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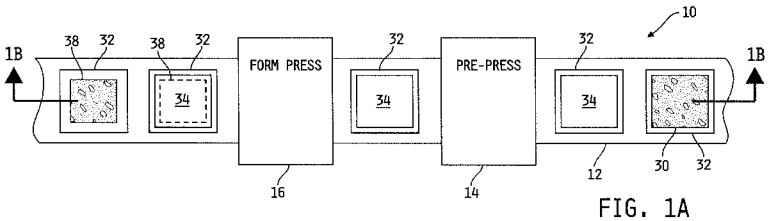


FIG. 1A

(57) Abstract: An apparatus and method are provided for producing a concrete tile from a strip of formable concrete. In one embodiment, a gas permeable membrane is positioned over the strip of formable concrete. A compression tool defines a recess surrounded by a mandrel. The inner periphery of the mandrel and the recess together define finished dimensions of the concrete tile. The strip of formable concrete and the gas permeable membrane are both sized larger than the inner periphery of the mandrel such that the mandrel contacts the gas permeable membrane and the strip of formable concrete completely about the inner periphery of the mandrel. Gas trapped in the recess of the compression tool passes through the gas permeable membrane and around the mandrel to ambient when the compression tool is pressed into the combination of the gas permeable membrane and the strip of formable concrete to produce the concrete tile.

APPARATUS AND PROCESS FOR PRODUCING CONCRETE TILE

CROSS-REFERENCE TO RELATED U.S. APPLICATION

[0001] This patent application claims the benefit of, and priority to, U.S. Provisional Patent Application Ser. No. 61/466,582, filed March 23, 2011, the disclosure of which is incorporated by reference herein.

Field Of The Invention:

[0002] The present invention relates generally to apparatuses and processes for producing an item from a formable amount of material, and more specifically to producing concrete tile from a strip of formable concrete.

BACKGROUND

[0003] It is desirable to produce concrete tile having desirable visual and physical properties. It is also desirable to produce concrete tile in a manner that facilitates uninterrupted operation of the concrete tile production process.

SUMMARY

[0004] The present invention may comprise one or more of the features recited in the attached claims, and/or one or more of the following features and combinations thereof. In one aspect, an apparatus for producing a concrete tile from a strip of formable concrete disposed on a tile carrier may comprise a gas permeable membrane positioned over the strip of formable concrete, and a compression tool defining a recess surrounded by a mandrel, the recess and inner periphery of the mandrel together defining finished dimensions of the concrete tile. The strip of formable concrete and the gas permeable membrane may both be sized larger than the inner periphery of the mandrel such that the mandrel contacts the gas permeable membrane and the strip of formable concrete completely about the inner periphery of the mandrel when the compression tool is brought into contact with the combination of the gas permeable membrane and the strip of formable concrete. The gas trapped in the recess of the compression tool passes through the membrane and around the mandrel to ambient when the compression tool is pressed into the combination of the gas permeable membrane and the strip of formable concrete to produce the concrete tile.

[0005] In another aspect, an apparatus for producing a concrete tile from a strip of formable concrete disposed on a tile carrier may comprise a membrane positioned over the strip of formable concrete, a pre-press tool defining a contact surface having a cross-sectional area sized at least as large as a cross-sectional area of a top surface of the strip of formable concrete, the contact surface configured to press the membrane onto the top surface of the strip of formable concrete, and a compression tool defining a recess surrounded by a mandrel, the recess and inner periphery of the mandrel together defining finished dimensions of the concrete tile. The compression tool may be controlled to press the recess and mandrel into the combination of the membrane and the strip of formable concrete to stamp the concrete tile with the finished dimensions from the strip of formable concrete after the pre-press tool is controlled to press the membrane onto the top surface of the strip of formable concrete.

[0006] In another aspect, an apparatus for producing a concrete tile from a strip of formable concrete disposed on a tile carrier may comprise a membrane application tool which applies a membrane over the strip of formable concrete, and a compression tool defining a recess surrounded by a mandrel, the recess and inner periphery of the mandrel together defining finished dimensions of the concrete tile. The compression tool may be controlled to press the recess and mandrel into the combination of the membrane and the strip of formable concrete to stamp the concrete tile with the finished dimensions from the strip of formable concrete after the membrane application tool applies the membrane to the top surface of the strip of formable concrete.

[0007] In another aspect, a process for producing a concrete tile from a strip of formable concrete disposed on a tile carrier may comprise placing a gas permeable membrane over the strip of formable concrete, and pressing a compression tool defining a recess surrounded by a mandrel into the combination of the gas permeable membrane and the strip of formable concrete to stamp the concrete tile from the strip of formable concrete such that the concrete tile has dimensions defined by the recess and an inner periphery of the mandrel. The strip of formable concrete and the gas permeable membrane may both be sized larger than the inner periphery of the mandrel such that the mandrel contacts the gas permeable membrane and the strip of formable concrete completely about the inner

periphery of the mandrel when the compression tool is pressed into the combination of the gas permeable membrane and the strip of formable concrete. Gas trapped in the recess of the compression tool may pass through the gas permeable membrane and around the mandrel to ambient when the compression tool is pressed into the combination of the gas permeable membrane and the strip of formable concrete to produce the concrete tile.

[0008] In another aspect, a process for producing a concrete tile from a strip of formable concrete disposed on a tile carrier may comprise pressing a membrane onto a top surface of the strip of formable concrete, and after pressing the membrane onto the top surface of the strip of formable concrete, pressing a compression tool defining a recess surrounded by a mandrel into the combination of the membrane and the strip of formable concrete to stamp the concrete tile from the strip of formable concrete such that the concrete tile has dimensions defined by the recess and an inner periphery of the mandrel. The strip of formable concrete and the membrane may both be sized larger than the inner periphery of the mandrel such that the mandrel contacts the membrane and the strip of formable concrete completely about the inner periphery of the mandrel when the compression tool is pressed into the combination of the membrane and the strip of formable concrete.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1A is a top plan view of one illustrative apparatus and process for producing concrete tile from a strip of formable concrete.

[0010] FIG. 1B is a cross-sectional view of the apparatus and process of FIG. 1A viewed along section lines 1B-1B.

[0011] FIG. 2A is a cross-sectional view of one illustrative embodiment of the pre-press apparatus of FIGS. 1A and 1B.

[0012] FIG. 2B is a cross-sectional and magnified view of the portion B of FIG. 2A illustrating the membrane, strip of formable concrete and tile carrier prior to the pre-press operation.

[0013] FIG. 2C is a cross-sectional and magnified view of the portion C of FIG. 2A illustrating the membrane, strip of formable concrete and tile carrier after the pre-press operation.

[0014] FIG. 3A is a cross-sectional view of one illustrative embodiment of the form press apparatus of FIGS. 1A and 1B illustrating the membrane, strip of formable concrete and compression tool of the form press partially through form press operation.

[0015] FIG. 3B is a cross-sectional view of the form press apparatus of FIG. 3A illustrating the membrane, strip of formable concrete and compression tool of the form press at the end of the form press operation.

[0016] FIG. 4A is a top plan view of another illustrative apparatus and process for producing concrete tile from a strip of formable concrete.

[0017] FIG. 4B is a cross-sectional view of the apparatus and process of FIG. 4A viewed along section lines 4B-4B.

[0018] FIG. 5 is a side elevational view of another illustrative embodiment of the pre-press and form press in the apparatus and process of FIGS. 4A and 4B.

[0019] FIG. 6A is a top plan view of an illustrative apparatus and process for producing concrete tile from a continuous strip of formable concrete.

[0020] FIG. 6B is a side elevational view of the apparatus and process of FIG. 6A.

DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS

[0021] For the purposes of promoting an understanding of the principles of the invention, reference will now be made to a number of illustrative embodiments shown in the attached drawings and specific language will be used to describe the same.

[0022] Referring now to FIGS. 1A and 1B, one illustrative apparatus and process 10 for producing concrete tile 38 from a strip of formable concrete 30 is shown. It will be understood that some of the dimensions of components and/or products illustrated in the attached drawings may be exaggerated from actual dimensions or from dimensions of some components and/or products relative to other components and/or products, and that this is done only for the purpose of illustrating the concepts of the disclosed subject matter.

[0023] In the embodiment illustrated in FIGS. 1A and 1B, the apparatus and process 10 includes a conveyance path 12 which sequentially transports a number of tile carriers 32 through at least a portion of a tile production process. The

conveyance path 12 is illustratively provided in the form of a conventional conveyor system. Although not illustrated in FIGS. 1A and 1B, at least portions of the conveyance system include conventional alignment structures which engage the various tile carriers 32 in a conventional manner to guide the tile carriers 32 along the apparatus and process 10. The tile carriers 32 are conventional, and may be referred to in the art as "cure boards." In one embodiment, the tile carriers 32 are illustratively formed of a resin based material, although the tile carriers 32 may alternatively be formed of other conventional materials, examples of which include, but should not be limited to, die cast materials, wood, or the like.

[0024] In the illustrated embodiment, a strip of formable concrete 30 is disposed on each sequential tile carrier 32 carried by the conveyance path 12. As used in this disclosure, the term "formable concrete" is defined as a concrete formulation that has been prepared, e.g., by mixing, but that has yet to cure to a hard, dry and final form. The formable concrete is flowable, and therefore formable, for a time period following preparation thereof, and is during this time period that the process illustrated in FIGS. 1A and 1B is carried out. Illustratively, the strips of formable concrete 30 are formed within several minutes of initial preparation of the concrete formulation. In one embodiment, the concrete formulation is that described in U.S. Patent No. 6,569,923, the disclosure of which is incorporated herein by reference, although other concrete formulations may alternatively be used without deviating from the scope of this disclosure.

[0025] The strip of formable concrete 30 may be formed using any of various techniques. In one embodiment, for example, a continuous strip or ribbon of formable concrete is formed, e.g., via a conventional extrusion process, and deposited on a continuous stream of cascaded tile carriers 32 (e.g., see FIG. 6B). The individual strips of formable concrete 30 are then illustratively formed by selectively cutting or otherwise separating the continuous strip of formable concrete such that each tile carrier 32 carries a single strip of formable concrete 30. In an alternative embodiment, each strip of formable concrete 30 is formed individually, e.g., via a conventional extruding process, and deposited on a different tile carrier 32. Other techniques and/or processes for forming the individual strips of formable concrete 30 may alternatively be used, and any such alternative techniques and/or processes are contemplated by this disclosure. In one embodiment, the thickness of

the strips of formable concrete 30 is illustratively about 240 thousandths of an inch, although other thicknesses of the strips of formable concrete 30 may alternatively be used.

[0026] As the strips of formable concrete 30 disposed on the tile carriers 32 advance along the conveyance path 12, a membrane 34 is positioned over each strip of formable concrete 30. Illustratively, the membrane 34 has length and width dimensions at least as great as the length and width dimensions of the strips of formable tile 30, and in one embodiment the membrane 34 has length and width dimensions slightly greater than those of the strip of formable tile 30 such that the outer periphery of the membrane 34 extends slightly beyond the outer periphery of the strips of formable tile 30 as illustrated in FIG. 1B. In one embodiment, the membrane 34 is illustratively gas permeable. In other embodiments, the membrane 34 may be gas impermeable. Examples of each will be described in greater detail hereinafter. In the process illustrated in FIGS. 1A and 1B, placement of the membrane 34 over the strips of formable tile 30 is illustratively a manual process carried out by a technician, although this disclosure contemplates alternate embodiments which include automatic placement of the membrane 34 over the strips of formable tile 30 as will be described in greater detail hereinafter.

[0027] In the embodiment illustrated in FIGS. 1A and 1B, a pre-press unit 14 is provided along the conveyance path 12. In one embodiment, the pre-press is a 40-ton press, although this disclosure contemplates alternative embodiments in which different weight presses may alternatively be used. In any case, the pre-press 14 includes a contact head 20 defining a rigid contact surface 22. The contact surface 22 illustratively has a cross-sectional area sized at least as large as a cross-sectional area of a top surface of the strip of formable concrete 30 so that the contact surface 22 contacts the entirety of the top surface of the strip of formable concrete 30 via the membrane 34. The pre-press 14 is controllable, e.g., either manually or via computer control, to press the contact surface 22 upon the combination 36 of the membrane 34 and the top of the strip of formable concrete 30.

[0028] The pre-press 14 serves at least two purposes. One purpose of the pre-press 14 is to press the membrane 34 against the top surface of the strip of formable concrete 30 in preparation for the form press 16 positioned downstream on the conveyance path 12. Referring to FIGS. 2A – 2C, for example, placement of the

membrane 34 over the top surface of the strip of formable tile 30 may result in a small gap, G, between the membrane 34 and the top surface of the strip of formable concrete 30, e.g., see FIG. 2B. Such a gap, G, may be uniform across the top surface of the strip of formable concrete 30, or may appear in the form of several non-uniform pockets along the top surface of the strip of formable concrete 30. Pressing of the contact surface 22 of the pre-press 14 against the combination 36 of the membrane 34 and strip of formable concrete 30 serves to press together the bottom surface of the membrane 34 and the top surface of the strip of formable concrete 30 to eliminate, or at least greatly reduce, any such air gap(s) G as illustrated in FIG. 2C.

[0029] In some embodiments, the tile carriers 32 may define a textured, embossed and/or porous top surface which results in a textured or embossed bottom surface of the resulting finished tile product after the pressing operations described herein. One example of such a textured top surface of a tile carrier 32 is illustrated in FIGS. 2B and 2C as a series of tooth-shaped recesses 50 extending across the top surface of the illustrated tile carrier 32. In such embodiments, air and/or other gas 52 may be trapped between the bottom surface of the strip of formable concrete 30 and the top surface of the tile carrier 32 as illustrated in FIG. 2A, and another purpose of the pre-press 14 is to press the bottom surface of the strip of formable concrete 30 against and into the top surface of the tile carrier 32 to thereby remove air and/or other gas 52 trapped between the tile carrier 32 and the bottom surface of the strip of formable concrete 30 as illustrated in FIG. 2B. In such embodiments in which the tile carriers 32 define a textured, embossed and/or porous top surface, yet another purpose of the pre-press 14 is to press the bottom surface of the strip of formable concrete 30 into the textured top surface of the tile carrier 32 to impress a corresponding textured surface into the bottom surface of the strip of formable concrete 30 as further illustrated in FIG. 2B.

[0030] In the embodiment shown in FIGS. 1B and 2B, the contact surface 22 of the contact head 20 of the pre-press 14 illustratively has a convex shape. In such embodiments, as the contact head is lowered and pressed into the combination 36 of the membrane 34 and the strip of formable concrete 30, it contacts the combination 36 of the membrane 34 and the top surface of the strip of formable concrete 30 first in the center of the membrane 34 and top surface of the strip of formable concrete

30 and then progressively toward the outer periphery thereof. This causes the center of the bottom surface of the strip of formable concrete 30 to be first pressed against and into the top surface of the tile carrier 32, and any trapped air and/or other gas is then forced outwardly from the periphery of the interface between the strip of formable concrete 30 and the top surface of the tile carrier 32 as the contact surface 22 is pressed into the combination 36 of the membrane 34 and the strip of formable concrete 30. In embodiments in which the membrane 34 is gas impermeable, any air and/or other gas trapped between the membrane 34 and the top surface of the strip of formable concrete 30 is likewise released about the periphery of the interface between the membrane 34 and the top surface of the strip of formable concrete 30 as the contact surface 22 is pressed into the combination 36 of the membrane 34 and the strip of formable concrete 30. In some alternate embodiments, the contact surface 22 of the contact head 20 of the pre-press 14 may have a shape other than convex. In other alternative embodiments, the contact head 20 may define a flexible or semi-flexible contact surface 20 defining a generally convex surface before contacting the combination 36 of the membrane 34 and the top of the strip of formable concrete 30. In one such embodiment, for example, the contact head 20 may be provided in the form of a flexible or semi-flexible bladder, e.g., formed of rubber or other suitable material, and in this embodiment the contact head 20 is connected to a conventional source of compressed gas, e.g., air, to inflate the flexible or semi-flexible bladder to a substantially constant pressure. In this embodiment, the flexible or semi-flexible bladder first contacts the center portion of the combination 36 of the membrane 34 and the top of the strip of formable concrete 30 as the contact surface 22 is controlled downwardly toward the combination 36, and the flexible or semi-flexible bladder then flattens out as the contact surface 22 is pressed into the combination 36 of the membrane 34 and the top of the strip of formable concrete 30. This results in the top surface of the strip of formable concrete 30 having a substantially flat or planar surface following the pre-press operation. In still other alternate embodiments, the pre-press 14 may be omitted and the conveyance path 12 may sequentially pass the tile carriers 32 with the combination 36 of the membrane 34 and strip of formable concrete 30 on each directly to a form press 16.

[0031] Referring again to FIGS. 1A and 1B, the conveyance path 12 moves the sequential combinations 36 of the membrane 34 and strip of formable concrete 30 from the pre-press 14 to a form press unit 16 positioned downstream of the pre-press unit 14. In one embodiment, the form press 70 is illustratively a 70-ton press hydraulic form press configured to form a single concrete tile from a single strip of formable concrete 30, although this disclosure contemplates alternative embodiments in which different weight presses may alternatively be used and/or in which multiple concrete tiles are formed from correspondingly multiple strips of formable concrete 30 during each press cycle of the form press 70. In any case, the form press 16 in the illustrated embodiment includes a compression tool 24 defining a recess 26 surrounded by a mandrel 28. The recess 26 and the inner periphery of the mandrel 28 together define the finished dimensions of the concrete tile 38 resulting from the form press operation. In one embodiment, the finished dimensions of the concrete tile 38 are less than the thickness, width and length of the strip of formable concrete 30. In some alternative embodiments, the width and/or length of the strip of formable concrete 30 is/are less than that of the finished dimensions of the concrete tile 38, and the thickness of the strip of formable concrete is greater than that of the finished thickness of the concrete tile such that operation of the form press 70 causes the thickness of the strip of formable concrete 30 to decrease while also expanding the width and/or length thereof. In any case, the form press 16 is controllable, e.g., either manually or via computer control, to press the compression tool 24 upon and into the combination 36 of the membrane 34 and the top of the strip of formable concrete 30.

[0032] Referring now to FIGS. 3A and 3B, operation of the form press 16 and the compression tool 24 as the compression tool 24 is pressed upon and into the combination 36 of the membrane 34 and the strip of formable concrete 30 is illustrated. In the illustrated embodiment, the strip of formable concrete 30 and the membrane 34 are both sized larger than the inner periphery of the mandrel 28, which is also the outer periphery of the recess 26, such that at least a portion of the mandrel 28 contacts the membrane 34 and the strip of formable concrete 30 completely about the inner periphery of the mandrel 28 when the compression tool 24 is brought into contact with the combination 36 of the membrane 34 and the strip of formable concrete 30. As the mandrel 26 penetrates the surface of the strip of

formable concrete 30 in the downward direction, D, of the form press 16, it takes with it the membrane 34 as illustrated in FIG. 3A. As the compression tool 24 continues advancing downwardly in the direction D, the terminal surface of the recess 26 contacts the membrane 34 and presses the membrane 34 and top surface of the strip of formable concrete 30 downwardly. The concrete tile 38 is produced by this stamping process with its finished dimensions as the mandrel 28 reaches the top surface of the tile carrier 32, as illustrated in FIG. 3B. The top surface of the strip of formable concrete 30, having an initial height or thickness T_1 above the tile carrier 32 as illustrated in FIG. 3A, is pressed down to its finished height or thickness T_2, as illustrated in FIG. 3B, by the terminal surface of the recess 26 of the compression tool 24, and the inner periphery of the mandrel 28 defines the length and width of the concrete tile. The finished thickness T_2 may be, but need not be, slightly less than the thickness T_1 of the strip of formable concrete 30. The foregoing tile stamping process produces some amount of waste concrete 40 about the periphery of the mandrel 28 which is discarded, e.g., manually or by machinery, when the form press 16 returns upwardly to its starting position.

[0033] Referring again to FIGS. 1A and 1B, the membrane 34 is removed, as is the waste concrete 40, following formation of the concrete tile 38 by the form press 16, and the concrete tile 38 is then further processed, e.g., sealed and/or cured, to its finished form.

[0034] In one illustrative embodiment, as briefly described hereinabove, the membrane 34 is a gas permeable membrane, and in this embodiment air and/or other gas 60 trapped within the recess 26 as the mandrel 28 advances into the strip of formable concrete 30 escapes the recess 26 by passing through the gas permeable membrane 34 and around the mandrel 28 to ambient as graphically illustrated by the flow arrows 62. In alternate embodiments, the membrane 34 may be gas impermeable, and in some such embodiments the compression tool 24 may be vented in the recess 26 and/or the mandrel 28 to allow air and/or other gas 60 trapped in the recess 26 during operation of the form press 16 to escape to ambient. In still other alternate embodiments, the membrane 34 may be gas impermeable if the compression tool 24 is not vented but if the pre-press 14 is included in the apparatus and process 10 and sufficiently reduces trapped air and/or other gas as described hereinabove such that any air and/or other gas trapped in the recess 26

does not produce undesirable structural features in the concrete tile 38 resulting from operation of the form press 16. Regardless of whether the membrane 34 is gas permeable or gas impermeable, one independent purpose of the membrane 34 is to provide a barrier to concrete deposition on the compression tool 24. Because the membrane 34 is positioned at all times between the strip of formable concrete 30 and all surfaces of the compression tool 24, i.e., the recess 26 and the mandrel 28, the membrane 34 keeps the compression tool 24 from coming into contact with concrete 30, thereby keeping the compression 24 unsoiled by concrete and providing for complete release of the compression tool 24 from the concrete tile 38. The form press 16 may thus be operated many times in succession to form successive concrete tiles 38 without cleaning the compression tool 24.

[0035] Regardless of whether the membrane 34 is gas permeable or gas impermeable, the texture of the surface of the membrane 34 that contacts the surface of the strip of formable concrete 30 will necessarily be imprinted on the surface of the resulting concrete tile 38. In embodiments in which the membrane 34 is gas permeable, a non-woven material, e.g., a polyester fabric or cotton fabric, may illustratively be used to produce a concrete tile 38 with a smooth top surface. In one alternate embodiment, a woven texture may be desired in which case the gas permeable membrane 34 may be a woven fabric. In embodiments in which the membrane 34 is gas impermeable, a smooth, gas impermeable material, e.g., polypropylene sheet, may illustratively be used to produce a concrete tile. Generally, the membrane 34 may be a synthetic or non-synthetic material. Illustratively, the membranes 34 may be recycled and/or reused. In embodiments in which the membrane 34 is gas permeable or gas impermeable, it may be desirable to produce the concrete tile 38 with a textured surface in which case a correspondingly textured membrane 34 may be used. For example, the membrane 34 may be embossed with the mirror image of a desired surface pattern, and when used with the form press 16 as described above the desired surface pattern will be transferred by the embossed pattern of the membrane 34 onto the top surface of the concrete tile 38.

[0036] Referring now to FIGS. 4A and 4B, another illustrative apparatus and process 10' for producing concrete tile 38 from a strip of formable concrete 30 is shown. The apparatus and process 10' is identical in many respects to the apparatus and process 10 illustrated in FIGS. 1A-3B, and like numbers are therefore

used to identify like components and functions. The apparatus and process 10' differs from the apparatus and process 10 in that the pre-press unit 14' includes a membrane application tool 70 that positions a membrane 34 over each strip of formable concrete 30 as the tile carriers 32 carrying the strips of concrete tile 30 are sequentially transported along the conveyance path 12. The membrane 34 may be gas permeable or gas impermeable, and may have any one or more of the physical attributes described hereinabove with respect to FIGS. 1A-1B. In the illustrated embodiment, the membrane application tool 70 dispenses membrane 34, e.g., from a roll of membrane material, downwardly to the contact head 20 of the pre-press tool 14'. As the pre-press unit 14' moves downwardly into contact with the top surface of the strip of formable concrete 30, the contact head 20 presses the membrane material onto the strip of formable concrete 30 and cuts the individual membranes 34 from the roll of membrane material such that the individual membranes 34 are positioned on the top surface of the strips of formable concrete 30 just prior to the pre-press process as described hereinabove. As illustrated in FIG. 5, an alternate embodiment of the pre-press 14'' in a modified apparatus and process 10'' applies the membranes 34 to multiple, e.g., two, strips of formable concrete 30 during each press cycle. In this embodiment, the membrane 34' illustratively is not cut between each adjacent tile carrier 32 but is rather cut after every other tile carrier 32 such that a single membrane 34' is simultaneously applied by an appropriately sized contact head 20' to two adjacent strips of formable concrete 30 during each pre-press operation. An alternate form press 16' is also provided in the apparatus and process 10'' which includes two side-by-side compression tools 24_1 and 24_2 each of which are identical to the compression tool 24 illustrated and described with respect to FIGS. 1A, 1B, 3A and 3B. In this alternate embodiment, the form press 70' is illustratively a 200-ton hydraulic form press configured to form two concrete tiles from two separate strips of formable concrete 30 during each form press operation, although this disclosure contemplates alternative embodiments in which different weight form presses may alternatively be used.

[0037] Referring now to FIGS. 6A and 6B, yet another illustrative apparatus and process 10''' for producing concrete tile 38 is shown. The apparatus and process 10''' is identical in some respects to the apparatus and process 10 illustrated in FIGS. 1A-3B, and like numbers are therefore used to identify like components and

functions. The apparatus and process 10''' differs from the apparatus and process 10 in that a continuous membrane 34'' is applied via a membrane application tool 100 to a continuous strip of formable concrete 30' disposed on a number of cascaded tile carriers 32 moving along the conveyance path 12, and the individual combinations 36 of the membrane 34 and strip of formable concrete 30 on each tile carrier 32 are cut by a cutting tool 110 downstream of the membrane application tool. In the embodiment illustrated in FIGS. 6A-B, a pick and place tool, e.g., robot, 80 sequentially places tile carriers 32 on the conveyance path 12 to form a number of adjacent, cascaded tile carriers 32 moving along the conveyance path 12. In one embodiment, the cascaded tile carriers 32 are placed on the conveyance path with a gap or space between each, although this disclosure contemplates embodiments in which the cascaded tile carriers 32 alternatively abut each other. Downstream of the pick and place tool 80 is an extruder 90 which operates to apply a continuous strip of formable concrete 30' onto the number of cascaded tile carriers 32 moving along the conveyance path 12. Illustratively, the extruder 90 operates in a conventional manner and the thickness of the continuous strip of formable concrete 30' is illustratively the same as, or similar to, that described hereinabove with respect to the individual strips of formable concrete 30.

[0038] In the illustrated embodiment, the membrane application tool 100 includes a membrane application roll 104 containing a continuous strip of the membrane 34 and a membrane roller 102 which rolls the continuous strip of the membrane 34'' into the top surface of the continuous strip of formable concrete 30'. The continuous strip of membrane 34'' may be gas permeable or gas impermeable, and may have any one or more of the physical attributes of the membrane 34 described hereinabove with respect to FIGS. 1A-1B. In one embodiment, the roller 102 is configured to apply sufficient force to the combination of the continuous membrane strip 34'' and the continuous strip of formable concrete 30' when rolling the continuous membrane strip 34'' onto the continuous strip of formable concrete 30' to press the bottom surface of the continuous strip of formable concrete 30' against the top surface of each tile carrier 32 to remove any air and/or other gas trapped between the bottom surface of the continuous strip of formable concrete 30' and the top of the tile carriers 32. In embodiments in which the tile carriers 32 define a textured top surface, such force applied by the roller 102 to the combination of the

continuous membrane strip 34'' and the continuous strip of formable concrete 30' when rolling the continuous membrane strip 34'' onto the continuous strip of formable concrete 30' also presses the bottom surface of the continuous strip of formable concrete 30' into the textured top surface of the tile carriers 32 such that a corresponding textured surface is impressed into the bottom surface of the continuous strip of formable concrete 30'. The roller 102 thus takes the place in the apparatus and process 10''' of the pre-press unit 14 described hereinabove in the apparatuses and processes 10 and 10'. It will be understood that such a roller 102 may alternatively be used in the apparatus and process 10, 10' or 10'' in place of the pre-press 14, 14' or 14''.

[0039] Downstream of the roller 102 is a cutting tool 110, e.g., a wire cutter, which is controllable, e.g., manually or via computer control, to cut the combinations 36 of the membrane 34 and strip of formable concrete 30 from the continuous strips of membrane 34'' and formable concrete 30' such that one combination 36 of a membrane 34 and a strip of formable concrete 30 is positioned on each tile carrier 32. Although not shown in FIGS. 6A and 6B, a form press 16 or 16'' is positioned along the conveyance path 12 and is operable as described hereinabove to produce the concrete tiles 38.

[0040] While the strips of formable concrete 30 and the concrete tile 34 are illustrated in the FIGS as being generally square in shape, it will be understood that the strips 30 and/or concrete tile 34 may alternatively be formed in other shapes. In such other embodiments, the membrane 34 will typically be provided and/or cut in a shape similar to that of the corresponding strip of formable concrete 30.

[0041] It will be understood that this disclosure contemplates embodiments of the process 10, 10', 10'' and/or 10'''' in which the pre-press tool 14, 14', 14'' or roll press 100 is omitted such that a membrane 34 is not applied to the top surface of the strips of formable concrete 30 by any such tool and/or process. In such embodiments, the form press 16, 16' may include a membrane application tool which places the membrane 34 onto the top surface of the strips of formable concrete 30 prior to the stamping operation of the form press 16, 16'. In other illustrative embodiments, the membrane 34 may be omitted, and in such embodiments the compression tool 24 may be vented in the recess 26 and/or the mandrel 28, or may otherwise be porous, to allow air and/or other gas 60 trapped in the recess 26 during

operation of the form press 16 to escape to ambient. In such embodiments, the pre-press 14 and/or roller 100 may further be included for the purpose of releasing air trapped between the strips of formable concrete 30 and the tile carriers 32, although this disclosure contemplates embodiments in which the pre-press 14 and/or roller 100 are omitted.

[0042] While the invention has been illustrated and described in detail in the foregoing drawings and description, the same is to be considered as illustrative and not restrictive in character, it being understood that only illustrative embodiments thereof have been shown and described and that all changes and modifications that come within the spirit of the invention are desired to be protected.

What is claimed is:

1. An apparatus for producing a concrete tile from a strip of formable concrete disposed on a tile carrier, the apparatus comprising:

a gas permeable membrane positioned over the strip of formable concrete, and

a compression tool defining a recess surrounded by a mandrel, the recess and inner periphery of the mandrel together defining finished dimensions of the concrete tile,

wherein the strip of formable concrete and the gas permeable membrane are both sized larger than the inner periphery of the mandrel such that the mandrel contacts the gas permeable membrane and the strip of formable concrete completely about the inner periphery of the mandrel when the compression tool is brought into contact with the combination of the gas permeable membrane and the strip of formable concrete,

and wherein gas trapped in the recess of the compression tool passes through the membrane and around the mandrel to ambient when the compression tool is pressed into the combination of the gas permeable membrane and the strip of formable concrete to produce the concrete tile.

2. The apparatus of claim 1 further comprising a pre-press tool defining a contact surface having a cross-sectional area sized at least as large as a cross-sectional area of a top surface of the strip of formable concrete, the contact surface configured to press the gas permeable membrane onto the top surface of the strip of formable concrete.

3. The apparatus of claim 2 wherein the pre-press tool is controllable, prior to production of the concrete tile by the compression tool, to press the contact surface upon the combination of the gas permeable membrane and the strip of formable concrete sufficiently to press the gas permeable membrane against the top surface of the strip of formable concrete.

4. The apparatus of either of claims 2 and 3 wherein the tile carrier defines a top surface supporting the strip of formable concrete,

and wherein the pre-press tool is controllable, prior to production of the concrete tile by the compression tool, to press the contact surface upon the combination of the gas permeable membrane and the strip of formable concrete sufficiently to press a bottom surface of the strip of formable concrete against the top surface of the tile carrier to thereby remove air trapped between the tile carrier and the bottom surface of the strip of formable concrete.

5. The apparatus of either of claims 2 and 3 wherein the tile carrier defines a textured surface supporting the strip of formable concrete,

and wherein the pre-press tool is controllable, prior to production of the concrete tile by the compression tool, to press the contact surface upon the combination of the gas permeable membrane and the strip of formable concrete sufficiently to press a bottom surface of the strip of formable concrete into the textured surface of the tile carrier to impress a corresponding textured surface into the bottom surface of the strip of formable concrete.

6. The apparatus of any of claims 2-5 wherein the contact surface of the pre-press tool is convex-shaped.

7. The apparatus of any of claims 2-5 wherein the pre-press tool comprises a membrane application tool which positions the gas permeable membrane over the strip of formable concrete.

8. The apparatus of claim 1 further comprising a membrane application tool which positions the gas permeable membrane over the strip of formable concrete.

9. The apparatus of claim 8 wherein the membrane application tool comprises a roller which rolls the gas permeable membrane onto a top surface of the strip of formable concrete.

10. The apparatus of claim 9 wherein the tile carrier defines a top surface supporting the strip of formable concrete,

and wherein the membrane application tool is controllable, prior to production of the concrete tile by the compression tool, to apply sufficient force to the combination of the gas permeable membrane and the strip of formable concrete when the roller is rolling the gas permeable membrane onto the top surface of the strip of formable concrete to press a bottom surface of the strip of formable concrete against the top surface of the tile carrier to thereby remove air trapped between the tile carrier and the bottom surface of the strip of formable concrete.

11. The apparatus of either of claims 9 and 10 wherein the tile carrier defines a textured surface supporting the strip of formable concrete,

and wherein the membrane application tool is controllable, prior to production of the concrete tile by the compression tool, to apply sufficient force to the combination of the gas permeable membrane and the strip of formable concrete when the roller is rolling the gas permeable membrane onto the top surface of the strip of formable concrete to press a bottom surface of the strip of formable concrete into the textured surface of the tile carrier to impress a corresponding textured surface into the bottom surface of the strip of formable concrete.

12. The apparatus of any of claims 9-11 further comprising means for disposing a continuous strip of the formable concrete onto a plurality of cascaded tile carriers moving along a conveyance path,

and wherein the membrane application tool applies a continuous strip of the gas permeable membrane to a top surface of the continuous strip of formable concrete.

13. The apparatus of claim 12 further comprising a cutting tool which cuts the combination of the continuous strip of the gas permeable membrane and the continuous strip of formable concrete as the plurality of cascaded tiles move along the conveyance path such that each of the plurality of cascaded tile carriers thereafter carries a single strip of formable concrete with a corresponding gas permeable membrane positioned on the top surface of the strip of formable concrete.

14. The apparatus of any of the preceding claims wherein the concrete tile is produced with the finished dimensions as the mandrel reaches the tile carrier when the compression tool is pressed into the combination of the gas permeable membrane and the strip of formable concrete to thereby stamp the concrete tile from the strip of formable concrete.

15. The apparatus of claims 1 wherein the compression tool comprises a membrane application tool which positions the gas permeable membrane over the strip of formable concrete.

16. The apparatus of any of the preceding claims wherein the gas permeable membrane comprises a non-woven material.

17. The apparatus of any of the preceding claims wherein the gas permeable membrane comprises one of a synthetic and a non-synthetic fabric.

18. The apparatus of claim 17 wherein the gas permeable membrane comprises a synthetic fabric, and wherein the synthetic fabric is a polyester fabric.

19. The apparatus of claim 17 wherein the gas permeable membrane comprises a non-synthetic fabric, and wherein the non-synthetic fabric is a cotton fabric.

20. The apparatus of any of the preceding claims wherein the gas permeable membrane is a reusable or recycled membrane.

21. The apparatus of any of the preceding claims wherein the gas permeable membrane comprises a woven material.

22. The apparatus of any of the preceding claims wherein the gas permeable membrane is embossed to impress a correspondingly embossed pattern into a top surface of the strip of formable concrete.

23. The apparatus of any of the preceding claims wherein the gas permeable membrane is textured to impress a correspondingly textured pattern into a top surface of the strip of formable concrete.

24. An apparatus for producing a concrete tile from a strip of formable concrete disposed on a tile carrier, the apparatus comprising:

a membrane positioned over the strip of formable concrete,

a pre-press tool defining a contact surface having a cross-sectional area sized at least as large as a cross-sectional area of a top surface of the strip of formable concrete, the contact surface configured to press the membrane onto the top surface of the strip of formable concrete, and

a compression tool defining a recess surrounded by a mandrel, the recess and inner periphery of the mandrel together defining finished dimensions of the concrete tile,

wherein the compression tool is controlled to press the recess and mandrel into the combination of the membrane and the strip of formable concrete to stamp the concrete tile with the finished dimensions from the strip of formable concrete after the pre-press tool is controlled to press the membrane onto the top surface of the strip of formable concrete.

25. The apparatus of either of claim 24 wherein tile carrier defines a top surface supporting the strip of formable concrete,

and wherein the pre-press tool is controllable, prior to production of the concrete tile by the compression tool, to press the contact surface upon the combination of the membrane and the strip of formable concrete sufficiently to press a bottom surface of the strip of formable concrete against the top surface of the tile carrier to thereby remove air trapped between the tile carrier and the bottom surface of the strip of formable concrete.

26. The apparatus of either of claims 24 and 25 wherein the tile carrier defines a textured surface supporting the strip of formable concrete,

and wherein the pre-press tool is controllable, prior to production of the concrete tile by the compression tool, to press the contact surface upon the combination of the membrane and the strip of formable concrete sufficiently to press a bottom surface of the strip of formable concrete into the textured surface of the tile carrier to impress a corresponding textured surface on the bottom surface of the strip of formable concrete.

27. The apparatus of any of claims 24-26 wherein the contact surface of the pre-press tool is convex-shaped.

28. The apparatus of any of claims 24-27 wherein the pre-press tool comprises a membrane application tool which positions the membrane over the strip of formable concrete.

29. The apparatus of any of claims 24-28 wherein the strip of formable concrete and the membrane are both sized larger than the inner periphery of the mandrel such that the mandrel contacts the membrane and the strip of formable concrete completely about the inner periphery of the mandrel when the compression tool is pressed into the combination of the membrane and the strip of formable concrete to form the concrete tile having the finished dimensions.

30. The apparatus of any of claims 24-29 wherein the membrane is gas permeable.

31. The apparatus of claim 30 wherein the gas permeable membrane comprises a non-woven material.

32. The apparatus of either of claims 30 and 31 wherein the gas permeable membrane comprises one of a synthetic and a non-synthetic fabric.

33. The apparatus of claim 32 wherein the gas permeable membrane comprises a synthetic fabric, and wherein the synthetic fabric is a polyester fabric.

34. The apparatus of claim 32 wherein the gas permeable membrane comprises a non-synthetic fabric, and wherein the non-synthetic fabric is a cotton fabric.

35. The apparatus of any of claims 32-34 wherein the gas permeable membrane is a reusable or recycled membrane.

36. The apparatus of claim 35 wherein the gas permeable membrane comprises a woven material.

37. The apparatus of any of claims 24-29 wherein the membrane is gas impermeable.

38. The apparatus of any of claims 24-37 wherein the membrane is embossed to impress a correspondingly embossed pattern into a top surface of the strip of formable concrete.

39. The apparatus of any of claims 24-37 wherein the membrane is textured to impress a correspondingly textured pattern into a top surface of the strip of formable concrete.

40. An apparatus for producing a concrete tile from a strip of formable concrete disposed on a tile carrier, the apparatus comprising:

a membrane application tool which applies a membrane over the strip of formable concrete, and

a compression tool defining a recess surrounded by a mandrel, the recess and inner periphery of the mandrel together defining finished dimensions of the concrete tile,

wherein the compression tool is controlled to press the recess and mandrel into the combination of the membrane and the strip of formable concrete to stamp

the concrete tile with the finished dimensions from the strip of formable concrete after the membrane application tool applies the membrane to the top surface of the strip of formable concrete.

41. The apparatus of claim 40 wherein the membrane application tool comprises a roller which rolls the membrane onto a top surface of the strip of formable concrete.

42. The apparatus of claim 41 wherein the tile carrier defines a top surface supporting the strip of formable concrete,

and wherein the membrane application tool is controllable, prior to production of the concrete tile by the compression tool, to apply sufficient force to the combination of the membrane and the strip of formable concrete when the roller is rolling the membrane onto the top surface of the strip of formable concrete to press a bottom surface of the strip of formable concrete against the top surface of the tile carrier to thereby remove air trapped between the tile carrier and the bottom surface of the strip of formable concrete.

43. The apparatus of either of claims 41 and 42 wherein the tile carrier defines a textured surface supporting the strip of formable concrete,

and wherein the membrane application tool is controllable, prior to production of the concrete tile by the compression tool, to apply sufficient force to the combination of the membrane and the strip of formable concrete when the roller is rolling the membrane onto the top surface of the strip of formable concrete to press a bottom surface of the strip of formable concrete into the textured surface of the tile carrier to impress a corresponding textured surface into the bottom surface of the strip of formable concrete.

44. The apparatus of any of claims 40-43 further comprising means for disposing a continuous strip of the formable concrete onto a plurality of cascaded tile carriers moving along a conveyance path,

and wherein the membrane application tool applies a continuous strip of the membrane to a top surface of the continuous strip of formable concrete.

45. The apparatus of claim 44 further comprising a cutting tool which cuts the combination of the continuous strip of the membrane and the continuous strip of formable concrete as the plurality of cascaded tiles move along the conveyance path such that each of the plurality of cascaded tile carriers thereafter carries a single strip of formable concrete with a corresponding membrane positioned on the top surface of the strip of formable concrete.

46. The apparatus of claims 40-45 wherein the concrete tile is produced with the finished dimensions as the mandrel reaches the tile carrier when the compression tool is pressed into the combination of the membrane and the strip of formable concrete to thereby stamp the concrete tile from the strip of formable concrete.

47. The apparatus of any of claims 40-46 wherein the membrane is gas permeable.

48. The apparatus of claim 47 wherein the gas permeable membrane comprises a non-woven material.

49. The apparatus of either of claims 47 and 48 wherein the gas permeable membrane comprises one of a synthetic and a non-synthetic fabric.

50. The apparatus of claim 49 wherein the gas permeable membrane comprises a synthetic fabric, and wherein the synthetic fabric is a polyester fabric.

51. The apparatus of claim 49 wherein the gas permeable membrane comprises a non-synthetic fabric, and wherein the non-synthetic fabric is a cotton fabric.

52. The apparatus of any of claims 49-51 wherein the gas permeable membrane is a reusable or recycled membrane.

53. The apparatus of any of claims 49-51 wherein the gas permeable membrane comprises a woven material.

54. The apparatus of any of claims 40-46 wherein the membrane is gas impermeable.

55. The apparatus of any of claims 40-54 wherein the membrane is embossed to impress a correspondingly embossed pattern into a top surface of the strip of formable concrete.

56. The apparatus of any of claims 40-54 wherein the membrane is textured to impress a correspondingly textured pattern into a top surface of the strip of formable concrete.

57. A process for producing a concrete tile from a strip of formable concrete disposed on a tile carrier, the process comprising:

placing a gas permeable membrane over the strip of formable concrete, and

pressing a compression tool defining a recess surrounded by a mandrel into the combination of the gas permeable membrane and the strip of formable concrete to stamp the concrete tile from the strip of formable concrete such that the concrete tile has dimensions defined by the recess and an inner periphery of the mandrel, wherein the strip of formable concrete and the gas permeable membrane are both sized larger than the inner periphery of the mandrel such that the mandrel contacts the gas permeable membrane and the strip of formable concrete completely about the inner periphery of the mandrel when the compression tool is pressed into the combination of the gas permeable membrane and the strip of formable concrete,

and wherein gas trapped in the recess of the compression tool passes through the gas permeable membrane and around the mandrel to ambient when the compression tool is pressed into the combination of the gas permeable membrane and the strip of formable concrete to produce the concrete tile.

58. The process of claim 57 further comprising pressing a pre-press tool onto the combination of the gas permeable membrane and the strip of formable concrete, prior to pressing the compression tool into the combination of the gas permeable membrane and the strip of formable concrete, sufficiently to press the gas permeable membrane onto a top surface of the strip of formable concrete.

59. The process of either of claims 57 and 58 wherein the tile carrier defines a top surface supporting the strip of formable concrete,

and wherein the process further comprises pressing a pre-press tool onto the combination of the gas permeable membrane and the strip of formable concrete, prior to pressing the compression tool into the combination of the gas permeable membrane and the strip of formable concrete, sufficiently to press a bottom surface of the strip of formable concrete against the top surface of the tile carrier to remove air trapped between the tile carrier and the bottom surface of the strip of formable concrete.

60. The process of any of claims 57-59 wherein the tile carrier defines a textured surface supporting the strip of formable concrete,

and wherein the process further comprises pressing a pre-press tool onto the combination of the gas permeable membrane and the strip of formable concrete, prior to pressing the compression tool into the combination of the gas permeable membrane and the strip of formable concrete, sufficiently to press a bottom surface of the strip of formable concrete into the textured surface of the tile carrier to impress a corresponding textured surface into the bottom surface of the strip of formable concrete.

61. The process of any of claims 57-60 wherein the gas permeable membrane is embossed,

and wherein pressing the compression tool into the combination of the gas permeable membrane and the strip of formable concrete causes the gas permeable membrane to impress a correspondingly embossed pattern into a top surface of the strip of formable concrete.

62. The process of any of claims 57-60 wherein the gas permeable membrane is textured,

and wherein pressing the compression tool into the combination of the gas permeable membrane and the strip of formable concrete causes the gas permeable membrane to impress a correspondingly textured pattern into a top surface of the strip of formable concrete.

63. A process for producing a concrete tile from a strip of formable concrete disposed on a tile carrier, the process comprising:

pressing a membrane onto a top surface of the strip of formable concrete, and

after pressing the membrane onto the top surface of the strip of formable concrete, pressing a compression tool defining a recess surrounded by a mandrel into the combination of the membrane and the strip of formable concrete to stamp the concrete tile from the strip of formable concrete such that the concrete tile has dimensions defined by the recess and an inner periphery of the mandrel, wherein the strip of formable concrete and the membrane are both sized larger than the inner periphery of the mandrel such that the mandrel contacts the membrane and the strip of formable concrete completely about the inner periphery of the mandrel when the compression tool is pressed into the combination of the membrane and the strip of formable concrete.

64. The process of claim 63 further comprising disposing a continuous strip of the formable concrete onto a plurality of cascaded tile carriers moving along a conveyance path,

and wherein pressing a membrane onto a top surface of the strip of formable concrete comprises applies a continuous strip of the membrane to a top surface of the continuous strip of formable concrete.

65. The process of claim 64 further comprising cutting the combination of the continuous strip of the membrane and the continuous strip of formable concrete as the plurality of cascaded tiles move along the conveyance path such that each of the plurality of cascaded tile carriers thereafter carries a single strip of formable

concrete with a corresponding membrane positioned on the top surface of the strip of formable concrete.

66. The process of claim 63 further comprising positioning the membrane on a top surface of the strip of formable concrete,

and wherein pressing a membrane onto a top surface of the strip of formable concrete comprises pressing a pre-press tool onto the combination of the membrane and the strip of formable concrete, prior to pressing the compression tool into the combination of the membrane and the strip of formable concrete, sufficiently to press the membrane onto a top surface of the strip of formable concrete

67. The process of any of claims 63-66 wherein the membrane is a gas permeable membrane such that gas trapped in the recess of the compression tool passes through the gas permeable membrane and around the mandrel to ambient when the compression tool is pressed into the combination of the gas permeable membrane and the strip of formable concrete to produce the concrete tile.

68. The process of any of claims 63-56 wherein the membrane is a gas impermeable membrane.

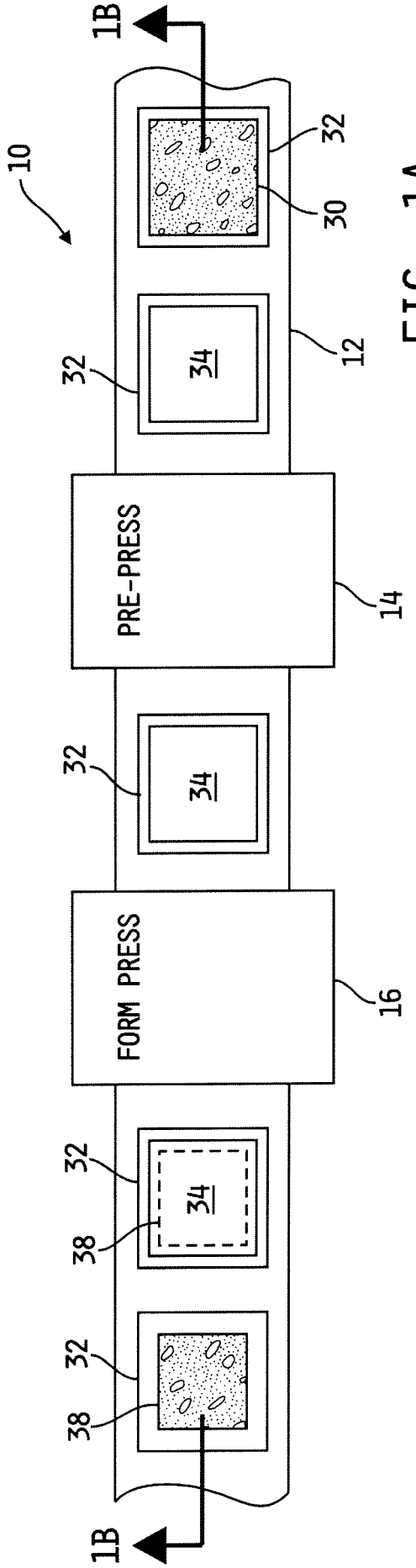

10
1B
32
30
34
12
PRE-PRESS
14
FORM PRESS
16
38
1B

FIG. 1A

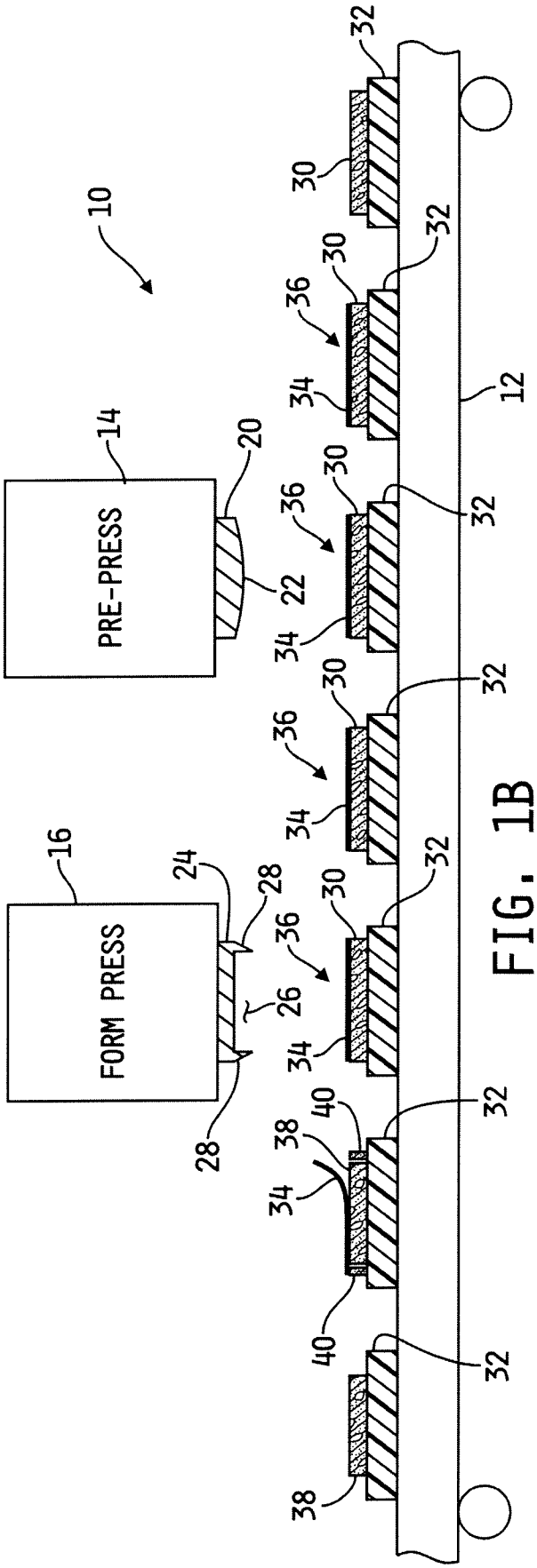

10
PRE-PRESS
14
20
22
FORM PRESS
16
24
26
28
30
32
34
36
38
40
12

FIG. 1B

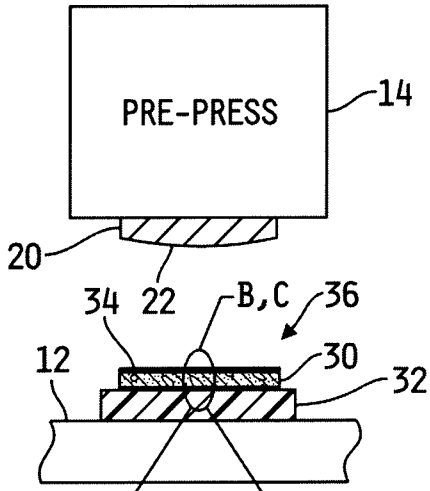


FIG. 2A

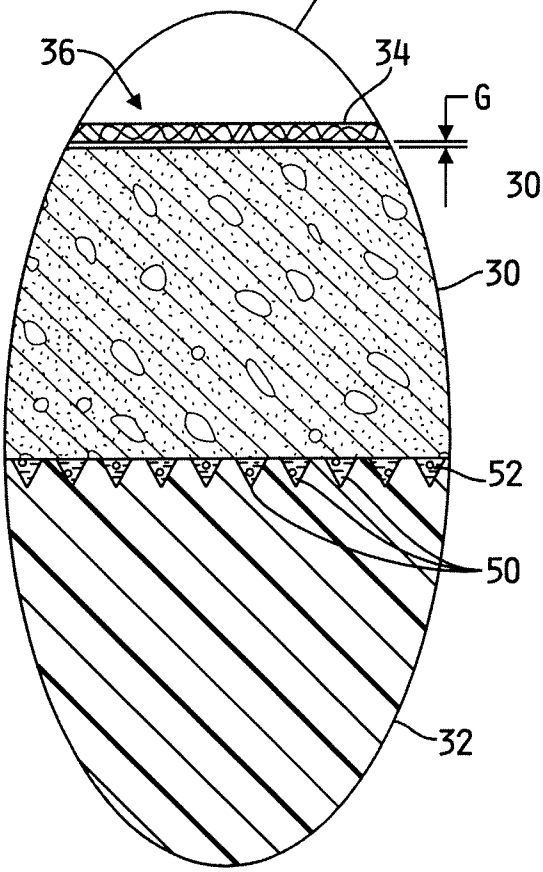


FIG. 2B

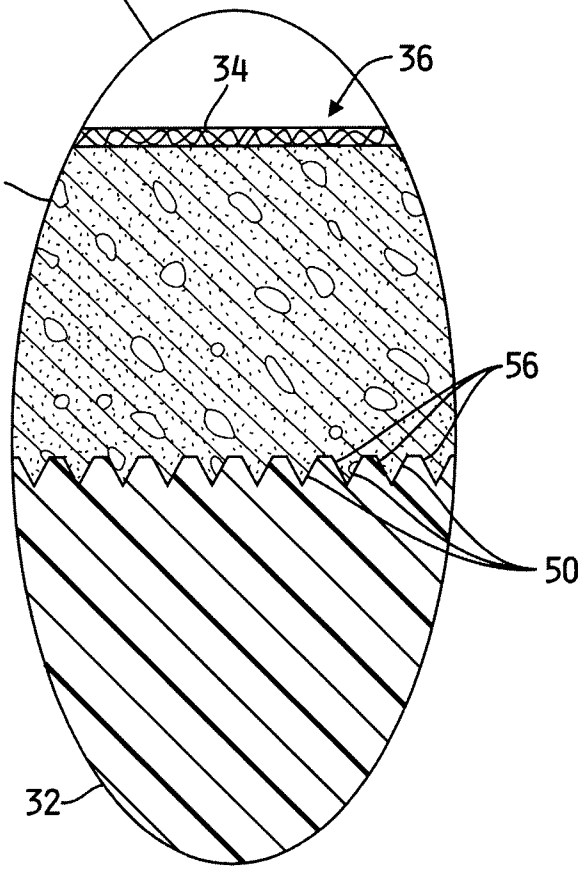
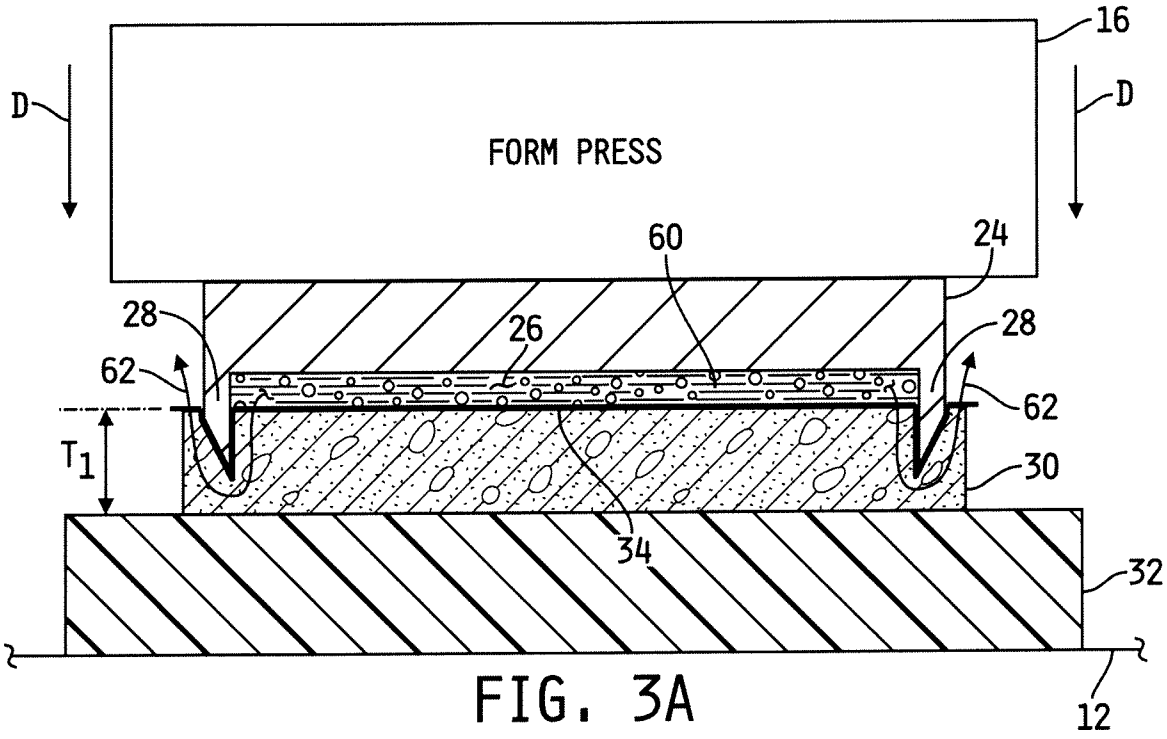


FIG. 2C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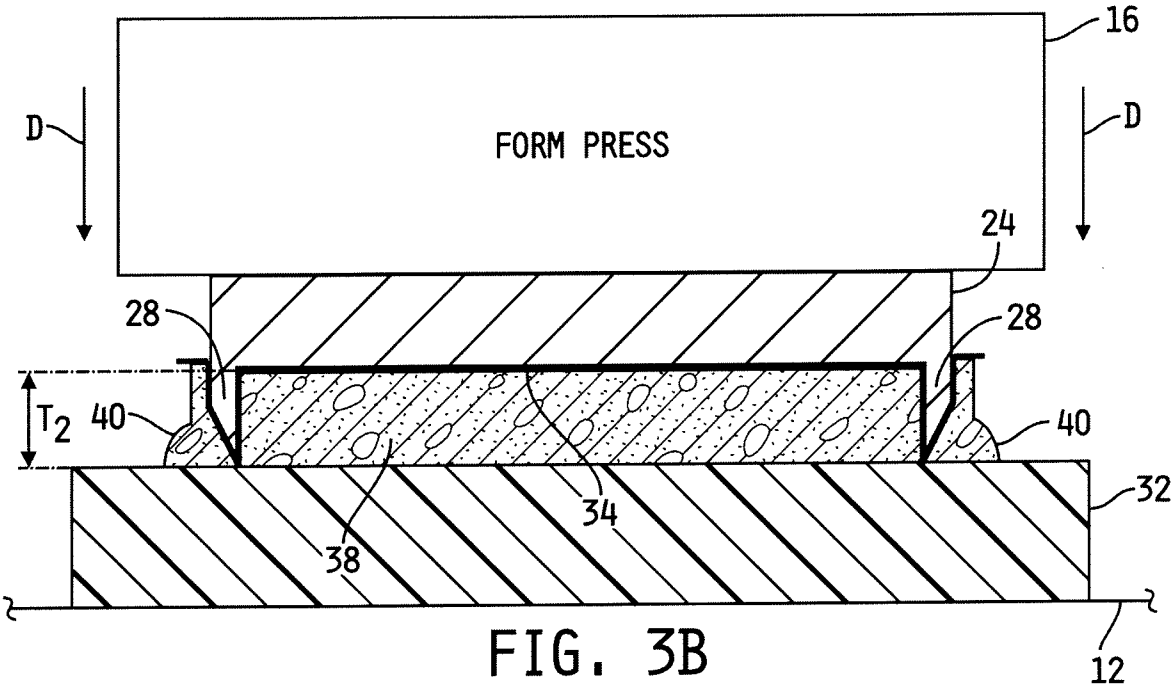
D
D
FORM PRESS
60
24
28
26
28
62
62
T_1
30
34
32
12

FIG. 3A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D
D
FORM PRESS
24
28
28
T_2
40
40
34
32
38
12

FIG. 3B

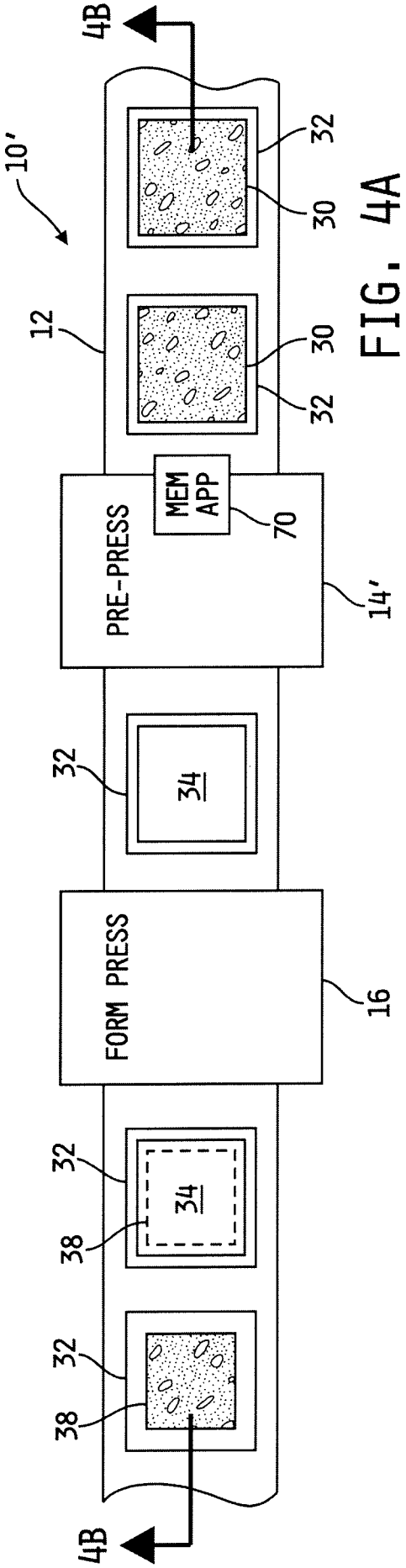
4B
10'
12
32
30
32
30
32
MEM APP
70
PRE-PRESS
14'
32
34
FORM PRESS
16
32
34
38
32
38
4B

FIG. 4A

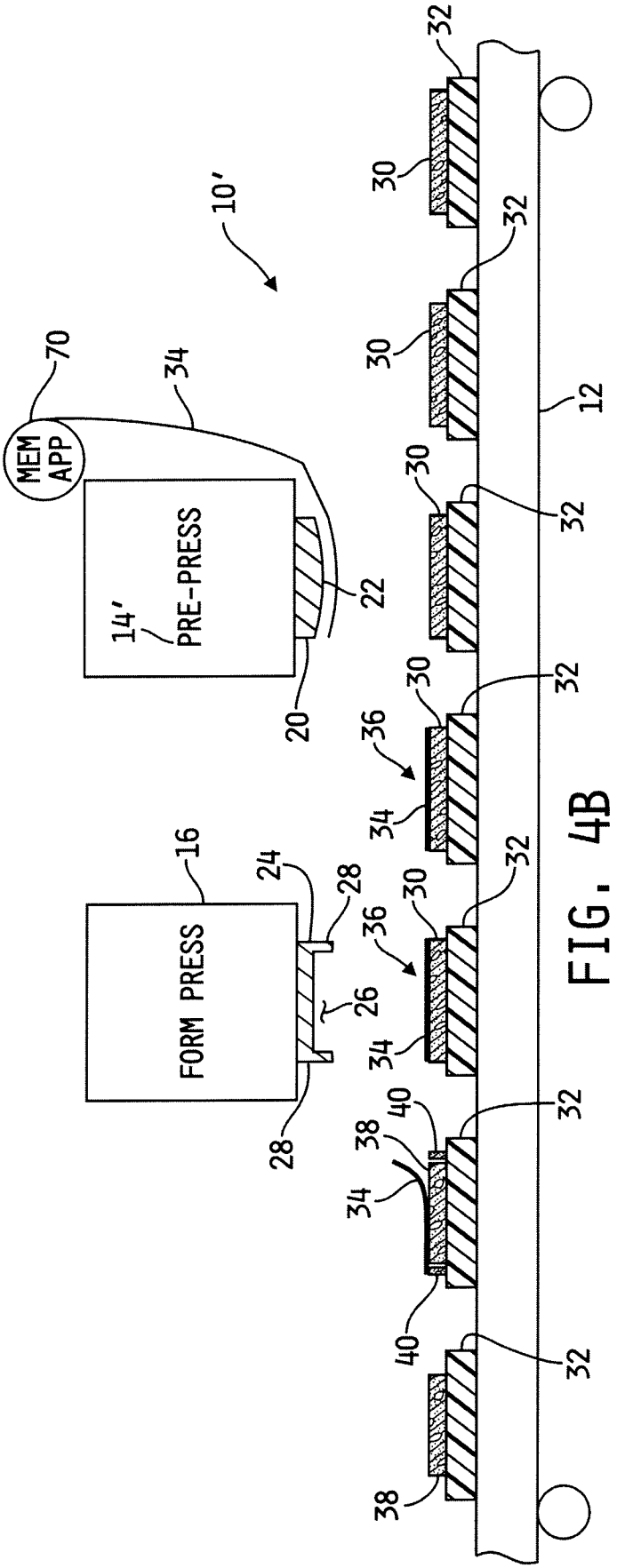
10'
70
MEM APP
34
14'
PRE-PRESS
22
20
16
FORM PRESS
24
28
26
28
36
30
32
34
38
40
12

FIG. 4B

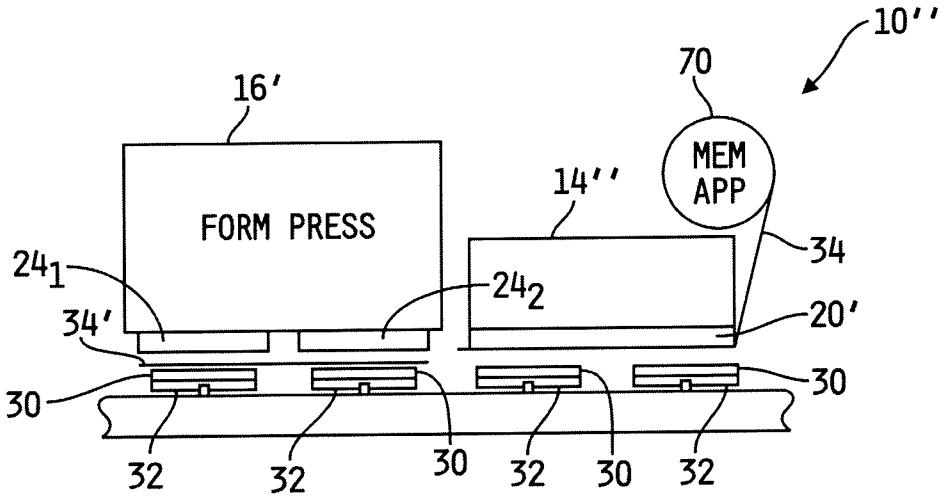

FIG. 5

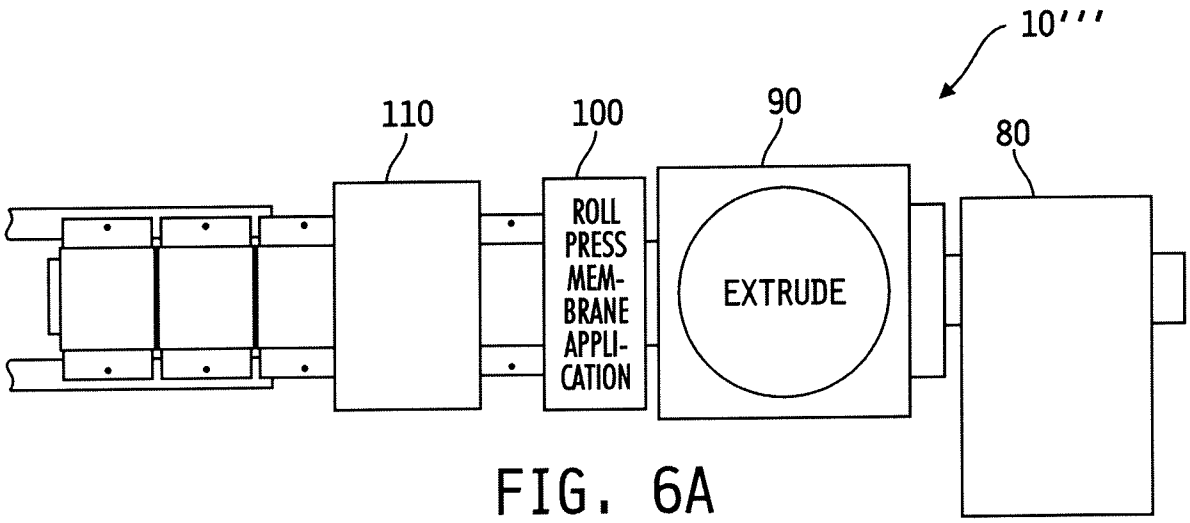

FIG. 6A

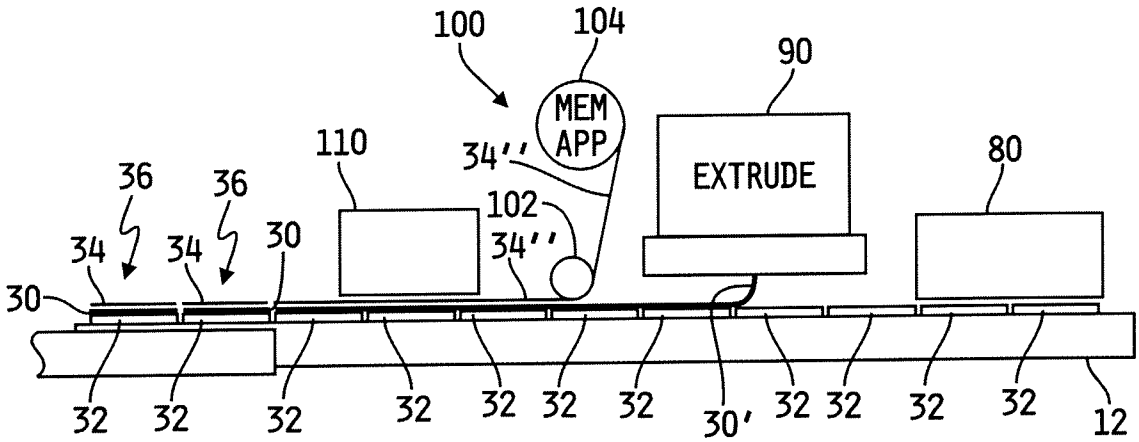

FIG. 6B