United States Patent

Siegal

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[54] METHOD OF MAKING HONEYCOMB CORE

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[52] **U.S. Cl.** **156/197,** 156/260, 156/512

[51] **Int. Cl.** **B31d 3/02**

[58] **Field of Search** 156/197, 548

[56] **References Cited**

UNITED STATES PATENTS

2,649,131 8/1953 Lincoln ..... 156/548 X

3,114,666 12/1963 Johnson 156/197

3,242,024 3/1966 Bova et al. 156/197

Primary Examiner—Benjamin A. Borchelt

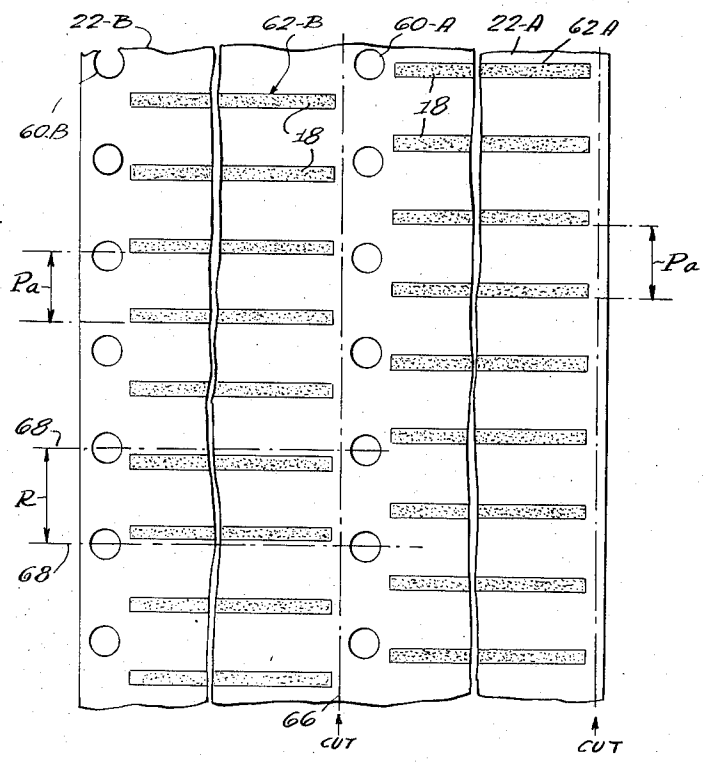
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[57] **ABSTRACT**

Two webs are imprinted with transverse lines of adhesive, the pattern on one web being staggered with respect to the pattern on the other web, so that if properly cut and stacked, there can be formed a lay-up which may eventually be expanded to produce honeycomb core.

15 Claims, 3 Drawing Figures



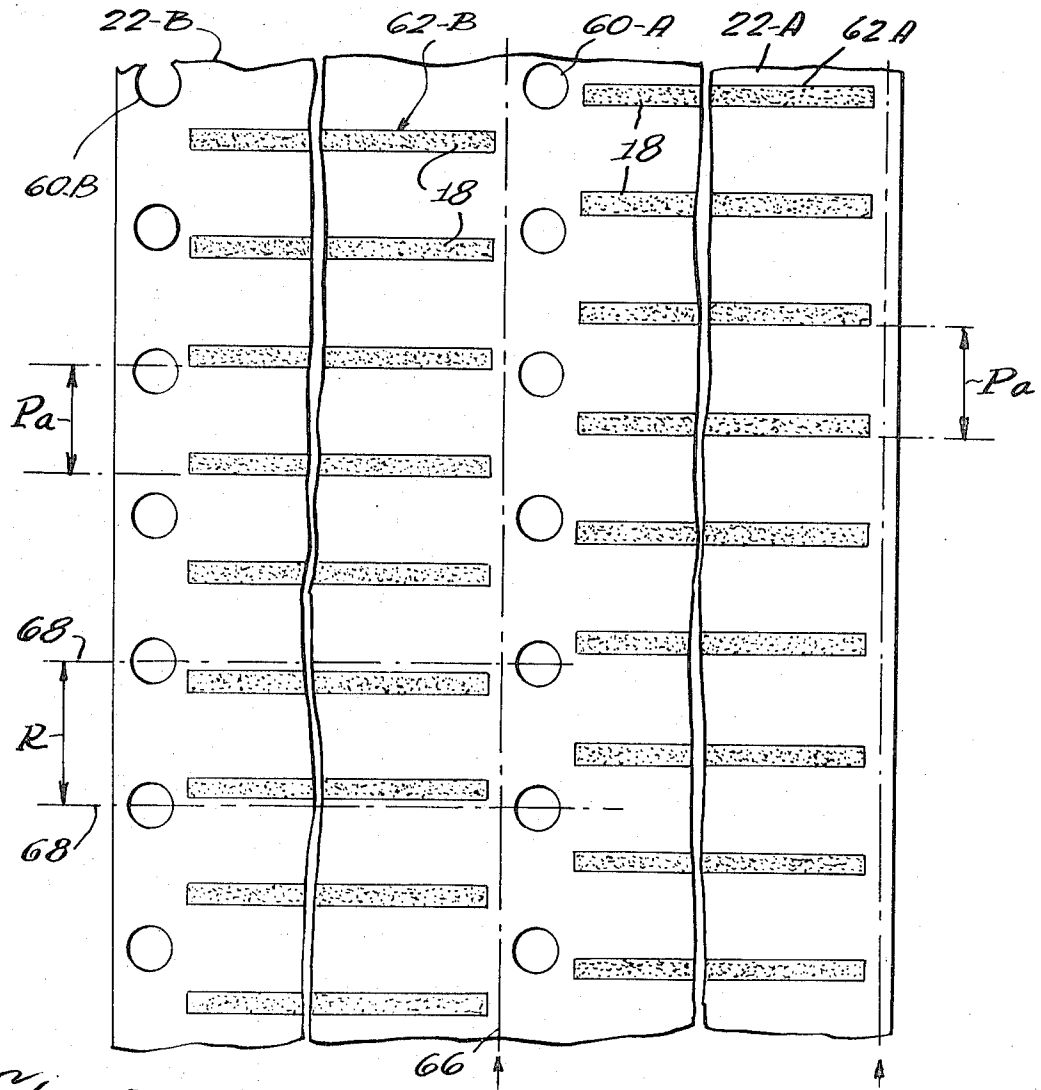


Fig. 3

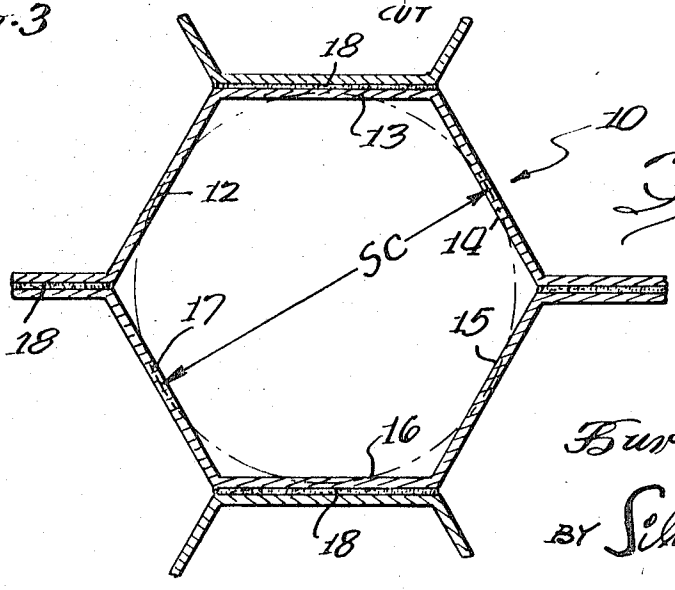


Fig. 1

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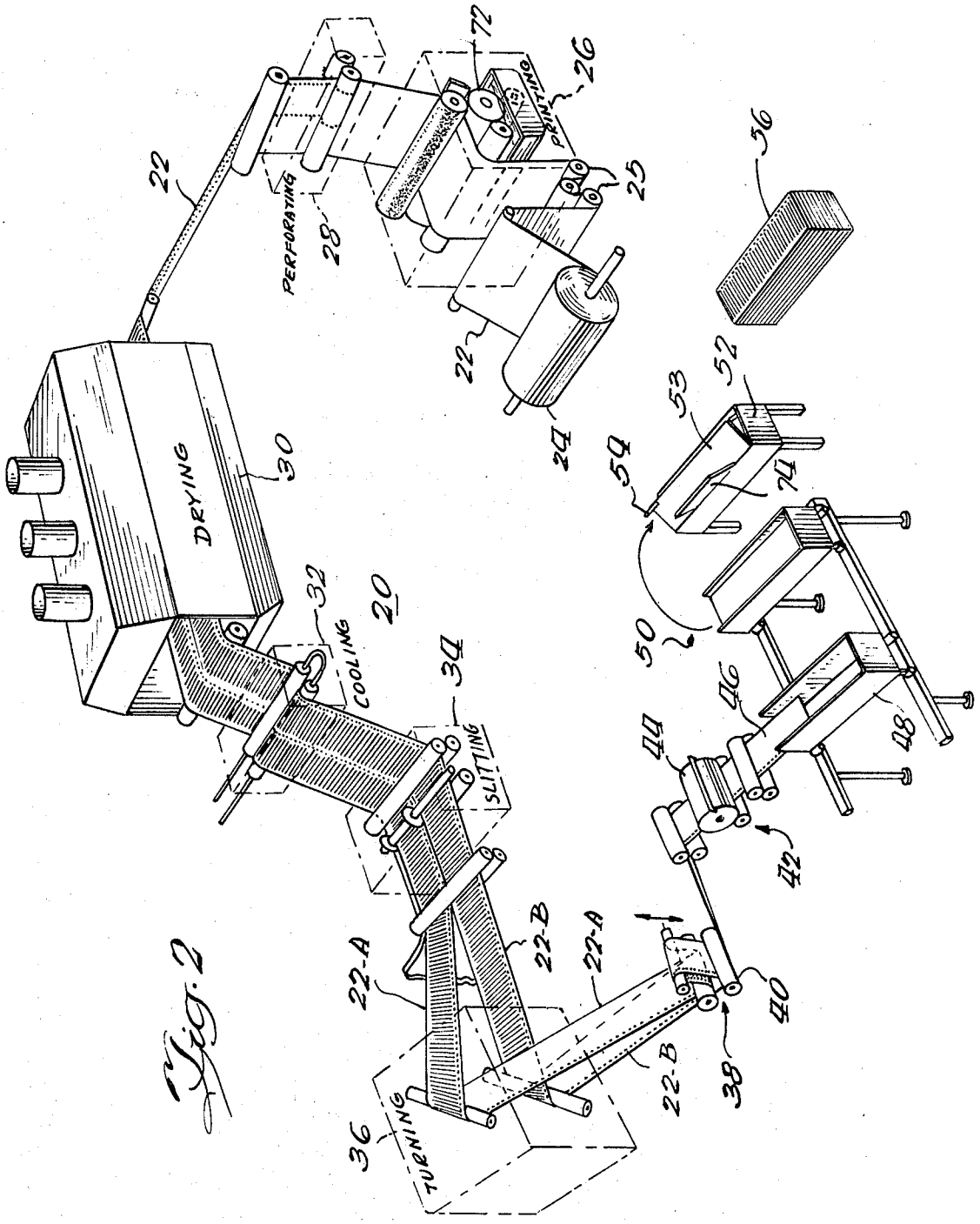


Fig. 2

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METHOD OF MAKING HONEYCOMB CORE

In addition to the printing, each web has identical perforations applied along one edge thereof, the perforations being applied in pairs, one on each web, while the web is passing a perforating station, for example, without staggering.

If each web has the same length cut therefrom, and the place of cutting is repeated for the next length, the perforations can be used to spindle the lengths and help stack them, providing a proper length is chosen which will produce a cutting point that is the same for each pair of lengths. This is accomplished by proper choice of length taking into consideration the pitches of the adhesive lines and the perforations. A length is chosen to be a whole number multiple of minimum distance at which the two pitches will be in phase. The pitch of the perforations need not be changed for different adhesive line pitches. Great flexibility is achieved by choosing the minimum common-in-phase distance to be a whole number, preferably less than ten inches.

A printing roll is constructed to be the same circumference for practically all of the pitches of adhesive lines which will be used, and the pitches are adjusted for the various sizes of honeycomb cells to give a number of lines on the roll which will provide the desired continuous pattern.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention herein relates to the printing of webs for making lay-ups of lengths of the webs stacked to provide the characteristic staggered node lines on alternate sides of each sheet so that when adhered and pulled apart, the usual six-sized cells will be formed.

The particular aspect of this art which is contemplated by the invention is concerned with transverse printing of the webs, where the problem of registration is more acute. The invention uses perforations as an aid in stacking, the sheets being imprinted with the adhesive lines in a peculiar relation to the perforations to give the advantages and benefits of the invention.

As will be explained, the invention is especially detailed in connection with a double width web passing through a suitable apparatus which imprints the lines and perforates, slits the web up the center and then laminates the two webs following which the webs are simultaneously cut in pairs and stacked. The stacking is accomplished by means of a spindling pin which engages one of the perforations of each sheet.

The invention is concerned with a method which teaches the application of the printed lines and perforations in a particular way to give rise to certain advantages which will be explained in the discussion concerning the prior art.

2. Description of the Prior Art and Departures Therefrom

The following patents disclose transverse printing: Lincoln U.S. Pat. No. 2,649,131; May U.S. Pat. No. 3,074,839; Knoll et al. U.S. Pat. No. 2,983,640; and Bova U.S. Pat. No. 3,242,024. Of these the Bova U.S. Pat. No. 3,242,024 discloses placing perforations along the edges of a web that is transversely printed on top and on bottom.

None of the disclosed methods is simple while being applied to high speed machinery, because the difficult problem is maintaining registration, uniformity, economy and efficiency. Most importantly, none of the methods is universally applicable to a machine which can produce honeycomb lay-ups using different cell sizes without requiring radical and substantial changes in the machine. According to the invention, the only change which need be made in the machine of the invention is to change the printing roll and adjust the sheeter for the different pitch size. lines will repeat at the

The invention makes possible cutting lengths of web of almost any desired size without concern about registration, so long as the length of web is according to a given factor which will be described hereinafter.

SUMMARY OF THE INVENTION

According to the invention, the double width web is imprinted with side by side patterns of transverse adhesive lines which are staggered with respect to one another along the length of the web, and each pattern is also provided with a row of perforations along one side edge thereof, the apparatus slitting the web into two single widths, and bringing these widths together in proper face-to-face engagement for enabling cutting into lengths and stacking. The pitch relationship of the adhesive lines and the perforations along the length are chosen to be such that a whole number of Lines will repeat at the same time that a whole number of perforations will occur, the repeat length where this occurs being a whole number, preferably much smaller than 10. Likewise, the circumference of the print roll is chosen so that a whole number of print lines of any of a large number of pitches may be provided thereon, this whole number being divisible by another whole number to give a substantially smaller whole number.

Thus, the length of web cut can be a multiple of the least common denominator of the pitches of the lines and perforations, and if properly chosen, this number can be quite small giving an almost unlimited choice of lengths.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a fragmentary sectional view through a piece of honeycomb core to show its construction;

FIG. **2** is a perspective diagrammatic view showing apparatus constructed using the method of the invention; and

FIG. **3** is a fragmentary top plan view of a double width web showing the application of printing lines and perforations thereto.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Prior to describing the preferred embodiment, some understanding should be had of the dimensional relationships involved in the art of honeycomb manufacture.

Honeycomb core material is formed of sheets of flexible web adhered face-to-face on staggered lines. In FIG. **1**, the piece of core **10** is shown formed of hexagonal cells. Each cell has the sides **12**, **13**, **14**, **15**, **16** and **17**. The sides **12**, **13**, and **14** are integral with an upper sheet which is corrugated during the pulling of the sheets apart, as well-known. The sides **15**, **16**, and **17** are integral with a lower sheet adhered to the upper sheet along node lines of adhesive at **18**. The core **10** is built up out of many cells of identical construction. The dimension across the cell is *Sc* or cell size, and in modern industry the sizes almost universally specified for *Sc* are ⅛ inch, 3/16 inch, ¼ inch, ⅜ inch and ½ inch. The theoretical pitch *P* (FIG. **3**) and theoretical node line width W for these cell sizes is computed on the basis of the formula:

$$P = 2.31\ Sc \qquad (1)$$

or, the pitch *P* of the node lines is equal to 2.31 times the nominal across-the-flats size of a given hexagonal cell of honeycomb. For the universally used sizes mentioned above, the following are the computed theoretical pitches and node line widths: (all dimensions in inches)

TABLE NO. 1

Cell Size Sc	Theoretical Pitch Pt	Theoretical Node Line Width Wt
1/8	0.288	0.072
3/16	0.433	0.108
1/4	0.577	0.144
3/8	0.866	0.216
1/2	1.155	0.289

Several factors modify these dimensions in the practical application of theory. The web material does not bend on a perfect 60° angle and hence it fillets; the adhesive spreads upon application of heat and/or pressure; the pitch must be a whole number to fit the circumference of the print roll and this may require some adjustment; the particular overall characteristics of the machinery and materials used may require variations to provide desired physical properties and appearance.

Accordingly, the following dimensions have been used to obtain practically acceptable results. In each case the width W of the node line is somewhat smaller than those of Table No. 1 above, and is a result of experiment, varying from material to material.

TABLE NO. 2

Cell Size Sc (in.)	Actual Pitch Pa (in.)
1/8	0.300
3/16	0.400
1/4	0.500
3/8	0.815
1/2	1.050

The choice of the actual pitch in each case was dictated by the desire to compromise between the theoretical and choosing a dimension which will give an even multiple on a printing roll of fairly easy manufacture. Obviously, the first three of Table No. 1 are not too difficult to provide on printing rolls with whole number circumferences, and the last two are applicable to printing rolls which are 22 or 44 inches in circumference.

As thus far described, the disclosure is within the skill of the artisan. Registration is obtainable for any given length of web by carefully choosing the point of cutting, and the prior art teaches this to be the identical point for each sheet or pair of sheets. The difficulty comes in finding the proper point and maintaining it in a high speed machine. Furthermore, even if the machine is capable of accurate cutting, it is suitable only for one size of cell. A change in cell size requires a complete change in the registration characteristics of the machine, introduction of new driving connections and synchronization, etc.

At this point, attention may be invited to FIG. **2** which shows in diagrammatic form a structure for practicing the invention.

The machine is designated generally by the reference character **20**. The double width web **22** is stripped off a roll **24** by in-feeding rolls **25** and passes through a printing station **26** and a perforating station **28**. The perforating station **28** may be before the printing station, depending upon the type of adhesive used and the type of web-driving equipment. Likewise, the roll **24** may be preperforated. The web **22** is then passed through a drying station **30**, a cooling station **32** and a slitting station **34** at which point it is divided into two half webs **22A** and **22B**. These are turned at **36** and after adjustment of one for registration at **38** are laminated together at the roll **40** and together pass into the sheeter **42**. The sheeter **42** cuts the sheets simultaneously by means of the rotary knife **44** whose speed is controlled by some variable speed drive (not shown) to provide pairs of cut sheets **46** of any desired length. The sheeter discharges the cut sheets at **46** into a bin **48** which, when filled, is rolled to the station **50** after which the sheets are removed and turned over onto a jogger **52**. The jogger **52** has a board **53** with a single spindling pin **54**, and the sheets are all spindled through the same perforation on this pin, and after jogging provide the stack **56** which is ready for further processing. There are alternative methods for receiving the sheets from the sheeter and forming the stack **56**.

The perforations are shown at **60A** and **60B** corresponding to the two half widths into which the web **22** will be cut. The two patterns of transverse adhesive lines **18** are best shown in FIG. **3**, and these are designated **62A** and **62B**. Note that the perforations are spaced to the left of the patterns and that each pattern and its line of perforations is disposed on opposite sides of the center or slitting line **66**. As previously mentioned, the perforations are located at identical places along the web length. Thus, the perforations are aligned as indicated by the lines **68**. The pitch of the perforations is the distance between perforation centers along the length of the web, and this is indicated as R. The same pitch R is maintained uniformly along the length of the web and is kept at the same value for all cell sizes which will be printed. Perforations will not necessarily occur alongside of individual adhesive lines **18**, but as will be seen, will repeat at some rate that can be synchronized with the rate of repetition of the adhesive node lines **18**, considering that both are passing a single point.

The pitch Pa of the printed adhesive node lines **18** is shown in FIG. **3**, being the same for both patterns **62A** and **62B**.

It was determined that a convenient circumference for the print roll **72** was a value that is divisible by the maximum number of whole integers. This was 24 inches, the circumference being divisible by 2, 3, 4, 6, 8, 12. Likewise, this number is divisible by the pitches that can be chosen quite closely to the theoretical for all of the commercial sizes of cells. Accordingly, for a 24-inch circumference print roll, the following pitch sizes were used to achieve substantially all of the commercial size honeycomb cells:

TABLE NO. 3

Cell Size Cs (in.)	Chosen Pitch Pc (in.)	Number of Node Lines in inches, Nn
1/8	0.300	80
3/16	0.400	60
1/4	0.500	48
3/8	0.800	30
1/2	1.000	24

It will be seen that the choice of perforation pitch R is a matter of finding a repeat grouping that will be in phase with the printed lines a desirable number of times per revolution. In the case of a pitch R of 1 inch, a maximum flexibility is achieved. In the case of a pitch R of 2 inches, a good result is obtained.

The length of the cut sheets **46** must be chosen as a multiple of the least number of node line pitch distances which corresponds to a whole number factor of the number of perforation pitch distances for the same circumferential length C as the printing cylinder. This may be expressed generally as follows:

$$L = M(X) \qquad (2)$$

where

L is the total length of the cut sheet,

M is any whole number multiple, chosen and maintained throughout any given run,

X is a distance which is a whole number factor of the circumference of the print cylinder and also,

$X = nPc = mR = C/u$ where n, m and u are whole numbers, Pc is the chosen pitch of node lines, and R is the perforation pitch.

Applying formula (2) to the information from Table No. 3, we can derive the following:

TABLE NO. 4

Assuming a print roll of 24 inches; $C = 24$

Cell Size Cs	Pc	R	$X=C/u$	u	n	m

1/8	0.300	1	3	8	10	3
3/16	0.400	1	2	12	5	2
1/4	0.500	1	1	24	2	1
3/8	0.800	1	4	6	5	4
1/2	1.000	1	1	24	1	1

From Table No. 4, it will be seen that for the chosen pitches *Pc* and a perforation pitch R of 1 inch and a 24-inch print roll, the sheet lengths can be any multiple of 3 inches, 2 inches, 1 inch, 4 inches and 1 inch for the respective cell sizes listed. A careful consideration of the factors involved will show that the cutting need not be done with respect to any specific line or perforation placement, so long as the total length is as defined in the formula (2). This is quite a simple application, and the operators of the apparatus need only be instructed as to the length or multiple for any given set of conditions.

With different perforation pitch, the values of X will change. Thus, with a perforation pitch of, say 2 inches, the values change as follows:

TABLE NO. 5

Assuming a print roll of 24 inches; $C=24$

Cell Size Cs	Pc	R	$X=C/u$	u	n	m
1/8	0.300	2	6	4	20	3
3/16	0.400	2	2	12	5	1
1/4	0.500	2	2	12	4	1
3/8	0.800	2	4	6	5	2
1/2	1.000	2	2	12	2	1

In making a lay-up, the operator of the apparatus is given the factor X and told to make the length of the cut sheets **46** in every case a multiple of this factor. If there is a nominal registration at the sheeter, say of the order of plus or minus ⅛ inch, the spindling of the sheets on the pin **54** and their jogging on the board **53** will provide the registration desired for proper stacking. It is understood that "registration" as used herein is intended to mean the stacking of the sheets on top of one another alternating from the A and B side so that the lines of adhesive will be staggered.

In stacking, it will be appreciated that the stacking or spindling pin **54** is at one end and at the top of the board **53**. Thus, the sheets will rotate by gravity during the jogging and will lay against the bottom guide **74**. Side drift of the web is taken care of by using two cutting knives in the slitting station **34**, one of which establishes a trimmed edge for purposes of assuring a minimum of variation in the width of the two webs **22A** and **22B**.

The advantages of printing two patterns side by side on the same web and perforating the web before slitting are, among others, the establishment of perfect relationships between perforations and lines, uniformity of the printing, and the great economy and efficiency of handling only one web with a minimum of waste until the web passes the slitting station **34**.

The invention's principles may be applied to other systems and methods in which two webs are printed and perforated separately and it is desired to stack the same. In such cases, the situation is identical from just before the laminating roll to the end of the process. The two half webs **22A** and **22B** are printed and perforated independently but having the print-line-to-perforation relationship which they would have if the entire web were printed and perforated. There is an important additional factor which must be taken account of. In such cases, the perforating must be done with the identical spaced relation along the length of the web with respect to both patterns, but of course, considering one pattern staggered with respect to the other.

In the case of the unitary double web, it is immaterial where the perforations occur with respect to the patterns, because they will always maintain the same relation to both patterns. This emphasizes another important benefit of printing and perforating the double web.

Spindling on any one or more of the perforations of the sheets, so long as the identical ones of each sheet are used, for achieving proper arrangement of sheets for stacking is an attribute of both methods. Multiple pin stacking eliminates the need for referencing on sheet edges.

It is also possible to print and perforate a single web with the printing on both sides, staggered with respect to one another, laminate the same with a blank web of a width to cover the transverse lines but not the edge perforations, and use the method of the invention to cut and stack. The system will operate the same, that is, so long as the distance X is based upon the formula (2) above, the length of the cut sheet will give registration irrespective of where the cutting is done with respect to the pattern. This obtains because the chosen factor X assures that the repeat pattern of perforations and printed lines will be in phase every time a cut is made.

Considerable variations are possible within the scope of the invention as defined in the appended claims.

What it is desired to secure by Letters Patent of the United States is:

1. In a method of making honeycomb core structure in a stack suitable for further processing by at least expanding the same and in which a pair of webs is laminated face-to-back, each web having a pattern of transversely printed adhesive node lines thereon, the pattern of one web being staggered along its length with respect to the other, and in which the laminated web is cut into a plurality of equal lengths that are stacked one upon the other to form a lay-up, the steps of:

A. printing the patterns of node lines side-by-side along the length of a double width web, on one face thereof, with the patterns staggered along the length of the web, each pattern occupying somewhat less than half of the web, respectively,

B. perforating the web along its length on two transversely spaced rows, one row being in a clear path between the side edge of one pattern and one edge of the double width web, the other being in a clear path between patterns, the perforation pitch of each row being equal along the row and each perforation of one row being transversely aligned with an identical perforation in the other row normally to the rows irrespective of the staggered arrangement of the patterns relative one another,

C. dividing the web along its center to provide a pair of half webs each having a pattern and a row of perforations,

D. bringing together the half webs with their perforations in register and without changing their lengthwise relative orientation substantially, to form a two-ply web prior to cutting, the cut length dimension being chosen as a multiple of a minimum dimension at which one pattern of adhesive lines has a whole number of node pitches and the row of perforations has a whole number of perforation pitches, both numbers being repetitive for each of said minimum dimension occurring.

2. The method as claimed in claim **1** in which the step of dividing is accomplished by slitting the web along two lines, each of which is spaced the same lateral distance from a row of perforations and in which the stacking is accomplished by spindling.

3. The method as claimed in claim **1** and the additional steps of cutting the two-ply web into double sheets of equal length and stacking the double sheets with the perforations in register and the ends of said sheets in vertical alignment.

4. The method as claimed in claim **3** in which the stacking is performed by spindling on at least one selected matched perforation of each sheet.

5. The method as claimed in claim **2** in which the stacking is accomplished by spindling on an end perforation of each sheet and using the side edge opposite the row of perforations as an alignment reference.

6. The method as claimed in claim **1** in which the node lines are applied by a printing cylinder of circumference C, in

which the node line pitch is Pc, and in which the perforation pitch is R and the relationship between these factors is defined by the formula

$$L = MX$$

where L is the length of the sheet and M is any whole number multiple and X is said minimum dimension and is a whole number factor of the circumference of the print roll and also satisfies the expression:

$$X = nPc = mR = C/u$$

where n, m, and u are whole numbers.

7. The method as claimed in claim **6** and the additional step of changing the cell size of the resultant honeycomb core structure solely by substituting for said printing cylinder, another printing cylinder having the same circumference but a different node line pitch.

8. The method of making honeycomb core structures of different cell sizes on the same machine in different runs with a minimum modification of the machine for each cell size, comprising the steps of:

A. printing, with a print roller of circumference C, a pattern of node lines of pitch Pc on the halves of a double width web;

B. staggering the node lines in one pattern relative to the other;

C. applying perforations of pitch R along an edge of each pattern in identical transverse location along the length of the web;

D. slitting the double web in half after printing and applying the perforations;

E. registering the two half webs in face to back engagement with the perforations of one half registered with those of the other half;

F. cutting simultaneously the engaged half webs in equal lengths L of any multiple M of a whole number X;

G. said steps of printing, applying perforations, and cutting in combination determining the dimensional requirements of

$$X = nPc = mR = C/u$$

where n, m, and u are whole numbers and;

H. changing only the print roller pitch Pc to a different value for said printing step for each respective cell size.

9. In a method of making honeycomb core structure in a stack suitable for further processing by at least expanding the same and in which a pair of webs is laminated face-to-back, each web having a pattern of transversely printed adhesive node lines thereon, the pattern of one web being staggered along its length with respect to the other, and in which the laminated web is cut into a plurality of equal lengths that are stacked one upon the other to form a lay-up, the steps of:

A. printing node lines and perforating each web in accordance with the following arrangements:

1. perforating both webs along the same edge thereof at an equal pitch in rows of perforations equally spaced from said respective edges, and extending along the lengths of said webs,

2. printing a pattern of node lines on each web in the same imperforate area, identically spaced from the respective rows, of identical node pitch, but with one pattern displaced from the other by half a node pitch, relative to the identical transverse alignment of perforations,

B. bringing the webs together alternately in face-to-back engagement with their perforations registered to form a two-ply web prior to cutting, and

C. cutting the two-ply web at a length chosen as a multiple of a minimum dimension at which one pattern of adhesive lines has a whole number of node pitches and the row of perforations alongside said pattern has a whole number of perforation pitches, both numbers being repetitive for each of said minimum dimension occurring.

10. The method as claimed in claim **9** in which the printing is done before the perforating.

11. The method as claimed in claim **9** in which the two webs comprise halves of a double web and the printing and perforating are performed on said double web, and which includes the further step of slitting said double web along its center to form the said two webs prior to bringing them together.

12. The method as claimed in claim **9** in which the node lines are applied by a printing cylinder of circumference C, in which the node line pitch is Pc, and in which the perforation pitch is R and the relationship between these factors is defined by the formula

$$L = MX$$

where L is the length of the sheet and M is any whole number multiple and X is said minimum dimension and is a whole number factor of the circumference of the print roll and also satisfies the expression: $X = nPc = mR = C/u$

where n, m, and u are whole numbers.

13. The method as claimed in claim **10** in which the node lines are applied by a printing cylinder of circumference C, in which the node line pitch is Pc, and in which the perforation pitch is R and the relationship between these factors is defined by the formula

$$L = MX$$

where L is the length of the sheet and M is any whole number multiple and X is said minimum dimension and is a whole number factor of the circumference of the print roll and also satisfies the expression:

$$X = nPc = mR = C/u$$

where n, m, and u are whole numbers.

14. The method as claimed in claim **10** in which the two webs comprise halves of a double web and the printing and perforating are performed on said double web, and which includes the further step of slitting said double web along its center to form the said two webs prior to bringing them together.

15. The method as claimed in claim **14** in which the node lines are applied by a printing cylinder of circumference C, in which the node line pitch is Pc, and in which the perforation pitch is R and the relationship between these factors is defined by the formula

$$L = MX$$

where L is the length of the sheet and M is any whole number multiple and X is said minimum dimension and is a whole number factor of the circumference of the print roll and also satisfies the expression:

$$X = nPc = mR = C/u$$

where n, m, and u are whole numbers.

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