July 29, 1969 J. D. BOVA ET AL 3,458,385

EXPANDABLE HONEYCOMB STRUCTURE

Original Filed May 29, 1963 5 Sheets-Sheet 1

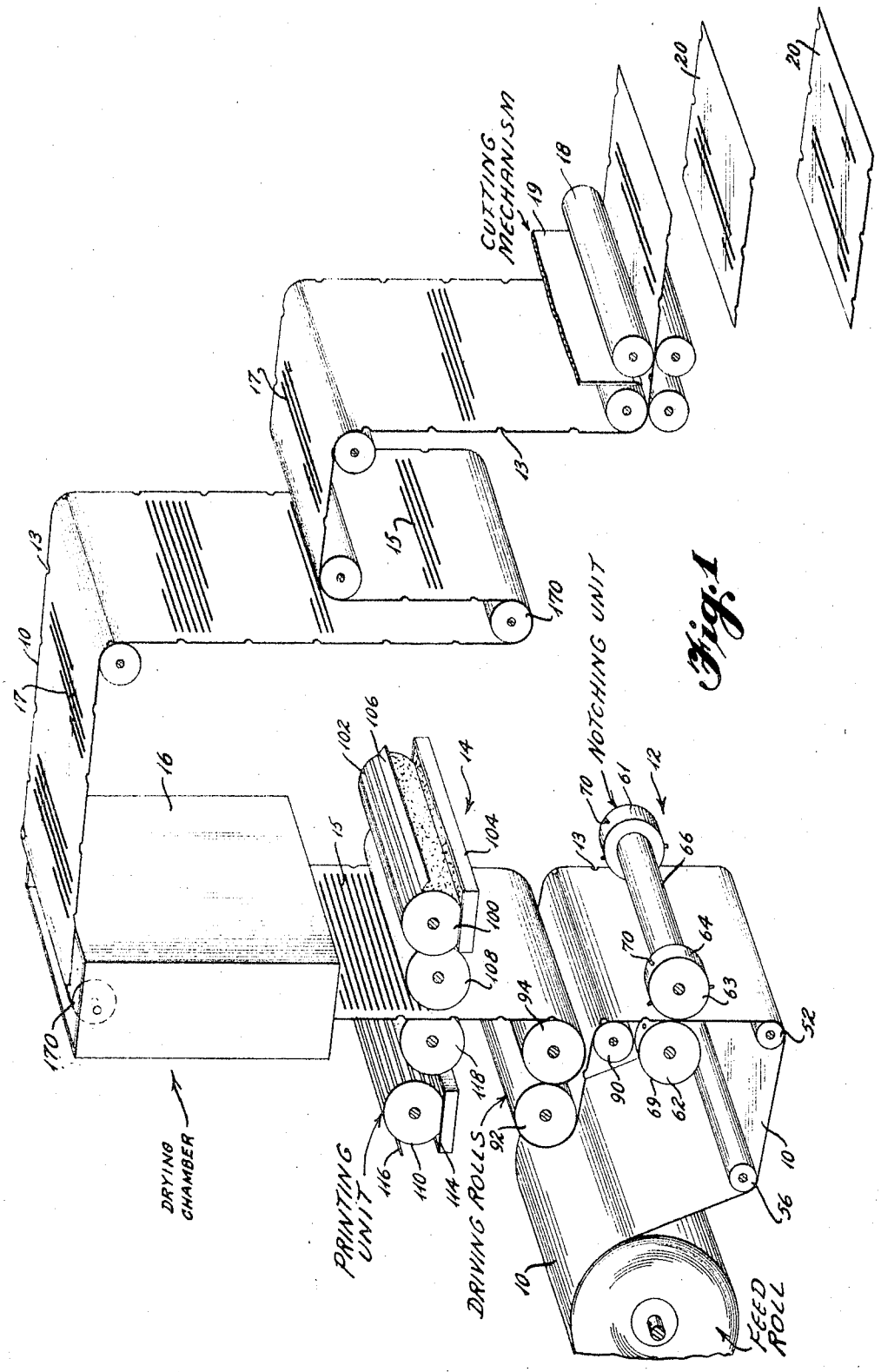
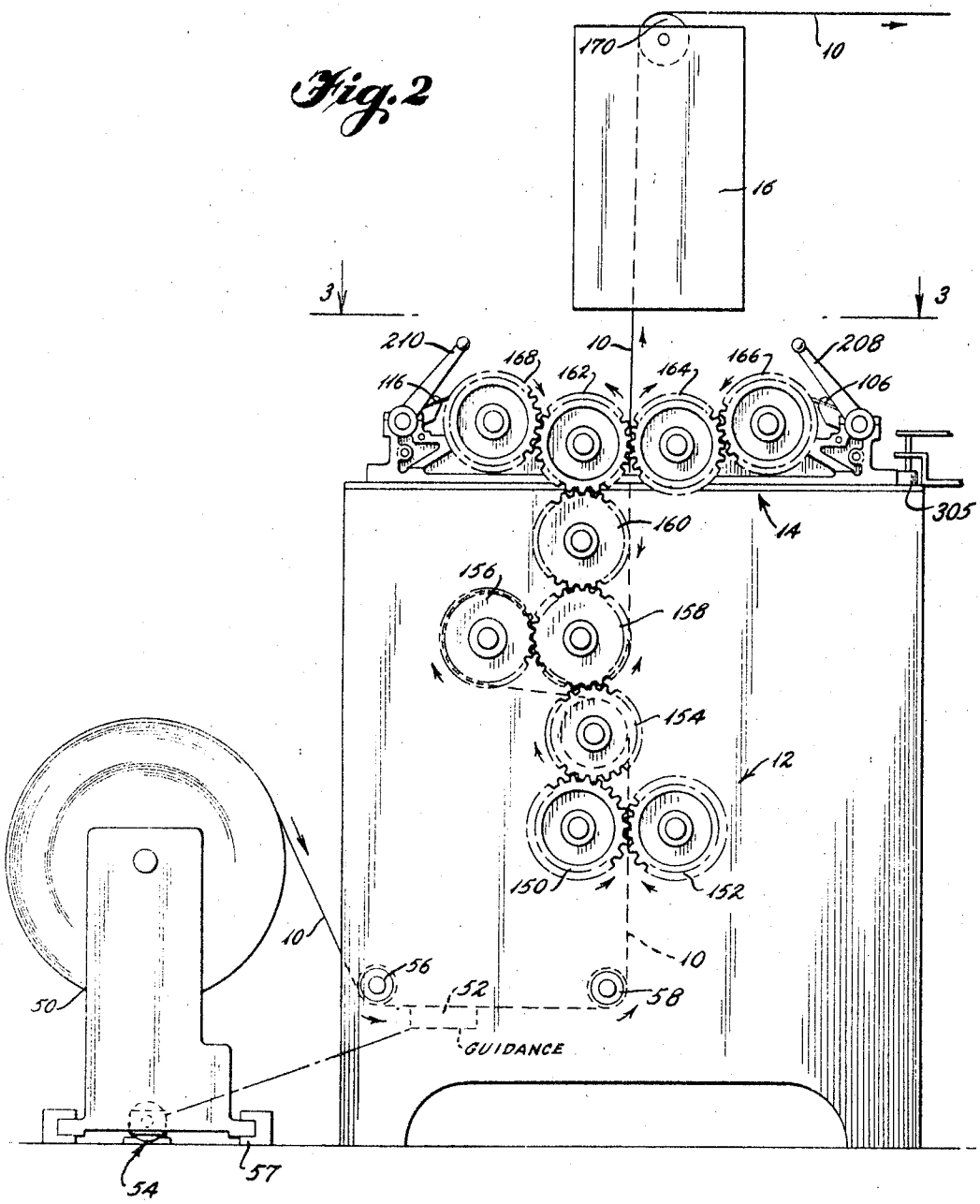


Fig. 1

EXPANDABLE HONEYCOMB STRUCTURE

Original Filed May 29, 1963 5 Sheets-Sheet 2

Fig. 2



EXPANDABLE HONEYCOMB STRUCTURE

Original Filed May 29, 1963 5 Sheets-Sheet 3

Fig. 3

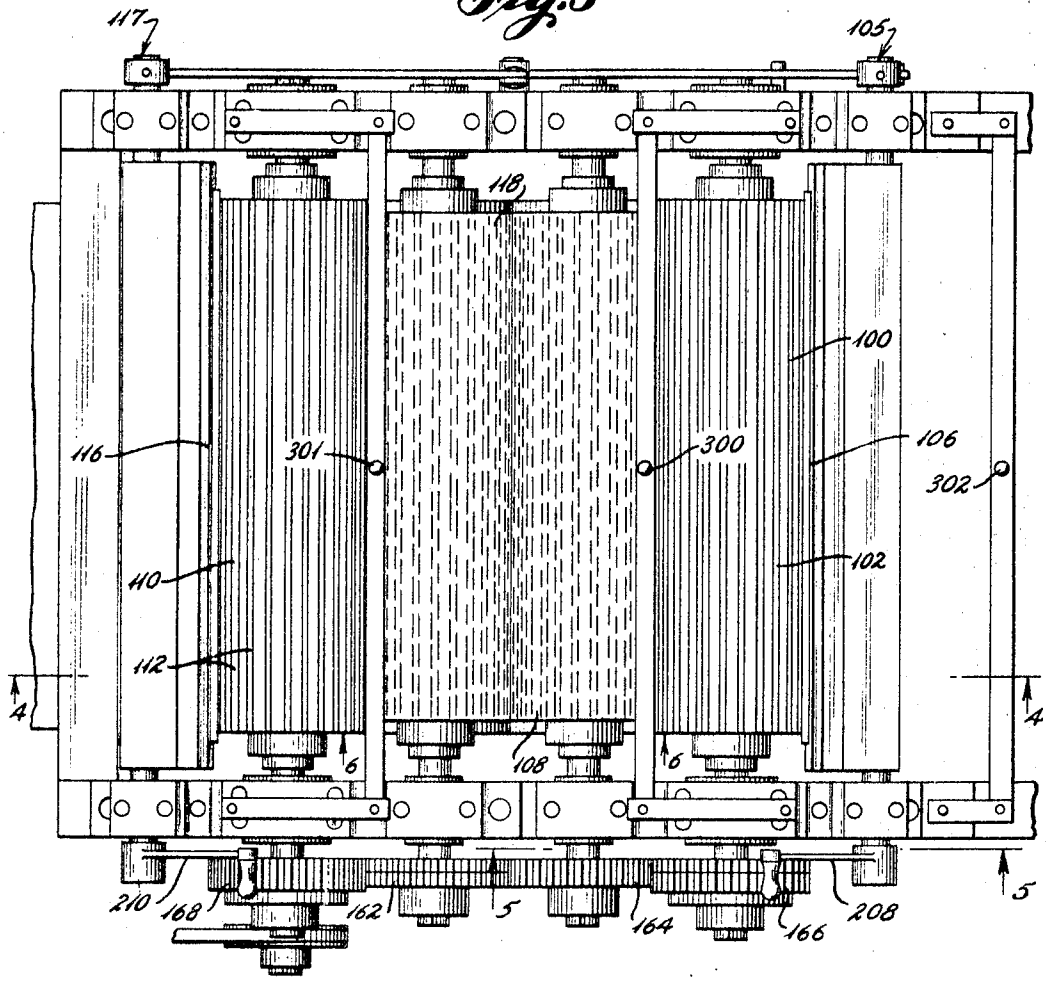
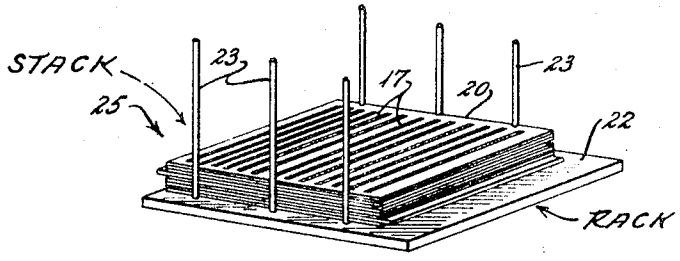


Fig. 9

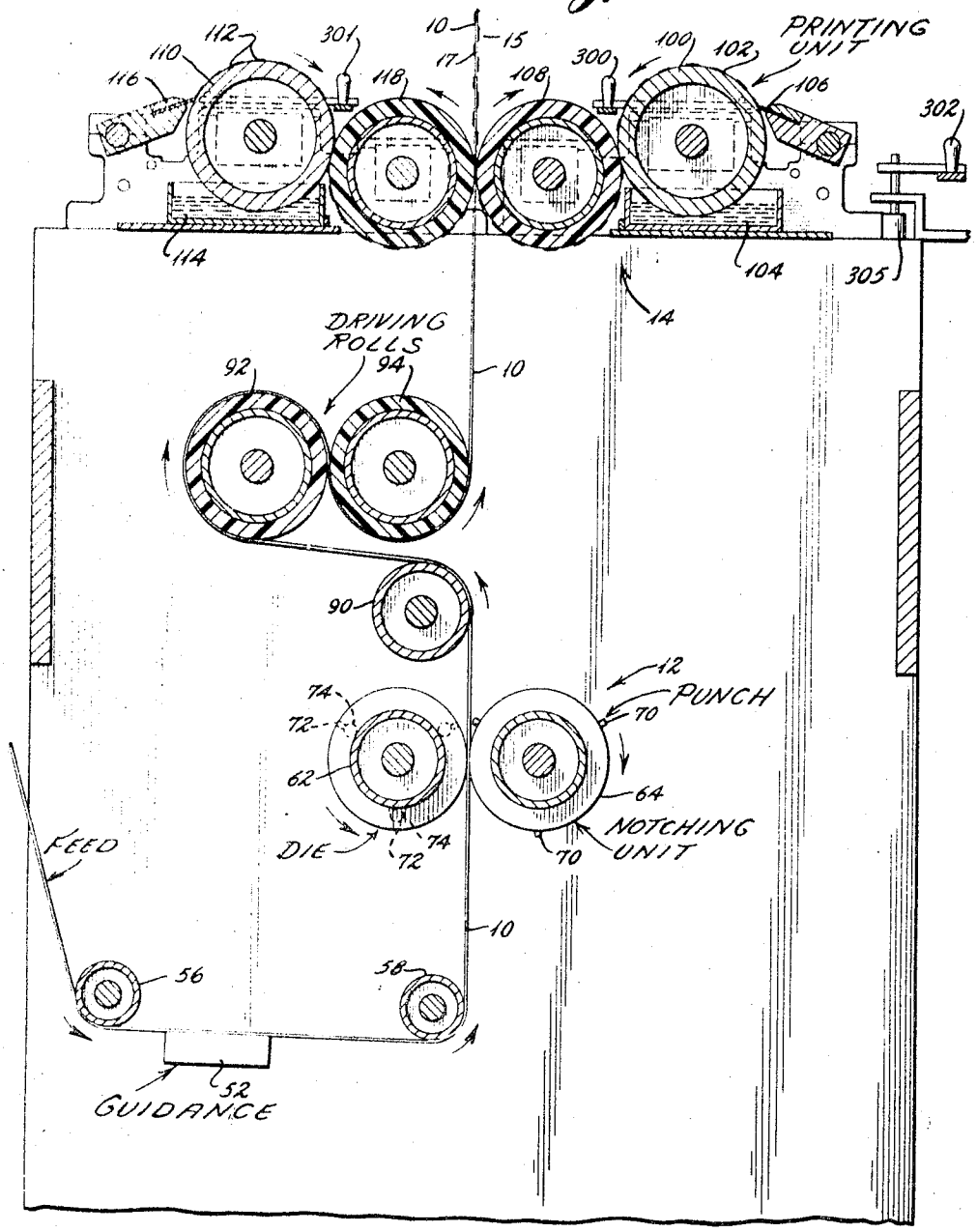


July 29, 1969 J. D. BOVA ET AL 3,458,385

EXPANDABLE HONEYCOMB STRUCTURE

Original Filed May 29, 1963 5 Sheets-Sheet 4

Fig. 4



July 29, 1969 J. D. BOVA ET AL 3,458,385

EXPANDABLE HONEYCOMB STRUCTURE

Original Filed May 29, 1963 5 Sheets-Sheet 5

Fig. 5

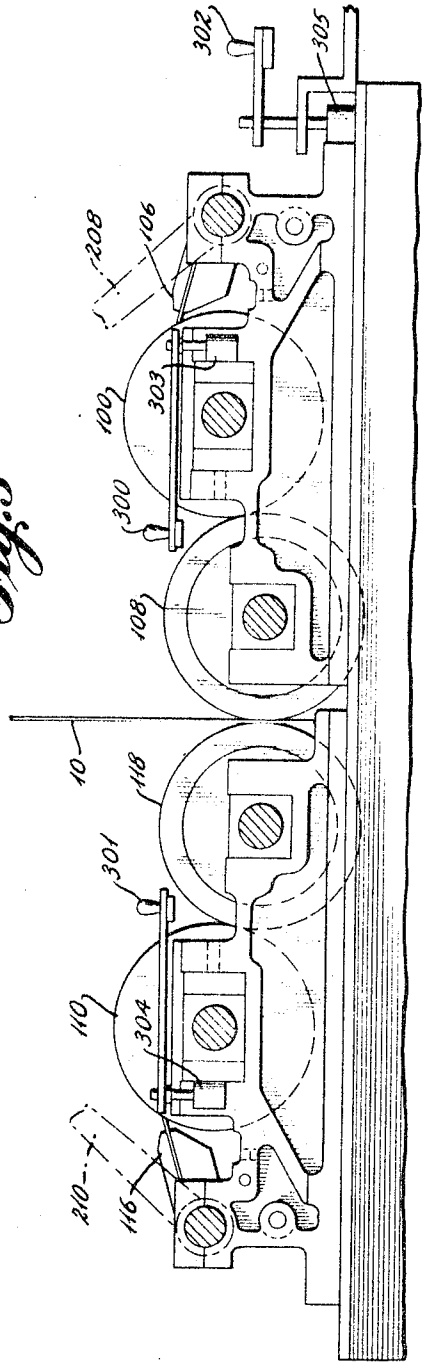


Fig. 8

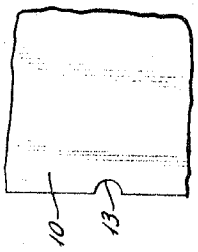


Fig. 7

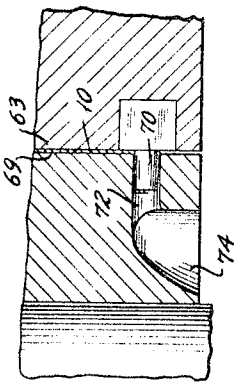
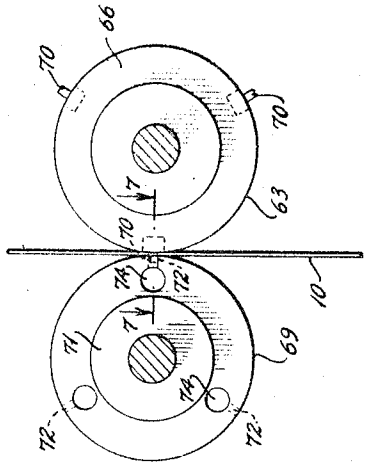


Fig. 6



United States Patent Office

3,458,385

Patented July 29, 1969

3,458,385

EXPANDABLE HONEYCOMB STRUCTURE

Joseph Don Bova, Fallston, and Harry Charles Engel, Havre de Grace, Md., assignors to American Cyanamid Company, Stamford, Conn., a corporation of Maine

Original application May 29, 1963, Ser. No. 284,097, now Patent No. 3,242,024, dated Mar. 22, 1966. Divided and this application Jan. 24, 1966, Ser. No. 522,747

Int. Cl. B32b 7/14; B32l 3/12

U.S. Cl. 161—68 3 Claims

ABSTRACT OF THE DISCLOSURE

A product employed during manufacture of honeycomb which constitutes a web transversely printed with parallel spaced-apart glue lines, the web being apertured at spaced-apart intervals. The glue lines and the apertures are in a constant spacing relationship to each other so that successive web sections cut from the web can be superposed into a honeycomb stack by alignment of the apertures. This aperture alignment causes the glue lines on each sheet to fall exactly into glue line to glue line contact.

This application is a division of Ser. No. 284,097 filed May 29, 1963, now Patent No. 3,242,024.

This invention relates to an improved transverse glue line printed web, a honeycomb stack or block and to an expanded structural honeycomb product.

Structural honeycombs are commonly formed by first forming a web of sheet material with parallel equally spaced apart glue or adhesive lines on both faces thereof, the glue lines on opposite faces being staggered relative to each other, cutting equal sections from the web, stacking the sections in face to face contact with every other sheet section being alternated so as to provide a glue-line to glue-line contact, and thereafter heat setting the glue to laminate the stack. When the laminated stack is expanded, the sheet material deforms into a hexagonally shaped honeycomb structure.

Perhaps the most common technique for forming honeycomb involves imprinting the web of sheet material (e.g. aluminum) with the parallel glue lines extending longitudinally of the web. Longitudinal glue lines permit the successive sections of web to be cut then superposed into a stack of sheets without encountering unduly severe registry problems. For one thing, exactly equal length sections do not have to be cut from the web since ragged ends on such a stack can be trimmed without affecting the ultimate honeycomb. Also, side jogging of the sheets in such a stack affects accurate glue-line to glue-line registry of the individual face to face sheets.

By the same token, however, the number of longitudinal glue lines for any fixed spacing which can be employed is predetermined by the width of the web. In consequence, the ultimate honeycomb has a fixed maximum length in the ribbon direction. Yet, applications requiring relatively long ribbon lengths exist. Almost obviously desirable is placement of the parallel glue or adhesive lines transversely of the running web, making possible manufacture of honeycomb with unlimited ribbon lengths. Relatively long, unsupported structural spans could be fabricated directly from honeycomb having the needed ribbon length.

While a switch from longitudinal glue lines to transverse glue lines would, as indicated, be quite advantageous, this switch is frought with technical difficulties. Virtually all the alignment or registry techniques employed for sheet sections imprinted with longitudinal glue lines must be substantially altered or replaced. For example, elongated sheets or web sections are difficult to stack with the proper degree of end to end alignment. When the glue lines extend longitudinally of the sheet, a ¼" end to end overlap of successive sheets in a jogged stack is of little consequence. However, when the glue lines are printed transversely of the web, the more easily achieved side registry of successive web sections in a stack has become less important; end to end registry is now critical. The same ¼" of overlap between successive web sections will result in a "holiday" wherein the transversely disposed glue lines of these face to face sheets in the stack do not contact each other. When the laminated stack is expanded, individual cells are deformed; a weakened honeycomb structure results. The problem of end to end registry is not hypothetical. Conventional jogging equipment now available does not pretend to achieve an alignment accuracy greater than about 1/16" for stacking 100 inch sheet lengths end to end. Misalignment of this magnitude would cause complete off register of an .060" line for a ⅛ cell size honeycomb. With equipment of this accuracy the stack would be completely displaced as jogging error will cause non-contact of the glue lines between adjacent sheets.

Still another real problem inherent in use of transverse glue lines resides in the difficulty of severing successive sections of sheet material from an indefinite web. Theoretically, cutting exactly equal web section lengths will provide sheets which can then be superposed in end to end glue line registry. True equality of length can hardly be attained. Consider again a 100 inch section. Conventional cutting equipment available as of this date promises a cutting accuracy of about 0.015". However, this .015" error coupled with another .015" error for edge cut and an additional misalignment for jogging 100" sheets end to end would be intolerable when considering that the glue line for a ⅛" cell honeycomb is only .060" wide.

Formation of satisfactory structural honeycomb material based upon transverse glue lines requires special techniques and equipment.

The present invention has as its principal object provision of a unique product made according to a method for imprinting transverse glue lines on both sides of a web at one station in a manner which allows a facile assemblage of successive sheets cut from the transversely printed web into an accurately aligned glue line to glue line honeycomb stack.

Other objects and advantages of the present invention will become apparent from the following detailed description thereof made with reference to the accompanying drawings in which a preferred embodiment of the apparatus is illustrated.

In the drawings:

FIGURE 1 is a schematic view diagrammatically illustrating the process and apparatus of the present invention;

FIGURE 2 is a side view diagrammatically illustrating the gear mechanism for the many rollers over which the continuous web travels;

FIGURE 3 is a top view illustrating the transverse

glue line printing mechanism, and is taken along the lines 3—3 of FIGURE 2;

FIGURE 4 is a side sectional view along lines 4—4 of FIGURE 3, and illustrates the rollers over which the continuous web sheet material is passed;

FIGURE 5 is an enlarged side sectional view taken along line 5—5 of FIGURE 3, and illustrates a portion of the glue line printing mechanism;

FIGURE 6 is a side view of the web notching mechanism;

FIG. 7 is an enlarged fragmentary section taken through line 7—7 of FIGURE 6, and illustrates the details of the web notching mechanism;

FIGURE 8 is an enlarged fragmentary view of the web showing the side notch; and

FIGURE 9 is a diagrammatic view illustrating how sheet sections are stacked in glue-line to glue-line registry.

Briefly, the procedure of the present invention in a preferred embodiment as schematically illustrated in FIGURE 1, involves feeding a web of sheet material **10** from a roll, first through a notching unit **12** wherein side notches **13** are cut into the sheet material at spaced intervals. Thereafter, the web is passed through a printing unit **14** which, by an off-set procedure, prints parallel glue lines transversely on both sides of the web at approximately the same time in the same station. The printing rolls are arranged so that the parallel equally spaced apart transverse glue lines **15** on one face of the web are in staggered relation to the parallel equally spaced apart transverse glue lines **17** printed on the obverse face of the web.

The web **10** leaving printing unit **14** passes through a drying unit **16** to a cutting mechanism **18**. The cutting element, e.g., guillotine **19** (which may be manually operated if such is desired), severs web **10** into approximately equal sized sheets **20**. The sheets **20** are passed in alternation (i.e., every other sheet being flipped over) to an aligning rack **22** such as is illustrated in FIGURE 9. As hereinafter explained, notches **13** in the sides of web **10** are exactly related to the position of transverse glue lines **15**, **17** on the faces of web **10** so that by alignment of the stacked sheet sections **20** in rack **22** by means of side pins **23** every sheet **20** in the stack **25** is accurately positioned into the desired glue line to glue line contact with its adjacent sheet. As illustrated in FIGURE 9, registry of the sheets **20** in stack **25** by means of side notches **13** and aligning pins **23** will often result in substantial overlap (up to perhaps ½") between successive sheets, but such overlap and the need to trim the ends of stack **25** should not be regarded as disadvantageous because the trim wastage is small compensation for achieving accurate glue line to glue line registry throughout the stack **25**.

Characteristic of the practice of the present invention, the equipment provided for printing and notching is meticulously aligned so that the spacing relationship of the side notches **13** to transversely applied parallel glue lines **15**, **17** remains constant from the beginning of the web to the end of the web. This accurately constant spacing is what permits successive sheet sections **20** of the web **10** to superpose inherently into face to face glue line to glue line contact when the stack **25** is aligned with pins **23** set in side notches **13** of each sheet section **20**.

For more details of the notching and printing mechanism than are shown in FIGURE 1, reference is now made to the structure shown on FIGURES 2 and 4. The roll of sheet material is mounted on a conventional constant linear speed unrolling mechanism **50** operated by an electric motor (not shown). Transverse or lateral alignment of the unrolling web **10** is maintained through the conventional guidance control mechanism only generally indicated o the drawing. A sensing element schematically indicated at **52** actuates a hydraulic cylinder **54** in accord with the position of the web. Movement of hydraulic cylinder **54** laterally, moves unrolling mechanism **50** on its base **57** appropriately. Such lateral control devices are

conventional (in the printing arts) and per se form no part of the present invention. In any event, as the web **10** of sheet material is unrolled from the mechanism **50** at a constant linear speed, it passes first under an idler roll **56** past sensing element **52** under another idler roll **58** and then vertically up through the notching rolls of unit **12**.

Notching unit **12** is comprised of male punches on roll **64** and female die sets on roll **62**. The punch roll **64** (FIGURE 1) is formed at its ends by cylinders **61**, **63** which engage the side marginal edges of web **10**, cylinders **61**, **63** and their connecting reduced diameter cylinder or shaft **66** forming an integral whole (of roll **64**) driven by gear **152** (FIGURE 2). Similarly, female die set roll **62** is formed at its ends by cylinders (of which only one, **69**, is shown in FIGURE 1) joined by a connecting reduced diameter cylinder or shaft and is driven as an integral whole by gear **150** (FIGURE 2). On cylinders **61**, **63** are punch elements **70** (FIGURES 4, 6, 7) which elements suitably are hardened steel inserts set in the body of cylinders **61**, **63**. Correspondingly, the cylinders of female die set roll, e.g., cylinder **69**, contain die structures **72** to receive the punchings and eject them through channel **74** to the side of the cylinder. The punchings from cylinder **59** fall clear of driving gear **150**. FIGURE 8 shows how punch **70** and die **72** form a semicircular notch **13** at the side edge of web **10**.

Important to the practice of this invention is the provision of punch roll symmetry so that the punches **70** (three being illustrated) are symmetrically disposed on each roll **61**, **63** and the punches of roll **61** are exactly aligned on opposite sides of web **10** with the punches of roll **63**. Such symmetry permits every other sheet section severed from web **10** to be alternated in stack **25** without upsetting the glue line registry achieved by superposing the notches **13** (FIGURE 9).

While side notches **13** are illustrated, it should be appreciated that hemispherical notches (as shown) or equivalent geometric notch shapes, e.g., triangular, are but a preferred embodiment of the present invention. Practice of the invention contemplates also such expedients as complete apertures (e.g.,, circles) punched out of the web **10** near the side marginal edges thereof and the term side apertures as used hereinafter and alternatively, the term cut-out is intended to include both open geometric shapes, e.g., notches **13** and closed geometric shapes, e.g., circles, squares, etc., adjacent the side marginal edges of the web.

From the notching unit **12**, web **10** then passes over idler roll **90**, loops around drive rolls **92** and **94** into off-set printing unit **14** whereon the transverse glue lines **15** are imprinted on one face of web **10** in parallel equally spaced apart relation, while the second set of glue lines **17** are similarly imprinted on the obverse face of web **10**. As can be seen from an exaggerated showing given in the cross-sectional view of FIGURE 4, glue lines **15** on one face of web **10** are exactly staggered relative to the glue lines **17** printed on the obverse face.

As best shown in FIGURES 1 and 4, printing unit **14** imprints through off-set techniques. A polished steel gravure cylinder **100** with spaced apart transversely disposed line engravings **102** on the surface thereof is mounted for partial submersion in adhesive or glue tank **104**. When rotated, steel gravure cylinder **100** will carry the liquid glue or adhesive up past doctor blade **106** (which wipes the glue from all but engraved portions of cylinder **100**) and transfer the glue from the engraved areas **102** to a rubber impression or back-up roll **108**. In turn, rubber roll **108** transfers the glue to web **10** forming thereon the equally spaced apart parallel transverse glue lines **15**. Similarly, for the obverse face of web **10**, gravure cylinder **110** with engraved line portions **112** picks up liquid glue or adhesive from adhesive tank **114**, is wiped by doctor blade **116**, then transfers glue lines from engraved line portions **112** to rubber impression or back-up roll

118 which in turn off-sets them as parallel transverse glue lines 17 on the obverse face of web 10. As has already been indicated, the transverse glue or adhesive lines 15 and 17 are equally spaced apart but are alternately staggered so that every other sheet section may be alternated and the ultimate laminated stack 25 (FIGURE 9) expanded into a hexagonal honeycomb.

As has already been indicated, the present invention provides an arrangement which insures that the successive side apertures in web 10 stay in a constant spacing relationship to glue lines 15 and 17. The gearing structure in FIGURE 2 illustrates the basic structure by which this constant relationship is maintained throughout the length of web 10. Die and punch rollers 62 and 64 are respectively rotated by a pair of gears 150 and 152 mounted on the same shaft as its roller (62, 64). These gears 150, 152 are driven by a gear 154 which advantageously is journalled on the same shaft as idler roll 90 (although gear 154 and idler roll 90 rotate in opposite directions). Powered gear 156 (mounted on the shaft on which driving roll 92 is mounted) and gear 158 serve to drive the notching roll gear train 150, 152, 154 and also the rollers in printing mechanism 14. Gear 158 (mounted on the same shaft as driving roll 94) also drives a gear 160 through which the gears 162 and 168 for the left side off-set roll 118 and gravure cylinder 110 are caused to rotate. Lastly, gear 162 drives gears 164 and 166 to rotate the right hand side off-set roll 108 and gravure cylinder 100. Advantageously, these gears are all of the same diameter, and the powered rolls (i.e., printing and punching rollers) are all of the same diameter. The direct interconnected drive of these various equal sized gears insures that the printing of glue lines 15, 17 on web 10 remains in a constant spacing relationship to the punching out of side apertures, i.e., notches 13.

Special efforts have been made, also, to avoid any slippage of the web 10 while passing through the notching and printing mechanism. The web is drawn through the rolls of notching unit 10 under tension by the action of driving rolls 92, 94. The rolls of notching unit 12 are intended solely to notch the web and do not assist in movement of web 10 through the notching mechanism. Similarly, the web is drawn through the printing mechanism 14 under a constant tension exerted by the weight of the dancer roll 170 (FIGURE 1), thereby avoiding stress on the rubber off-set rolls 108 and 118 and slippage of web 10 in passing through the printing mechanism 14.

The details of the gear and the roll mounting for the printing unit 14 is shown in FIGURE 3 where also is shown part of the arrangement for maintaining the various gears in tight engagement. Selected gears, e.g., gears 162 and 166, are split gears so that the gear halves may be radially displaced to make for a tighter engagement with each other and with their related gears 160, 168 and 164. Similarly, gear 152 and, if desired, other gears in the gear train, may be made of this same split gear or anti-backlash type. In addition to anti-backlash, provision has been made for minor adjustments in the timing relationship of the rolls by provision of (conventional) timing gears for the gears 152, 168 and 166. The timing gear structure (not shown) permits independent movement of the individual roll connected thereto, e.g., printing cylinder 110 or notching roller 64, as much as an eighth of a revolution.

In consequence, minor adjustments can be made in the position of notches 13 relative to the glue lines 15, 17, and/or alternatively of either glue line 15 or 17 to the other and to the notches while web 10 is threaded through the notching and printing mechanism. This adjustment is quite important at start-up since otherwise exactly registering glue lines 15 to the desired position equidistant of the glue lines 17 on the obverse face of web 10 would be virtually impossible. However, with the above described timing gears, the machine can be started, and after it has been determined how far off the desired exactly staggered relationship glue lines 15, 17 fall on web 10 (e.g., by optical examination or caliper measurement), a small adjustment in timing at gear 168 or 166 will shift the glue lines 15, 17 into proper spacing.

Other important adjustability features have been built into the printing mechanism 14, as for example to provide for the occasions when web 10 is being first threaded through the system, or for when there is need to run web 10 through the system without printing glue lines thereon or to print only one side of the web.

By way of introduction to these adjustability features, it should be pointed out that gravure cylinders 100 and 110 should not ever come to rest while adhesive or glue tanks 104 and 114 contain liquid adhesive therein. This is because the exposed adhesive present in engraved lines 102, 112 on the non-submerged or exposed portions of these cylinders tends to dry up thereby fouling the engraved areas of gravure cylinders 100 and 110. Subsequently, imperfect glue lines will become off-set on rubber roll 118 and 108 and in turn on web 10. Accordingly, special provision is made through the gearing relationship to drive cylinders 100 and 110 even when printing on web 10 is not desired. Cylinder 100 and rubber roll 108 can be separated from each other, and/or alternatively the two may be displaced as a paired unit from contact with web 10. The same can be done with cylinder 110 and rubber roll 118.

As illustrated in FIGURES 3 and 5, movement of cam arm 300 partly rotates an actuating arm 303 which in turn moves gravure cylinder 100 against rubber off-set roll 108. Similarly, cam arm 301 partially rotates cam 304 to move gravure cylinder 110 against rubber off-set roll 118. Movement of cam arm 302 partially rotates cam 305 which in turn serves to bring cylinder 100 and rubber roll 108 as a unit into and out of printing position.

The doctor blades 106 and 116 are made to oscillate by a standard gear arrangement, the same as is normally used in the printing industry, some of this structure being indicated on FIGURE 3 at 105 and 117.

Changes and modifications are contemplated within the spirit of the invention. One contemplated instance of such a change is placement of notching elements on the rubber off-set rollers so that web 10 is notched simultaneously with the printing. Another contemplated variation involves placement of the driving rolls (92, 94) ahead of or after the notching and printing mechanisms instead of between them.

What is claimed is:

1. A step product in the formation of structural honeycomb which comprises an elongated flat web of sheet material with cutout alignment means at spaced apart intervals and with transverse parallel equally spaced apart glue lines printed on at least one face of said web, the cut-outs and glue lines being in constant spacing relationship one to the other, each cut-out being a predetermined fixed distance from the glue lines closest thereto, whereby stacking successively cut sheets in the glue line alternation of a hexagonal honeycomb stack may be effected by superimposing successively cut sheet sections of the web with the cut-outs aligned.

2. An unexpanded structural honeycomb stack which comprises a multiplicity of approximately equal length flat web sections transversely cut from an elongated web of sheet material apertured at spaced apart intervals, and transverse parallel equally spaced apart glue lines printed on both faces of the web, the glue lines on one face being staggered relative to the glue lines on the other face, the transverse glue lines and apertures being in constant spacing relationship to each other, the web sections being superposed one upon the other into a stack with the apertures aligned throughout the stack and with the glue lines of each adjacent two sections in glue line to glue line contact, the stack thereby defining an expansible honeycomb structure.

3. The honeycomb structure formed by expansion of the product of claim 2.

References Cited

UNITED STATES PATENTS

2,815,795	12/1957	Vander Poel	156—197 X
2,983,640	5/1961	Knoll et al.	156—197
3,044,921	7/1962	Wentworth et al.	156—512 X

ROBERT F. BURNETT, Primary Examiner

WILLIAM A. POWELL, Assistant Examiner

U.S. Cl. X.R.

156—197, 252, 291, 510; 161—112, 148