

Feb. 15, 1966

E. KOPPELMA ETAL

3,234,972

MULTI-PLY FABRIC

Original Filed Dec. 24, 1959

9 Sheets-Sheet 1

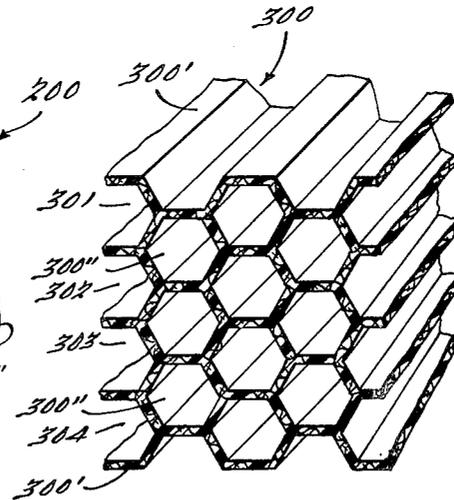
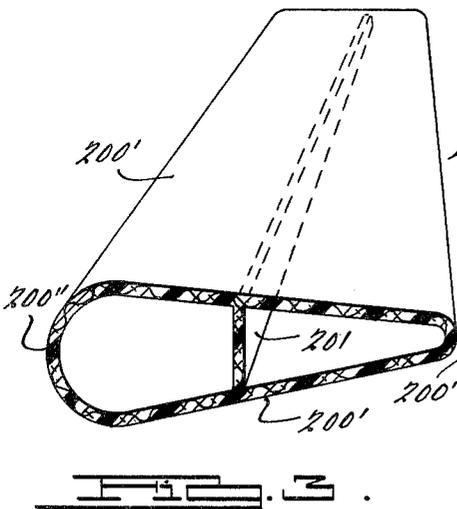
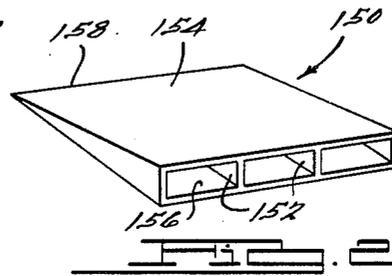
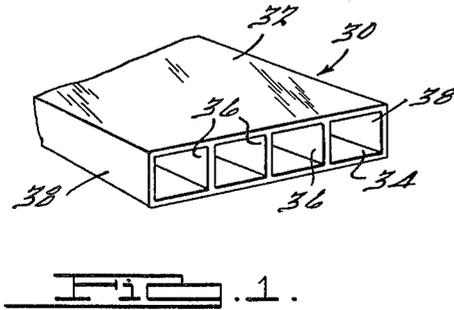


FIG. 4.

INVENTORS
Edward Koppelman
Arthur R. Campman
BY
Karnes, Dubey & Pire
ATTORNEYS

Feb. 15, 1966

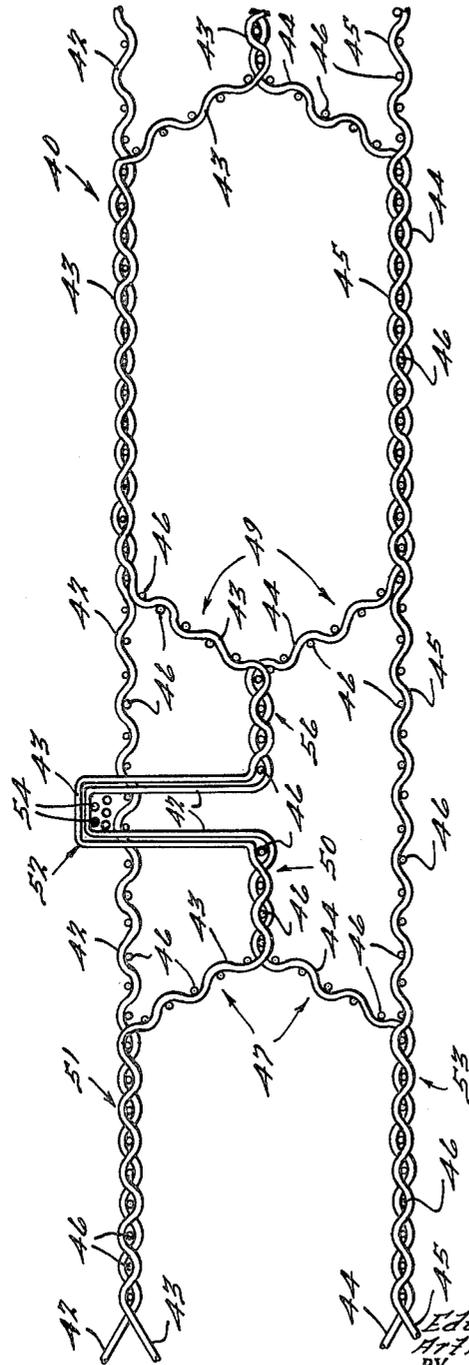
E. KOPPELMAN ETAL

3,234,972

MULTI-PLY FABRIC

Original Filed Dec. 24, 1959

9 Sheets-Sheet 2



INVENTORS
Edward Koppelman
Arthur R. Campman
BY
Werner, Dickey & Peine
ATTORNEYS

Feb. 15, 1966

E. KOPPELMAN ETAL

3,234,972

MULTI-PLY FABRIC

Original Filed Dec. 24, 1959

9 Sheets-Sheet 3

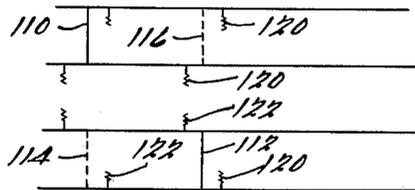
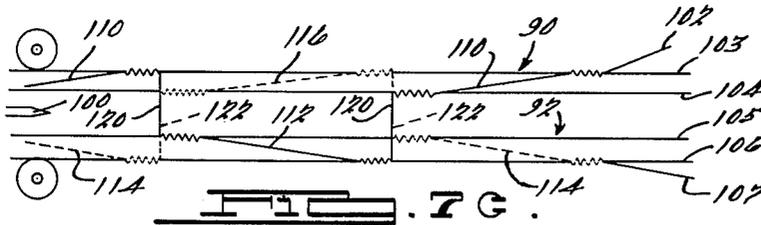
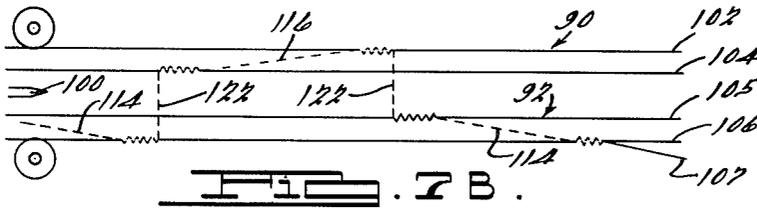
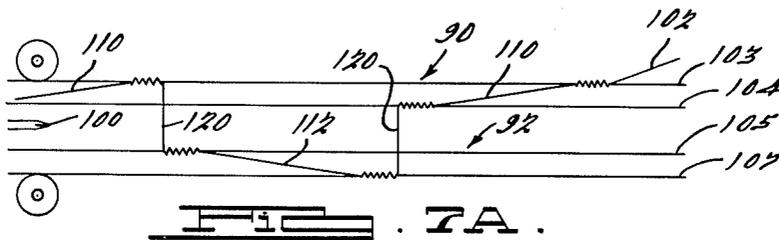
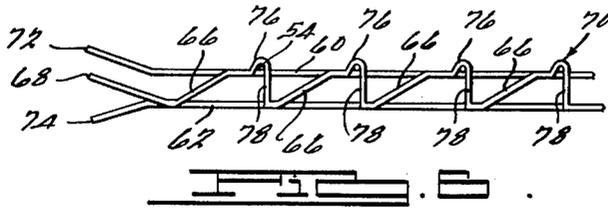


FIG. 8

INVENTORS.
 Edward Koppelman
 Arthur R. Campman.
 BY
 Harness, Dickey & Peire.
 ATTORNEYS.

Feb. 15, 1966

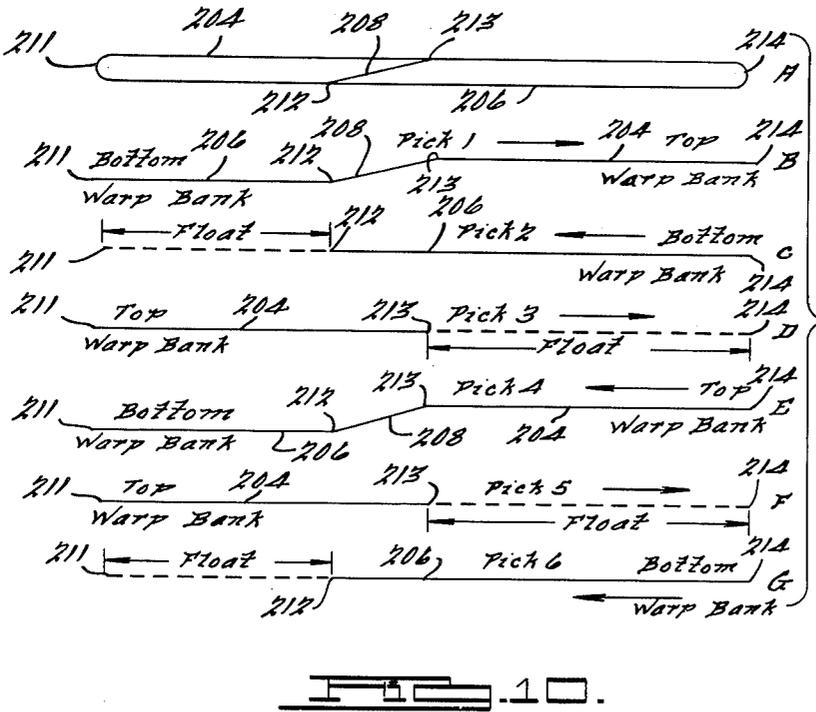
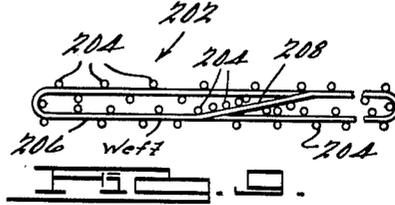
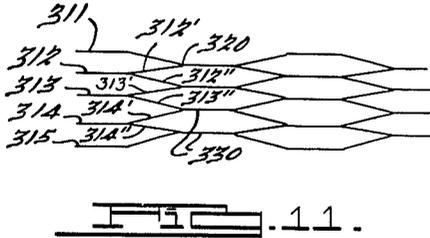
E. KOPPELMAN ETAL

3,234,972

MULTI-PLY FABRIC

Original Filed Dec. 24, 1959

9 Sheets-Sheet 4



INVENTORS
 Edward Koppelman
 Arthur A. Campman
 BY
 James Dickey Piere
 ATTORNEYS

Feb. 15, 1966

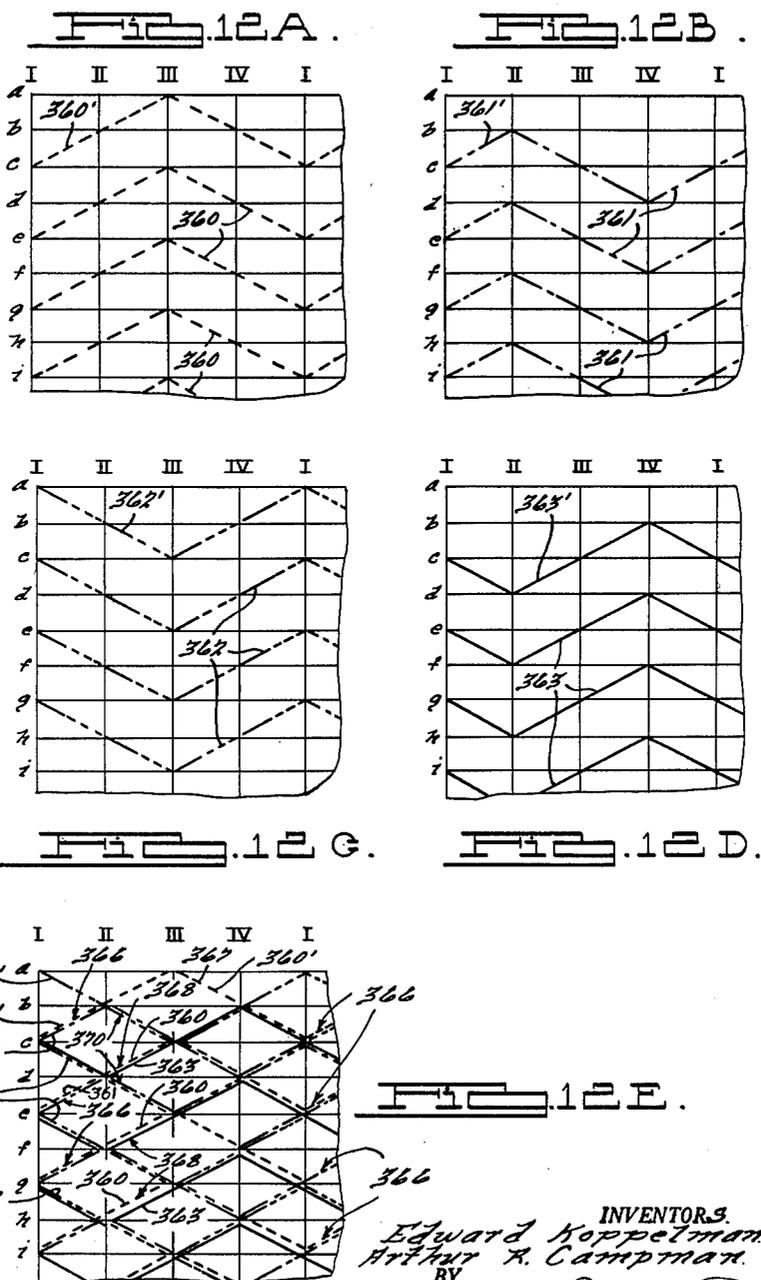
E. KOPPELMAN ETAL

3,234,972

MULTI-PLY FABRIC

Original Filed Dec. 24, 1959

9 Sheets-Sheet 5



INVENTORS
Edward Koppelman
Arthur R. Campman.
BY
Harniss, Dickey & Pierce.
ATTORNEYS

Feb. 15, 1966

E. KOPPELMAN ETAL

3,234,972

MULTI-PLY FABRIC

Original Filed Dec. 24, 1959

9 Sheets-Sheet 6

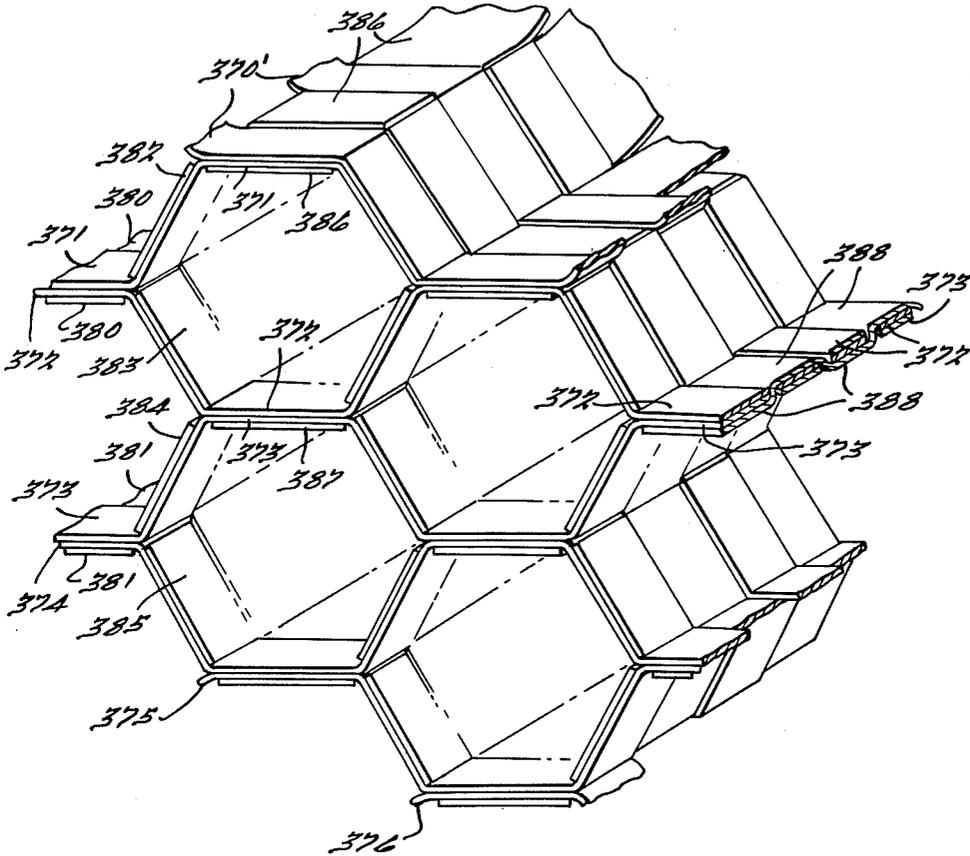


FIG. 13.

INVENTORS
Edward Koppelman
Arthur R. Campman.
BY
Harness, Dickey & Perie
ATTORNEYS

Feb. 15, 1966

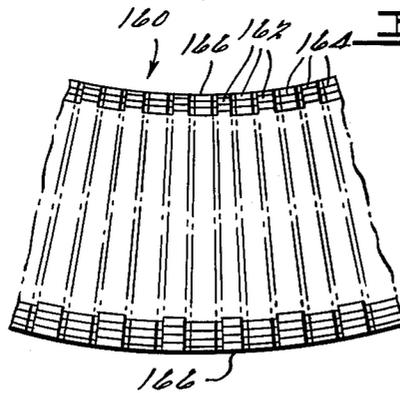
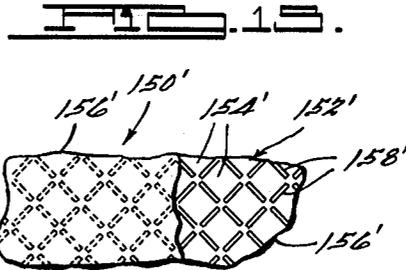
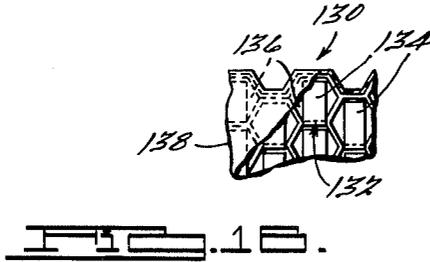
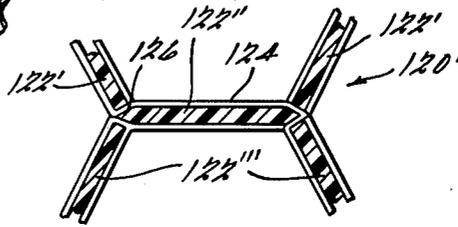
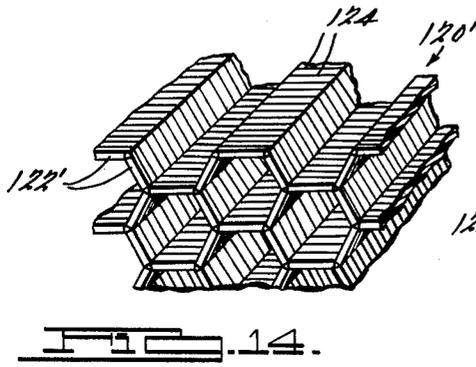
E. KOPPELMAN ETAL

3,234,972

MULTI-PLY FABRIC

Original Filed Dec. 24, 1959

9 Sheets-Sheet 7



INVENTORS.
Edward Koppelman.
Arthur R. Campman.
BY
Thomas Dickey & Pene
ATTORNEYS

Feb. 15, 1966

E. KOPPELMAN ETAL

3,234,972

MULTI-PLY FABRIC

Original Filed Dec. 24, 1959

9 Sheets-Sheet 8

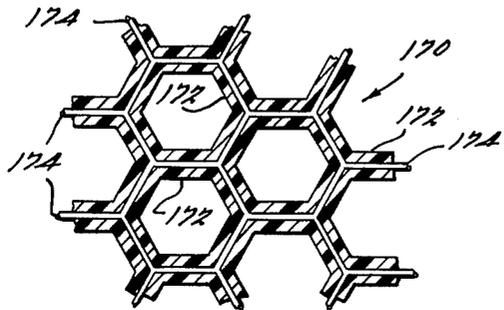


FIG. 19 .

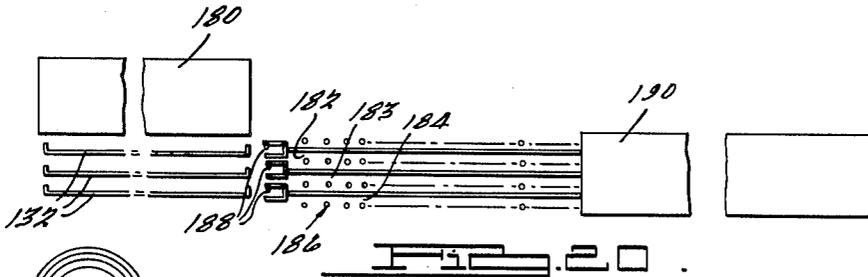


FIG. 20 .

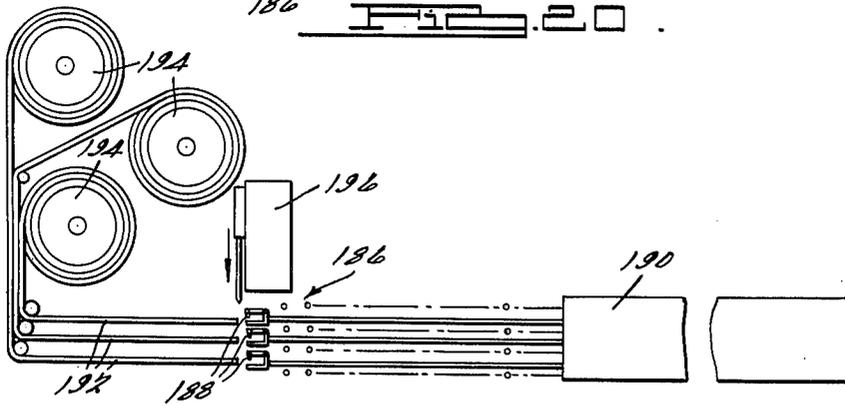


FIG. 21 .

INVENTORS.
Edward Koppelman.
Arthur R. Campman.
BY
James Dickey Purie,
ATTORNEYS

Feb. 15, 1966

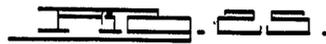
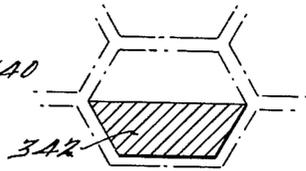
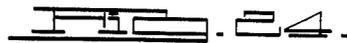
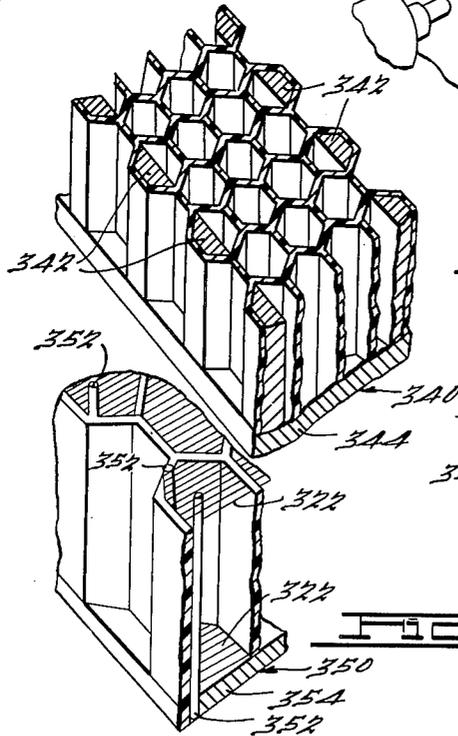
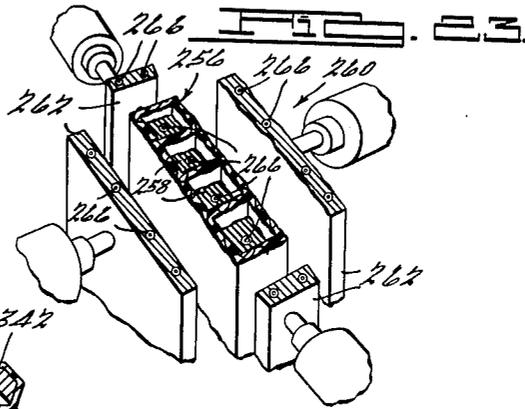
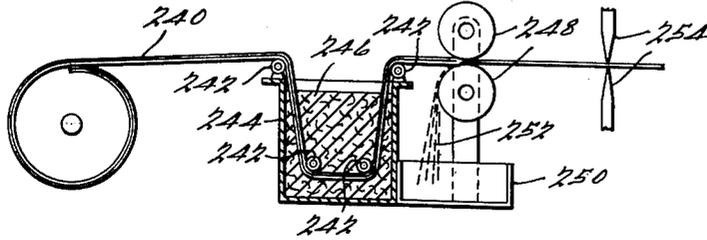
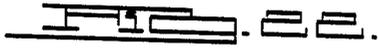
E. KOPPELMAN ETAL

3,234,972

MULTI-PLY FABRIC

Original Filed Dec. 24, 1959

9 Sheets-Sheet 9



INVENTORS.
Edward Koppelman
Arthur R. Campman.
BY
Harness, Dickey & Perie.
ATTORNEYS

1

3,234,972

MULTI-PLY FABRIC

Edward Koppelman, Huntington Park, and Arthur R. Campman, Los Angeles, Calif., assignors, by direct and mesne assignments, to Raymond Development Industries, Inc., Huntington Park, Calif., a corporation of Delaware

Original application Dec. 24, 1959, Ser. No. 861,959, now Patent No. 3,102,559, dated Sept. 3, 1963. Divided and this application Dec. 3, 1962, Ser. No. 246,856
1 Claim. (Cl. 139—384)

This application is a continuation-in-part of application Serial No. 663,805, filed June 5, 1957, now abandoned, and a continuation-in-part of copending application Serial No. 730,282, filed April 23, 1958, now abandoned, and is a division of application Serial No. 861,959 filed December 24, 1959, now U.S. Patent No. 3,102,559.

This invention relates to improved methods of weaving multi-ply fabrics and to articles made thereby. More particularly, the invention relates to improved methods of weaving multi-ply fabrics capable of being opened out, or expanded, into a cellular structure, and to cellular structures formed from such fabrics.

The term "cellular structure" as used herein refers to multi-ply fabric composed of two or more plies of fabric interconnected by spaced apart rib portions and also multi-ply fabric composed of a multiplicity of plies interconnected to produce a honeycomb-like structure in which the cells may be hexagonal, rectangular or of such other cross-sectional configuration as is possible within the limits of weaving techniques capable of being employed in weaving fabrics in accordance with this invention and in which the cell walls constitute, in effect, ribs. The term "fabric" as used herein refers to a material composed of one or more banks of warp elements woven with weft elements and in which the warp and/or weft elements may be threads, strands, tapes, slats, tubes or the like formed of any suitable material capable of being woven. The term "ply" as used herein refers to a woven material composed of one warp bank woven with weft elements. The term "bank" as used herein refers to a group of warp elements prior to their being woven with weft elements.

Cellular structures of the kind described are presently used in a variety of applications where light weight combined with considerable strength are needed. The problem arises, however, of how to make these cellular structures to have adequate strength at the edge connection of the rib portions with the plies. In prior art constructions the rib portions have been bonded at their edges to their adjoining plies. Accordingly, the strength of the cellular structures thus provided is a measure of the strength of the edge joint connections between the ribs and the plies.

An important object of the present invention is to provide an improved material capable of being conformed to a cellular structure in which the plies and ribs are woven so as to be integral with one another.

Thus, in accordance with this invention, a cellular structure is provided in which the ribs, including the cell walls in the case of a honeycomb-like structure, are woven with the plies. The invention pertains to such integral woven structures and to methods of weaving the same upon a flat power loom.

The above and other objects and advantages of the invention will become more apparent and understood from consideration of the following detailed description with reference to the accompanying drawings in which:

FIGURE 1 is a fragmentary perspective view of a cellular article incorporating fabric material in accordance with this invention rigidified as by being molded with a thermosetting plastic;

2

FIG. 2 is a fragmentary perspective view of an alternative cellular article of taper formation;

FIG. 3 is a perspective view of another form of a cellular structure capable of being made with the use of a fabric in accordance with this invention, also rigidified as with the use of a thermosetting plastic;

FIG. 4 is a fragmentary isometric view of a honeycomb-like cellular article incorporating fabric material in accordance with the present invention rigidified as by being molded with a thermosetting plastic;

FIG. 5 is a schematic longitudinal section on an enlarged scale illustrating one method of weaving fabric for use in a cellular article as depicted in FIGS. 1 and 2;

FIG. 6 is a schematic longitudinal section illustrating another method of weaving fabric for use in a cellular article as depicted in FIGS. 1 and 2;

FIG. 7A is a schematic longitudinal view illustrating one stage in the method of weaving two layers of fabric simultaneously;

FIG. 7B is a schematic longitudinal view illustrating another stage in the method partly shown in FIG. 7A;

FIG. 7C is a schematic longitudinal view representing the superposition of FIGS. 7A and 7B one upon the other to illustrate the simultaneous operation of both of the method steps shown in FIGS. 7A and 7B;

FIG. 8 is a schematic longitudinal view of a pair of fabrics woven according to the method shown in FIGS. 7A, 7B and 7C, showing the fabrics after they have been taken from the loom, and separated, and extended to their full structural shapes;

FIG. 9 is a schematic view illustrating a method of weaving fabric suitable to form a cellular article as depicted in FIG. 3;

FIG. 10 is a series of schematic diagrams designated A through G illustrating a weft picking sequence for weaving a fabric as illustrated in FIG. 9;

FIG. 11 is a schematic diagram of a weaving sequence employed for weaving a honeycomb-like structure as depicted in FIG. 4;

FIGS. 12A, 12B, 12C and 12D are schematic longitudinal views illustrating the different steps in a method of weaving a fabric conformable to a honeycomb-like structure having cells of rectangular section;

FIG. 13 is a fragmentary isometric view, on an enlarged scale, of a honeycomb-like fabric according to the invention shown opened out and formed from interwoven tapes;

FIG. 14 is a fragmentary perspective view of a honeycomb-like fabric structure according to the invention opened out and having weft slats;

FIG. 15 is a fragmentary section of a portion of the fabric of FIG. 14 on an enlarged scale;

FIG. 16 is a fragmentary section of a modified form of the fabric shown in FIGS. 14 and 15;

FIG. 17 is a fragmentary diagrammatic view of a honeycomb-like fabric woven with weft slats to have rectangular section cells;

FIG. 18 is a fragmentary diagrammatic view of a honeycomb-like fabric of curved configuration;

FIG. 19 is a fragmentary section of a further modified fabric construction utilizing tubular warp elements;

FIGS. 20 and 21 are schematic views illustrating modes of weaving fabrics according to FIGS. 14, 15 and 16; and

FIGS. 22, 23, 24, 25 and 26 are fragmentary and sectional views illustrating modes of rigidifying fabric material made in accordance with the invention.

Examples of cellular structures capable of being produced by the invention (FIGS. 1, 2, 3 and 4)

FIGS. 1, 2, 3 and 4 are representative of cellular structures capable of being made with the use of fabric woven according to this invention and made (as by being rigidi-

fied with the use of a thermosetting plastic) to maintain its expanded cellular form.

In FIG. 1, the cellular structure, indicated generally at 30, has opposite plain side faces 32, 34 interconnected by ribs 36 and has closed end walls 38.

In FIG. 2, the cellular structure, indicated generally at 150, has a tapering form and has opposite plain side faces 154, 156 tapering to a closed edge 158 and interconnected by correspondingly tapered ribs 152.

The weaving of fabrics for use to produce cellular structures as depicted in FIGS. 1 and 2 is described with reference to FIGS. 5 to 8.

In FIG. 3, the cellular structure is indicated generally at 200 and is composed of oppositely inclined side faces 200' joined by integral edge portions 200'' to form an airfoil-like structure having a rib 201 interconnecting the faces 200' intermediate the edge portions 200''. The weaving of fabric for use to produce this type of cellular structure is described with reference to FIGS. 9 and 10.

In FIG. 4, the cellular structure is indicated generally at 300 and is composed of opposite faces or plies 300' which have a generally corrugated appearance and are interconnected by intermediate wall portions to form a multiplicity of honeycomb-like cells 300''. The weaving of fabric for use in the production of this type of cellular structure is described with reference to FIG. 11 and FIGS. 12A to 12E. FIGS. 12A to 12E relate to a method of weaving a honeycomb-like conformable fabric having rectangular section cells, instead of hexagonal cells as depicted in FIG. 4, and woven as described with reference to FIG. 11.

Weaving fabric material for use to form cellular articles as depicted in FIGS. 1, 2 and 3

Referring first to FIG. 5, the fabric material is woven from a warp, divided into four banks 42, 43, 44 and 45, which are substantially coextensive in width. (The fabric material, indicated generally at 40, is shown in this figure on a distorted scale for purposes of clarity, the separate plies being shown separated one from another by substantial intervals, whereas in actual practice they are formed in closely adjacent relationship, one immediately on top of the other.) The top and bottom banks 42 and 45 of the warp may be taken from a single source since their take-up rates would be the same, whereas the intermediate banks 43 and 44 are taken from a separate source to allow for a take-up differential between the outer and the intermediate warp banks. The weaving can be done on a flat loom having eight heddle frames.

The warp banks 42 to 45 are initially combined in pairs, each pair of warp banks being woven with a weft 46 as single, separate ply portions 51 and 53 for a distance approximately equal to the desired spacing between adjacent ones of the ribs 36 (FIG. 1). The weaving may be done according to any desired pattern to lock the warp banks 42, 43 and 44, 45 firmly in the fabric ply portions 51 and 53. When the ply portions 51 and 53 have been woven in this manner, the warp banks 42 to 45 are woven separately for a distance approximately equal to one-half of the height of the ribs 36. In this interval, the intermediate banks 43 and 44 are separately woven with the weft 46 to form intermediate ply portions 47 which later form the rib portions of the fabric, the length of each one of such portions 47 being about one-half the height of a said rib 36. After these intermediate warp banks 43 and 44 are combined with each other for a few picks of the weft 46 to form a locking tab 50. Immediately thereafter, both the intermediate warp banks 43 and 44 are raised above the top bank 42 and floated (unwoven) over weft-like elements 54 laid upon the top warp bank 42. Alternatively, the floated portion 52 of the intermediate warp banks may be brought down below the bottom warp bank 45. It is only necessary that the floated portion 52 be exposed on one face of the fabric material 40, either top or bottom. The intermediate warp banks 43 and 44 are then again

brought down to their position between the outer warp banks 42 and 45 and again combined and woven to form a second locking tab 56, substantially equal in length to the first locking tab 50. After completion of weaving of this second locking tab 56, all four of the warp banks 42 to 45 are again woven separately for a distance equal to one-half the height of a said rib 36, the intermediate banks 43 and 44 forming further separate ply portions 49, which later combine to form a further rib 36 (FIG. 1). The two upper warp banks 42 and 43 and the two lower warp banks 44 and 45 are then again combined and woven with the weft in pairs. This weaving sequence is repeated along the full length of the warp banks.

During this weaving, the weft picking sequence may be arranged according to any desired pattern, and the weaving pattern produced in the individual plies may be varied, as desired, within the capabilities of the loom. It is necessary, however, that a portion of the intermediate warp banks 43 and 44 between the locking tabs 50 and 56 be brought in unwoven condition out of the fabric 40 through one of the plies thereof so that the intermediate warp banks 43 and 44 may be severed at points intermediate the rib forming portions 47 and 49 to permit the fabric 40 to be extended or opened out to its full structural shape.

It will be seen that each one of the fabric ribs is made up of two portions 47, 49 which include the warp of the upper intermediate warp bank 43 and the warp of the lower intermediate warp bank 44, with the said portions being locked together by the woven tabs 50 and 56, which include the warp of both of the intermediate warp banks 43, 44.

Referring now to FIG. 6, fabric material 70 is woven having top and bottom plies 60 and 62 interconnected by rib portions 66, all woven from a single intermediate warp bank 68. The fabric material 70 is woven from a three-bank warp, the top and bottom warp banks 72 and 74 being woven in the plies 60 and 62 of the fabric. The intermediate warp bank 68 is woven separately to form the rib portions 66, and is alternately combined at spaced intervals with the top and bottom warp banks 72 and 74.

As in the previously described weaving method, portions 76 of the intermediate warp bank 68 between the woven rib portions 66 are floated outside the top or the bottom ply 60, 62 to bring them into position for severing.

In weaving according to the method illustrated in FIG. 6, the intermediate warp bank 68 may, for example, be first combined with the bottom warp bank 74 and woven, the two banks being woven with weft in a common shed for a certain predetermined distance. All three of the warp banks 68, 72 and 74 are then woven separately for a distance corresponding to the height of the ribs 36 (FIG. 1), and the intermediate warp bank 68 is then combined with the top warp bank 72 and woven with the weft for another predetermined distance. The intermediate bank 68 is then floated over thread or equivalent elements which facilitate severing these floated warp portions to free the woven rib formable portions of the woven fabric 70. When thus floated, the warp bank 68 is brought down and combined again for weaving with the bottom warp bank 74, and so on.

In view of the scale distortion in the drawing required in order to show the weaving sequence clearly, it should be pointed out again that in the actual weaving operation the fabric plies 60 and 62 will lie close together on top of one another as the fabric 70 is woven, with the woven rib formable portions 66 sandwiched between the plies 60, 62.

Referring now to FIGS. 7A-8, the invention provides whereby fabric material suitable for use to form cellular structures as depicted in FIGS. 1 and 2 can be manufactured in two layers simultaneously upon a flat power loom equipped with a knife assembly in the manner of a loom adapted to form a plush-weave, the knife assembly being indicated at 100 in FIGS. 7A, 7B and 7C and the two layers 90 and 92 of woven fabric severed thereby being shown in FIG. 8. For the production of the fabric in

this way the warp is arranged in six banks 102 to 107 and is woven with the use of at least twelve heddle frames so that each one of the six warp banks 102, 103, 104, 105, 106 and 107 may be woven with weft independently of and simultaneously with the other warp banks. In this method, two complete fabrics 90 and 92 are woven simultaneously.

For greater clarity, so that the weaving sequence may be more readily understood, the warp weaving sequence for each of the two intermediate rib-forming warp banks 103 and 106 is shown separately in separate figures, FIGS. 7A and 7B, respectively. In actual practice, however, the weaving of the entire fabric is accomplished simultaneously as shown in FIG. 7C, the added views of FIGS. 7A and 7B being included to show clearly and specifically the paths of the separate intermediate warp banks 103 and 106.

Referring first to FIG. 7A wherein five warp banks 102, 103, 104, 105 and 107 are shown, of the six banks in the entire warp, two of the warp banks 102 and 104 are woven with weft on top to form the two plies of the one fabric 90 while the warp banks 105 and 107 are simultaneously woven with weft beneath to form the plies of the bottom fabric 92.

The intermediate warp bank 103 shown in FIG. 7A is first woven with the top warp bank 102 for a predetermined distance and then all of the warp banks are woven separately, with the intermediate warp bank 103 disposed between the two upper warp banks 102 and 104 being woven to form a rib portion 110 in the upper fabric 90 for a distance corresponding to the height of the ribs 36 (FIG. 1). Then the intermediate warp bank 103 is combined with the lower warp bank 104 to lock the woven rib portion 110 securely with the fabric woven in this warp bank 104, and immediately thereafter, the warp bank 103 is brought down to the lower warp banks 105-107 by means of an unwoven warp portion 120 and combined with the bottom warp bank 107 of the bottom fabric 92. All of the warp banks are then again woven separately, with the intermediate warp bank 103 disposed between the two plies of the bottom fabric 92, thereby forming a woven rib portion 112 locked into and between the plies of the bottom fabric 92. The intermediate warp bank 103 is then combined with the top warp bank 105 of the lower warp banks and thereafter brought again up to the top warp bank 102 of the upper fabric 90 by means of a second unwoven warp portion 120. This weaving sequence is repeated for the full length of the warp, the upper intermediate bank 103 being woven to form rib portions 110 and 112 alternately in the upper fabric 90 and then in the lower fabric 92.

The sequence of weaving the lower intermediate warp bank 106 is complementary to the sequence of weaving the upper intermediate warp bank 103. As shown in FIG. 7B, the warp banks 105 and 107 are simultaneously woven with weft beneath to form the plies of the bottom fabric 92.

As shown in FIG. 7B, the lower intermediate warp bank 106 is first combined with the bottom warp bank 107 of the lower fabric 92, then is woven by itself to form a woven rib portion 114, and then is combined with the top warp bank 105 of the lower fabric 92. It is then brought directly to the top warp bank 102 of the upper fabric 90 by an unwoven warp portion 122, and combined therewith. Thus, the lower intermediate warp bank 106 is woven to form woven rib portions 114 and 116, alternately, first in the lower fabric 92 and then in the upper fabric 90. The sequence of weaving of the upper and lower intermediate warp banks 103 and 106 are identical except for their complementary disposition. When the upper intermediate warp bank 103 is being woven to form a rib portion 110 in the upper fabric 90, the lower intermediate warp bank 106 is being woven to form a rib portion 114 in the lower fabric 92, and vice-versa.

Unwoven portions 120 and 122 of the two intermediate

warp banks 103 and 106 cross each other and extend vertically between the upper and lower fabrics 90 and 92, serving to tie the two fabrics 90 and 92 together. These unwoven warp portions 120 and 122 are severed by the knife assembly 100 as the fabric leaves the loom, thus simultaneously releasing the upper fabric 90 from the lower fabric 92, and severing the intermediate warp banks 103, 106 so that the upper and lower fabrics 90, 92 may be extended to their full cellular structural shapes as depicted in FIG. 8.

Cellular articles of tapering form, as depicted in FIG. 2, can be produced with a fabric woven according to the invention by a modified form of the methods illustrated in FIGS. 5, 6 and 7A-8. A Jacquard head (not shown), or an equivalent device capable of individually raising and lowering the different warp banks, is employed in this instance for weaving the ribs 152 (FIG. 2) of tapering height and for controlling the introduction of the intermediate warp banks into the fabric plies corresponding to the side faces 154 and 156 of the structure.

The weaving of fabric material having woven rib forming portions of tapering construction corresponding to the ribs 152 in FIG. 2 can be done, generally similarly to the method described with reference to FIG. 7A, except that the woven rib portions 110, 112, 114 and 116 are tapered in length (their length being taken in the warp direction) and are introduced into the fabric plies 102, 104, 105 and 107 at longitudinally displaced points as with respect to the woven connection of a rib portion with one ply, the ply 102 for instance, and the woven connection of this rib portion with the other ply 104. For example, referring to FIG. 7A, the rib forming warp bank 103 is first woven with the uppermost warp bank 102 for a predetermined distance to secure the bank 103 in the bank 102 and is then progressively dropped out from the bank 102 and woven separately. The separate yarns or the equivalent of the rib forming bank 103 are progressively dropped from the warp bank 102, starting from one edge of the fabric, until the entire width of the rib forming warp bank 103 is separated from the warp bank 102. The line of juncture between the rib portion 110 and the woven bank 102 is thus made to extend obliquely across the width of the fabric.

If the thin edge 158 of the article is to be sharp, as shown in FIG. 2, the rib forming warp bank 103 is immediately introduced into the lower warp bank 104, again progressively and gradually, but complementarily to the progression by which it was dropped from the upper warp bank 102. That is, the threads or the like (tapes for example) of the warp bank 103 that were the last to be dropped from the upper warp bank 102 are the first to be introduced into the lower warp bank 104, so that the line of juncture between the woven rib portion 110 and the lower warp bank 104 is inclined in the opposite direction across the width of the fabric from the previous line of inclination as with respect to the rib portion 110 and the upper warp bank 102. The rib forming warp bank 103 is then woven with the lower warp bank 104 for a sufficient distance to secure the woven rib portion 110 firmly to the partially woven warp bank 104, after which the rib bank 103 is brought down to the bottom pair of warp banks 105, 107 and the weaving sequence is continued.

Since the rib portions formed in the fabric as the fabric is woven are of either triangular or trapezoidal shape (as seen in FIG. 2) the opposed woven plies of the fabric corresponding to the facings 154 and 156 must necessarily be swung with respect to each other when the fabric is opened out to its structural cellular shape. This requires that the woven threads or the like constituting the fabric plies should "slip" to accommodate the distortion that would otherwise result. It has been found from experience in weaving this fabric material that even relatively tightly woven fabric material provides adequate slip to eliminate the distortion which would otherwise occur upon opening out the fabric.

Fabric material having woven rib portions corresponding to the ribs 152 in FIG. 2 need not be closed along one edge as shown in FIG. 2, but may be open at both edges so that the ribs are trapezoidal in shape instead of triangular. This can be accomplished by weaving the entire rib forming warp bank 103 separately from the other warp banks for a selected distance between the time the bank 103 is dropped from one warp bank 102, for example, and the time it is progressively introduced into the next warp bank 104, for example.

When the fabric material is to be capable of being conformed to a triangular configuration as just described, the combining of the intermediate warp bank with the lower warp bank commences as soon as the separation of the intermediate warp bank from the upper warp bank has ended. If desired, the upper and lower warp banks may be joined together along the edge which thus forms the apex of the triangle by weaving the extreme edge threads or the like of these warps with a common weft.

It should also be noted that in weaving this fabric material having triangular or trapezoidal rib conformable portions, it is not necessary to join the woven rib portions progressively to both of the outer warp banks, although this method may be preferred, since it minimizes distortion when the fabric material is expanded to its structural shape. In practice, especially where the taper angle of the rib portion is to be relatively small, substantially equivalent results are obtained by connecting the rib-forming warp bank to one of outer warp banks (e.g., banks 102 and 104) in the normal, straight-rib forming manner as described with reference to FIGS. 5 and 6, and weaving in the entire taper by an angular connection with only one of the outer warp banks.

All of the foregoing embodiments pertain to the weaving of fabric material having rib conformable portions for extending in the weft direction. In certain cases, however, it may be desired to provide for the construction of a cellular article, as depicted in FIG. 3, in which the rib 201 extends in the warp direction. Fabric material 202 (FIG. 9) of integrally woven construction conformable to the shape of the article 200 depicted in FIG. 3 may be woven according to the present invention upon a flat loom. In FIG. 9, the fabric material is seen looking in the warp direction, in contrast to the preceding figures where the fabric is to be considered as looking in the weft direction, i.e., transversely of the fabric. The fabric material 202 can be woven in tubular form using a warp arranged in three banks, the separate banks thereof being designated 204, 206 and 208, respectively. The top and bottom warp banks 204 and 206 are woven into the flattened tubular form. The intermediate warp bank 208 need not be as wide as the upper and lower warp banks 204 and 206. The warp bank 208 is woven to form a rib conformable portion which finally forms the rib 201 in the article, as depicted in FIG. 3, such rib portion being joined by the weft to the upper and lower warp banks 204 and 206 to integrate it with the tubular fabric as it is produced on the loom. A picking sequence for weaving the tubular fabric 202 is explained with reference to FIG. 10, in which part A represents a schematic cross-sectional view of the fabric with certain identifying points thereof being designated 211, 212, 213 and 214. These points 211 to 214 trace the paths of successive wefts as they are laid in the warp banks 204 to 208. In all, six picks, or shuttle passes are made in the illustrated sequence, and are repeated along the length of the warp banks.

On the first pick, and referring to part B of FIG. 10, the shuttle or its equivalent passes from left to right, entering the bottom warp bank 206 at the left-hand point 211, leaving the bottom bank 206 at the point 212, passing from this point completely through the intermediate warp bank 208 to the point 213 and from this point passing along the top warp bank 204 to the right-hand point 214. On the return or second pick and referring to part C of FIG. 10 the shuttle passes through the bottom bank

206 from the right-hand point 214 to the point 212 and from there is floated across the rest of the bottom warp bank 204. On the next and third pick, and referring to part D of FIG. 10, the weft is laid from left to right in the top warp bank 204, and in the intermediate warp bank 208, from the point 211 to the point 213 and is then floated across the remainder of the top warp bank 204. On the next and fourth pick, and referring to part E of FIG. 10, the weft is laid in the top bank 204 from the right hand point 214, to point 213, through the intermediate warp bank 208, and then through the left-hand portion of the bottom warp bank 206 back to the point 211. On the fifth and next pick, and referring to part F of FIG. 10, the shuttle passes through the top warp bank 204, from the point 211 to the point 213, and is then floated across the remainder of the top warp bank 204 to the point 214. On the next and sixth pick, and referring to part G of FIG. 10, the weft passes from right to left, through the bottom warp bank 206, from the point 214, and is then floated across the remainder of the bottom warp bank 206.

This picking sequence is repeated to form the tubular fabric 202, as illustrated in FIG. 9, which is expandible to conform to the shape of the molded article 200 (FIG. 3). The floated (i.e., nonwoven) portions of the weft may be trimmed from the fabric or allowed to remain to provide reinforcement, as desired. In the completed fabric the portion corresponding to the rib 201 is composed of the intermediate warp bank 208 woven with the weft and woven also into the warp banks 204, 206.

It will be appreciated that the conformable portion of the fabric can be tapered in height along the length of fabric, as desired, by progressively dropping or adding threads or the like to the intermediate warp bank 208 and correspondingly adjusting the locations of the points 212 and 213 as the weaving progresses.

Weaving fabric material for use to form cellular fabric material conformable to a honeycomb-like structure as depicted in Fig. 4.

Referring now to FIG. 11 and FIGS. 12A to 12E, there will be described a weaving sequence for weaving fabric material conformable to a honeycomb-like structure.

Referring first to FIG. 11, the warp is arranged in a plurality of banks, one more than the maximum number of honeycomb cells in the thickness, or height of the fabric. For example, to produce a honeycomb-like structure having four tiers of cells 301-304, as seen in FIG. 4, the warp is arranged in five banks 311, 312, 313, 314 and 315 (FIG. 11). The intermediate warp banks 312, 313 and 314 are each divided into two sub-banks 312', 312'', to 314' and 314''.

The warp banks 311 to 315 are separately woven for a distance corresponding to the length of a cell wall and the two groups of each one of the intermediate warp banks 312, 313 and 314 are combined together. The top and bottom warp banks 311 and 315 and the warp sub-banks 312' and 312'' to 314'' are then separately woven for a second length, each one of the intermediate warp banks 312 to 314 being split into its two sub-banks 312' and 312'' to 314' and 314'', which are separately shedded and woven apart from each other. At the end of the second length, indicated by the point 320, the warp banks are again combined, but in a criss-cross arrangement relative to the arrangement at the start of the weave. The top warp bank 311 is combined with the upper warp sub-bank 312' of the intermediate warp bank 312. The next two adjacent warp sub-banks 312'' and 313' are combined and the warp sub-banks 313'' and 314' are also combined, as are the warp sub-bank 314'' and the bottom warp bank 315. The warps are woven in this manner for a distance corresponding equal to a third cell wall, and then the separate warp sub-banks are again woven separately without being combined with each other for another cell wall

length, after which the initial pattern is re-established and the weaving repeated.

Although only a four tier cell structure is shown in FIG. 4, it will be appreciated that the fabric can be made to conform to a greater number of cell tiers. In practice, fabrics as high as 25 or 30 cells have been woven with satisfactory results, and without excessive crowding of the reed. A single or a multiple operation can be used for laying the weft in the warp, and the picking sequence may be varied as required.

It will be appreciated, of course, that in the actual weaving operation the fabric material is woven completely flat with its separate plies arranged immediately one on top of the other. Accordingly, the fabric take-up on the loom should be adjusted to take up the fabric only one pick distance after the weft has been laid through all of the warp banks, regardless of how many warp banks are included in the weave, and regardless of how many picks are needed to weave all of the warp banks.

In a practical application for weaving a relatively lightweight honeycomb-like fabric, for example, the top and bottom warp banks 311 and 315 and each one of the groups of the intermediate warp banks 312, 313 and 314 may include approximately forty ends (threads or the equivalent) per inch, and the woven fabric may be taken up on the loom at the rate of approximately forty picks per inch. Thread of any desired size and material compatible with this count is used. Those portions of the fabric where two warp groups are combined, such as the portions 330 shown in FIG. 11, will include eighty ends per inch, while in those portions where the warp groups are woven separately, each fabric ply will include only forty ends per inch. The weft density, however, may be substantially constant throughout. If, for example, the cell height of the completed fabric is to be approximately one-half inch (that is, the spacing between opposite walls of the cells when the fabric is extended) and the fabric is to be woven at the rate of forty picking cycles per inch, twelve picking cycles are taken in the first length of the fabric, then eleven cycles in the next succeeding length, and continuing on, alternating between twelve and eleven picking cycles on successive adjacent lengths. Each one of the picking cycles, of course, includes the laying of a weft in each warp bank, or group of the warp banks and the woven fabric is taken up one-fortieth of an inch after the completion of each cycle.

Fabric material conformable to a honeycomb-like structure can be woven either with open ended cells, as shown in FIG. 4, or with the ends of the cells bridged across by the weft. Since the fabric is woven in relatively flat form the adjacent plies will ordinarily be bound together at the edges by the weft, so that the fabric cannot be extended to its honeycomb-like form unless the weft is "floated" at the said edges an extent sufficient to leave the adjacent plies to be moved apart from one another or, if the weft is not floated, provision is made to sever the weft and the said edges.

For weaving closed cell honeycomb-like constructions, the weft may be tensioned on gauge wires spaced outwardly different respective distances from the edge of the fabric, as it is woven, and controlled during weaving by a Jacquard or comparable selection mechanism (not shown). Different ones of the wefts, according to this method, are tensioned on different gauge wires according to their positions along the length of the fabric with respect to the honeycomb-like cells. A particular one of the gauge wires is selected by the Jacquard mechanism to tension each particular one of the wefts so that the length of each one of the weft threads between the points where it leaves and re-enters the warp banks is adjusted to correspond with the cell space between these points. Thus, when the fabric is extended, the wefts will extend across the ends of the cells. In this case, the wefts are not severed, but remain as an integral part of the fabric.

Strictly speaking, the term "honeycomb" may suggest

cells that are regular hexagons, but in the present document, the term is used in a broader sense to describe any three dimensional structure having cells elongated in one dimension and extending in side-by-side relationship in both other dimensions, with each cell sharing common walls with its neighbors, regardless of the cross-sectional shape of the individual cells.

Honeycomb-like constructions having square, rectangular, or diamond-shaped cells may be woven according to the method illustrated in FIG. 11 by making the wall portions 330, in which two warp groups are woven together, relatively short. These wall portions 330 may be substantially eliminated by merely crossing the two groups over a single weft, and then continuing to weave the warp groups separately, apart from one another.

Strength may be obtained in square, or rectangular, celled construction, however, by weaving them according to the method illustrated in FIGS. 12A to 12E, according to which each wall portion of the fabric includes two combined warp banks, four of which 360, 361, 362 and 363 are included in each repeat. The warp banks 360 to 363 are arranged in a staggered array, criss-crossing each other at the lines where the cells are joined together. One of the two warp banks forming the wall of any one cell is extended straight on beyond the end of the cell wall and combined with a different warp bank to form the wall of another cell in the two immediately above or below the one cell, thus securing the cell walls together with maximum strength, while at the same time avoiding undue crowding in the loom reed, and making for a permissible loom arrangement.

For greater clarity, so that the weaving sequence may be more readily understood, the disposition of each one of the four warp banks 360 to 363 in the fabric is shown separately in the diagrammatic views of FIGS. 12A to 12D, respectively. In actual practice, of course, the entire fabric is woven simultaneously, as shown diagrammatically in FIG. 12E, the views of FIGS. 12A-12D being included to show clearly and specifically the paths of the separate warp banks 360 to 363 in the fabric. The grid reference lines *a*, *b*, *c*, etc., and I, II, III, etc., represent the same horizontal and vertical positions, or planes, respectively in the fabric throughout these figures.

The several warp banks 360 to 363 are always woven together in pairs, so that each one of the cell walls includes two of the warp banks. However, different ones of the warp banks are paired together in different walls. Each one of the warp banks is disposed in the fabric according to a zig-zag scheme, corresponding to two cells high and three cells wide. Specifically, in the example illustrated, portions 360' and 361' of the two warp banks 360 and 361 are woven together to form a cell wall 366 extending from the start of the weave at the grid line I to the next line II. The distance between the grid lines I, II, III, etc., is selected to be equal to the desired wall length of the cells in the completed fabric. The warp bank portion 360' at the top of the fabric is then either floated, or woven separately, in the interval from the second grid line II to the third grid line III, forming a relatively lightweight cell wall 367. All of the other warp banks 360 which are in similar positions, but lower down in the fabric, are then each woven with a portion 363' of the various warp banks 363 to form a cell wall 368 extending from the second grid line II to the third grid line III. The other warp bank 361 of the first cell wall 366 is turned downwardly at the grid line II and woven through the succeeding interval with portion 362' of the warp bank 362 to form a cell wall 370.

The arrangement, although difficult to describe, provides a high degree of strength both with respect to securing the cell together and to minimizing the chance of slip in the weave, which would tend to distort the fabric and make the cells nonuniform. The fabric is also relatively simple to weave, since only four heddle frames are required, one for each of the banks 360 to 363 of the warp.

Multiple-eye heddles are used to accommodate as many repeats as are required to make the full height of the fabric. All of the warp banks 360, for example, can be threaded in a single heddle frame, the yarns or equivalent elements of the separate warp banks 360 going through separate sets of heddle eyes and each set of eyes being vertically spaced from the other sets of eyes. With this arrangement, multiple needle, or multi-shuttle looms can be used for maximum production, speed and economy of loom utilization.

The single weave top and bottom cell walls, such as the cell wall 367, which as hereinabove explained may be of woven fabric, or of floated warps, may be trimmed away after weaving, or may be left in place, or may be folded inwardly to provide added strength in the next adjacent row of cell walls.

The square-celled woven honeycomb fabric of the present invention may be woven with open, or closed, end cells similarly to the hexagonal celled fabrics hereinabove described.

Tape construction

FIG. 13 shows a modified construction in which the warp and weft members, instead of being comparatively narrow members such as threads or wire, are wide, tape-like, relatively flexible members made of fibers, metal or any other suitable material. Substitution of tapes for threads or strands is possible in regard to all respects of the present invention. FIG. 13 shows the use of tapes in the formation of a honeycomb-like construction, but they may be employed with equal advantage in the manufacture of fabric to form ribbed constructions in the manner of FIGS. 1, 2 and 3.

As illustrated in extended form in FIG. 13, the honeycomb-like construction is of the hexagonal type and includes a plurality of superposed banks of warp tapes of which seven banks 370', 371, 372, 373, 374, 375 and 376 are shown. The tapes are woven in pairs with the weft members, in the same way as has already been described in connection with FIG. 11. Warp banks 371 and 372 are woven together with weft tape 380, while warp banks 373 and 374 are woven together with weft tape 381. Warp banks 371 and 372 are then separated and woven individually with weft tapes 382 and 383 respectively, while warp banks 373 and 374 are separated and each woven with a weft tape 384 and 385. Warp bank 371 is then paired with warp bank 370' and woven with weft tape 386, while warp bank 372 is paired with warp bank 373 and woven with weft tape 387. This pairing, separating, re-pairing in a different grouping, separating again, and then re-pairing in the first grouping goes on continuously along the full length and depth of the structure as well as across the full width of the warp banks. The weft tapes are interwoven either with a single bank of warp tapes when (the warp banks are separated), or with two banks of warp tapes (when the latter are paired—see for example the weft tape 388). While in FIG. 13 the warp and weft structures are both shown as tapes, one or the other could be replaced by threads, strands, wires or the like.

Weaving honeycomb-like construction with the use of weft slats or tubular elements (FIGS. 14-21)

As shown in FIGS. 14 and 15, a honeycomb-like construction 120' has a hexagonal cell arrangement and comprises relatively rigid, flat cell wall members or slats 122''' and 122', which may be of any desired material such as sheet metal, wood, extruded plastic, or fiber, or fabric reinforced plastic. The slats 122''' and 122' constitute the weft in the fabric and are woven in a warp (not separately designated) the individual ends 124 of which extend transversely across the slats 122''' to lock them securely together in a honeycomb pattern. As woven, the slats 122''' become hinged to each other by the warp 124. The warp 124 passes first over one of the slats 122''', then

under one of the next adjacent slats, and then over a succeeding slat, and so on. The entire structure may be rigidified by coating or impregnating it with a plastic, and curing the plastic while the structure is held in its expanded form upon a mandrel or by any other desired means. If the construction is woven of metal, using sheet metal slats 122''' and a warp in the form of wire or like threads 124, it may alternatively be rigidified by brazing or welding. In the form as shown in FIG. 15, the edges 126 of selected ones 122' of the slats are beveled to reinforce the corners of the cells and assist in holding the slats in their desired angular relationship to each other.

According to the embodiment illustrated in FIG. 16, the honeycomb-like construction 130 is woven similarly to the construction 120 illustrated in FIGS. 14 and 15 except that selected ones 132 of the slats have tabs 134 provided at their ends. The tabs 134 extend over the otherwise open ends of the individual cells 136 to provide maximum anchorage for a facing panel 138, which is bonded to the honeycomb structure 130.

The honeycomb-like structure 150' illustrated in FIG. 17 includes a woven honeycomb structure 152' having square or diamond shaped cells 154', and sheet metal material facings 156' bonded to close the cell ends. The structure 152' includes relatively rigid slats 158', which are joined together by a warp (not shown) to form the cells 154'. The warp is arranged in banks, as previously described, and the individual warp ends are selectively switched from one warp bank to another after each weft pick to secure the slats in the warp. Each one of the warp ends follows a zig-zag path through the material thus woven, passing first over one of the slats 158', then under another one and over the next one, and so on.

If desired, selected ones of the slats 158' may be provided with tabs (not shown) similar to the tabs 134 shown in FIG. 16 extending over the otherwise open ends of the cells 154' to provide a large area bonding surface for the facings 156'. The structure 152' may be rigidified by any desired means.

In the embodiment illustrated in FIG. 18, tapered slats 162 are used, and are woven together in a warp 164, as hereinabove described, to form a structural fabric 160 which is curved along its length. The fabric 160 is illustrated in its flat, unexpanded form as woven. The ends 166 of the slats are preferably curved to conform to a desired edge curvature of the fabric construction, and selected ones of the slats 162 may be provided with tabs (not shown) to extend over the otherwise open ends of the cells, as in the preceding embodiments. The cells in this construction may be made of hexagonal, square, or other cross-sectional shape as desired through appropriate arrangement of the weaving sequence.

Still another embodiment of the invention is illustrated in FIG. 19, which shows a woven honeycomb-like structure 170 including tubular cell members 172 bonded together in a warp 174. The individual warp ends of the warp extend in zig-zag fashion between the cell members 172, and bind them securely together. The cell members 172 may be of extruded plastic, or of any other desired material such as, for example, metal, wood or paper having the required strength.

One method of weaving this "slat" type honeycomb material is illustrated schematically in FIG. 20. According to this method, the slats 132 are pre-cut and loaded in a magazine 180 from which they are delivered to a "feed" position by any desired mechanism (not shown). The slats 132 are then pulled into the sheds 182, 183 and 184 in the warp 186 by reciprocating gripper mechanisms 188, which are driven back and forth through the sheds 182, 183 and 184 by any desired drive 190 arranged for operation in timed relationship to the operation of the lay of the loom.

According to another method illustrated in FIG. 21, the slats are cut during weaving from strips 192 of resiliently flexible material, which may be coiled in rolls 194

adjacent to the loom. The strip material 192 is drawn from the rolls 194 by the gripper mechanisms 188 and are cut to proper length by any convenient cutting means 196 when the gripper mechanisms 188 are in their fully retracted positions, that is, fully withdrawn toward the right as viewed in FIG. 21.

The method illustrated in FIG. 20 is particularly adapted for weaving a honeycomb fabric with relatively rigid slats, and with slats having tabs 134, and also for weaving honeycomb fabric with tubular slats 172. The method illustrated in FIG. 21 is adaptable for us in weaving, as previously described, relatively flexible slats of honeycomb fabric with light sheet metal or relatively thin thermoplastic or like material.

Rigidifying fabric material according to the invention and molding plastic articles reinforced with the fabric material (FIGS. 22-26)

All the hereinabove described fabric materials may be rigidified by any suitable method and with any suitable material and the fabrics are well suited for reinforcing molded plastic articles. One method of forming such reinforced articles is by the so-called matched metal technique. As illustrated in FIG. 22, fabric material 240 woven according to the invention and having rib conformable portions (not shown in this figure) extending transversely of the warp, after being suitably trimmed, is trained over a battery of rollers 242 and passed through a tank 244 containing a liquid resin 246, or other hardenable plastic mixture, and thoroughly saturated with the resin. After the fabric 240 is drawn out of the resin 246, it is passed between a pair of squeeze rolls 248, which may be power driven to draw the fabric through the bath 246. These rolls 248 squeeze excess resin from the fabric into a drain tray 250 as illustrated, or if the rolls are arranged directly over the tank 244 excess resin may drain directly back into the bath 246. In any event, the squeeze pressure of the rolls 248 may be adjusted in view of the viscosity of the resin 246 to control the amount of resin carried by the fabric material into the molding operation. After the fabric has passed through the squeeze rolls 248, it may be severed into appropriate lengths by any convenient means, diagrammatically indicated by a pair of shear blades 254.

Referring now to FIG. 23, each separate length 256 of a resin-saturated fabric is fitted upon a mandrel 258, which forms the male portion of a molding die generally designated 260. The female portion of the die 260 may comprise separate synchronously actuatable pressure plates 262 arranged to controllably press the saturated fabric material 256 upon the mandrel 258. Both the mandrel 258 and the pressure plates 262 may be provided with internal heating elements 266 so that the plastic may be cured under simultaneous heating and pressure for maximum strength. The mandrel 258 and the pressure plates 262 may be coated with a release material to facilitate release of the molded article from the die after the plastic is cured and the pressure plates 262 are withdrawn from engagement with the completed article.

Self-supporting and rigidified metal fabric material

The invention is applicable to warps and wefts or non-metallic material such as paper, cotton, linen, silk, nylon, glass, or the like, or of suitable metal such as stainless steel, copper, aluminum or bronze. The choice of material will depend upon the use to be made of the fabric material, and the properties desired therein. When the fabric material is to be used for reinforcing molded plastic articles, it may be preferred to weave the fabric material from nonmetallic material because of the usually porous nature of such materials; which facilitates plastic impregnation and ensures maximum bonding between the fabric and the plastic. The fabric can be woven from metallic material chosen for its strength, heat, and corrosion re-

sistance characteristics, according to the requirements of the end use of the fabric material.

Metal fabric, such as fabric material woven of wire or metal tape or strips may be made of varying degrees of flexibility depending on the choice of metal gauge and hardness, and may be relatively soft and flexible, or relatively stiff and rigid. If desired, the fabric material can be heat treated after it is woven and while such material is supported in its fully expanded condition, thus increasing the stiffness and strength of the material beyond the limits set by the weaving process.

For maximum rigidity, however, it is possible to bond the woven metal fabric material securely together to insure against slip, or skewing of the warp with respect to the weft. This may be done by brazing or soldering. The metal used in the weaving may be coated with braze metal or solder before it is woven, in which case the completed fabric need only be heated to the brazing or soldering temperature while it is supported in its desired extended shape. Depending upon the nature of the braze metal or solder, flux may be needed, or the heating may be done in a controlled atmosphere furnace, but many variations in this respect will be readily apparent to those skilled in the metal bonding arts.

Rigidifying honeycomb-like woven fabric material

The honeycomb-like woven fabric material may be rigidified by any suitable process and with any suitable material and is capable of being molded in plastic articles, by impregnating the fabric with a plastic or resin, cutting the same to desired lengths, and then fitting the same upon mandrels such as the mandrels 340 and 350 shown in FIGS. 24, 25 and 26. The mandrel illustrated in FIG. 24 is particularly suited for curing the open ended cell constructions and includes a plurality of fingers 342 rigidly fixed in upright position and in parallel, spaced rows upon a base 344. As shown in FIG. 25, each one of these fingers 342 is shaped to conform to and substantially fill approximately half of one of the cells of the honeycomb structure, and may, if desired, be enlarged to substantially fill the entire cell. When the plastic impregnated fabric is extended and the cells along its top and bottom are fitted over the fingers 342, the intermediate cells are drawn out to their full structural shapes. The plastic may then be cured by heat treatment, or otherwise as desired, and the resulting structure removed from the mandrel.

The mandrel 350 shown in FIG. 26 is particularly adapted for curing honeycomb-like structures having closed cells, and, in place of the relatively large cell-filling fingers 342, includes two spaced apart rows of relatively small rods or pins 352, rigidly mounted in upstanding position upon the base 354 of the mandrel 350. These rods 352 are spaced apart to fit in the corners of the cells along the top and bottom of the cellular structure to hold the plastic saturated fabric material in properly extended position during curing.

Woven metal honeycomb constructions may, if necessary, be rigidified by any suitable means such as by brazing together the individual metal strands, strips or slats throughout the fabric, as hereinabove described in connection with the ribbed constructions. For this purpose, mandrels similar to those illustrated in FIGS. 25 and 26 may be used for holding the metal fabric during brazing, but the mandrels should be made of, or provided with surface coatings, of, a material that will not become bonded to the braze metal. The use of a mandrel for brazing will, of course, be necessary only when the metal fabric is relatively soft and flexible, and is not self-supporting. Relatively stiff metal fabrics may be sufficiently rigid to support themselves during brazing, in which case no mandrel is required.

What is claimed is:

An integral multi-ply fabric conformable to a cellular structure comprising adjacent face plies of woven warp

15

and weft elements, and a rib also of woven warp and weft elements and integrally woven with said face plies, said rib ply tapering in a weftwise direction and said face plies converging toward one another, at least certain of said rib warp elements being warp elements of said face plies.

References Cited by the Examiner

UNITED STATES PATENTS

Re. 24,007	5/1955	Foster	-----	139—384	X
2,046,039	6/1936	Schaar	-----	139—384	
2,254,008	8/1941	French	-----	139—384.1	
2,424,928	7/1947	Glendinning et al.	---	139—384	

16

2,613,695	10/1952	Moberg	-----	139—384
2,715,916	8/1955	Nelson	-----	139—20
2,719,542	10/1955	MacIntyre	-----	139—409
2,732,865	1/1956	Neisler	-----	139—20
3,056,432	10/1962	Glaze	-----	139—425
3,102,559	9/1963	Koppelman	-----	139—384

FOREIGN PATENTS

Ad. 47,529	2/1937	France	-----	139—408
------------	--------	--------	-------	---------

10 ROBERT R. MACKEY, *Acting Primary Examiner.*
DONALD W. PARKER, *Examiner.*