Oct. 14, 1947. G. MAY 2,428,979

STRUCTURAL ELEMENT MADE FROM PAPER AND LIKE SHEETS

Filed Oct. 15, 1945 4 Sheets-Sheet 1

Fig. 1.

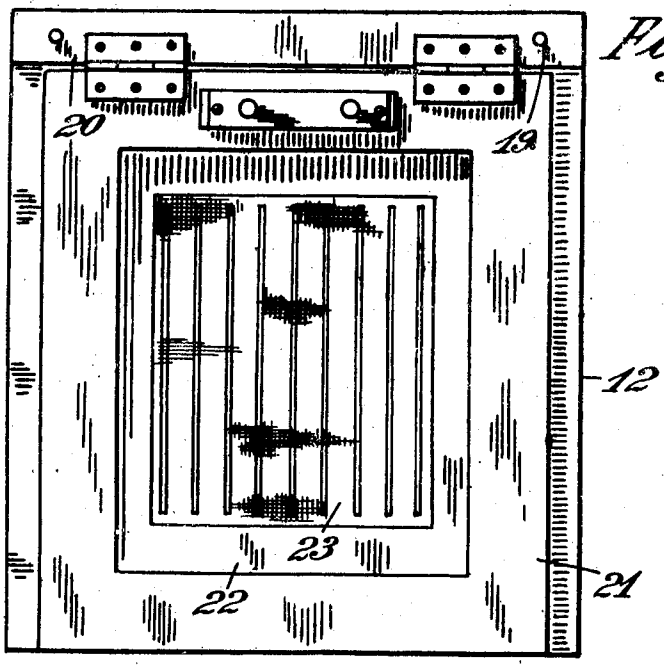

Fig. 2.

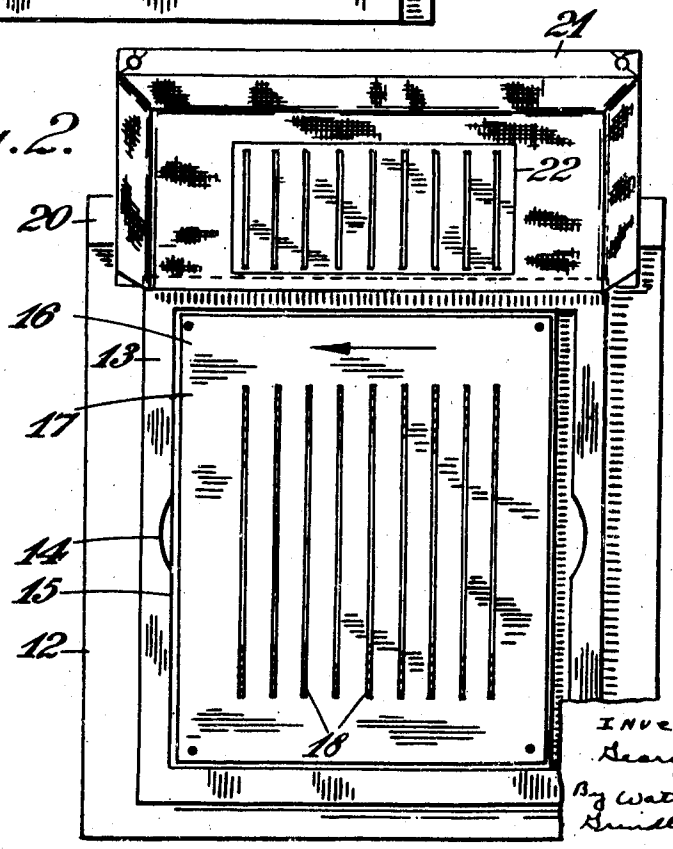

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Fig. 3.

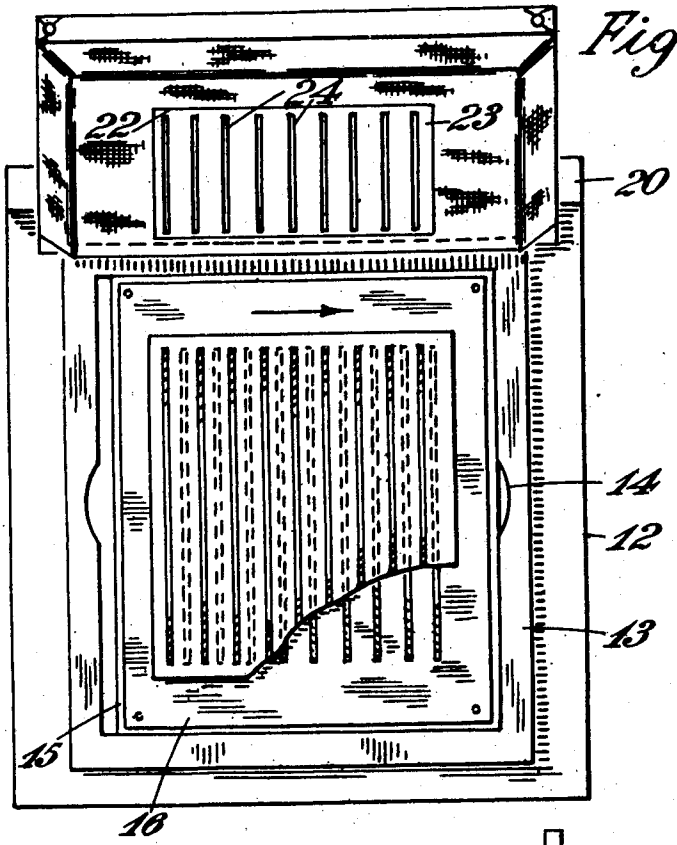

Fig. 4.

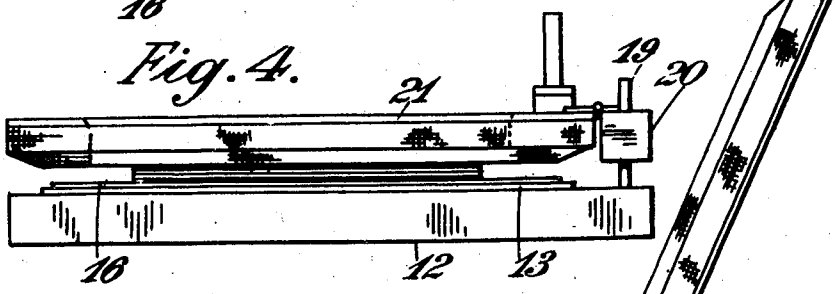

Fig. 5.

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Fig. 6.

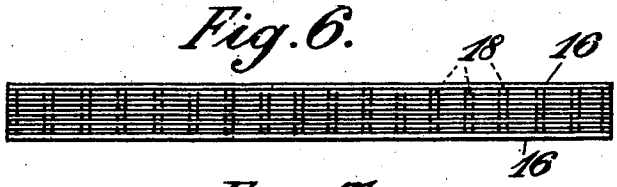

Fig. 7.

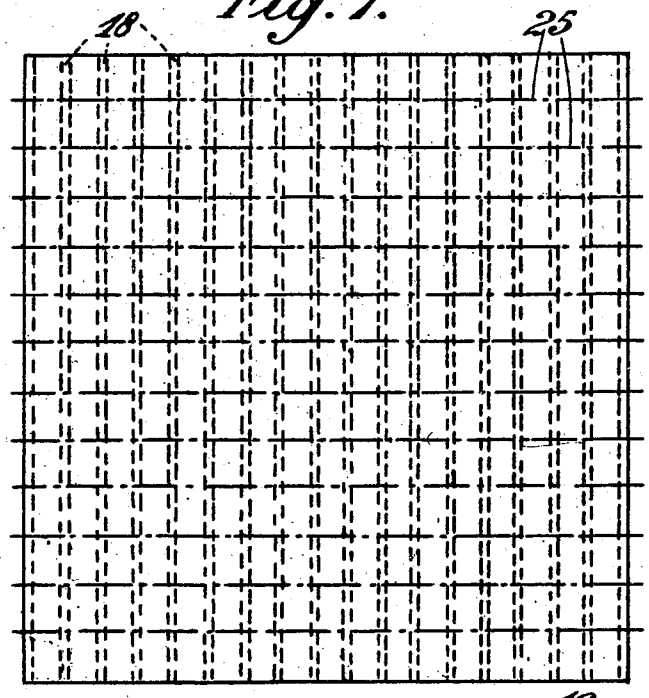

Fig. 8.

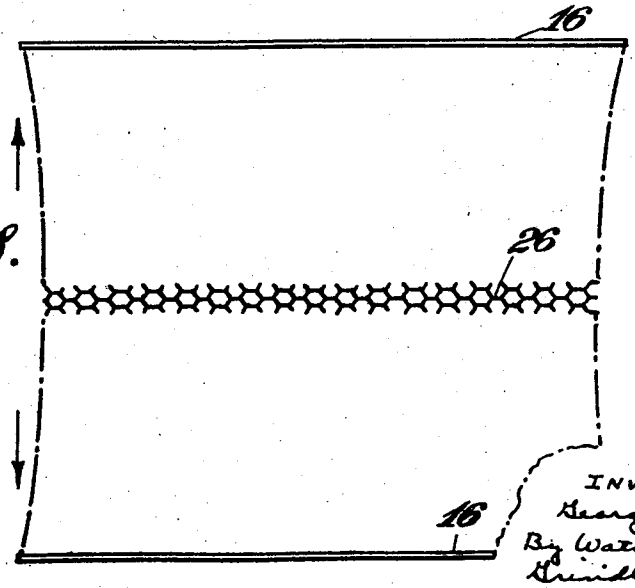

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Fig. 9.

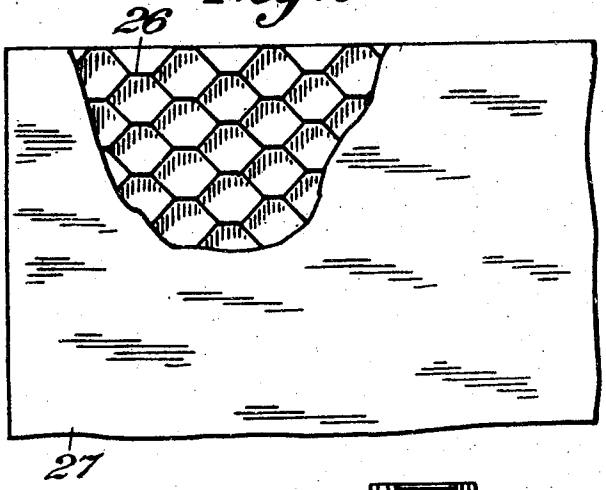


Fig. 10.

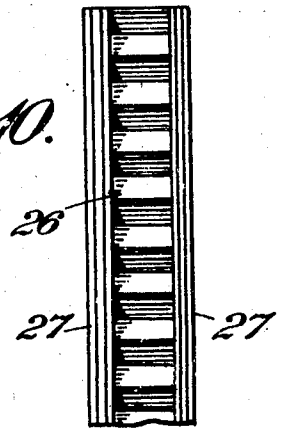
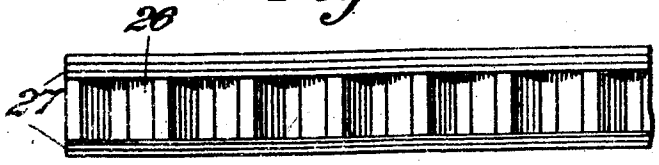


Fig. 11.



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Patented Oct. 14, 1947 2,428,979

UNITED STATES PATENT OFFICE

2,428,979

STRUCTURAL ELEMENT MADE FROM PAPER AND LIKE SHEETS

George May, Wembley, England, assignor to Dufay-Chromex Limited, London, England, a British company

Application October 15, 1945, Serial No. 622,454
In Great Britain May 25, 1944

10 Claims. (Cl. 154—122)

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This invention consists of improvements in structural elements made from paper and like sheets and includes a method of building up such elements and for producing double-skin structures with intermediate spacing. The elements may be flat or curved panels or may have double curvature or stream-line form, and may form doors, walls, partitions or parts or fittings for aircraft such as stream-line tanks or nacelles.

Many proposals have been made for fabricated structural elements having external sheets of plywood, veneer, cardboard or the like separated by stringers or fillings taking a wide variety of forms. The present invention relates to the same general type of structural elements. The objects of this invention are to provide economic methods of making effective structural elements particularly those of stream-line form.

According to this invention a method of making a cellular filling for a double-skin structural element includes the steps of applying to a sheet of paper (or to a film of cellulose ester or like plastic) lines (or rows of dots) of adhesive e. g. glue, by the use of a stencil, superimposing a number of such sheets with the adhesive lines alternately staggered, cutting the pile of sheets at right-angles to said adhesive lines into piles of the width desired for the thickness of said cellular filling and opening out the not-adhering walls to form a honeycomb or lattice.

The preferred method of applying the lines of adhesive is that known as the silk screen process in which a flat screen of silk associated with a stencil is hinged along one edge so that the screen and stencil may be raised for the insertion of a sheet of paper after which the screen is lowered on to the paper and the adhesive is applied to the paper through the interstices of the stencil and through the silk by the use of a squeegee.

Instead of using a separate stencil in association with the silk screen, the silk screen itself may be painted or otherwise coated with a resist such as a varnish which prevents glue from passing through the screen and a series of parallel lines on the screen are left without resist to allow the glue to pass through.

Preferably in using the silk screen process the successive sheets are not removed from the silk screen apparatus but are left to accumulate in a pile in the apparatus. This involves two mechanical provisions: (*a*) the base of the silk screen apparatus is provided with a shallow rectangular upstanding frame within which can slide laterally a board which supports the sheets and the lateral stroke of the board is equal to half

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the pitch of the parallel lines so that after a first sheet has received its parallel lines of adhesive and a second sheet is laid thereon, the board is shifted laterally before the second sheet receives its set of parallel lines of adhesive while after the third sheet is laid on the second and the board is again shifted laterally back to the first position, the third sheet receives lines of adhesive which are in register with those on the first sheet and so on; (*b*) in order that the silk screen apparatus may accommodate the growing pile of sheets, the screen frame is not hinged directly to the base but is hinged on a transom which is movable vertically on pins or like guides. The bottom and top sheets may be of cardboard to assist in keeping the pile of sheets solid and readily handled in the subsequent guillotine operation.

In another method of using the silk screen device where paper sheets of a uniform size and shape are used, there may be two hinged screens and stencils (for treating alternate sheets) so that the staggering of the adhesive lines in alternate sheets of a pile can be most economically effected. An alternative economic method is to dispose the lines so that the outermost line at one side is closer to the edge than the outermost line at the other side (closer by one-quarter the distance separating adjacent lines) so that when every second sheet is turned in its own plane through 180°, the staggering of the adhesive lines will be automatically produced. Where it is desired that the walls of the honeycomb shall be pyramidal, the lines of adhesive applied through the stencil may be in short sections and may be inclined to one another.

The setting of the adhesive may be hastened by well-known means (e. g. heat and/or pressure). The cutting of the assembled pile of adhering sheets into narrow widths can be done before or after opening out the sheets to the honeycomb or lattice form but preferably before opening out. The expansion may be assisted by the use of air currents. The filling (i. e. the expanded honeycomb or lattice) may be strengthened by dipping in a solution or suspension of an artificial resin or a solution of a cellulose ester plastic or other suitable setting plastic in liquid form.

The lattice or honeycomb when opened out may be metallised, i. e. may be coated by dipping, spraying or like operation with a varnish containing a very finely divided metallic powder (such as very finely divided aluminium) blended with cellulose acetate solution or a synthetic

resin or plastomer. The result of this is to render the lattice or honeycomb proof against moisture and water vapour. It also tends to give the lattice or honeycomb a permanent set in its open position.

An alternative method of applying the lines of adhesive to the sheets of paper or the like is by a printing machine such as a Wharfedale printing machine or a platen printing machine and in order that contiguous sheets may have the adhesive lines staggered, the sheet delivery of the printing machine or the sheet feed of the printing machine may be so arranged as to provide for this alternate staggering of the printed lines of adhesive on successive sheets.

To build up a structural element, the filling above described is secured on both sides by adhesive to boards such as plywood, fibre board or plastic wood sheets or to sheets of paper or the like which sheets lie in contact with the edges of the open honeycomb or lattice. In a streamline strucutral element the inner surface may first be built up on a mandrel or mould of appropriate shape say by sticking two layers or three layers of paper together over said mandrel.

Preferably the first sheet to be applied to the mandrel or mould is built up from laminations of paper or of thin fabric or of both. The paper or fabric may be of odd lengths and pieces or may be cut up into comparatively small squares and each piece is laid in position and secured by an adhesive. If desired a chemical setting adhesive can be employed, for example a mixture of a urea formaldehyde glue with a hardening agent or of casein and a paste made from starch. In building up this layer the pieces will overlap and may be rubbed down. The layer as a whole may on an average comprise two or three laminations. Then the filling (in pieces of suitable size) is applied and secured by adhesive to the inner skin thus formed, the walls of the filling being of course at right-angles to the inner skin at each point. Then the outer skin is again built up over the filling in the same way as the inner skin was built up.

In stream-line nacelles for certain electrical devices it is important to have a double-skin casing and it is also important that the spacing between the skins should be uniform. The above arrangement ensures such result.

The nature of this invention and of subsidiary features thereof and the manner in which the same is performed, will be appreciated from the following description of an example, reference being made to the accompanying drawings in which:

Figure 1 is a plan of the silk screen apparatus ready for squeegeeing the first lines of glue,

Figure 2 is a similar plan with the lid open, and with one set of lines of glue applied to a bottom sheet of cardboard or paper board.

Figure 3 is a plan similar to Figure 2 showing the lines of adhesive which have been applied to the first sheet of paper laid in register with the cardboard,

Figure 4 is a similar side view with the lid lowered but indicating the gradual raising of the transom and of the lid hinged thereto.

Figure 5 is a side view of the apparatus with the lid raised, and

Figure 6 is a side view of a complete "book" or pile of paper sheets,

Figure 7 is a plan corresponding with Figure 6 and showing in transverse chain lines the position of the guillotine cuts,

Figure 8 is a plan view of a cellular filling opened out,

Figure 9 is a plan view partly broken away, and

Figure 10 is a side end view, and

Figure 11 a bottom end view of a structural element in which the cellular filling is covered on each side with plywood.

The base 12 of the silk screen apparatus has a rectangular upstanding frame 13 about a quarter of an inch high with finger recesses 14 on its inner lateral faces. A board 15 of the same thickness as the height of the frame 13 is capable of lateral movement in the frame 13 but by an amount equal to half the pitch of the lines of adhesive (the other edges being a sliding fit in the frame 13) and the first operation is to attach by tacks 16 to the board 15 a sheet of cardboard 17 which receives the first set of lines of adhesive 18. The base 12 at the back has upstanding pins 19 on which can slide vertically a transom 20 to which is hinged the lid 21 carrying the screen say of fabric 22 painted or coated with the impervious varnish or resist 23 leaving the parallel pervious lines 24 extending from front to back of the screen, the lines having the same length as the sheet to be treated. It will be appreciated that if a set of lines is applied by squeegee to the sheet of cardboard 17 as indicated in Figure 2 and if a sheet of paper is laid on the cardboard, and if the board 15 is then shifted laterally from the position shown in Figure 2 to the position shown in Figure 3 and then another set of lines is applied by squeegee on to said paper as indicated in Figure 3, the second set of lines will be staggered in relation to the first and so on. After an appropriate number of sheets (say 200) have been treated and piled up in this way a sheet of cardboard is laid on the top and pressed down so as to adhere to the top sheet with the adhesive lines on said sheet and the result is a book or pile as shown in Figure 6. This book or pile is cut in a guillotine along the chain lines 25 at right-angles to the lines of adhesive 18, and each slice can be opened out as indicated in Figure 8 to form a filling having a honeycomb or lattice structure as indicated at 26.

In Figures 9, 10 and 11 plywood boards 27 are shown stuck to each side of the filling. In making an article such as a board or panel or door, the peripheral spaces between the plywood sheets may be cleared away for a short depth and filled up with a setting filler such as plastic wood. This filler may be of thermoplastic material and may be applied manually by a little trowel or equivalent. In place of plywood, glass fibre cloth may be used. As explained above, the filler may be treated with a metallised varnish to render it proof against moisture or water vapour.

I claim:

1. A method of making a cellular filling for a double-skin structural element which includes the steps of applying to a cellulosic sheet lines of adhesive, superimposing a number of such sheets into a stack with the adhesive lines alternately staggered, cutting the stack of sheets at right-angles to said adhesive lines into slices of the width desired for the thickness of said cellular filling and opening out the non-adhering walls to form a lattice.

2. A method of making a cellular filling for a double-skin structural element which includes the steps of stencilling on to a cellulosic sheet

lines of adhesive, superimposing a number of such sheets into a stack with the adhesive lines alternately staggered, cutting the stack of sheets at right-angles to said adhesive lines into slices of the width desired for the thickness of said cellular filling and opening out the non-adhering walls to form a lattice.

3. A method of making a cellular filling for a double-skin structural element which includes the steps of stencilling on to a cellulosic sheet parallel lines of adhesive, superimposing a number of such sheets into a stack with the adhesive lines alternately staggered, cutting the stack of sheets at right-angles to said adhesive lines into slices of the width desired for the thickness of said cellular filling and opening out the non-adhering walls to form a lattice.

4. A method of making a cellular filling as claimed in claim 1 in which the adhesive lines are applied by the silk screen process.

5. A method of making a cellular filling as claimed in claim 1 in which the adhesive lines are applied by printing.

6. A method of making a cellular filling for a double-skin structural element which includes the steps of applying to a sheet of paper by the silk screen process a number of parallel lines of adhesive, then applying to a second sheet of paper parallel lines of adhesive uniformly staggered in relation to the lines of the first sheet, treating a third sheet in the same way as the first sheet, superimposing a large number of such sheets into a stack with the adhesive lines alternately staggered so that the contiguous sheets cohere along the adhesive lines, cutting the stack of sheets at right-angles to said adhesive lines into slices of the width desired for the thickness of said cellular filling and opening out the non-adhering walls to form a lattice.

7. A method as claimed in claim 6 in which the lattice when opened out is coated with a varnish containing a very finely-divided metallic powder blended with an artificial resin so that the finished cellular filling has a thin metallised coating.

8. A method of making a double-skin structural element which includes the steps of applying to a cellulosic sheet parallel lines of adhesive, superimposing a number of such sheets into a stack with the adhesive lines alternately staggered, cutting the stack of sheets at right-angles to said adhesive lines into slices of the width desired for the thickness of said cellular filling, opening out the non-adhering walls to form a lattice and securing on each side of said lattice a covering plate.

9. A method of making a double-skin structural element which includes the steps of applying to a cellulosic sheet parallel lines of adhesive, superimposing a number of such sheets into a stack with the adhesive lines alternately staggered, cutting the stack of sheets at right-angles to said adhesive lines into slices of the width desired for the thickness of said cellular filling, opening out the non-adhering walls to form a lattice and securing on each side of said lattice a plate of plywood.

10. A method of making a double-skin structural element which includes the steps of applying to a cellulosic sheet parallel lines of adhesive, superimposing a number of such sheets into a stack with the adhesive lines alternately staggered, cutting the stack of sheets at right-angles to said adhesive lines into slices of the width desired for the thickness of said cellular filling, opening out the non-adhering walls to form a lattice and securing on each side of said lattice a covering skin built up from paper and adhesive.

GEORGE MAY.

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The following references are of record in the file of this patent:

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