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Systems and Methods for Forming a Can End Shell

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SYSTEMS AND METHODS FOR FORMING A CAN END SHELL

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FIELD OF THE INVENTION

[0001] This application relates to systems and methods for forming can end shells. More particularly, this application relates to systems and methods for forming can end shells using electromagnets.

BACKGROUND

[0002] Can end shells for can bodies are frequently made from various metals such as aluminum or aluminum alloys. Can end shells traditionally have been fabricated by positioning a metal sheet within a shell die and stamping a metal sheet with a shell press ram to form the can end shell, after which the can end shell is ejected from the die. Traditional shell die systems are relatively complex and include a number of mechanical parts, many of which are movable relative to one another. As such, maintenance and control over the numerous moving parts is limited, and the potential for system errors from instability or malfunction of one of these parts relative to another is relatively high.

SUMMARY

[0003] According to certain examples, a can end shell forming system includes a die defining a forming pocket having a shaping surface and adapted to receive a portion of a sheet during can end shell forming. The can end shell forming system also includes an inductor within the forming pocket that is adapted to selectively propel the portion of the sheet against the shaping surface to form a can end shell.

[0004] According to various examples, a can end shell forming tool includes a shaping surface provided within a forming pocket defined by the can end shell forming tool. The can end shell forming tool also includes an inductor within the forming pocket that is adapted to selectively force a portion of a sheet against the shaping surface to form a can end shell.

[0005] According to some examples, a method of forming a can end shell includes positioning a portion of a sheet within a forming pocket of a can end shell forming tool. The method also includes activating an inductor within the forming pocket and propelling the portion of the sheet against a shaping surface within the forming pocket such that the portion of the sheet is formed into the can end shell.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The features and components of the following figures are illustrated to emphasize the general principles of the present disclosure. Corresponding features and components throughout the figures can be designated by matching reference characters for the sake of consistency and clarity.

[0007] FIG. 1 is a schematic of a can end shell forming system according to aspects of the present disclosure.

[0008] FIG. 2 is a schematic of the can end shell forming system of FIG. 1 during a can end shell forming process according to aspects of the current disclosure.

[0009] FIG. 3 is another schematic of the can end shell forming system of FIG. 1 during a can end shell forming process.

[0010] FIG. 4 is another schematic of the can end shell forming system of FIG. 1 during a can end shell forming process.

[0011] FIG. 5 is another schematic of the can end shell forming system of FIG. 1 during a can end shell forming process.

[0012] FIG. 6 is another schematic of the can end shell forming system of FIG. 1 during a can end shell forming process.

[0013] FIG. 7A is another schematic of the can end shell forming system of FIG. 1 during a can end shell forming process.

[0014] FIG. 7B is another schematic of the can end shell forming system of FIG. 1 during a can end shell forming process.

[0015] FIG. 8 is a flow chart of a can forming process according to aspects of the current disclosure.

DETAILED DESCRIPTION

[0016] FIGs. 1-7B illustrate an example of a can end shell forming system 100 according to aspects of the current disclosure that includes a can end shell forming tool 102 having an inductor 106. During a can end shell forming process, and as explained in detail below, the can end shell forming system 100 forms a portion of a material sheet into a can end shell having a desired profile or shape. In some non-limiting examples, the material sheet formed into the can end shell may be various metals including, but not limited to, aluminum, aluminum alloys, copper, copper-based materials, steel, steel-based materials, or various other materials suitable for can end shells. In various examples, the material may be a material having a high electrical conductivity.

[0017] The can end shell forming tool 102 is a die that defines at least one forming pocket 104. Although one forming pocket 104 is illustrated in FIGs. 1-7B, the can end shell forming system 100 may include an number of forming pockets as desired. In certain cases, the can end shell forming tool 102 includes a top guide 126 and a center die 128 that together define the forming pocket 104. In certain cases, the top guide 126 and the center die 128 may be monolithically formed as a single component. In other examples, the top guide 126 and the center die 128 may be separate components that are coupled together through one or more permanent or non-permanent joining mechanisms. As one non-limiting example, the top guide 126 may be removably secured to the center die 128 such that a user can selectively access portions of the forming pocket 104 within the center die 128 by removing the top guide 126.

[0018] The forming pocket 104 has a shaping surface 108. Optionally, the shaping surface 108 is within the center die 128 of the can end shell forming tool 102. The shaping surface 108 has a profile that shapes or forms a portion of a material sheet 110 into the can end shell 112 during the can end shell forming process, as described in detail below. The particular profile of the shaping surface 108 (and the shape of the can end shell 112) illustrated in FIGs. 1-7B should not be considered limiting on the current disclosure, as in various examples, the shaping surface 108 may have various profiles or shapes depending on the desired profile of the can end shell 112.

[0019] In some aspects, the can end shell forming tool 102 defines a guiding channel 114 such that the portion of the material sheet 110 can be positioned within the forming pocket 104. In some aspects, the guiding channel 114 is defined by the top guide 126, although it need not be in other examples. For examples, in other cases, the guiding channel 114 may be defined by the center die 128. The shape or position of the guiding channel 114 should not be considered limiting on the current disclosure as the guiding channel 114 may be at various positions relative to the forming pocket 104 and/or may have various shapes or profiles as desired.

[0020] In various examples, the can end shell forming tool 102 also defines an ejection slot 116. In certain aspects, the ejection slot 116 is defined by the center die 128, although it need not be in other examples. The ejection slot 116 may optionally be between the shaping surface 108 and the guiding channel 114, although it need not be in other examples. The ejection slot 116 is dimensioned such that the can end shell 112 can be ejected from the forming pocket 104 through the ejection slot 116 after the can end shell 112 has been formed. The shape or position of the ejection slot 116 should not be considered limiting on the current disclosure as the ejection slot 116 may be at various positions relative to the forming pocket 104 and/or may have various shapes or profiles as desired.

[0021] Optionally, the can end shell forming tool 102 includes a cutting edge 118 within the forming pocket 104. In certain aspects, the cutting edge 118 is at a location within the forming pocket 104 between the guiding channel 114 and the shaping surface 108, although it need not be in other examples. During the can end shell forming process, the cutting edge 118 may cut the portion of the material sheet 110 from the material sheet 110 to form a blank 120 as the portion of the material sheet 110 engages the cutting edge 118. The shape or position of the cutting edge 118 should not be considered limiting on the current disclosure, as the cutting edge 118 may be at various positions within the forming pocket 104 and/or may have various shapes or profiles as desired.

[0022] As illustrated in FIGs. 1-7B, in some optional examples, the can end shell forming tool 102 includes one or more air chambers 122 that are in fluid communication with the forming pocket 104. In various aspects, the air chamber 122 is in fluid communication with the forming pocket 104 through one or more apertures defined in the shaping surface 108. In some aspects, the air chamber 122 is formed by the center die 128, although it need not be in other examples. In some cases, and as described in detail below, during the can end shell forming process, air may be forced out of the forming pocket 104 and/or forced into the forming pocket 104 through the air chamber 122. In certain cases, the can end shell forming tool 102 includes at least one air channel 124 that is in fluid communication with the air chamber 122 such that air can be forced out of or forced into the air chamber 122 through the air channel 124. Optionally, the air channel 124 may be in fluid communication with an air control supply, including, but not limited to, a compressed air supply, although it need not be in other examples. In other aspects, other fluids and/or mechanisms may be utilized instead of air.

[0023] As illustrated in FIGs. 1-7B, the inductor 106 of the can end shell forming system 100 is positioned within the forming pocket 104. In examples where a plurality of forming pockets 104 are included, an inductor 106 may optionally be provided in each forming pocket 104. In other examples, a single inductor 106 may be adapted to influence the material sheet 110 in a plurality of forming pockets 104. Moreover, in some cases, a plurality of inductors 106 may be provided in a single forming pocket 104.

[0024] The inductor 106 is positioned within the forming pocket 104 such that during the can end shell forming process, the portion of the material sheet 110 is received within the forming pocket 104 between the inductor 106 and the shaping surface 108. Optionally, the guiding channel 114, ejection slot 116, and/or cutting edge 118 are between the inductor 106 and the shaping surface 108, although they need not be in other examples.

[0025] In various examples, the inductor 106 is an electromagnet, meaning that it only retains its magnetism when an electrical current is running through it. The inductor 106 is connected to a power source that supplies the electrical current. The power source may be a component of the can end shell forming tool 102, although it need not be in other examples. Applying current to energize the inductor 106 can include using a tuned or tunable forming circuit to supply energy to the forming coil. A tuned or tunable forming circuit can include one or more inductors (e.g., the forming coil and/or a tuning coil), one or more capacitors, and optionally one or more resistors. Certain circuit elements, such as capacitors, resistors, or inductors (e.g., a tuning coil) may be adjustable to permit adjustability in the tuning of the forming circuit, although that need not be the case, and some or all circuit elements may be non-adjustable such that the forming circuit maintains a preset tuning. Tuning of the forming circuit can refer to the characteristics of the current it outputs, such as the current, voltage, and frequency of the output current. In a charging step, the capacitor/plurality of capacitors can be isolated from the remainder of the forming circuit by a switch, such as an electrical switch (e.g., a manually operated button or automatic actuator-operated electrical switch) or an electronic switch (e.g., a transistor, such as a field effect transistor). The capacitor/plurality of capacitors can be electrically charged from a voltage source, such as to a set amount of energy (e.g., from about 0.1 kiloJoules (kJ) to about 100 kJ, or from about 0.1 microFarads (μF) to about 200 μF). During forming with the inductor 106, the capacitor/plurality of capacitors can be connected to the remainder of the forming circuit by activating the switch. Activating the switch can allow the capacitor/plurality of capacitors to discharge energy through the forming coil. The forming circuit can be tuned by changing at least one of capacitance, inductance, and resistance of any electrical components. The forming circuit can be tuned to provide an oscillating current having a frequency of from about 1 kiloHertz (kHz) to about 100 kHz. For example, tuning the forming circuit can provide a forming circuit that is optimized for a specific material, application, or any suitable forming requirement.

[0026] In some examples, energizing the forming coil can further apply an electromagnetic force to the portion of the metal sheet 120 such that the portion of the metal sheet 120 is forced against the cutting edge and the shaping surface 108 (see arrows 132). In particular, the portion of the metal sheet 120 is forced away from the inductor 106 and towards the shaping surface 108 to form the can end shell 112.

[0027] In some aspects, the magnetic fields from the inductor 106 are controlled by applying an alternating current at a predetermined frequency. In some non-limiting examples, the predetermined frequency may be from about 1 kHz to about 10 kHz, although it may be less than 1 kHz or greater than 10 kHz in other examples. In some aspects, the predetermined frequency may be used to form can end shells at a desired processing time for forming one can end shell. In various aspects, the processing time for one can end shell is from about 0.1 ms to about 5.0 ms. In other examples, the processing time may be greater than about 5.0 ms. In certain examples, the magnetic fields may also be controlled by controlling an amount of electrical current provided to the inductor 106, controlling a current supply time or duration, controlling a frequency and/or pattern at which the electrical current is supplied, reversing the magnetic fields, controlling aspects of the inductor 106 (e.g., diameter, current, wiring, etc.), an angle of the inductor 106, and/or through various other mechanisms or controls as desired.

[0028] It should be noted that the particular orientation illustrated in FIGs. 1-7B should not be considered limiting on the current disclosure. For example, in FIGs. 1-7B, the inductor 106 is illustrated vertically above the shaping surface 108 such that the portion of the material sheet 110 is propelled by the inductor 106 generally downwards to engage the shaping surface 108. However, in other examples, the shaping surface 108 may be vertically positioned above the inductor 106, and the inductor 106 is configured to propel the portion of the material sheet 110 generally upwards to engage the shaping surface 108. As another example, the orientation may be rotated such that the sheet is fed into the system 100 vertically (i.e., the sheet flow direction would be from top to bottom rather than side to side as illustrated in FIGs. 1-7B). Various other configurations of the inductor 106 relative to the shaping surface 108 (and optionally relative to other components such as the cutting edge 118, guiding channel 114, and/or ejection slot 116) may be provided as desired.

[0029] In some optional examples, a cooling system is provided with the inductor 106 to thermally control the inductor 106. For example, in some aspects, the cooling system may thermally manage the inductor 106 to reduce or prevent the possibility of overheating. In some optional examples, the coil of the inductor 106 is hollow such that coolant can be passed through the center to thermally manage the inductor 106.

[0030] By using the inductor 106, the mechanical complexity of the can end shell forming system 100 is simplified because there are no moving parts to form the portion of the material sheet 110 into the can end shell 112. In addition, because there are no moving parts, the overall stability of the can end shell forming system 100 is improved because the potential for variability from moving parts is decreased and/or eliminated. In some aspects, the can end shell forming system 100 also provides an increased production rate of can end shells due to the faster processing time to form a can end shell compared to traditional systems. In various cases, the fast rate of deformation may also increase the formability of material and provide a faster processing time. The reduced complexity of the can end shell forming system 100 may further decrease maintenance costs for the can end shell forming system 100 because there are fewer parts and/or components to maintain.

[0031] FIGs. 2-7B illustrate various steps during a can end shell forming process and are described in detail below in conjunction with the process 800 provided in FIG. 8.

[0032] Referring to FIG. 2 and block 802 in FIG. 8, the material sheet 110 is guided in the guiding channel 114 such that a portion of the material sheet 110 is positioned within the forming pocket

104. In certain aspects, the material sheet 110 is guided such that the portion of the material sheet 110 in the forming pocket 104 is between the inductor 106 and the shaping surface 108. In some optional examples, the material sheet 110 is guided such that the portion of the material sheet 110 in the forming pocket 104 is between the inductor 106 and the cutting edge 118. In certain optional examples, the material sheet 110 is guided such that the portion of the material sheet 110 in the forming pocket 104 is between the inductor 106 and the ejection slot 116.

[0033] Referring to FIGs. 3-5 and blocks 803 and 804, an electrical current is supplied to the inductor 106 such that the inductor 106 is activated. The activated inductor 106 generates the magnetic fields against the portion of the material sheet 110. The magnetic fields propel the portion of the material sheet 110 away from the inductor 106 and towards the shaping surface 108. In some aspects, the magnetic fields propel the portion of the material sheet 110 away from the inductor 106 such that the portion of the material sheet 110 engages the cutting edge 118 and is cut the from the material sheet 110 to form the blank 120. In such examples, the magnetic fields may propel the blank 120 towards the shaping surface 108 after it has been cut from the material sheet 110.

[0034] In some examples, the magnetic fields from the inductor 106 propel the blank 120 such that the blank 120 contacts the shaping surface 108 and is formed into the can end shell 112. In some optional examples, as the magnetic fields cause the blank 120 to engage the shaping surface 108 and/or just after the blank 120 engages the shaping surface 108, air 130 may be forced out of the forming pocket 104 through the air chamber 122 and/or air channel 124 (see FIG. 4). In some of these examples, the removal of the air 130 may further aid in the shaping of the blank 120 into the can end shell 112.

[0035] In certain aspects, once the can end shell 112 is formed by the engagement of the blank 120 with the shaping surface 108, the inductor 106 is deactivated (see FIG. 5).

[0036] Referring to FIGs. 6, 7A, and 7B, and block 806, the can end shell 112 is disengaged from the shaping surface 108 after it has been formed and ejected through the ejection slot 116. In some examples, disengaging the can end shell 112 from the shaping surface 108 and ejecting the can end shell 112 through the ejection slot 116 includes forcing air 130, such as compressed air, into the forming pocket 104 through the air chamber 122 and/or air channel 124. In other examples, the air volume within the forming pocket 104 and/or within the air chamber 122 may be controlled such that system 100 is self-ejecting, meaning that the can end shell 112 is ejected through the ejection slot 116 without needing compressed air or another ejecting fluid introduced into the system 100. In such examples, the volume of the air chamber 122 may be controlled such that the resonant frequency of the resulting Helmholtz resonator is conducive to the ejection of the shell.

[0037] In various aspects, the steps illustrated in FIGs. 2-7B (and in blocks 802-806) to form one can end shell 112 are completed in a processing time. As mentioned above, in various aspects, the processing time for one can end shell may be from about 0.1 ms to about 5.0 ms. In other examples, the processing time may be greater than about 5.0 ms.

[0038] Referring to FIG. 8, in a block 808, it is determined whether additional can end shells should be formed. A controller or an operator may perform this determination. If no additional can end shells are to be formed, the process ends. If additional can end shells are to be formed, the process returns to block 802.

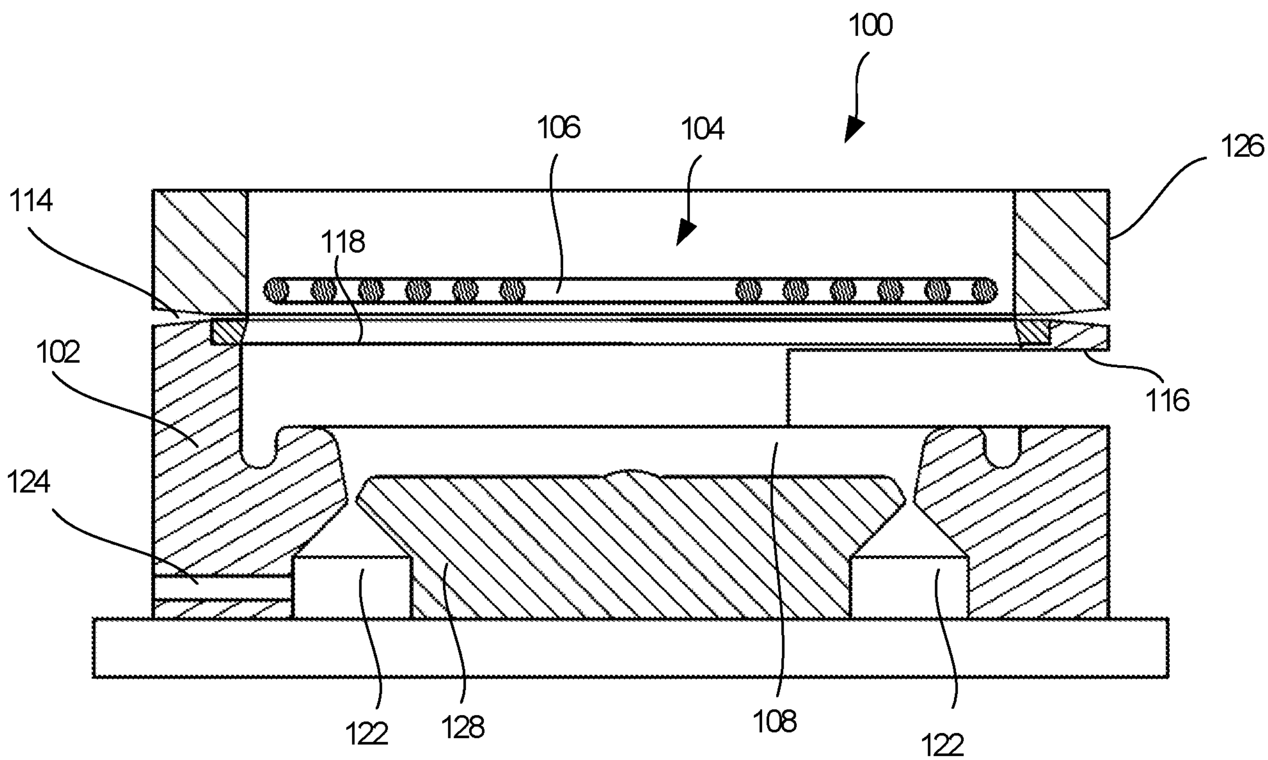

100
106
104
126
114
118
102
116
124
122
128
108
122

FIG. 1

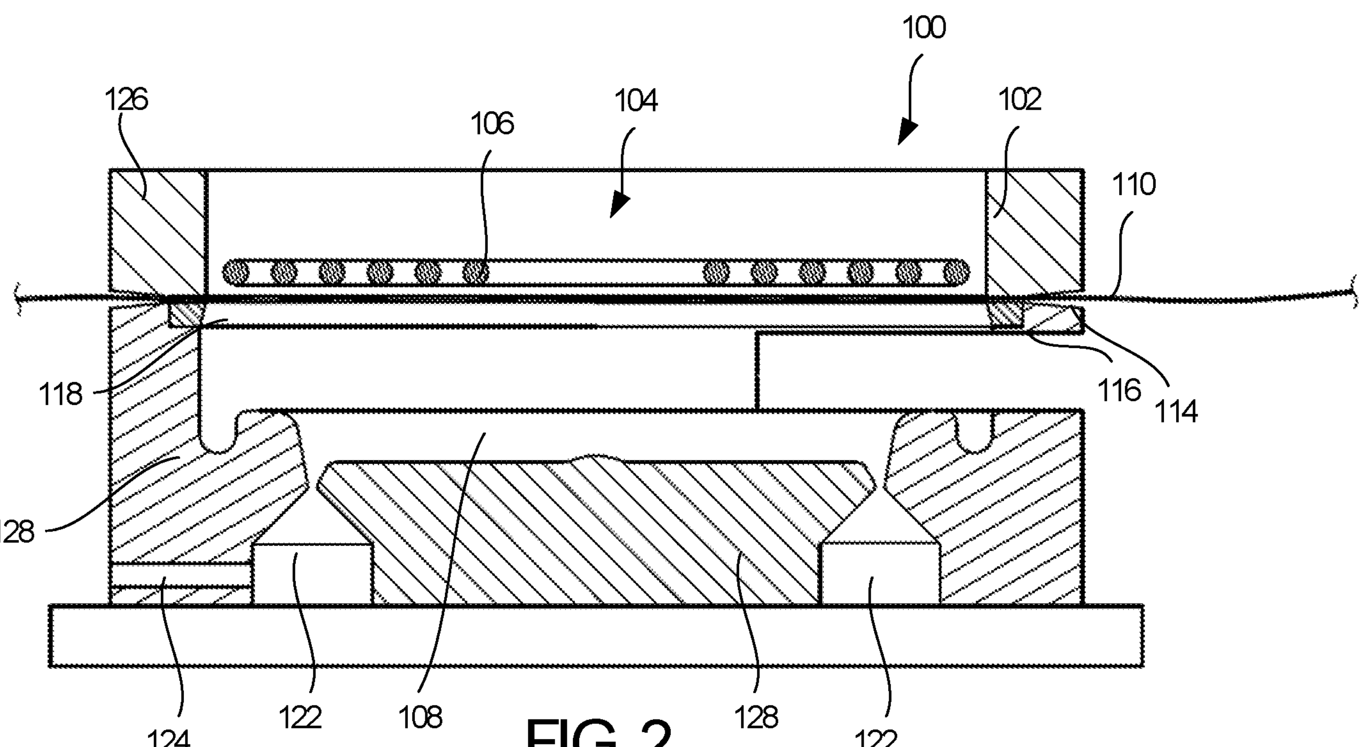

100
126
106
104
102
110
118
116
114
128
124
122
108
128
122

FIG. 2

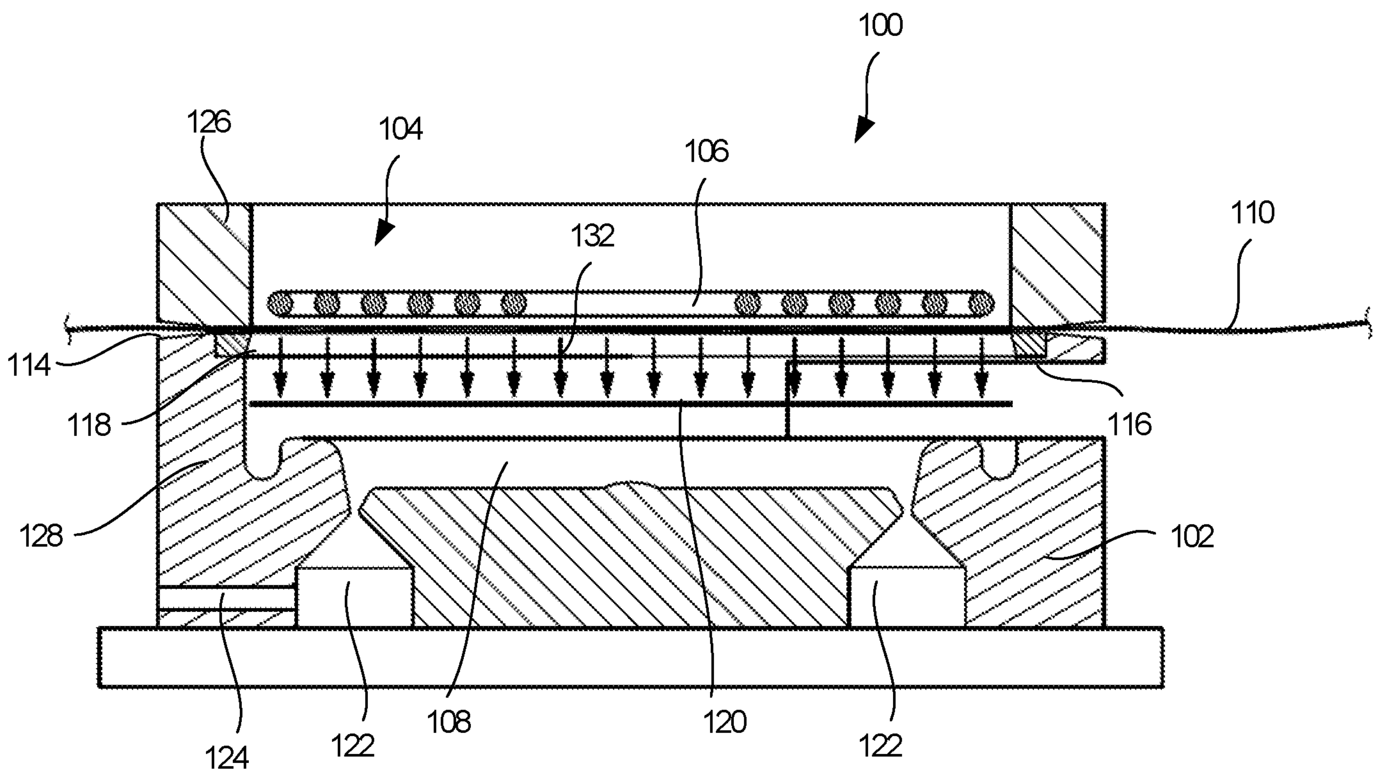

100
126
104
106
110
132
114
118
116
128
102
124
122
108
120
122

FIG. 3

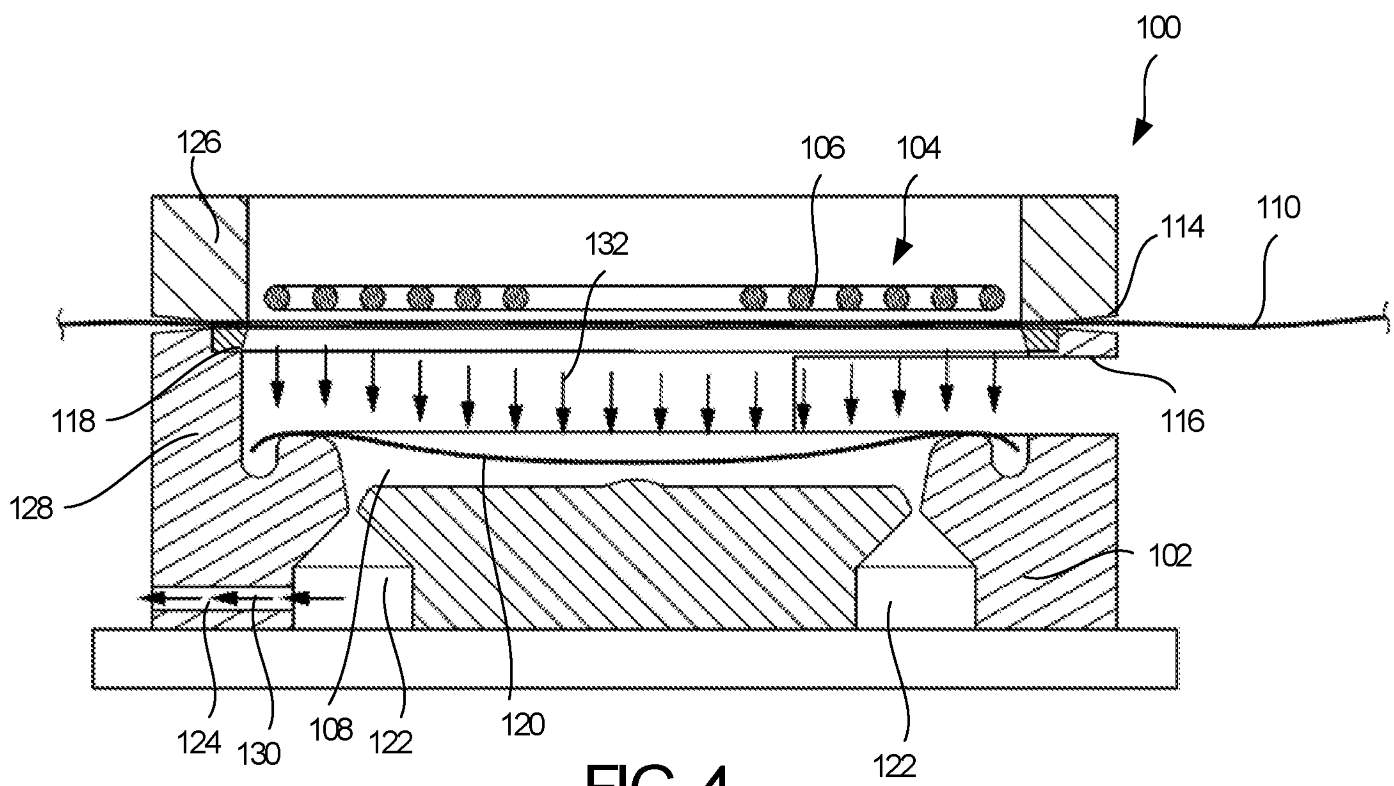

100
126
106
104
110
114
132
118
116
128
102
124
130
108
122
120
122

FIG. 4

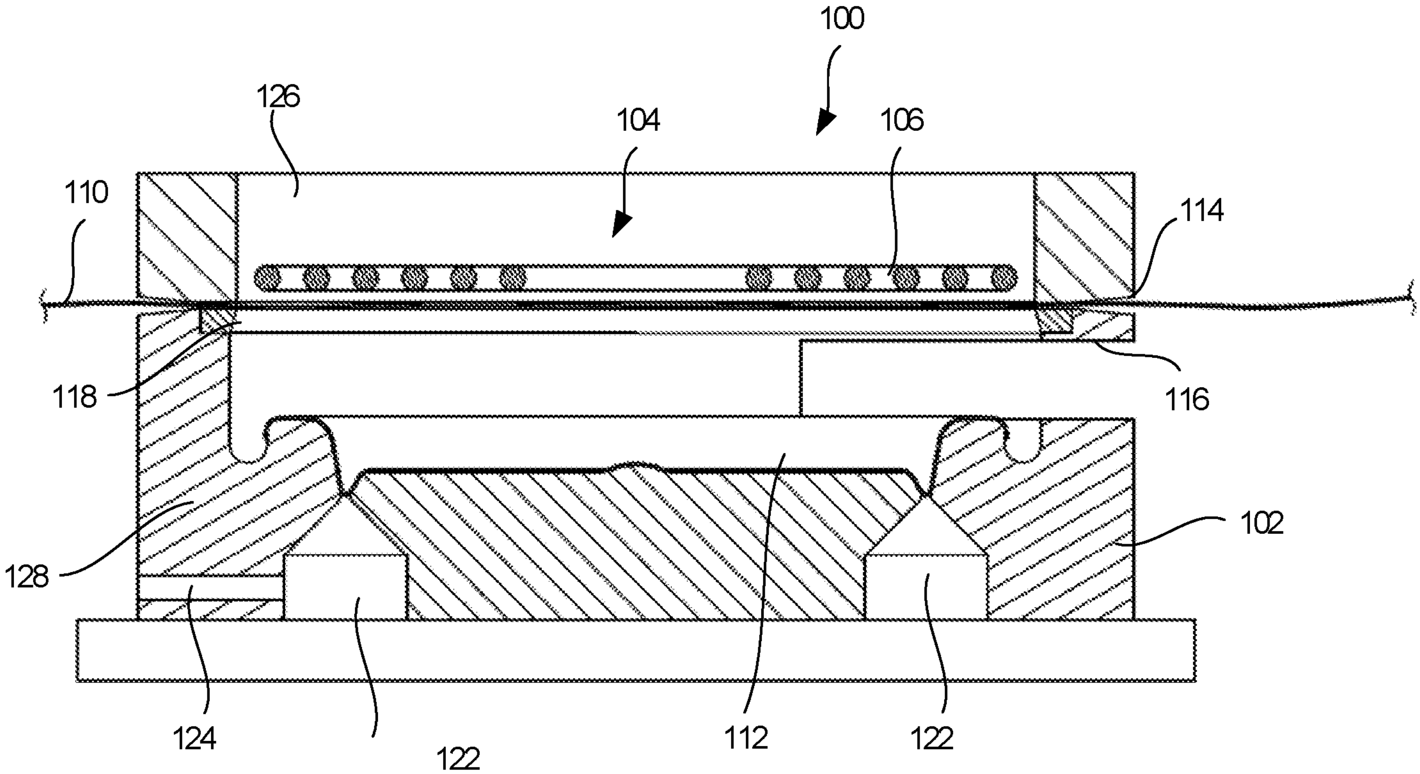
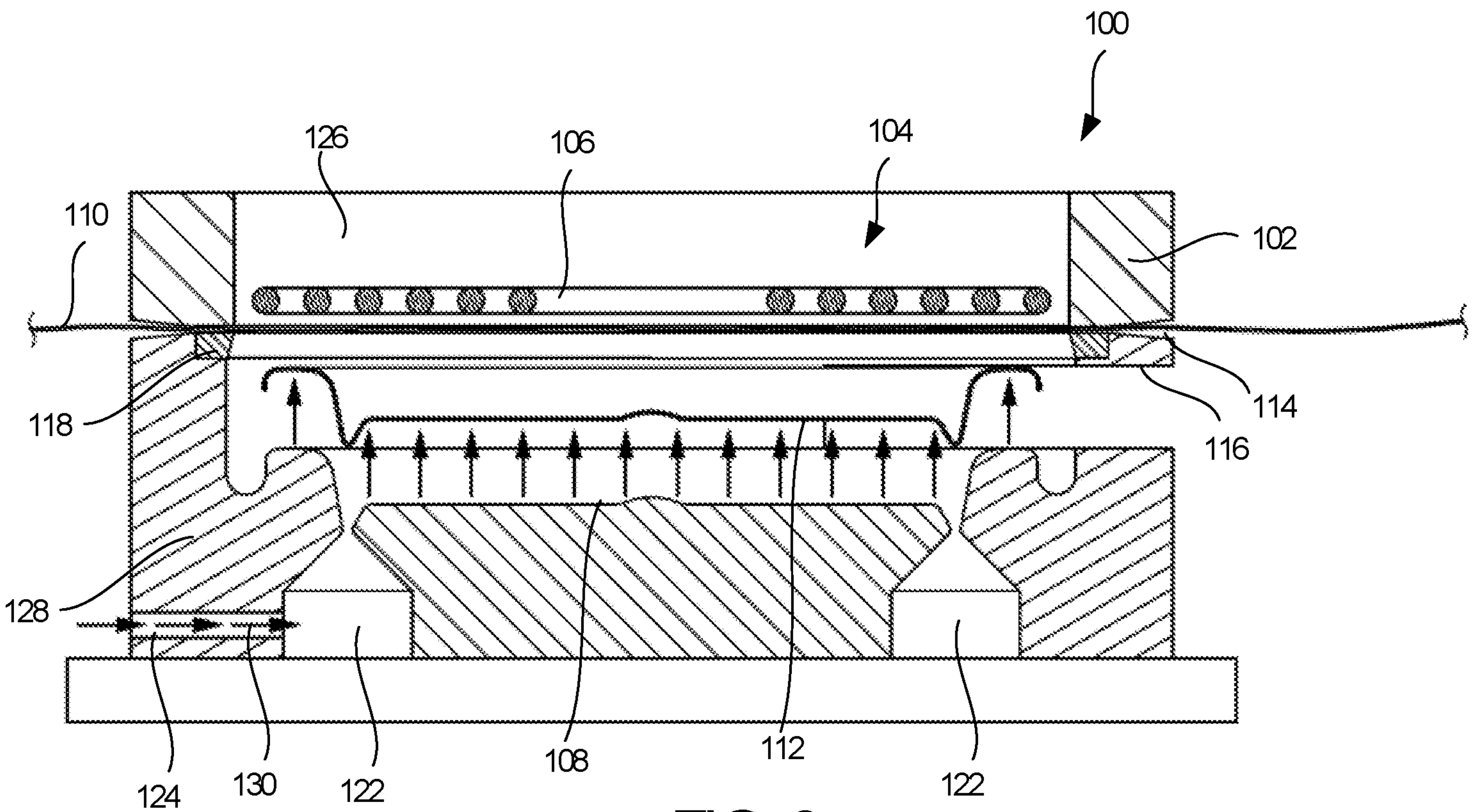

100
126
104
106
110
114
118
116
102
128
124
122
112
122
122

FIG. 5


100
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106
104
110
102
118
114
116
128
124
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112
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FIG. 6

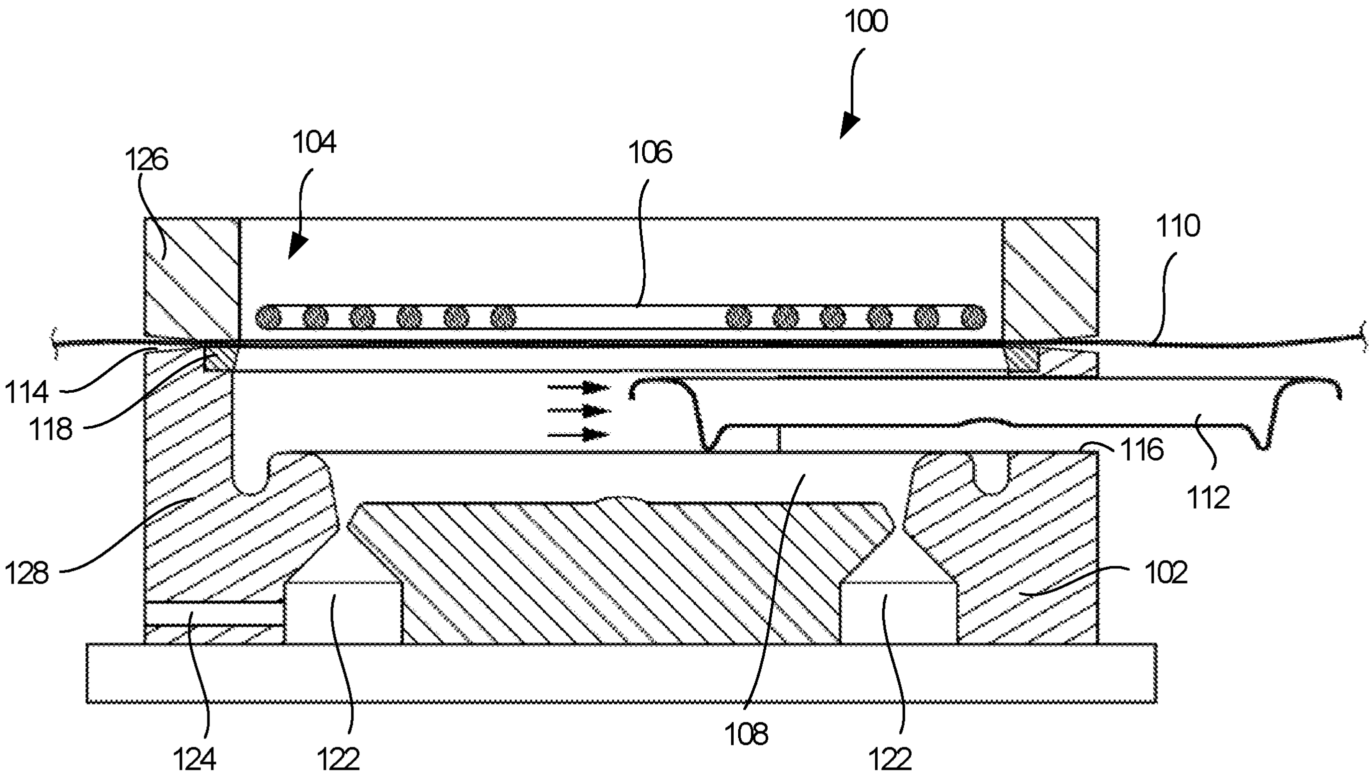
100
104
126
106
110
114
118
116
112
128
102
124
122
108
122

FIG. 7A

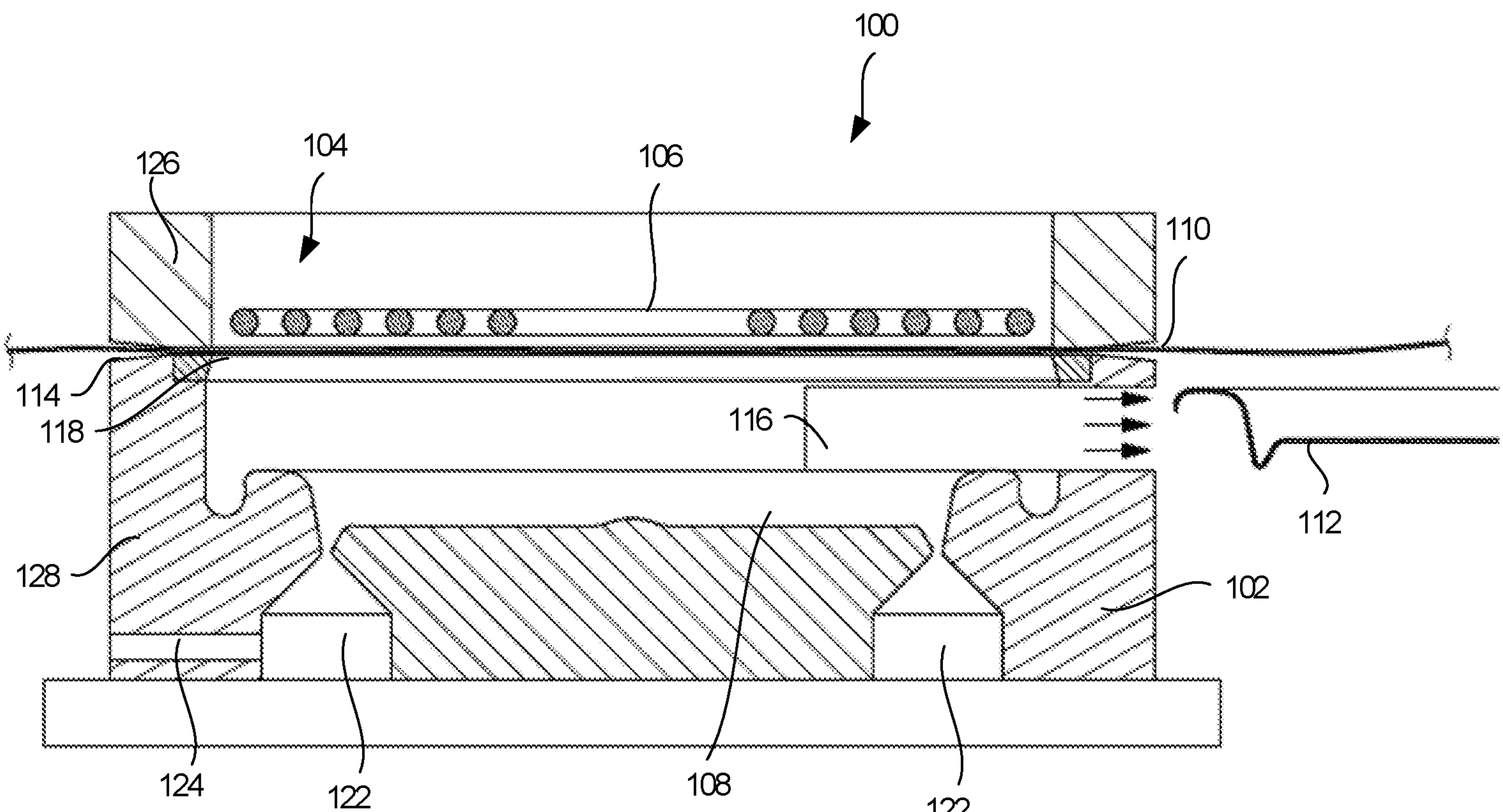
100
104
126
106
110
114
118
116
112
128
102
124
122
108
122

FIG. 7B

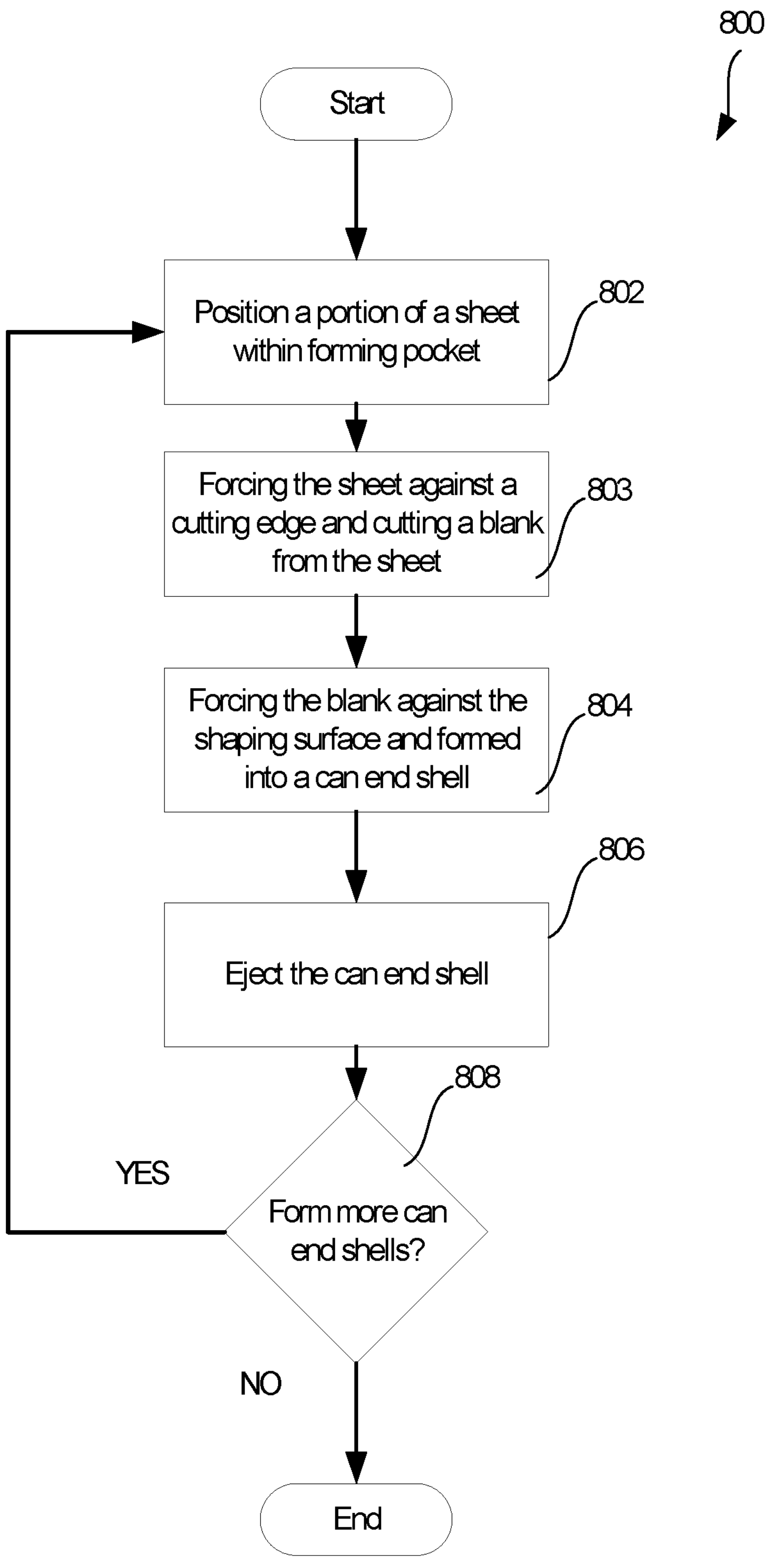
800
Start
Position a portion of a sheet within forming pocket
802
Forcing the sheet against a cutting edge and cutting a blank from the sheet
803
Forcing the blank against the shaping surface and formed into a can end shell
804
806
Eject the can end shell
808
YES
Form more can end shells?
NO
End

FIG. 8