoming web 60.

[0054] Each group of strips 63 exiting the glue roll is accelerated on a speed-up conveyor 66 to separate the strips from the next incoming group of strips. The strip group 68 is then cross-transferred onto a lateral feed conveyor 67 where each of the strips now extends laterally across the feed conveyor 67. At the downstream end of the lateral feed conveyor 67, a strip upender 35 identical to the one described with respect to the preceding embodiment, operates to sequentially reorient each strip 63 from a horizontal to a vertical position. Each reoriented strip is positioned with its glued flute tips extending vertically and facing in the downstream direction and is brought into contact with the smooth web on the back of the preceding strip 63.

[0055] Referring to Figs. 8-11, each unglued strip 65 forms the lead strip of a hollow core element 70 (see the Fig. 14 detail) of a desired size. The unglued lead strip 65, after it is upended, is brought into contact with a toothed gate 71 operating between the strip upender 35 and the upstream end of an element forming conveyor 72. When a hollow core element 70 is formed, the toothed gate 71 is retracted and the element 72 moves into contact with a downstream compactor plate 73 on the element forming conveyor 72. As the elements 72 move downstream, an upstream compactor plate 74 moves into contact with the smooth web face of the upstream most stream 63 in the formed element 70. Because the downstream compactor plate 73 engages an unglued strip 65 and the upstream compactor plate 74 engages the smooth web face of the last strip which carries no glue, the problem of a strip adhering to the toothed gate 71 or one of the compactor plates 73 or 74 is minimized.

[0056] Instead of utilizing an unglued strip 65, it is also possible to insert an unglued sheet of paper 84 which adheres to the glued flute tips of the facing strip and becomes part of the core element 70. Alternately, the face of the downstream compactor plate 73, in the previously described embodiment, may be coated with a non-stick material.

[0057] In an alternate method for compacting the formed core elements 70, the element forming conveyor 72 may be angled downwardly to utilize the force of

gravity to help press the strips 63 together. In addition, a weighted plate may be inserted against the smooth web face of the rearmost strip of the core element 70.

[0058] In a presently preferred apparatus for forming flutes in a continuous web, reference is made to Figs. 15-17. The apparatus includes an upper rotary fluting roll 85 made of a rigid tubular cylindrical shell 86. The fluted outer surface is defined by circumferentially spaced flute teeth 87 having adjacent tips 88 and gullets 90. The teeth 87 are spaced at a common flute pitch which, for example, for a large fluting apparatus, may be 3/4" (about 19 mm). The flute tooth depth vertically from tip 88 to gullet 90 may be 1/2" (about 13 mm). As indicated previously, the flutes are substantially larger than typically formed in the corrugating industry for the manufacture of corrugated paperboard and the like. The fluting roll 85 may have a nominal diameter of 16" (about 406 mm).

[0059] The lower rotary counterroll 91 is mounted and positioned for counterrotational engagement with the fluting roll 85. Typically, the upper fluting roll 85 is the driving roll and the counterroll 91 is the driven roll. The nominal diameter of the counterroll 91 may be 8" (about 203 mm). The counterroll 91 also has a rigid cylindrical interior shell 92, but it is covered on its exterior with an elastomer sleeve 93, preferably made of a relatively hard rubber, such as conventional dye rubber. Imbedded in the elastomer sleeve 93 are a plurality of circumferentially spaced fluting bars 94 having round outer tips 95 circumferentially spaced at the pitch of the fluting roll 85. As may be seen in the drawings, the fluting bars 94 have a sort of tear drop cross sectional shape and are preferably made from hollow aluminum extrusions. The fluting bars 94 and the flute teeth 87 of the fluting roll 85 extend axially together and parallel to one another the full width of the rolls 85 and 91, which conveniently may be 96" (about 245 cm). However, axial roll length is not critical and the rolls may be made with any length suited to the web material on which they operate.

[0060] The flute teeth 87 of the fluting roll 85 are generally V-shaped in cross section with the gullets 90 having a circular cross section. The tips 88 also have a circular cross section. The flute teeth 87 have flat flanks 96 between the tips

and gullets. It is significant in the formation of large pitch flutes in a web 97, as shown in Fig. 17, that the fluting bars make contact with the formed web flutes 98 only in the gullets 90 of the fluting roll 85. In addition, there is no contact between the fluting roll flute tips 88 and the flanks 100 of the counterroll fluting bars 94. Thus, as may best be seen in Fig. 17, the tips 95 of the fluting bars 94 progressively engage and push the web material 97 into the gullets 90 of the fluting roll 85 with operative contact between the fluting bar tips 95 and the teeth 87 of the fluting roll only at the points of full web flute formation.

[0061] Preferably, the tips 95 of the fluting bars 94 have a radius slightly less than the radius of the flute teeth gullets 90 of the fluting roll 85. Typically, for a web 97 of a given thickness, radius of the fluting tips 95 is less than the radius of the flute teeth gullets 90 by an amount approximately equal to the web thickness, e.g. .009" (.23 mm). Instead of circular cross section tips 88 and 95 on the fluting roll teeth 85 and fluting bars 94, respectively, a compound radius may be used.

[0062] The rubber sleeve 93 in which the fluting bars 94 are embedded serves two important functions. First, if the lower counterroll 91 were made with the fluting bars 94 rigidly attached to the steel shell 92, the inherent change in the vertical radial distance between the two roll centers, as the paper web 97 passes through the fluting nip, is forced to change. Without the cushioning effect provided by the rubber sleeve 93, the rigid steel rolls would be forced to deflect, resulting in high vibration and noise and, quite possibly, damage to the web. For example, using 16" diameter fluting roll 85 and 8" diameter counterroll 91, referring to Figs. 16 and 17, as the fluting bar 101 that is just upstream from the top dead center position of the rolls and has the web fully engaged with the gullet 90, moves to the top dead center position (Fig. 17), the rolls move relatively more closely together by .027" (.7 mm). However, the deflection that would otherwise have to be taken up by rigid steel rolls is absorbed by the rubber sleeve 93, thereby minimizing vibration and noise, as well as possible damage to the web 97.

[0063] In addition, after the fluting bar 94 passes the top dead center position (moving from Fig. 17 to Fig. 16), the resilience of the rubber sleeve 93 pushes the

tip 95 of the fluting bar radially outwardly so that it maintains contact with the fluted web until the following fluting bar makes full contact in the tooth gullet 90 with which it is associated. This provides a smooth transition from flute bar to flute bar without loss of intimate fluting contact between the fluting bar tips 95 and the fluting roll gullets 90.

[0064] To assist in formation of the flutes 98, it is desirable to provide vacuum to the gullets 90 of the upper roll flute teeth 87. Vacuum is supplied through a series of circumferentially spaced, axially extending vacuum bores 102 in the fluting roll shell 86. With appropriate internal valving, the vacuum is preferably applied at the point of flute formation, as shown in Figs. 16 and 17. As the fluted web progresses out of the fluting nip between the rolls 85 and 91, the vacuum is released so that the fluted web 103 may be more easily separated from the flute teeth 87.

[0065] It may also be desirable to heat the fluting roll 85 by supplying steam to a circumferentially spaced, axially extending series of steam bores 104 formed in the fluting roll shell 86. As shown, the steam bores 104 alternate circumferentially with the vacuum bores 102. However, any convenient arrangement may be used. The heat applied to the roll 85 and the web 97 helps precondition the fluted web for downstream application of an adhesive, such as a starch-based glue, to the flute tips of the fluted web 103, as will be described in more detail below.

[0066] Because in some applications it may be desirable to waterproof a paper web 97, the heated fluting roll 85 may assist in drying a liquid adhesive applied to the web 97 before fluting. For example, if an A-phase phenolic resin is applied to the paper web, it is dried to a B-phase before fluting.

[0067] In accordance with the overall system of the present invention for producing open core elements, fluted webs are joined with an adhesive to plane unfluted webs in various steps of the operation to progressively form the open core elements as shown schematically in Figs. 12-14. In the system previously described, for example, glue rolls 23 (Fig. 1), 80 (Fig. 7), 30 (Fig. 3) and 64 (Fig. 8)

are used to apply a liquid adhesive to the flute tips of a fluted web. Figs. 18 and 19 show a glue machine which may include any of the glue rolls just identified.

[0068] In Fig. 18, a glue machine 105 includes a pump 106 for supplying a liquid adhesive, such as an aqueous starch-based adhesive, and a glue roll assembly 107 for applying the adhesive to the flute tips of an incoming web 108.

[0069] A presently preferred pump 106 comprises a ganged array of positive displacement pumps commonly driven to provide laterally spaced beads of adhesive to the glue roll 110 of the glue roll assembly 107. Preferably, the pump 106 comprises a ganged peristaltic pump which receives a supply of a liquid adhesive to the inlet ends 111 of laterally spaced flexible tubes 112 made of a suitable synthetic rubber, such as neoprene. The tubes extend through the pump 106 and terminate in outlet ends 113 evenly spaced laterally across the surface of the glue roll 110. The pump 106 may, for example, have 24 supply tubes 112 and, if the adhesive is being applied to a 48" web, the tubes 112 would be spaced at about 2" intervals.

[0070] The pump 106 includes a supporting frame 114 that includes a semicylindrical backing surface 115 and a driven rotating roller assembly 116 that has an axis of rotation coincident with the axis of the backing surface 115. In the embodiment shown, there are four laterally spaced roller assemblies, each of which carries three orbitally mounted rollers 117. The adhesive supply tubes 112 extend from an upstream tube harness 118 downwardly between the backing surface 115 and the roller assembly 116 to the outlet ends 113 adjacent the surface of the glue roll 110. Rotation of the orbital rollers 117 brings individual rollers sequentially into contact with the tubes 112, squeezing them against the backing surface 115 and pushing accurately metered amounts of liquid adhesive through the tubes to the outlet ends 113. By carefully controlling the supply of liquid adhesive to the inlet ends 111 of the tubes 112, the pre-calculated exact volume of adhesive desired to be applied to the web is delivered by the pump to the glue roll. In this manner, the pump supplies only the volume of adhesive needed and there is no need to recirculate unused adhesive which could be contaminated or otherwise

unsatisfactory for reuse. Once the starch formula has been used to calculate the mix of starch and water (with other well known additives), the volume to be supplied to the pump and the transferred to the glue roll calculated based on pump rotational speed, web speed and web width. One important benefit of utilizing a peristaltic pump apparatus is that none of the pump mechanism, except the tubes 112, is contacted by the adhesive. This minimizes adhesive build up on internal parts and facilitates considerably the cleaning of the glue machine, as will be described.

[0071] The outlet ends 113 of the adhesive supply tubes 112 are attached to a tube outlet support assembly 120 extending across the width of the glue machine 105 above the glue roll 110. The glue roll assembly 107 includes a flexible adhesive spreading tongue 121 that has its upper edge attached to a tongue support 122 and a free downstream end 123 that is shaped to lie against and conform to the cylindrical surface of the glue applicator roll 110. The beads of liquid adhesive supplied to the glue roll surface upstream of the shaped end 123 of the spreading tongue 121 are smoothed into a uniform layer on an engraved surface on the glue roll 110 from which it is applied to the flute tips of the incoming web 108 that makes tangent contact with the glue roll 110.

[0072] The outlet ends 113 of the adhesive supply tubes 112 are mounted on the support assembly 120 such that their positions can be selectively adjusted to a desired spacing in order to accommodate different width webs 108. In the embodiment shown in Fig. 19, each tube end 113 is carried on a separate tube holder 124 and all of the tube holder are mounted on an elastic band 125 that is partially stretched to provide an initial closely spaced array. By stretching the band equally and in opposite directions, as with a lead screw arrangement 126, the tube holders 124 and attached tube ends 113 may be moved to an increased spacing.

[0073] The glue machine 105 also includes a laterally adjustable adhesive width control assembly 127 that includes a pair of laterally adjustable doctor blades 128 which may be moved into contact with the glue roll surface to remove unneeded adhesive and to define the width of the glue layer to be applied to the

incoming web 108. The doctor blades 128 are slidably mounted on a lateral support member 130 and each doctor blade assembly includes a vacuum connection 131 from the pump 106 is terminated and the inlet ends 111 of the glue supply tubes 112 are supplied with a cleaning fluid that travels through the tubes, onto the glue roll and mating face of the spreading tongue 121 and over the cleaning doctor blade 133.

[0074] It is also preferable to mount the adhesive supply tubes 112 so they can be adjusted axially in the tube harness to adjust their positions to present different areas to contact by the pump rollers 117. In this manner, the points at which constant intermittent squeezing of the tubes occurs can be changed to present fresh unstressed tube portions to the rollers.

CLAIMS

I claim:

1. A method for continuous manufacture of open core elements, comprising the steps of:

(1) forming two composite web halves each comprising a smooth web and a fluted web;

5 (2) orienting said composite web halves with the exposed fluted web flutes facing up;

(3) applying an adhesive to the exposed flute tips of one web half;

(4) adhering the other web half by its smooth web to the glued flute tips of said one web half to form an open face double wall web;

10 (5) slitting the open face double wall web longitudinally to form a plurality of adjacent equal width open face double wall strips;

(6) applying an adhesive to the exposed flute tips of said open face double wall strips;

(7) cutting said strips transversely to a common selected length, and,

15 (8) upending the strips onto common lateral strip edges and adhering the glued flutes of each strip to the smooth web of the next adjacent strip to form an open core element.

2. The method as set forth in claim 1 including, prior to the step of adhering said other web half to said one web half, the step of aligning the flute tips of the web halves tip-to-tip.

3. The method as set forth in claim 1 including, after the step of adhering said other web half to said one web half, the step of heating the open face double wall web to cure the adhesive.

4. The method as set forth in claim 1 including, prior to the upending step, the steps of:

(1) accelerating said strips to form a gap between said strips and the next following plurality of strips; and,

5 (2) cross-transferring said strips out of the path of said next following plurality of strips.

5. The method as set forth in claim 1 including the additional step of applying a normal force to the upended and adhered strips

6. The method as set forth in claim 1 including the step of cutting the open core element to a selected size.

7. The method as set forth in claim 6 wherein the cutting step comprises at least one of:

(1) cutting one edge of the core element in the longitudinal direction of the strips; and,

5 (2) cutting one end of the core element in a direction transverse to said strips.

8. The method as set forth in claim 1 wherein each of said composite web halves is formed separately.

9. The method as set forth in claim 8 wherein said webs are formed with the fluted web flutes facing downwardly, and including the step of reorienting said webs before applying an adhesive to position the flutes to face upwardly.

10. The method as set forth in claim 1 including the steps of:

5 (1) forming a double width composite web; and,

(2) slitting the double width web to form said two composite web halves.

11. A method for the continuous manufacture of open core elements, comprising the steps of:

(1) forming a composite web comprising at least one smooth web and a fluted web;

5 (2) orienting said composite web with the fluted web flutes facing up;

(3) slitting the web longitudinally to form a plurality of adjacent equal width strips;

(4) applying an adhesive to the exposed flute tips of said plurality of strips;

(5) cutting said strips transversely to a common selected length; and,

10 (6) upending the strips onto common lateral strip edges and adhering the
glued flutes of each strip to the smooth web of the next adjacent strip to form an open
core element.

12. The method as set forth in claim 11 including the steps of:

(1) eliminating the application of adhesive to a lead strip for a strip group
having a selected number of strips;

(2) supporting the upended lead strip on its unglued face; and,

5 (3) pressing the subsequent upended strips of the group against said lead strip.

13. The method as set forth in claim 12 including the step of orienting the
upended strips to form a downwardly directed core element.

14. The method as set forth in claim 13 including the step of inserting a
weighted strip on the upper end strip of each core element.

15. The method as set forth in claim 11 including, prior to the upending step,
the step of aligning the flute tips on adjacent strips tip-to-tip.

16. The method as set forth in claim 11 wherein the forming step comprises
forming two composite webs, and further including the step of joining said webs to
form an open face double wall web.

17. The method as set forth in claim 16 including the preliminary steps of:

(1) forming a double width composite web; and,

(2) slitting said double width web to form said two composite webs.

18. The method as set forth in claim 16 wherein said composite webs are
formed separately.

19. The method as set forth in claim 18 wherein said webs are formed with
the fluted web flutes facing downwardly, and including the step of reorienting said
webs before joining with the flutes facing upwardly.

20. A method for continuous manufacture of open core elements,
comprising the steps of:

(1) forming a composite web from two webs including at least one fluted
web;

5 (2) orienting said composite web with exposed fluted web flutes facing up;

(3) slitting the composite web longitudinally to form a plurality of adjacent equal width strips;

(4) applying an adhesive to the exposed upwardly facing flute tips of said strips;

10 (5) cutting said strips transversely to a common selected length; and,

(6) upending the strips onto common lateral strip edges and adhering the glued flutes of each strip to the next adjacent strip to form an open core element.

21. An apparatus for forming flutes in continuous web material comprising:
a rigid fluted rotary fluting roll with flute teeth defined by adjacent tips and gullets spaced circumferentially at a given flute pitch;

5 a counterroll having parallel fluting bars circumferentially spaced at the flute pitch and having fluting tips adapted to extend to the gullets of the fluting roll teeth when the counterroll is mounted for counterrotational engagement with the fluting roll;

the counterroll having a rigid cylindrical core and an outer elastomer sleeve;
and,

10 said fluting bars embedded in said elastomer sleeve to permit individual fluting tips to move in response to fluting tip to gullet contact.

22. The apparatus as set forth in claim 21 wherein the flute teeth are generally V-shaped in cross section and the gullets have a circular cross section.

23. The apparatus as set forth in claim 22 wherein the fluting tips have a circular cross section and a radius slightly less than the radius of the gullets.

24. The apparatus as set forth in claim 23 wherein the web material has a given thickness, and the radius of the fluting tips is less than the radius of the gullets by an amount approximately equal to the web thickness.

25. The apparatus as set forth in claim 22 wherein the corrugating roll flute teeth have flat flanks between adjacent tips and gullets.

26. The apparatus as set forth in claim 25 wherein the counterroll fluting bars make contact with the formed web flutes only in the flute gullets of the fluting roll.

27. The apparatus as set forth in claim 26 wherein there is no contact between the fluting roll flute tips and flute flanks of the counterroll.

28. The apparatus as set forth in claim 21 wherein said corrugating roll includes a vacuum system for supplying vacuum to the flute gullets.

29. The apparatus as set forth in claim 28 including a system for heating said corrugating roll.

30. The apparatus as set forth in claim 29 wherein said corrugating roll comprises a cylindrical tubular body and said vacuum system and said heating system comprise axial bores formed in said tubular body.

31. The apparatus as set forth in claim 21 wherein said fluting bars comprise hollow aluminum extrusions.

32. The apparatus as set forth in claim 23 wherein the fluting bars have a teardrop cross sectional shape including a wide base embedded in the elastomer and opposite converging sides terminating in said fluting tips.

33. An apparatus for applying a liquid adhesive to a moving web comprising:

a ganged positive displacement pump having an array of laterally spaced flexible adhesive supply tubes having inlet ends receiving the adhesive from an adhesive supply and outlet ends for adhesive delivery in parallel streams;

an adhesive applicator roll arranged to receive the streams of adhesive from the outlet ends on an outer roll surface;

a flexible adhesive spreading tongue mounted adjacent the applicator roll and having a downstream end portion shaped to conform to the roll surface to spread the adhesive to a uniform layer on the rotating roll; and,

a web delivery arrangement for bringing the web into tangent contact with the roll downstream of the end of the tongue to pick up adhesive from the roll surface.

34. The apparatus as set forth in claim 32 wherein the pump comprises a peristaltic pump and includes a pump housing having a semicylindrical backing

surface and a driven rotating roller assembly having an axis of rotation coincident with the axis of the backing surface and operable to intermittently press the tubes
5 against the backing surface to deliver laterally spaced uniform streams of adhesive.

35. The apparatus as set forth in claim 33 wherein the inlet ends of the pump supply tubes receive from the adhesive supply the proper volume of adhesive to be applied to the web, whereby no adhesive supplied by the pump to the applicator roll must be recycled.

36. The apparatus as set forth in claim 34 wherein the adhesive is an aqueous starch-based glue and including means for calculating the volume of adhesive based on pump rotational speed, web speed and web width to supply the proper volume of adhesive to the pump.

37. The apparatus as set forth in claim 33 including a device for mounting the outlet ends of the supply tubes adjacent the applicator roll at a selectively adjustable lateral spacing.

38. The apparatus as set forth in claim 36 wherein the tube end mounting device comprises an elastic band to which the tube ends are attached at a selected uniform lateral spacing in a partially stretched condition and with which tube spacing is increased by stretching the band in opposite directions by equal amounts.

39. The apparatus as set forth in claim 32 including laterally adjustable adhesive layer width controls operative to contact the roll surface and remove therefrom adhesive lying laterally beyond the width of the web.

40. The apparatus as set forth in claim 38 wherein the width controls comprise vacuum assisted doctor blades.

41. The apparatus as set forth in claim 32 including a roll cleaning doctor blade extending the full length of the roll and movable vertically into reverse angled contact with the roll surface downstream of the end of the tongue.

42. The apparatus as set forth in claim 40 including means for circulating cleaning solution through the pump tubes and over the roll, the tongue, the vacuum assisted doctor blades and roll cleaning doctor blade.

43. The apparatus as set forth in claim 32 including means for adjusting the axial positions of portions of the tubes pressed by the roller assembly to present fresh portions to contact by the roller assembly.



FIG. 1

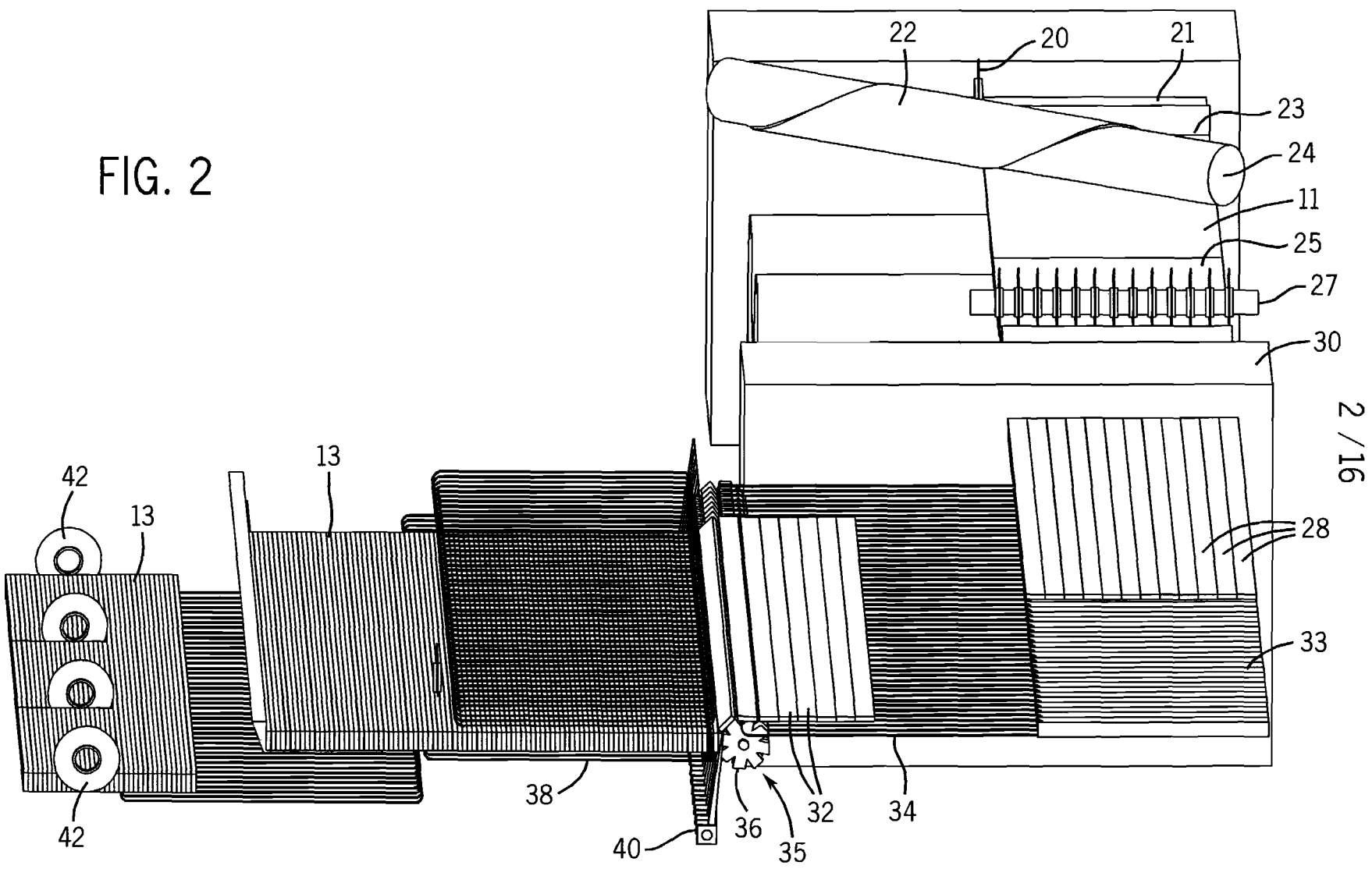


FIG. 2

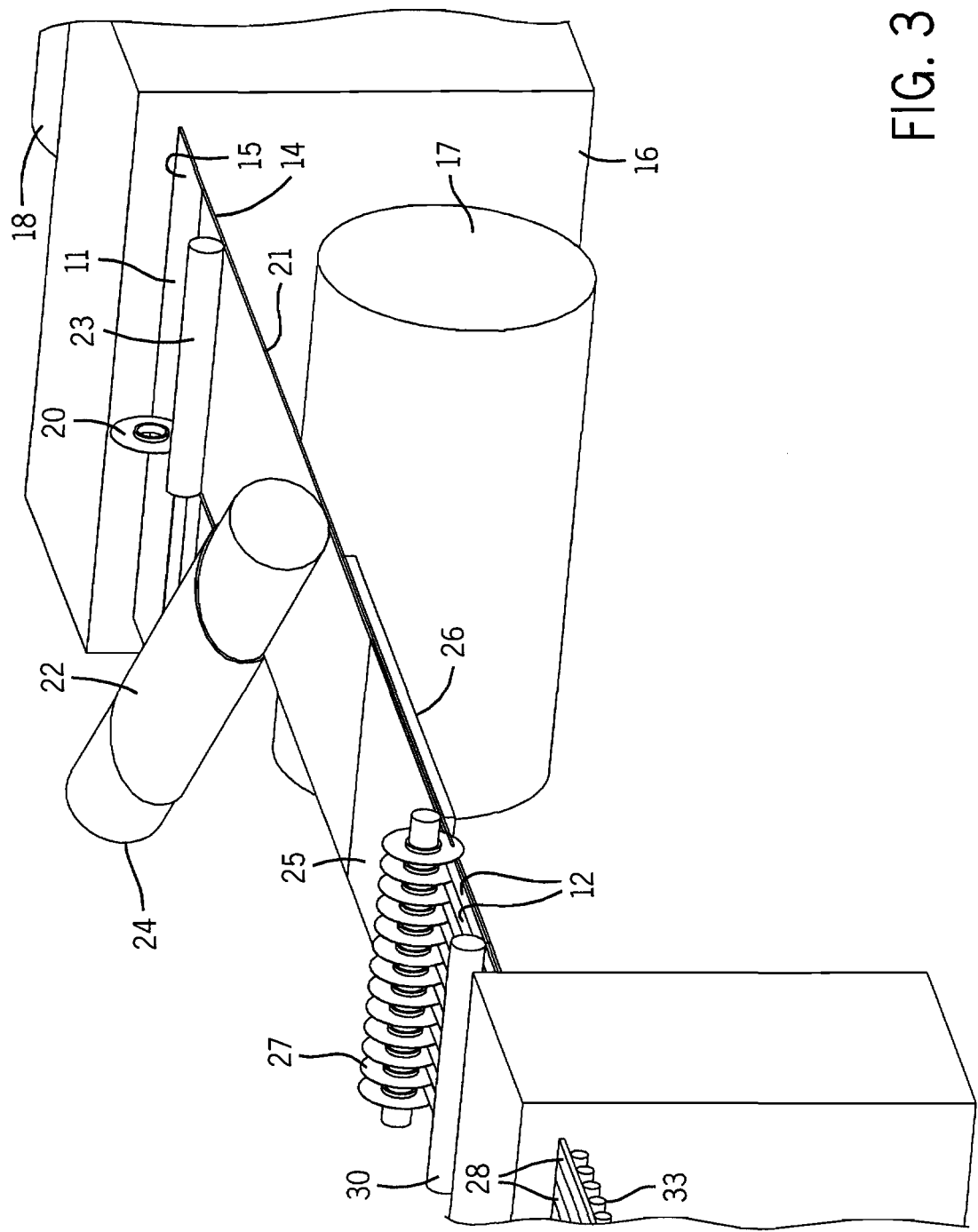


FIG. 3

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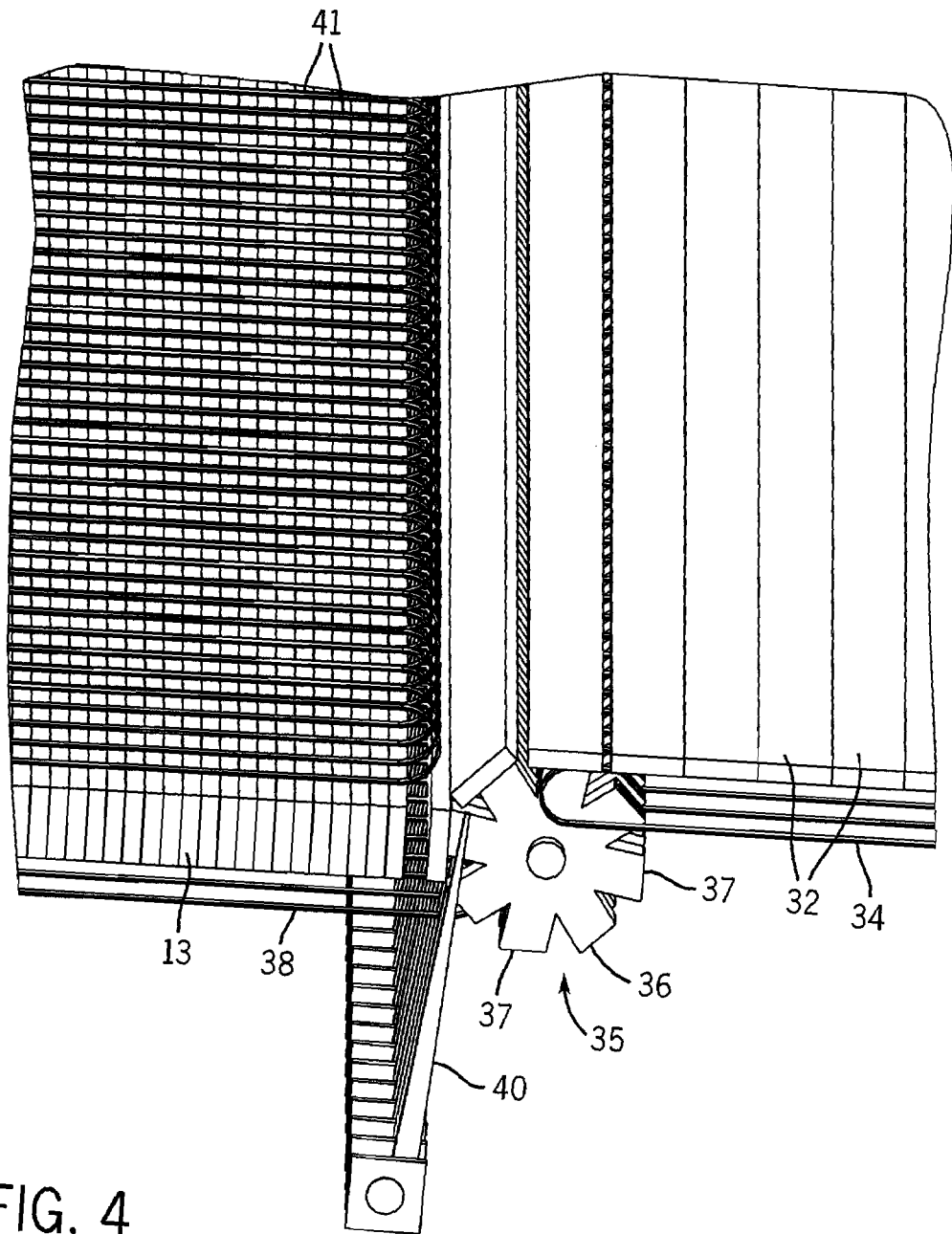


FIG. 4

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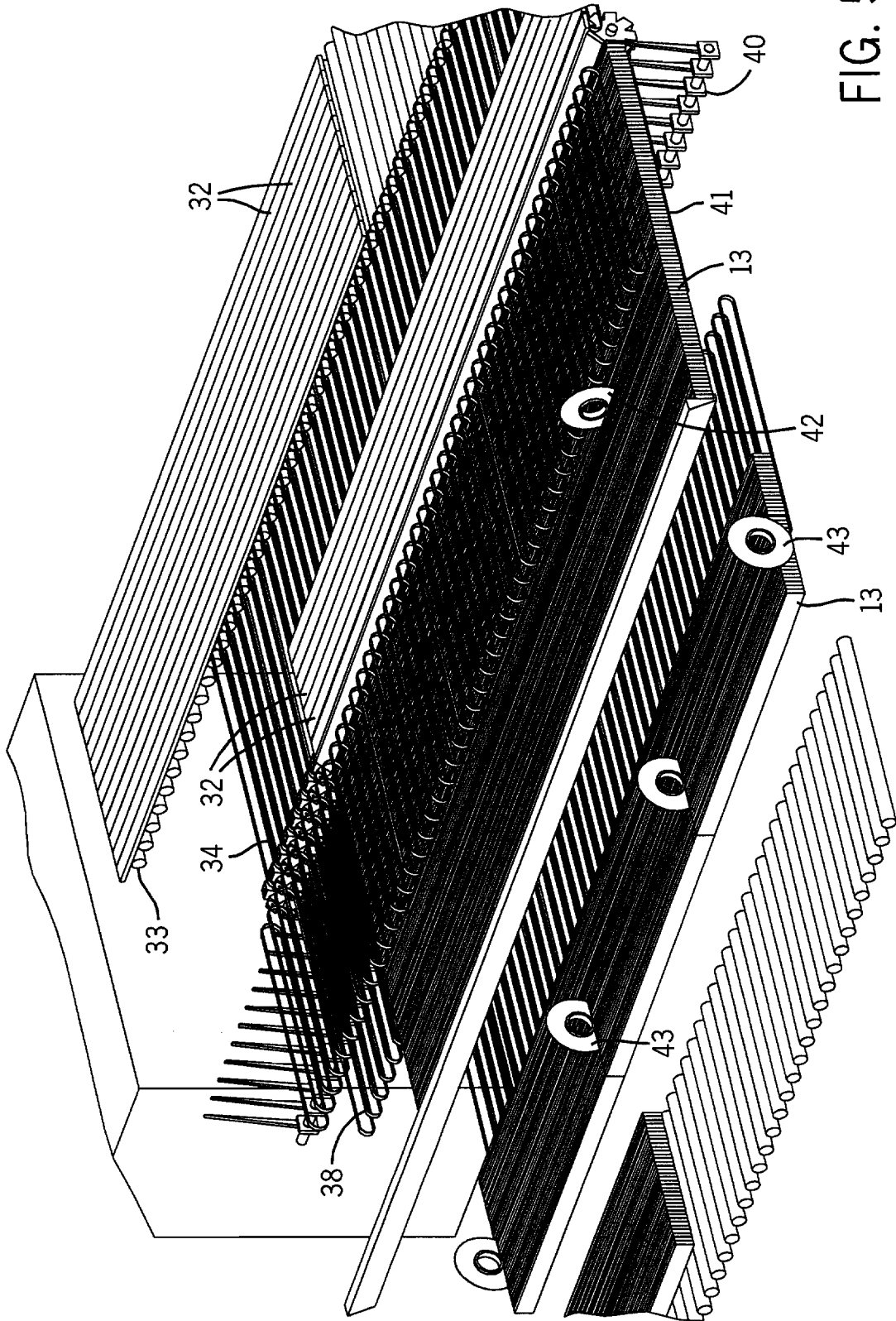


FIG. 5

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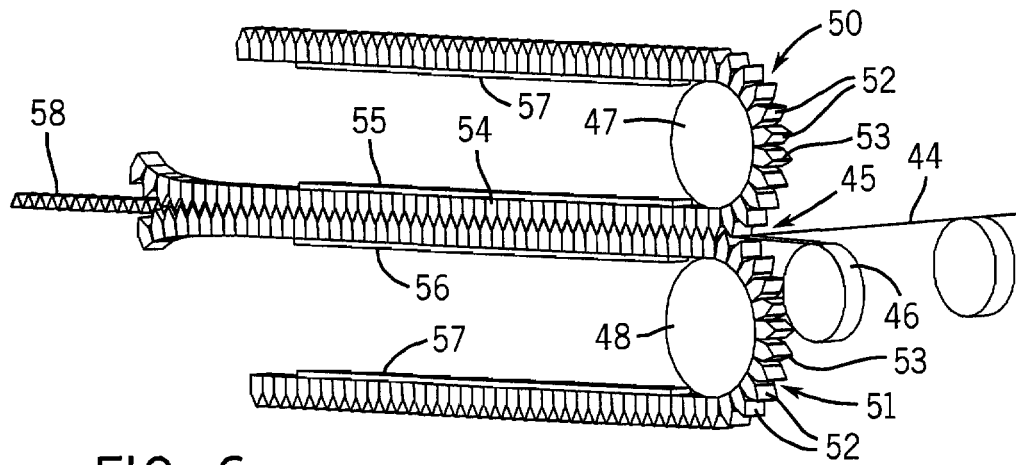


FIG. 6

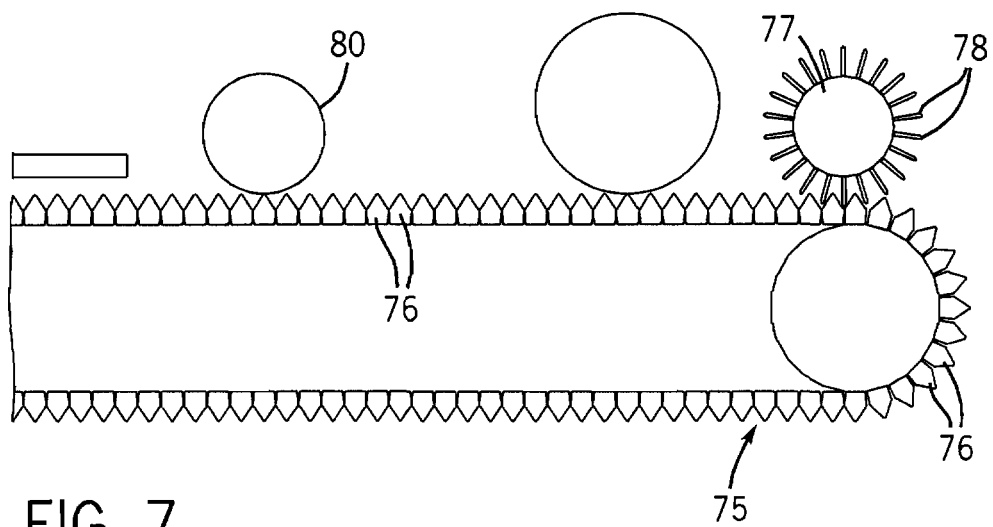


FIG. 7

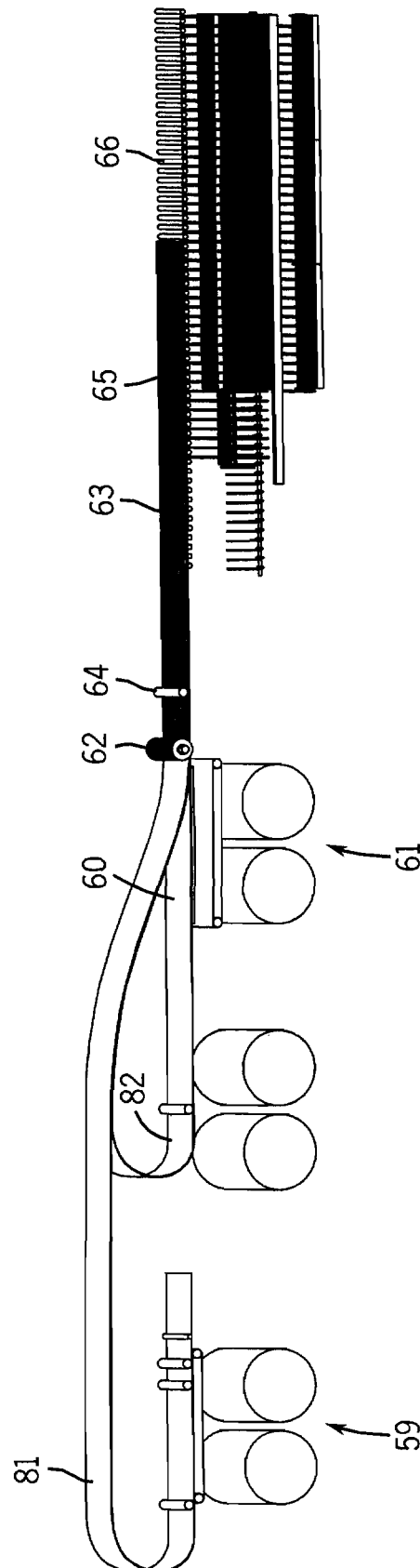
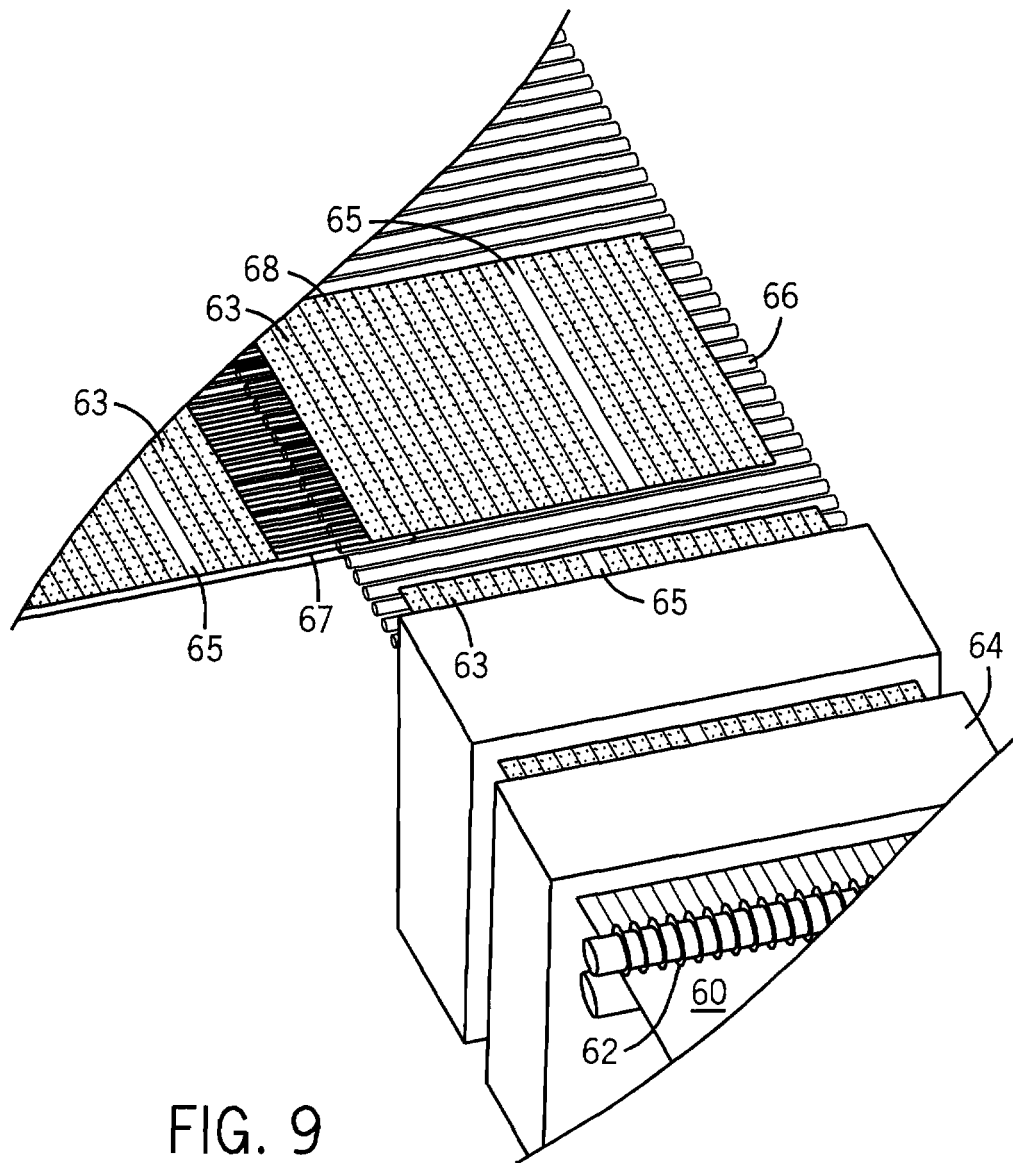


FIG. 8

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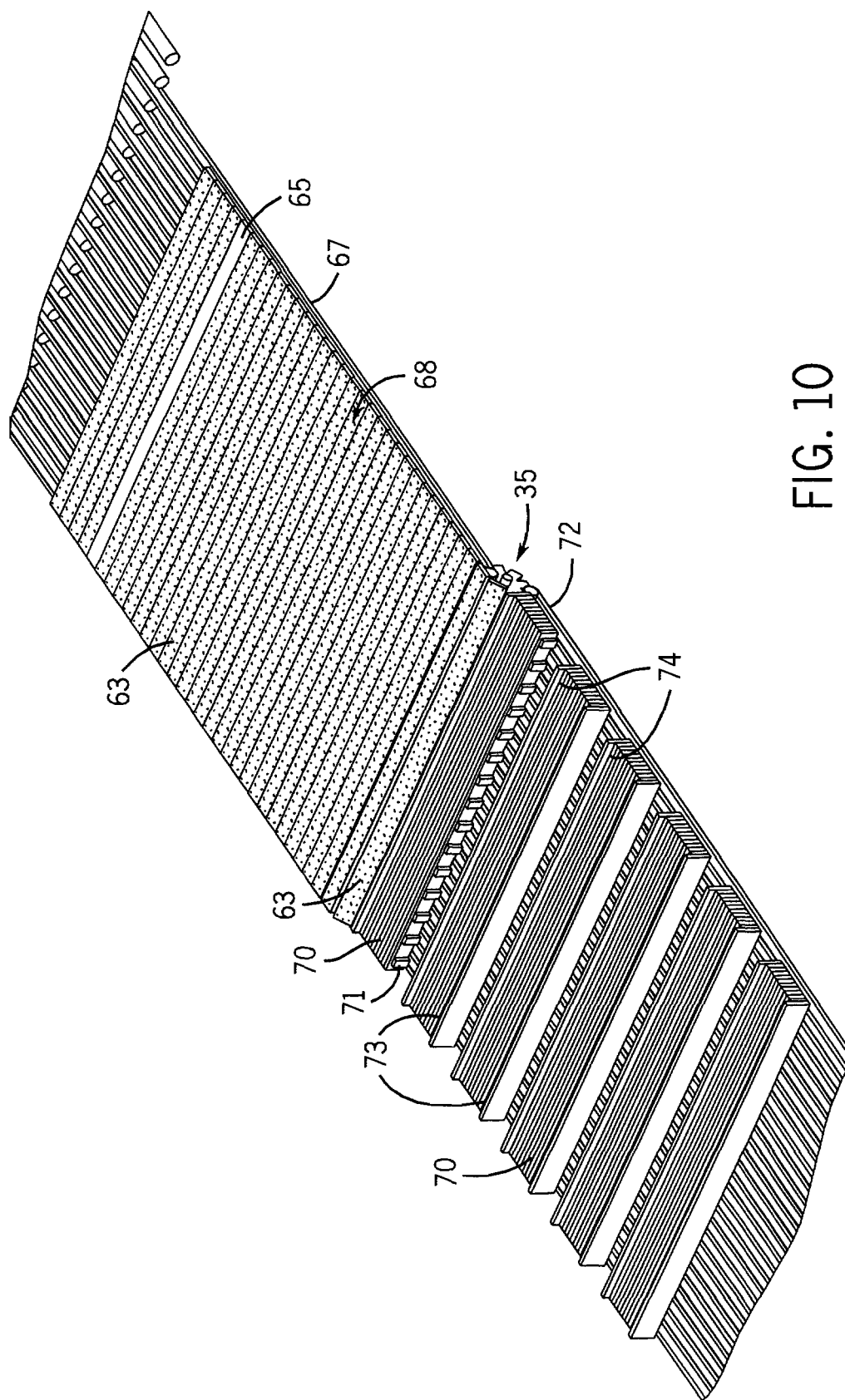


FIG. 10

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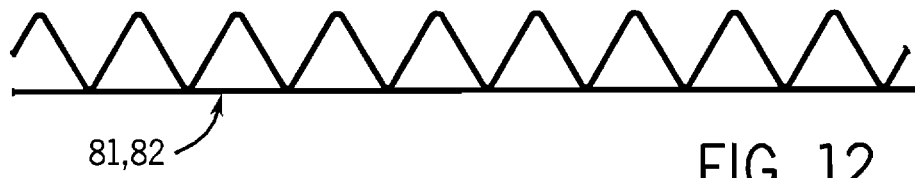


FIG. 12

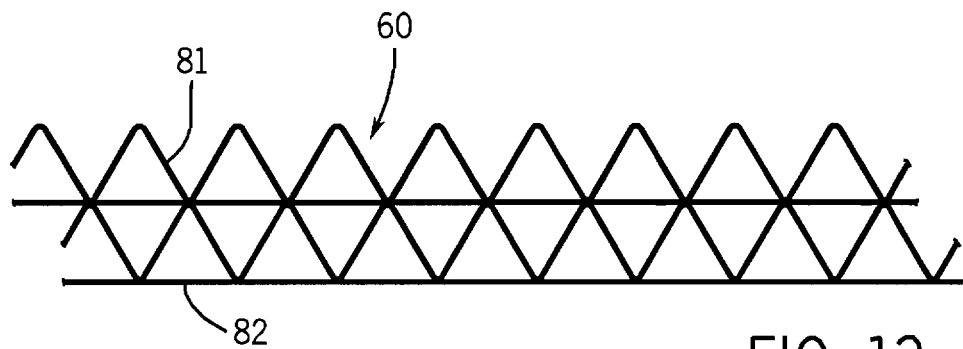


FIG. 13

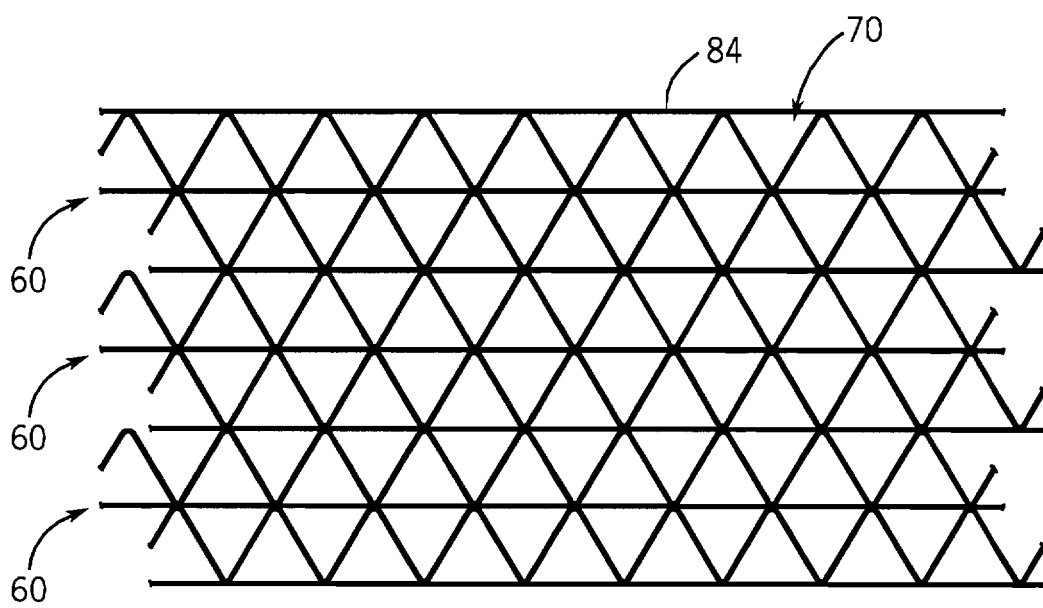


FIG. 14

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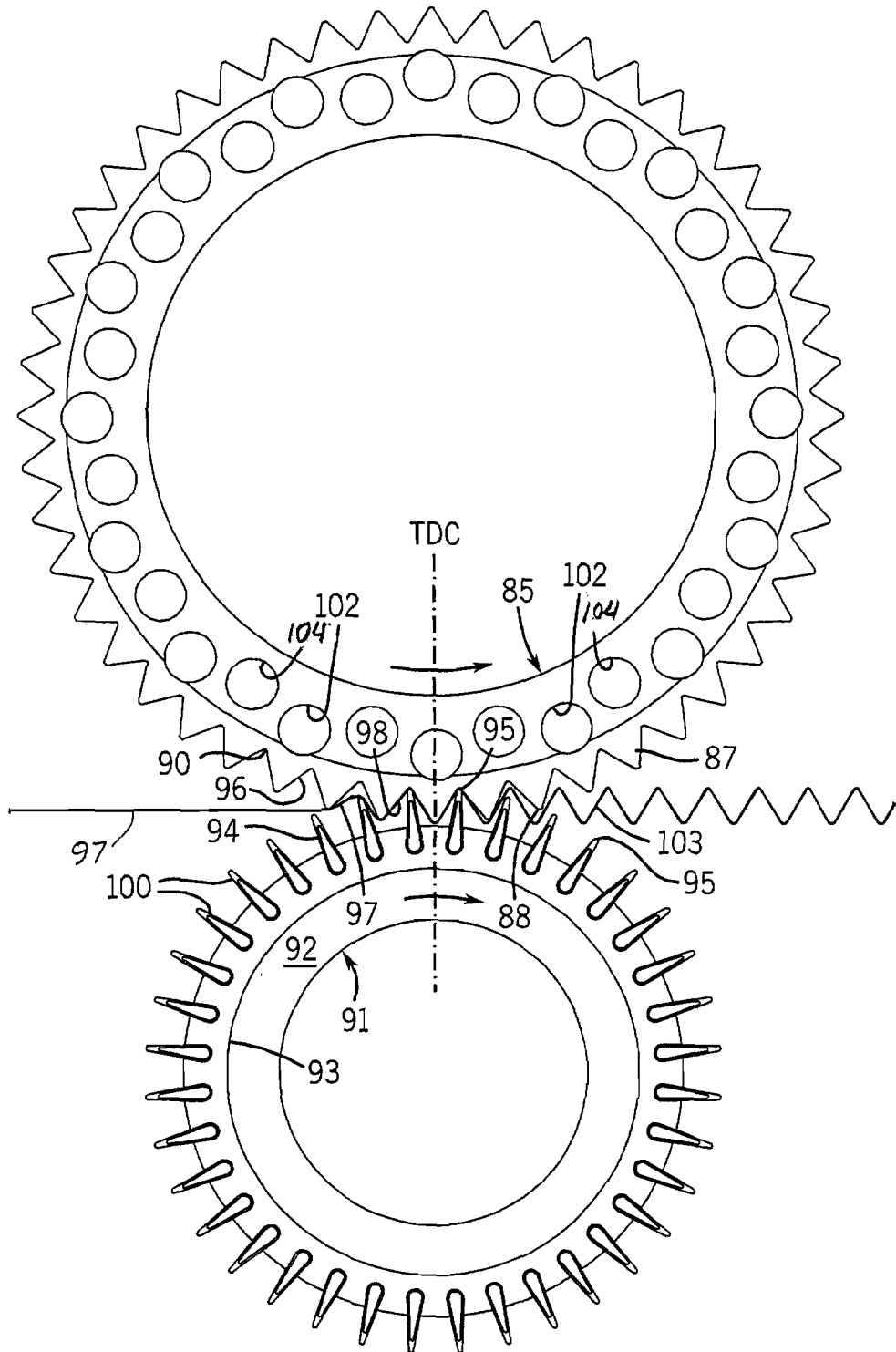


FIG. 15

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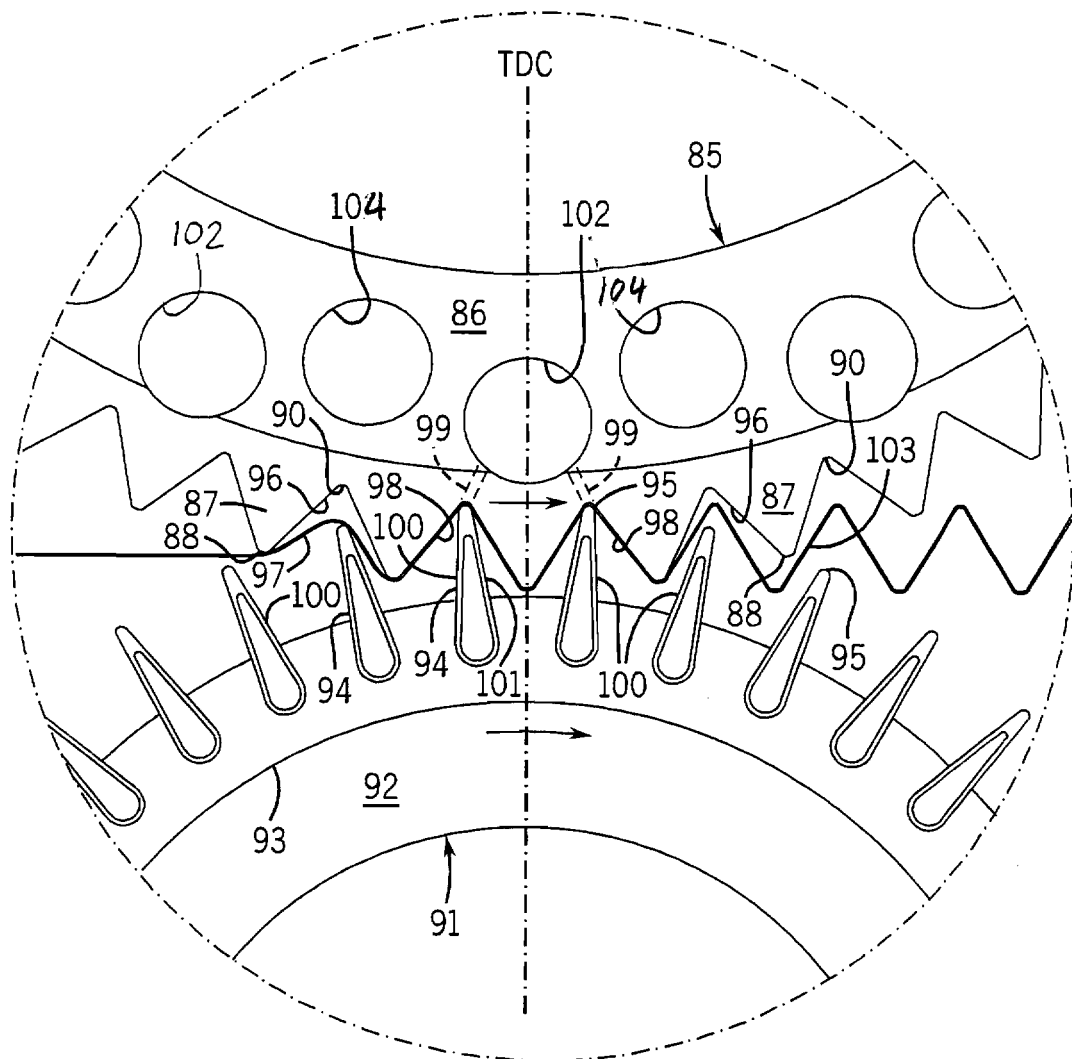


FIG. 16

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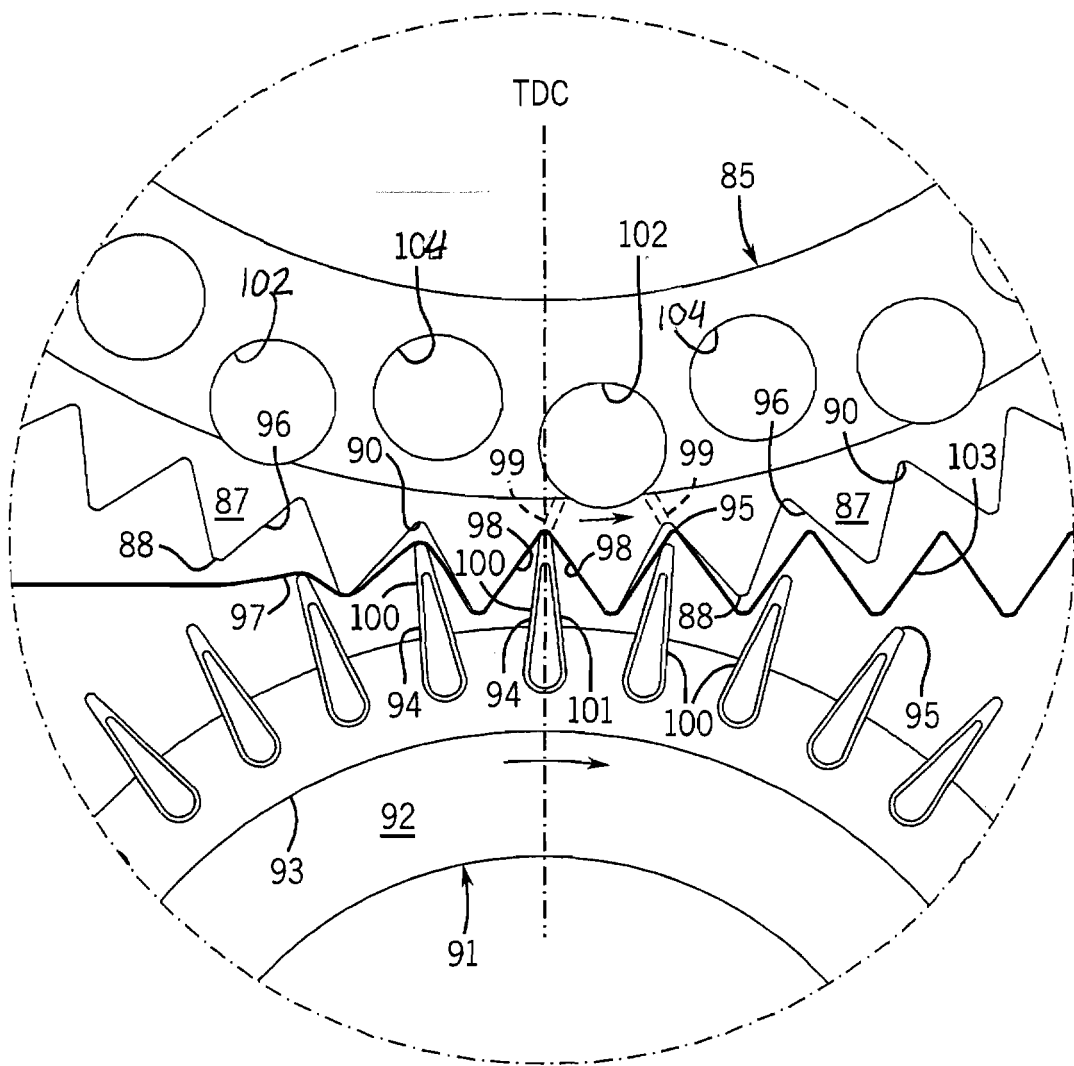
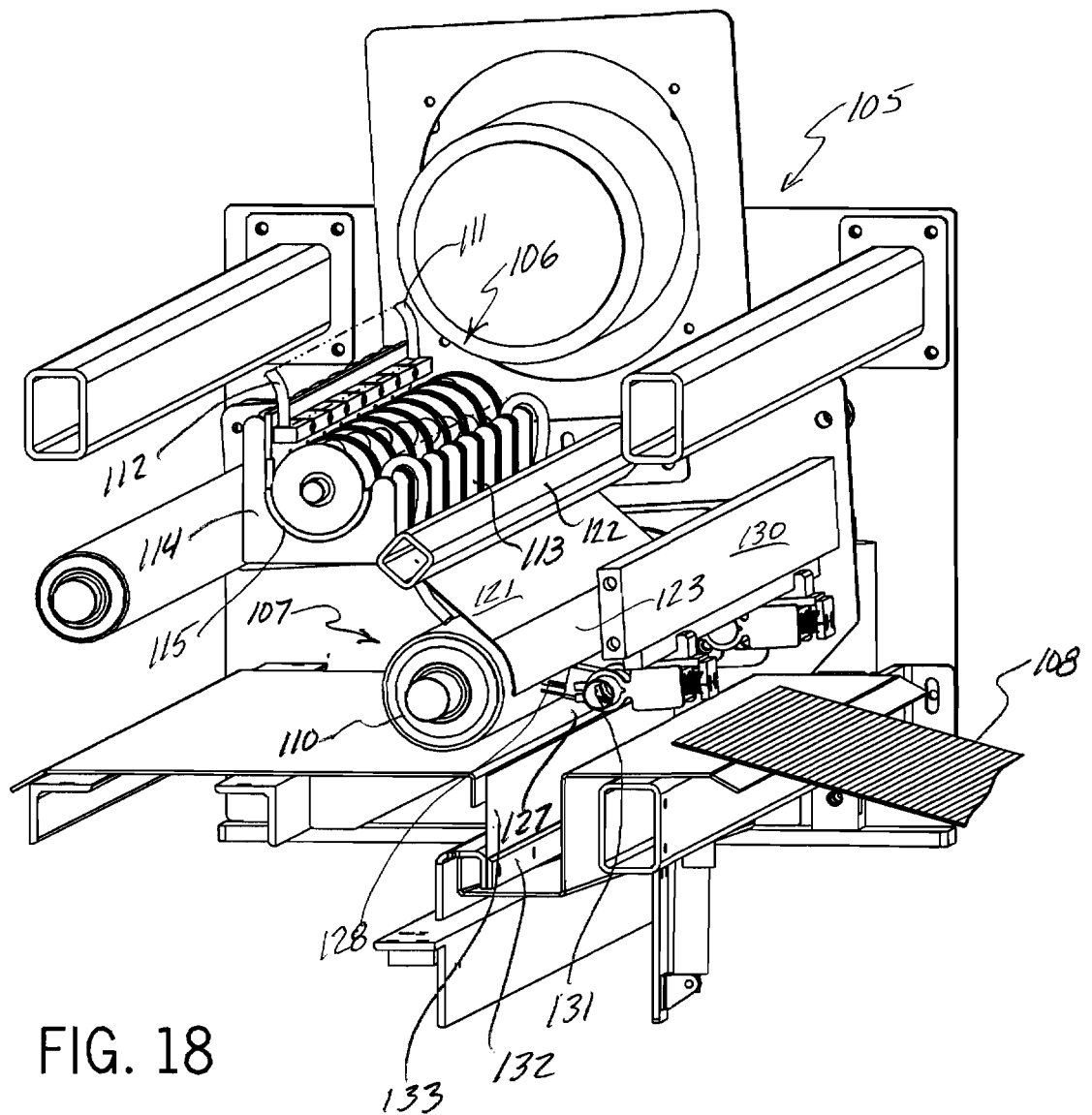


FIG. 17

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