Jan. 19, 1965 D. D. WHITE ETAL 3,166,456

STRUCTURAL HONEYCOMB MATERIALS

Filed March 14, 1962

Fig.1.

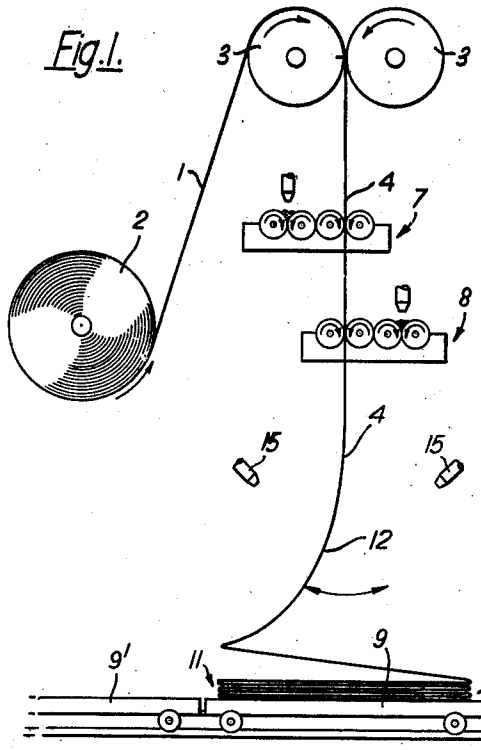


Fig.3.

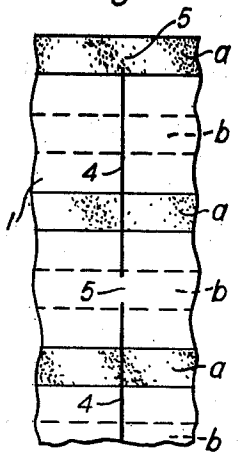
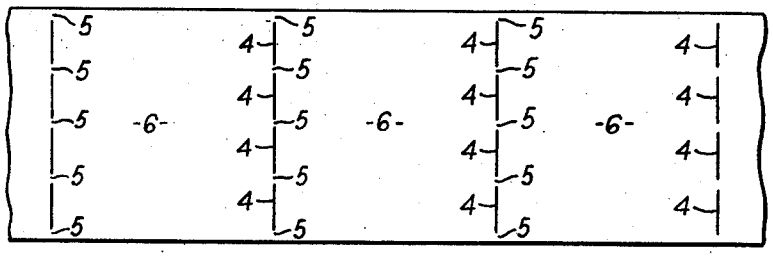


Fig.2.



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United States Patent Office 3,166,456 Patented Jan. 19, 1965

3,166,456

STRUCTURAL HONEYCOMB MATERIALS

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Filed Mar. 14, 1962, Ser. No. 179,703
Claims priority, application Great Britain Mar. 22, 1961, 10,441/61
3 Claims. (Cl. 156—197)

The present invention relates to the production of structural honeycomb material of the expandable type from bibulous sheet material, for example paper, using a wet adhesive. In its expanded form the material is widely used as the core of sandwich structures on account of its high strength to weight ratio and favorable cost.

Basically the production of the material for expansion involves securing together layers of sheet material in face to face contact by parallel bands of the adhesive positioned such that the bands at one face of any layer are staggered with reference to the bands at the other face thereof.

Various methods of bringing the layers and the adhesive automatically into the required relationship have been proposed but all have exhibited disadvantages. Except for production of inferior quality, arrangements must, in practice, be made for giving accurate registration of the wet adhesive between the layers on first contact thereof and preventing subsequent movement of the layers while the adhesive is wet. Such arrangements have hitherto involved the provision of machinery which has been wasteful in operation or whose rate of output has been disappointing in relation to capital cost, space occupied or maintenance requirements.

One type of method which has been proposed involves folding a continuous web of the sheet material bearing the wet adhesive in such a manner as to produce a stack in which the layers are formed by folding the material backwards and forwards and it is with this type of method that the present invention is concerned. To provide apparatus for merely folding material backwards and forwards is a simple matter but major difficulties arise from the need to accomplish accurate folding in the presence of the wet adhesive. Once a pair of layers has been brought together with the adhesive between them relative movement must be prevented, otherwise the outline of the adhesive is lost and the quality of the product spoiled. Thus the first contact of one layer with the next must be made accurately in the finally required position, no subsequent correction being possible. The folding mechanisms which have been proposed to ensure satisfactory results have been elaborate in nature and low in output or inflexible or wasteful in operation. A high folding speed has been obtainable only by giving the layers such small dimensions between folds as to enable the material to be produced only in or near its finally required thickness, taken in the axial direction of the cells, and so has not enabled the rate of production to be effectively multiplied by subsequently forming the stack into a large number of slices. Because of its multiplying effect, its dimensional accuracy, the ease with which the thickness can be varied as well as the low trimming waste per volume of product, slicing is always attractive. Moreover, the apparatus is suitable for serious commercial use, only with adhesives which can be dried before the layers are contacted together and subsequently activated in a final step of the process. The wet adhesives with which the invention is concerned are preferred in the art and adopted where possible in spite of their difficulties.

Modern mechanized methods of forming a stack for slicing by piling up pre-cut sheets with wet adhesive appropriately positioned can in practice be made to operate

at about 20 sheets per minute. Taking the number of slices as about 40, which is typical, it will be seen that the folding rate required to produce the same product directly in the required thickness and at the same speed would be as high as 800 folds per minute.

One form of the folding method which has been proposed involves feeding a web of paper printed with glue lines on both sides vertically downwardly towards a support and folding the material upon the support by the action of arms or other mechanical members operating from the opposite ends of the support in turn, the feeding and folding steps being carried out at such relative speeds that there is always a sufficient length of suspended material to permit its being folded without appreciable drag thereon. The speed of this method depends upon the speed of the mechanical members which has to be limited in order to avoid tearing the suspended material. Moreover, the folds obtained tend to be bulky rather than sharp with the result that pronounced bulges build up at the ends of the block and considerable trimming waste is incurred.

In accordance with the present invention there is provided a method for the production of structural honeycomb material which comprises applying wet bands of adhesive to both faces of a web of bibulous sheet material in positions such that the bands applied to one face are staggered with reference to the bands applied to the other face, feeding the web downwardly towards a support and folding it backwards and forwards upon the support so that it is accumulated upon the support in the form of a stack of layers which are adhered together by the wet bands and are interconnected at their ends, characterized in that the web is formed at equidistant intervals along its length and thereby divided into discrete sheet sections, with hinge formations, conveniently sets of colinear transverse slits which leave the sheets joined together by intervening sections of intact material, and is fed dodwnwardly to the support at a rate of feed such that it swings freely backwards and forwards under the reaction of the support and is accumulated in the form of a stack of layers in which each layer is constituted by one of said sheets and the sheets are joined together by folds at the position of the hinge formations.

By the foregoing method the folding of the web is obtained, without mechanical interference therewith, in a rapid and satisfactory manner. Even though the bands of adhesive are wet during the descent and folding of the web, accurate registration of the bands in the folded material is obtained.

Under the free swinging conditions each sheet is guided accurately into position as it descends by its hinged attachment to the preceding and succeding sheets. There are no impulsive disturbances producing shock waves or other sources of distortion. The movement of the sheet material during the descent closely resembles a wave motion with no significant folding at the hinge formations until the particular sheets which they define are being laid on the support. Obviously the form of this motion is rendered complex by air-damping and by the discontinuities introduced by the hinge formations where the sheets are attached one to the other. As a rough guide it may be noted that the maximum rate of free swing approximates to the rate of a simple pendulum whose length equals the distance of free descent. The system would be too complex, even in the absence or air-damping, for any precise relationships to be formulated but the required motion is readily achieved by adjusting the rate of feed of the web and/or the distance of its descent to the support.

The rate of output depends upon the frequency of free swinging, and for convenient dimensioning of the layers a speed of 30 layers per minute is typical.

Because the folding of the web is produced without the aid of mechanical components acting intermittently the apparatus required is simple and the method is attractively economical for this reason alone. In addition the method permits a procedure which has never been applicable heretofore. Thus the support may be mounted for horizontal movement in the direction of the length of the accumulated sheets so that, on such movement, the material accumulates in a fresh stack by the side of the first which may be removed without interrupting the feeding of the web. This is especially advantageous when the stacks are required to have only a small number of layers, as in the manufacture of honeycomb of large cell size for packaging purposes. Additionally the operator is enabled to withdraw the accumulated material for consolidation under pressure at frequent intervals and without interrupting the process, thereby increasing the quality of the product by minimizing the time between laying the wet adhesive and consolidation.

The following description in which reference is made to the accompanying drawing is given by way of illustration.

In the drawing:

FIG. 1 is a diagrammatic side elevation of an apparatus used in the method of the invention,

FIG. 2 shows the arrangement of the slits in the web, and

FIG. 3 shows a portion of the slit web after the application of adhesive thereto.

A web **1** of paper, e.g. kraft paper or the thin cardboard known as chipboard, is drawn from a supply roll **2** to pass between a pair of slitting rollers **3** which operate to provide hinge formations in the sets of colinear transverse slits **4** dimensioned to leave narrow intact hinge portions **5** of the web material therebetween. After such slitting the web may be regarded as a series of sheets **6** interconnected by the hinge portions **5**.

The web passes downwardly through printing heads **7** and **8** to be printed with parallel longitudinally extending bands *a* and *b* of wet adhesive, the bands *a* printed on one side lying between the bands *b* printed on the other side. It is preferably arranged, as shown in FIG. 3, that the hinge portions **5** lie on some of the adhesive bands while other adhesive bands pass through the slits.

The web leaving the lower printing head **8** descends to a horizontal support **9** and accumulates thereon in a stack of layers which are joined at their ends **10** and **11** by the hinge portions **5**. During accumulation of the stack the suspended material **12** swings backwards and forwards in the direction shown by the arrows, the rate of feed of the web being adjusted so that the swinging takes place at the natural frequency which is governed by the vertical distance from the lower printing head **8** to the support **9**.

The support **9** is mounted on rails **13** and after a chosen number of layers has accumulated, the support is moved rapidly by air cylinder **14**, without interrupting the feeding of the web, to bring a second support **9'** into position below the printing heads for the reception of further layers. The material on support **9** is removed and consolidated under pressure for conventional slicing in the guillotine.

Intermittently acting air nozzles **15** are provided to initiate the swinging of the web on starting the apparatus, but are not essential.

The method described herein is especially advantageous over methods involving the use of a rotary former when applied to manufacture from chipboard or other material whose thickness causes the waste, characteristic of such methods, to become substantial. The trimming loss involved in squaring the end of the stack is trivial.

It will be understood that the foregoing description of one example of the method, given with reference to the drawing, is provided for purposes of illustration only.

We claim:

1. A method for producing structural honeycomb material consisting in forming rows of colinear spaced apart slits transversely of a flat web of bibulous sheet material, spacing said rows of slits at equal intervals along the length of said web dividing said web into sheet sections, spacing the slits in each of said rows thereof providing hinge sections of intact material between each pair of said slits joining adjacent sheet sections, applying wet bands of adhesive to both faces of said web at positions thereon such that the bands applied to one face are staggered with reference to the bands applied to the other face of said web, feeding said web of bibulous sheet material in a downward direction onto a receiving support, accumulating said web on said receiving support in stacks of superimposed layers in which each layer is constituted by one of said sheets and which layers are joined together by their hinge sections folded under the reaction of each sheet section reaching the material therebeneath on said receiving support, bonding said layers together in their stacked condition by said adhesive and slicing said bonded stacked layers into expandable sections.

2. A method for producing structural honeycomb material as claimed in claim 1 including controlling the rate of speed at which said web travels during its downward feeding imparting a free lateral swing to said web folding said hinge sections as they reach the end of each swing of said web.

3 A method for producing structural honeycomb material as claimed in claim 1 in which said sheet material is chipboard.

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