(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 November 2018 (29.11.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/213914 A1

(51) International Patent Classification:
*B29C 45/14* (2006.01) *B29C 45/26* (2006.01)

(21) International Application Number:
PCT/CA2017/051591

(22) International Filing Date:
22 December 2017 (22.12.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/509,820 23 May 2017 (23.05.2017) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,

**(54) Title:** APPARATUS AND METHOD FOR IN-MOLD SUBSTRATE BINDING TO ARTICLES MANUFACTURED BY INJECTION MOLDING

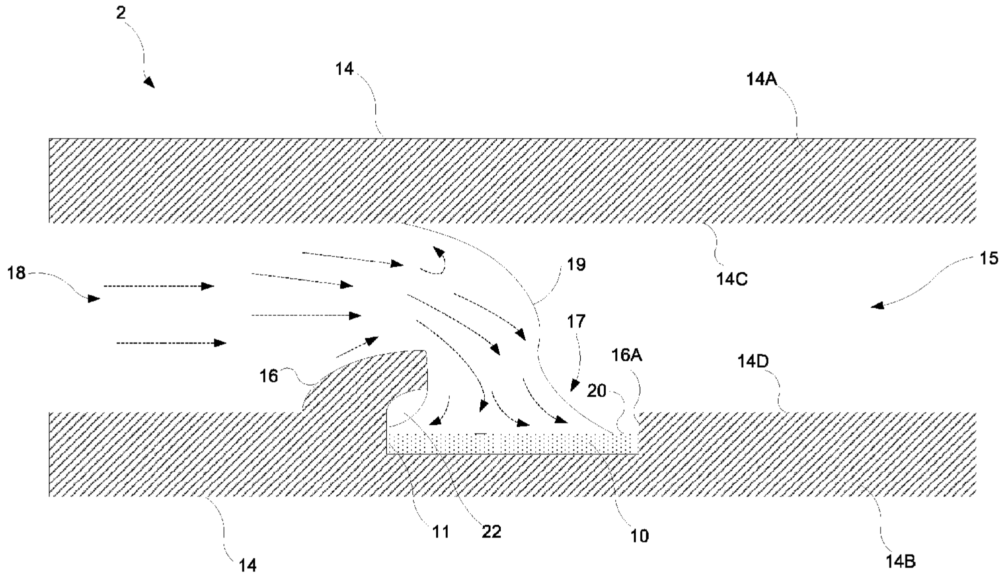


*FIG. 2*

**(57) Abstract:** Disclosed is an injection mold for manufacturing an injection-molded article to which a substrate is bound in-mold during injection, the substrate having an adhering surface for binding to the article and a leading edge at an upstream end of the substrate. The injection mold comprises a first mold component and a second mold component together defining a cavity into which a molten plastic material is injected to form the article. The injection mold includes a flow deflector disposed on at least one of the first and second mold components, wherein the flow deflector deflects a flow of the molten plastic material over the leading edge of the substrate such that the flow makes first contact with the substrate downstream of the leading edge, thereby forming a temporary air pocket at the leading edge of the substrate which is then back-filled by the subsequent flow of the molten plastic material.

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SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

**(84) Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

**Published:**

— *with international search report (Art. 21(3))*

# APPARATUS AND METHOD FOR IN-MOLD SUBSTRATE BINDING TO ARTICLES MANUFACTURED BY INJECTION MOLDING

## TECHNICAL FIELD

**[0001]** The present invention relates generally to injection molding and, more specifically, to apparatuses and methods for in-mold binding or over-molding of substrates onto molded articles.

## BACKGROUND

**[0002]** Injection molding is a manufacturing process in which a molten plastic material is injected into a mold cavity where it solidifies into a shape that conforms to the interior of the mold. Typically, the molten plastic material is a thermoplastic polymer or a thermosetting polymer.

**[0003]** The binding of substrates to injection-molded articles is typically done after the article has been molded which therefore requires additional manufacturing steps that are costly, time-consuming and which may pose a number of challenges especially when manufacturing objects with irregular shapes or when using noxious chemicals to promote adherence.

**[0004]** In-mold binding of the substrate onto a molded article presents a number of advantages but also a number of challenges. One problem resides in the positional stability of the substrate during injection. Injection molding requires that the molten thermoplastic be injected at very high pressure. The molten thermoplastic flow exerts a force on the substrate that can easily displace the substrate inside the mold. Binding of a tape onto a molded article is one example of a particularly challenging operation. Immobilization of the substrate in the mold by clamping the substrate, for example, may result in the clamping structure(s) creating discontinuities in the articles. However, without mechanically immobilizing the substrate, the molten plastic material can easily seep underneath the substrate, displacing it, deforming it or otherwise creating imperfections in the finished product that are unacceptable given the stringent specifications required in many industries.

**[0005]** One example of in-mold binding of a substrate is in-mold labeling. U.S. Patent 7,140,857 (Graham) discloses a technique for in-mold labeling in which a label ledge is provided for injection molding of containers. The ledge protects the leading edge of the in-mold label from the flow of resin under certain conditions. Because the leading edge of the label is protected under certain conditions, the resin flows over the leading edge of the label and secures the label to the cavity wall of the mold, creating a container with a label formed on the container wall. However, due to its geometry (and in particular its obtuse angle) the ledge only adequately functions to divert the resin over the leading edge when the viscosity and injection conditions enable a sufficient resin flow velocity. If the injection conditions and/or the viscosity of the resin do not enable the velocity of the flow to be sufficiently high, the ledge will not prevent the resin from contacting the leading edge of the label. In such cases, the label is susceptible to being displaced and/or deformed by the resin.

**[0006]** In certain applications, in-mold substrate binding involves a substrate that has relatively delicate functional structures such as flock tape. Attempting to in-mold bind flock tape may lead to flock fiber flattening and disruption of its appearance and functionality. In such cases, secondary operations, like brushing for example, to straighten the fibers back into position are required. Not only do these secondary operations constitute additional costs but may also remove flock coating sometimes applied to the fibers to improve their properties (anti-freeze for example).

**[0007]** There is therefore a need in the molding industry for an improved method and apparatus to address the technical problems identified above associated with in-mold substrate binding.

**SUMMARY**

**[0008]** The following presents a simplified summary of some aspects or embodiments of the invention in order to provide a basic understanding of the invention. This summary is not an extensive overview of the invention. It is not intended to identify key or critical elements of the invention or to delineate the scope of the invention. Its sole purpose is to present some embodiments of the invention in a simplified form as a prelude to the more detailed description that is presented later.

**[0009]** One aspect of the invention is an injection mold for manufacturing an injection-molded article to which a substrate is bound in-mold during injection, the substrate having an adhering surface for binding to the article and a leading edge at an upstream end of the substrate. The injection mold comprises a first mold component and a second mold component together defining a cavity into which a molten plastic material is injected to form the article. The injection mold includes a flow deflector disposed on at least one of the first and second mold components, wherein the flow deflector deflects a flow of the molten plastic material over the leading edge of the substrate such that the flow makes first contact with the substrate downstream of the leading edge, thereby forming a temporary air pocket at the leading edge of the substrate which is then back-filled by the subsequent flow of the molten plastic material.

**[0010]** Another aspect of the invention is an injection mold assembly for manufacturing an injection-molded article to which a substrate is bound in-mold during injection, the substrate having an adhering surface for binding to the article, and flock- fibers on a surface opposite the adhering surface, the injection mold assembly comprising: a first mold component and a second mold component together defining a cavity into which a molten plastic material is injected to form the article; a plurality of fiber-receiving channels in a bottom side of a substrate cavity located in one of the first and second mold components wherein the substrate is placed in the substrate cavity such that at least some of the fibers are within the plurality of fiber-receiving channels during injection.

**[0011]** In yet another aspect of the invention is a method of injection-molding an article to which a substrate is bound in-mold during injection, the substrate having an adhering surface for binding to the article and a leading edge at an upstream end of the substrate. The method entails providing a first mold component and a second mold component together defining a cavity, injecting a molten plastic material into the cavity to form the article and deflecting a flow of the molten plastic material over the leading edge of the substrate using a flow deflector deflects such that the flow makes first contact with the substrate downstream of the leading edge, thereby forming a temporary air pocket at the leading edge of the substrate which is then back-filled by the subsequent flow of the molten plastic material.

**[0012]** Other aspects of the invention may become apparent from the detailed description and drawings.

**BRIEF DESCRIPTION OF THE DRAWINGS**

**[0013]** The invention will be better understood by way of the following detailed description of embodiments of the invention with reference to the appended drawings, in which:

**[0014]** Figure 1 is a cross-sectional view of a molten plastic material flowing inside a portion of an injection mold.

**[0015]** Figure 2 is a cross-sectional view of an injection mold having a flow deflector having an overhang in accordance with an embodiment of the invention.

**[0016]** Figure 3 is a cross-sectional view of an injection mold having the flow deflector of Figure 2 wherein the substrate is shorter than the substrate cavity.

**[0017]** Figure 4 is a cross-sectional view of an injection mold having no substrate cavity in accordance with another embodiment of the invention.

**[0018]** Figure 5 is a cross-sectional view of an injection mold having a flow deflector shaped like a rounded lip in accordance with another embodiment of the invention.

**[0019]** Figure 6 is a cross-sectional view of an injection mold of Figure 5 depicting the impingement of the molten plastic material onto the substrate downstream of the leading edge.

**[0020]** Figure 7 is a cross-sectional view of an injection mold having a flow deflector shaped like a ramp in accordance with yet another embodiment of the invention.

**[0021]** Figure 8 is a cross-sectional view of an injection mold of Figure 4 except that the substrate is shorter than the recess into which it is placed.

**[0022]** Figure 9 is a cross-sectional view of an injection mold having a flow deflector having an undercut as a flow deflector in accordance with a further embodiment of the invention.

**[0023]** Figure 10 is a cross-sectional view of an injection mold having a dual angled ramp as a flow deflector in accordance with a further embodiment of the invention.

**[0024]** Figure 11 is a cross-sectional view of an injection mold having a flow-directing structure in accordance with another embodiment of the invention.

**[0025]** Figure 12 is a cross-sectional view of an injection mold having a movable flow-directing structure in accordance with another embodiment of the invention.

**[0026]** Figure 13 is a cross-sectional view of an injection mold having a movable flow deflector in accordance with another embodiment of the invention.

**[0027]** Figure 14 is a cross-sectional view of an injection mold having a vacuum source as a substrate stabilizer in accordance with another embodiment of the invention.

**[0028]** Figure 15 is a cross-sectional view of an injection mold having an angled injection port in accordance with another embodiment of the invention.

**[0029]** Figure 16 is a cross-sectional view of an injection mold having a stepped flow deflector in accordance with another embodiment of the present invention.

**[0030]** Figure 17 is a cross-sectional view of an injection mold having a substrate retention member in accordance with another embodiment of the invention.

**[0031]** Figure 18A is a cross-sectional view of an injection mold having a plurality of flock receiving channels in accordance with another embodiment of the invention.

**[0032]** Figure 18B is a cross-sectional view of an injection mold having a plurality of obliquely angled flock receiving channels in accordance with another embodiment of the invention.

**[0033]** Figure 19A is a cross-sectional view of an injection mold having a mesh structure that provides the flock receiving channels.

**[0034]** Figure 19B is a cross-sectional view of an injection mold having a mesh structure that provides the flock receiving channels in which strands of the mesh are rounded at the top.

**[0035]** Figure 20 is a top view of laser-cut flock receiving channels.

**[0036]** Figure 21 is a side view of the laser-cut flock receiving channels.

**[0037]** Figure 22 is a cross-sectional view of an injection mold having a mesh structure that provides the flock-receiving channels and further having a vacuum-based retention system in accordance with another embodiment of the invention.

**[0038]** Figure 23A is a photomicrograph of flocking fibers on a flock tape.

**[0039]** Figure 23B is a photomicrograph of flocking fibers on a flock tape that has been exposed to in-mold binding while resting on a mesh of 150 mesh size.

**[0040]** Figure 23C is a photomicrograph of flocking fibers on a flock tape that has been exposed to in-mold binding while resting on a mesh of 180 mesh size.

**[0041]** Figure 23D is a photomicrograph of flocking fibers on a flock tape that has been exposed to in-mold binding while resting on a mesh of 250 mesh size.

**[0042]** It will be noted that throughout the appended drawings, like features are identified by like reference numerals.

## DETAILED DESCRIPTION

**[0043]** Disclosed herein is a novel injection mold (or injection mold system) for manufacturing a molded article having a substrate bound thereto. By bound it is meant that the substrate adheres permanently to the article or is otherwise over-molded on the article to become integral therewith. The substrate thus becomes permanently and integrally bound to the article within the mold as the molten plastic material, such as thermoplastic or thermoset, is injected and deposited on the substrate and subsequently cooled or cured to form the molded article.

**[0044]** The substrate can be any type of material that can be over-molded or adhered to the molded article in the injection conditions. The substrate may exhibit various shapes and at least a substantial part of it is usually bound to the surface of the molded article. One example of a substrate is a tape. Tapes may serve esthetic or functional purposes in many types of applications. Tape having flocking fibers on one of its sides is such an example.

**[0045]** Thus, by substrate it is meant a material that comprises at least one adhering surface which contacts and binds to the molded article. The substrate also has an outside (non-bound) surface and edges.

**[0046]** Generally, the outside (non-bound) surface of the substrate is facing the (bottom) surface of the mold. During the injection, the molten plastic material, e.g. thermoplastic, fills the cavity and, in the process, is deposited onto the adhering surface of the substrate (molded article contacting surface of the substrate). Depending on the molded article structure and the relative position of the substrate, one or more edges of the substrate, in particular the upstream or leading edge, may be exposed to the incoming front of the flow of the molten thermoplastic within the mold during injection. This head-on encounter between the front of the flow of molten plastic (e.g. melted thermoplastic) and the edge of the substrate can easily displace the substrate by the pressure exerted on the edge. Additionally, the edges of a substrate are almost never perfectly lined up with the surface of the mold creating discontinuities or gaps and the front of the flow can easily seep underneath the substrate through these gaps.

**[0047]** These technical problems are overcome by the new injection mold disclosed herein which has a flow deflector configured to deflect the flow of molten plastic material over a leading edge of the substrate. Having made first contact with the substrate downstream of the leading edge, the flow (an "edge directional flow") of the molten plastic material forms a temporary air pocket (temporary dead zone) between the leading edge of the substrate and this point of first contact with the substrate. The molten plastic material flows from a central area of the adhering surface of the substrate towards the one or more edges, including rearwardly to back fill the temporary air pocket. The flow deflector thus prevents the front of the flow from coming into contact head-on with an edge of the substrate. Thus, in one embodiment, the injection mold comprises mating mold components that define an interior space or cavity designed to provide the desired shape for the molded article and further comprising a flow deflector for creating an edge directional flow such that deposition of the molten plastic material on the substrate happens downstream of the leading edge of the substrate. The flow, subsequent to first contact with the substrate, then proceeds from a generally central area of the adhering surface of the substrate towards one or more edges of the substrate. The "edge directional flow", as this expression is used herein, means a flow of molten plastic material that moves in a direction toward an edge or periphery of the substrate from an initial point of contact on the substrate that is distal from the edge or periphery.

**[0048]** In at least some embodiments, as depicted conceptually in Figure 1, the flow deflector exploits the naturally occurring rearward curl that is referred to as "fountain flow". In an injection mold system **2** having a mold **14** formed by a first mold component **14A** and a second mold component **14B** defining a cavity **15**, the flow **18** of molten plastic material such as thermoplastic is believed to be characterized, in some cases, by an advancing front **19** having a generally parabolic profile as shown in Figure 1. An outer concentric portion of the flow congeals prematurely along the first and second mold surfaces **14C**, **14D** as "frozen layers" that solidify due to the slightly lower temperature of the first and second mold surfaces **14C**, **14D** relative to the molten plastic material. These "frozen layers" are denoted by reference numeral **18A**. The curls defining the "fountain flow" denoted by reference numeral **18B** are exploited by the flow deflector in at least some embodiments of this invention to generate a backflow that back-fills the temporary air pocket that is formed downstream of the flow deflector and upstream of the point of first contact of the flow on the substrate.

**[0049]** It will be appreciated that the present invention is also compatible with other kind of flows such as completely laminar flows for example. Furthermore, the flow may also be multi-vectorial meaning that there may be more than one propagation front travelling in different directions and different velocities depending on the characteristics of the mold.

**[0050]** In the embodiment depicted by way of example in Figure 2, an injection mold (or injection molding system or injection molding apparatus) designated generally by reference numeral **2** is designed to bind a substrate **10** to an article (or object) being molded within a cavity **15** of a mold **14**. The mold **14** is shown partially and in cross-section in Figure 2. In this example, the mold has an upper mold component **14A** (i.e. a first mold component) and a lower mold component **14B** (i.e. a second mold component). The upper and lower mold components **14A**, **14B** have smooth interior surfaces that respectively define a first molding surface **14C** and a second molding surface **14D**. These molding surfaces are illustrated with an arbitrarily flat shape although it will be appreciated that these molding surfaces may have any suitable contours, curves, shapes or geometry to mold a desired part. The lower mold component **14B** includes an optional substrate cavity **17** (i.e. a recess) for receiving the substrate **10**. In the embodiment depicted in Figure 2, the injection mold has a flow deflector **16**. The main function of the flow deflector **16** is to deflect or divert a flow **18** of molten plastic material so as to prevent the front **19** of the flow **18** from contacting the leading edge(s) of the substrate **10** head-on. The flow deflector **16** instead deflects the flow **18** so that the front **19** of the flow **18** makes first contact with the adhering surface **20** of the substrate **10** downstream of the leading edge **11**. The molten plastic material flows backward toward the leading edge, which is referred to herein as “an edge directional flow”. The edge directional flow is created in part by the flow deflector **16** and in part by the dynamic of the molten plastic flow within the mold. In the embodiment depicted in Figure 2, the flow deflector **16** includes an overhang (or overhanging structure) that extends rearwardly over the substrate cavity **17** to deflect the flow of molten thermoplastic inside the mold over the leading edge of the substrate **10** in the substrate cavity **17**. The positioning of the overhang over the cavity and the substrate (in other words the dimension of the overhang) is optimized as a function of the leading edge **11** position relative to the flow deflector and the side wall of the substrate cavity **17**. As can be seen in Figures 3 and 18A for example, there can exist a small gap between the leading edge and the wall of the substrate cavity. This gap, when present, may vary as a function of the tolerance in the specifications of the length or width of the substrate such as a tape (that is to say normal variations in the dimensions of a tape within a production batch or between batches). The overhang (and flow deflector **16**) dimensions are preferably optimized by taking into account the variations in the size of the gap created by the tolerance (variations in dimensions) in the manufacture of the substrate. Therefore the flow deflector **16** should extend over the substrate cavity by an amount that will ensure that it also extends over the substrate by a predetermined minimum amount even when the dimension of the substrate vary slightly between different injection runs. In the case of tape such as flock tape for automotive applications, the length of the overhang that is immediately above the tape is preferably between about 0.03 mm and 0.3 mm.

**[0051]** The flow deflector **16** may have a curved front surface as shown in this figure. This flow deflector **16** guides the flowing molten thermoplastic over the leading edge **11** of the substrate **10** so that the molten thermoplastic first contacts the adhering surface **20** downstream of the leading edge i.e. contacts a central portion of the substrate **10** that is distal from the leading edge **11** prior to flowing back toward the leading edge **11**. Without wishing to be bound by theory, it is believed that, when a fountain flow is generated, the curl of the fountain flow helps to generate the backflow that backfills the temporary air pocket **22**. In the embodiment shown in Figure 2, the substrate **10** is disposed within the recess or substrate cavity **17** formed in the lower mold component **14B** defined between the flow deflector **16** and a rear wall **16A**. Although the substrate **10** is shown as having the same length (or width) as the recess of the lower mold component **14B**, and thus fitting exactly within the recess, it will be appreciated that a smaller substrate **10** may be placed within the recess in variants of this technique as shown in the embodiment depicted in Figure 3, where the substrate **10** is shorter than the substrate cavity **17**. In this particular embodiment, the downstream end of the flow deflector

**16** is substantially aligned with the leading edge **11** of the substrate **10**, although it is not necessary that these be aligned in other embodiments and variants. In this embodiment, the flow deflector **16** deflects the flow **18** over the leading edge **11** onto the substrate **10.**Substrates that are slightly smaller than the cavity may be easier to position in the mold prior to the injection. The gap created between the wall of the substrate cavity and the leading edge **11** may be small and allowing very little or virtually no melted thermoset to seep in. In other embodiments the gap may actually form part of the structure of the final molded article but the leading edge **11** is still protected, by flow deflector **16,** from a head on impact with the front of flow **18** since the gap will be filled by an edge directional flow. Although the flow **18** in this figure is illustrated as generally unidirectional, it will be appreciated that the flow **18** is multidirectional in most cases, i.e. the flow may also be perpendicular or oblique to the main flow direction shown in the figure.

**[0052]** While **14B** is referred as the lower mold component, it will be appreciated that it refers to the part of the mold that receives the substrate and that the mold may be oriented vertically in some applications.

**[0053]** In the embodiment depicted in Figure 4, the injection mold **2** does not have a substrate cavity to receive the substrate. Instead, the substrate **10** rests directly on the second molding surface **14D**. In this embodiment, the flow deflector **16** also deflects the flow **18** over the leading edge **11** onto the substrate **10**.

**[0054]** The behavior of molten plastic material (whether thermoplastics or thermosets) under different conditions of temperatures and pressures is complex and is generally understood to be dependent on the physico-chemical properties of the molten plastic material. In particular, the viscosity of the molten plastic material under the conditions at which the injection is performed is important to consider in optimizing the process. Furthermore, the flow may exhibit an uneven velocity distribution within a given cross-section of the flow. As was illustrated in Figure 1, the central or middle portion of the flow typically exhibits a greater velocity than the sections that are closer to the walls of the mold. Therefore, when the flow of molten plastic material encounters a change in the structure of the mold the slower portions of the flow tend to follow the contour of the walls of the mold while the central or middle portion of the molten thermoplastic material tends to flow where the least resistance is encountered.

**[0055]** In the embodiment depicted in Figure 5, the flow deflector **16** is a ramp-like lip or ridge extending orthogonally from the lower mold component **14B** toward the upper mold component **14A**. . In the particular embodiment depicted in Figure 5, the ramp-like flow deflector **16** is a rounded or curved lip or ridge. The rounded lip may have a constant curvature or a variable curvature or it may have one or more portion of constant curvature and one or more portions of variable curvature. The upstream side of the flow deflector **16** of Figure 5 may be curved or rounded as shown. The downstream side of the flow deflector **16** may be flat or straight as shown. It will be appreciated that this geometry may be varied in other embodiments. In the embodiment shown in Figure 5, the flow deflector **16** is a lip-like structure or ridge-like protrusion that extends substantially orthogonally to the direction of flow, i.e. in a direction that is orthogonal to the planes defined by the first molding surface **14C** and the second molding surface **14D**.

**[0056]** The flow deflector **16** is positioned and shaped to deflect the flow of molten plastic material away from the second molding surface **14D** so that the molten plastic material avoids contact with the leading edge **11** of the substrate **10** that is immediately downstream of the flow deflector **16**. The molten plastic material travels over the flow deflector **16** to create what is termed herein a “temporary dead zone” or temporary air pocket **22**. This temporary air pocket **22** is formed immediately downstream of the flow deflector **16**. The air pocket is temporary because it is back-filled by the flow of molten plastic material. In other words, due to the flow deflector **16**, an air pocket **22** is temporarily formed straddling the junction or interface between the leading edge **11** of the substrate **10** and the downstream side of the flow deflector **16** such that substantially none of the molten plastic material flows head-on onto the leading edge **11** of the substrate **10**. Thus, unlike prior-art injection molding techniques, the molten plastic material does not follow the contour of the mold to impinge upon the leading edge of the substrate. Instead, the molten plastic material is deflected over the leading edge **11** of the substrate **10** and makes first contact with the substrate **10** downstream of the leading edge **11**. The molten plastic material that makes first contact with the substrate thus exerts an initial securing pressure on a central part of the substrate to thereby initially immobilize the substrate. Immediately thereafter, due to the continuous inflow, the molten plastic material flows toward the edges of the substrate. The flow of the molten plastic material is both forward and rearward. In other words, part of the molten plastic material flows in a generally forward direction toward a downstream edge of the substrate while another portion of the molten plastic material flows rearwardly (upstream) to back-fill the temporary air pocket. This is illustrated in Figure 6. Thus, the expressions “temporary dead zone” and “temporary air pocket” are meant to refer to a volume or space within the mold that is adjacent an upstream edge of the substrate and immediately downstream of the flow deflector that remains temporarily empty or free of molten plastic material despite the immediate surroundings being filled by the molten plastic material. The temporary dead zone or temporary air pocket is eventually filled by the molten plastic material but in a directionally controlled manner by which the flow of molten plastic material travels from a generally central area of the adhering surface of the substrate towards the edge(s) or periphery of the substrate. As such, the temporary dead zone or temporary air pocket **22** is a collapsing space that progressively diminishes as the molten plastic material flows backward toward the leading edge **11**.

**[0057]** The creation of a temporary dead zone **22** (i.e. a shrinking pocket of empty space) along the leading edge **11** of the substrate **10** is dependent on several factors as mentioned above. The shape of the flow deflector **16** can be optimized to provide a desired size of temporary dead zone **22**. One such embodiment is depicted in Figure 7 in which the flow deflector **16** has a linear ramp shape. The shape of the flow deflector **16** can be altered to situate the point of first contact of the molten plastic material on the substrate **10**. In some cases, it may be desirable to have the molten thermoplastic material make first contact with the center point of the substrate **10**. In some embodiments, the substrate **10** is shaped to fit exactly within the recess in the lower mold component **14B**. In other words, in these embodiments, the length (or width, depending on the shape of the substrate) of the substrate **10** is equal to (or slightly less than) the length of the recess. In other embodiments, as depicted by way of example in Figure 8, the substrate **10** can be shorter than the recess, i.e. the length of the substrate **10** is less than the length of the recess. In this embodiment, the overmolding can cover the front and rear faces of the substrate **10**. .

**[0058]** Another embodiment of the injection mold is shown in Figure 9 in which the flow deflector **16** is formed as an angled undercut under which the leading edge of the substrate **10** may be disposed. The undercut is designed to create the temporary dead zone especially with higher viscosity thermoplastics or in conditions where the flow velocity is particularly slow. Such an undercut may also contribute to maintaining the substrate **10** in position by preventing it from lifting up. In a specific embodiment, the upstream edge (leading edge) **11** of the substrate **10** may be gently wedged into the angular space formed by the undercut so that the upstream edge (leading edge) **11** of the substrate **10** is physically restrained.

**[0059]** It will be appreciated that the flow deflector **16** may exhibit different shapes and features to optimize the dynamic of the flow according to particular conditions, type of substrate, physico-chemical properties of the molten plastic material or other relevant factors. Another embodiment of the injection mold **2** is shown in Figure 10. In the embodiment shown in Figure 10, the injection mold **2** has a dual angled flow deflector **16** that has a first angled ramp-like portion having a first angle and a second angled ramp-like portion having a second angle different from the first angle.

**[0060]** It will be appreciated that while the flow characteristics of different types of molten plastic materials may differ, the embodiments of the invention described above can be applied or adapted to the injection molding of various thermoplastics and thermosets.

**[0061]** In the embodiments depicted by way of example in Figures 11 and 12, the injection mold **2** may include one or more flow-directing structures **40** attached to, or integrated into, the mold to direct and optimize the flow over the substrate **10**. As shown in the embodiment of Figure 11, the injection mold **2** includes a single flow-directing structure **40** protrudes from an upper mold component **14A** to force the flow of molten plastic material onto a desired section of the substrate **10**, e.g. a generally central portion of the substrate. In the example shown in Figure 11, the flow-directing structure **40** is disposed on a first side of the mold opposite to a second side of the mold that receives the substrate. Specifically, in the embodiment depicted in Figure 11, the flow-directing structure **40** protrudes from the upper mold component **14A** toward the lower mold component **14B**. In the embodiment depicted in Figure 11, the flow-directing structure **40** is substantially aligned with a midpoint of the substrate **10** although in other variants the flow-directing structure **40** is not aligned with the midpoint of the substrate and thus may be upstream or downstream of the midpoint of the substrate. In other embodiments, there may be more than one flow-directing structure **40** which may have the same size and size or different sizes and different shapes.

**[0062]** The flow deflector **16** and the flow-directing structure **40** may be retractable or otherwise dynamically displaceable during the injection in order to optimize the flow and/or reduce the impact of the presence of these structures on the finished article. Figure 12 depicts an example of a retractable or movable flow-directing structure **40**. In the embodiment depicted in Figure 12, the injection mold **2** includes a retraction mechanism **41** for moving (i.e. extending and retracting) the movable flow-directing structure **40**. The retraction mechanism **41** may extend from and retract into the upper mold component **14A** as shown by way of example in Figure 12. The retraction mechanism **41** may be driven by, for example, a hydraulic actuator **42** having a rod **43** connected to an insert **44** that is mounted to the flow-directing structure **40**. The insert **44** may have one or more seals or gaskets to slide tightly inside the bore in the upper mold component **14A**. The actuator **42** is controlled in this embodiment by a controller **45**.

**[0063]** Figure 13 depicts an injection mold **2** having a movable flow deflector **16**. The movable flow deflector **16** is extended and retracted by a retraction mechanism **46** that includes an actuator **47** that drives a slidable insert **48**. The actuator **47** in this embodiment is controlled by a controller **49**.

**[0064]** Small variations in the positioning of the substrate **10** within the injection mold **2** prior and during injection may result in disruption of molten thermoplastic deposition on the substrate **10**. In this respect, substrate position stabilizing means (or substrate stabilizer) to help to maintain the position of the substrate **10** is optionally provided**.** In one aspect and as shown in Figure 17, rear wall **16A** may comprise a substrate retention member **16B** to prevent the substrate from being pushed out or lifted up of the substrate cavity **17** or to prevent warping or wrinkling of the substrate as the flow exert pressure on it. The shape and size of substrate retention member **16B** are adapted according to a number of factors including the shape of the substrate cavity **17**, the thickness of the substrate, the flow pressure, viscosity of the melted thermoset and the like. Figure 17 depicts an embodiment in which the substrate cavity **17** is curved and the substrate retention member **16B** protrudes slightly from rear wall **16A** above substrate **10** enough to prevent the substrate from being pushed out or lifted up from substrate cavity **17**. It will be appreciated that the size of the substrate retention member **16B** is configured to minimize disruption of the structure of the object being molded. Other configurations for the substrate retention member **16B** are also possible. For example it could be positioned at an intermediate location between the bottom and the top of rear wall **16A**.

**[0065]** The substrate retention member **16B** may also serve to enable the use of a vertical mold (in which the plane defined by the junction of the upper mold component and lower mold component is oriented vertically). In such a case, the retention member **16B**, optionally cooperatively with the flow deflector **16**, prevents the substrate from falling off due to gravity while it is being position in the mold prior to closing the mold and proceeding with the injection.

**[0066]** The positional stability of the substrate **10** may also be enhanced by exerting a force on the substrate **10.** The force may be applied prior to the injection and maintained during the injection cycle or applied only during pre-determined segments of the injection cycle. In one aspect the force may be applied while positioning the substrate in the mold prior to injection.

**[0067]** Thus, the substrate stabilizer may, for example, exert a stabilizing force on the substrate **10** by application of a vacuum or partial vacuum, an electrostatic force, a magnetic force or a mechanical force.

**[0068]** As depicted by way of example in Figure 14, when a vacuum is used as the stabilizing means, multiple vacuum channels **50** in the lower mold component **14B** where the substrate **10** is positioned are connected to a vacuum tank **52** that is evacuated fully or partially by a vacuum source such as a vacuum pump **54** to create suction (downward pressure) on the substrate **10**.

**[0069]** The use of a force as a substrate stabilizing means may be combined with a structural component stabilizer such as the substrate retention member **16B**. Together they can cooperatively stabilize the substrate or act separately at different stages of the molding process.

**[0070]** In yet another embodiment of the invention, the injection mold **2** includes an angled injection port **60** as depicted in Figure 15 to obliquely inject molten plastic material into the mold cavity **15**. The angled injection port **60** may be disposed at an angle to optimize the path of the molten plastic material so that the material flows over the leading edge **11** of the substrate **10**.

**[0071]** In the embodiment depicted by way of example in Figure 16, the flow deflector **16** comprises a step. The stepped flow deflector is substantially orthogonal to the flow of molten thermoplastic inside the mold as shown in the figure. The flow deflector **16** has a height or depth (i.e. “thickness”) extending in an orthogonal direction that is greater than that of the substrate **10** such that there is a stepwise gap between the interface of the flow deflector **16** and the second molding surface **14D** and the adhering surface **20** of the substrate **10**. The rear wall **16A** may have the same height or “thickness” as the flow deflector **16** although in other variants, the rear wall **16A** may differ in height or shape.

**[0072]** In the case of a relatively high-viscosity thermoplastic, the shape and size of the flow deflector **16** of Figure 16 may be adjusted to have a more accentuated stepwise shape to prevent the head-on contact between the slower part of the front of the flow and the edge of the substrate. In this embodiment, the flow deflector **16** is designed to substantially prevent the flow from penetrating underneath the substrate at its leading edge through spaces at the interface between the edge of the substrate and the side of the flow deflector **16**.

**[0073]** In some applications, the substrate may be a tape comprising a functional structure on the side that is not bound to the molded object. For example flock tape (a tape with flocking fibers on the non-adherent side), which is often used in the automotive industry to provide functionalities such as sealing, noise reduction, reduced friction and the like. The stringent specifications in industries in general and the automotive industry in particular require that functional structures such as the flocking fibers on flock tape remain essentially intact or at least that any alterations to the fibers be limited to a strict minimum compatible with proper function of the part comprising the tape.

**[0074]** The conditions within the mold can be harsh for the substrate as a result of the high pressures involved. These harsh conditions may result in damage to functional structures of substrates. In the case where the substrate is flock tape, damage can be in the form of flattening of the fibers as a result of the pressure exerted by the flow of the melted thermoset and/or by the substrate stabilizing means (vacuum for example). Thus in another aspect of the invention there is provided a flocking fibers protective structure whereby the fibers of the flock are substantially protected from flattening while sufficient support is provided to maintain the shape of the substrate (tape) during injection.

**[0075]** Referring to Figure 18A an exemplary embodiment is schematically represented in which a plurality of flock fibers receiving channels **70** are embedded in lower mold component **14B** just underneath the substrate positioning area which, in some instances, coincides with substrate cavity **17**. The flock receiving channels **70** are dimensioned to accommodate the length of flocking fibers **71** with some extra space at the bottom to allow for variations in length of the fibers and/or slight downwards displacement of the tape when subjected to the pressure of the flow of melted thermoset. Thus the depth of the flock receiving channels **70** may be, for example, between about 0.2 and 1 mm, a range comprising typical length of flock fibers. The extra space at the bottom may be of the order of about 10-20% of the length of the flock fibers.

**[0076]** Each flock receiving channel **70** is separated from its neighbors by a distance commensurate with the maximum amount of flattening that can be tolerated. That is to say, the sections **72** of the lower mold component **14B** between the channels contribute to flattening (or substantially displaced from their original generally vertical arrangement) of the flock fibers. Thus the area, defined by their top surface **73**, occupied by these sections is preferably minimized while retaining sufficient supportive strength to withstand the pressure during injection. Acceptable “damage” to the fibers depends on the required specifications of the final product. For the automotive industry this may represent no more than about 10% and preferably about 1% to 5% of the fibers being flattened. This can perhaps be better appreciated by referring to Figure 20 where a top view of the area of lower mold component **14B** comprising the flock receiving channels **70** is shown. Thus the total top surface **73** would be no more than about 10% and preferably about 1% to 5% of the surface occupied by flock fibers on the tape. Less stringent product specifications may permit top surface **73** to occupy a greater total surface area. The distance (occupied by top surface **73**) between any two the flock receiving channels is preferably between about 0.05 mm and 0.1 mm. Figure 20 exemplifies a regular pattern of disposition of flock receiving channels **70** with rounded-corners squares openings but it will be appreciated that other patterns may also be used such as a honeycomb pattern or a pattern where the openings for flock receiving channels **70** are round for example. Also, the pattern need not necessarily be regular and may be designed to adapt to the shape of the substrate cavity for example. Furthermore the edges of surface **73** between channels **70** may be rounded so that the top of sections **72** is dome shaped. Such a shape may advantageously force flock fibers to deviate in one or another flock receiving channel **70** thereby further reducing flattening of the fibers.

**[0077]** The flock receiving channels **70** can be created with a laser. In the case of laser engraving, the channels may have a generally conical shape as illustrated in Figures 18A and 18B as a result of the tapering of the laser beam power along the depth of the channel. However the tapering can be controlled to provide sufficient volume to accommodate the fibers. The fibers may tolerate a certain level of crowding within the channel to the extent that they are resilient enough to regain their original orientation once the molded object is removed from the mold. Other geometries for the flock receiving channels **70** are also contemplated such as cylindrical, cubic and the like. The orientation of the channels **70** within the lower mold component **14B** may depend on the shape of the substrate cavity **17**. For example in Figure 18B some of the channels are obliquely oriented to accommodate the curvature of the substrate cavity **17**. Other means of creating the channels 70 include, without being limited to, electrical discharge machining (EDM), plasma cutting and the like.

**[0078]** Figures 20 and 21 are illustrations of a mold having a plurality of conically shaped flock-receiving channels **70** that have been laser-engraved into the lower mold component **14B**. The configuration (in terms of size and spacing) of the channels **70** is merely illustrative of the concept and may be varied for different operating parameters, materials, pressures, etc. and/or to achieve different results. In one specific implementation, which is presented solely to illustrate one particular configuration that is believed to provide excellent results, the height of the conically shaped channels is 0.3-0.7 mm and the width is 0.05-0.15 mm. Other geometries and dimensions may be used as further described below.

**[0079]** As will be appreciated, flock receiving channels that are too wide could result in a downward displacement of the tape as a result of the pressure exerted by the flow of the melted thermoset (lack of sufficient support). Thus, the size of the flock receiving channels **70** is adjusted as a function of parameters such as the substrate resiliency, pressure generated by the melted thermoset, substrate cavity size, stabilizing force exerted on the substrate and the like.

**[0080]** In an alternative embodiment shown in Figure 19A, the flock receiving channels may be created with a mesh structure **76** superimposed on the lower mold component **14B** or substrate cavity **17** when such a cavity is present. In this case the flock receiving channels **70** are the pores or sieves of the mesh while the strands (or sections **72**) of the mesh itself provide support for the tape (or other type of substrate). Advantageously the mesh structure may be removed and replaced by a mesh of different dimension allowing the same mold to be re-used for substrates and/or flocking fibers of different dimensions. The mesh may be made of any suitable material such as metal, fiber-reinforced polymers, plastic and the like. In one advantageous embodiment, the material is one that does not bind to the thermoplastic material used for the injection. For example the mesh could be made of a polyamide when thermoplastic vulcanizates (TPV) or polypropylene (PP) are used as thermoplastics for the injection. Thus in case of infiltration of the thermoplastic melt in the mesh it is easily cleanable.

**[0081]** The pores or sieves dimensions are in the same ranges as described for the flock receiving channels **70** created in the lower mold component 14B. Thus preferred size comprises mesh size of between about 100 to 300 mesh and more preferably about 150 mesh which correspond to pore or sieves size of about 0.05 mm to about 0.15 mm and more preferably about 0.1 mm. In one embodiment shown in Figure 19B, the top surface **73** of the sections **72** of the mesh may be rounded as was described above in the case where the flock receiving channels **70** are made directly in lower mold component **14B**.

**[0082]** The lower dimension limit for the width of flock receiving channels **70** is reached when the number of fibers per channel is too small. This lower limit ratio can be determined by taking into account the size and density of the fibers.

**[0083]** The mesh structure may be retained by retaining means to avoid displacement and/or facilitate the positioning of the substrate thereon. The substrate cavity **17** alone may be sufficient to that effect or may cooperate with additional retention structures.

**[0084]** In one aspect the flock receiving channels **70** can cooperate with the substrate stabilizing means. For example, the mesh structure may be coupled with a vacuum system. The porous nature of the mesh advantageously provides for an easy connection with a vacuum system by enabling the propagation of the vacuum and offers flexibility as to the number, size and positioning of the vacuum channels (such as vacuum channels **50**) allowing strategic positioning of the vacuum channels **50** within the mold.. Furthermore the suction action of the vacuum may contribute to straightening the fibers.

**[0085]** The flock receiving channels **70** can also contribute to the stabilization of the substrate. The fibers once inserted in the flock receiving channels **70** contribute to resist any lateral displacement of the substrate. In this respect, the flock receiving channels **70** may be sufficient, that is to say without a flow deflector, to prevent infiltration of the thermoplastic melt under the substrate without a flow deflector as shown in Figure 22. This may be especially the case when the flock receiving channels **70** are comprised in a mesh structure and combined with a vacuum or partial vacuum. The mesh structure allows the vacuum to reach substantially all the surface of the substrate and therefore provide good stabilization of the substrate especially at the critical leading edge of the substrate.

**[0086]** The leading edge **11** of substrate **10** in the case of a tape such as a flock tape is typically not perfectly even and leveled sometimes exhibiting small ripples on its top surface. Thus when the substrate **10** is of the same thickness as the depth of substrate cavity **17** as shown in figure **22**, these ripples may protrude slightly higher than surface **14D**. In such a case, the flow may run into these ripples and displace the tape. However, as described above, the combination of the mesh structure and a vacuum may be sufficient to stabilize the tape by reducing the ripples and/or providing sufficient suction at the edge **11** (because of the propagation of the vacuum in the mesh to reach all the surface of the tape) to prevent the displacement by the front of the flow.

**[0087]** Alternatively, the flock receiving channels (created by a mesh structure or directly in lower mold component **14B**) may advantageously cooperate with the flow deflector **16**, the substrate cavity **17** or the retention member **16B**, either separately or together, to maintain the substrate in place and prevent infiltration of the thermoset material under the substrate.

**[0088]** Mesh structures can be made by methods known to persons skilled in the art. More recent technologies such as 3D printing can advantageously be used.

**[0089]** The various mold structures and arrangements described above may be combined, adapted and/or configured to accommodate various configurations of thermoset melt injection points. For example, a single injection point may be used but a plurality (two or more) injection points can also be used such as in sequential molding techniques. It will be appreciated that the various injection point(s) configurations will results in different flow patterns and thereby requiring adaptation of the mold configuration.

**[0090]** Another aspect of the invention is a method for in-mold binding of a substrate on an injection-molded article. The method entails steps, acts or operations of positioning the substrate within the mold prior to injection of the molten plastic material and injecting the molten plastic material, e.g. thermoplastic, and then causing the deflection of the flow of molten plastic material inside the mold using a flow deflector to deflect the flow of molten plastic material over the leading edge of the substrate thereby preventing head-on contact between a front of the flow and the leading edge of the substrate. This method reduces the likelihood of the substrate being displaced or deformed during the molding process. As a result, the method facilitates in-mold binding of a substrate to an injection-molded article.

**[0091]** As will be appreciated, additional steps, acts and operations to complete the injection molding may involve a cooling cycle and removal of the molded article from the mold.

**[0092]** Thus, in some embodiments, the method involves positioning the substrate within an injection mold prior to injection of the molten plastic material, closing the mold while maintaining the substrate in the desired position (i.e. the finished molded object position), applying any optional stabilizing means (e.g. a vacuum) to hold the substrate in place, and injecting the molten plastic material into the mold to create a flow that is deflected by a flow deflector over the leading edge of the substrate to prevent head-on contact between a front of the flow and an edge of the substrate. In the embodiments of this method, the flow makes first contact with the upper adhering surface of the substrate downstream of the leading edge to secure the substrate in place. A temporary air pocket is formed upstream of the point of first contact. The edge directional flow then back fills the temporary air pocket while the also flow spreads forward toward the downstream edge(s) of the substrate. In other words, in some embodiments of the method, the front of the flow is directed onto a central portion or middle point of the adhering surface of the substrate away from the edge or edges of the substrate prior to allowing the flow to spread over the entire adhering surface of the substrate.

**[0093]** The step of deflecting the flow to prevent head-on contact between a front of the flow and an edge of the substrate is achieved using one or more flow deflectors that divert the flow of the molten plastic material such that it initially makes contact with the adhering surface of the substrate away from the edge(s) before spreading to the edge(s) of the substrate. In one aspect this may be achieved by creating a temporary dead space at or near the edge(s) of the substrate during injection to allow the flow to first contact the adhering surface centrally, i.e.

away from the edge(s). By avoiding the edges, the substrate is bound in-mold to the article without the problems that affect the prior art.

**[0094]** The method may also involve directing the flow using one or more flow-directing structures within the mold.

**[0095]** Furthermore, in one embodiment of the method, the flow deflector and/or the flow-directing structure can be dynamically displaced, moved or retracted during injection or during the cooling cycle.

**[0096]** In some embodiments, the positional stability of the substrate **10** can be enhanced by applying a restraining or stabilizing force or pressure on the substrate **10**. For example, a vacuum may be generated underneath the substrate **10** to create suction that forces the substrate **10** against the bottom of the mold. The vacuum may be applied before starting the injection, during the injection or both.

**[0097]** In yet a further embodiment of the method, the flow of melted thermoplastic is not deflected but the leading edge of the substrate (especially in the case of a tape) is stabilized within the substrate cavity to prevent small imperfections in the alignment of the surface of the tape with the surface of the mold cavity from being lifted or pushed by the front of the flow. The stabilizing can be done for example by using a vacuum as stabilizing force in combination with a mesh structure to support the substrate.

**[0098]** In another aspect there is provided a method for adjusting the texture of flock fibers on a flock tape to match the texture of flock fibers on a separate section of the finished product. Complex molded pieces may comprise a plurality of sections or parts that are manufactured separately and then assembled by various processes. Sometimes flock tape may be applied to different sections using a different process. For example, on one part the flock tape may be applied as a secondary operation with a roll and on another it may be applied in-mold as described above. Those different processes may result in the flock fibers from different parts of the finished product having different degree of flattening which may be unacceptable or outside the specifications. The mold of at least one embodiment of the present invention enables the adjustment of the flock fibers texture or degree of flattening to match that of the flock fibers produced by another process. The matching can be accomplished by adjusting the size of surface **73** so that the amount of flattening of the flock fibers created by in-mold substrate binding will match that of the flock fibers produced by a separate manufacturing process. The mesh structure is particularly advantageous in this respect since it is easy to test several sizes of mesh until a "match" is found without having to machine the mold to create the flock receiving channels **70**.

**[0099]** The match or the degree of flocking fibers flattening can be assessed visually by comparing the color (shade of gray on a gray scale) of the flock surface of flock tape. Figures 23A-D show photographs of magnified images of flock tapes that have been exposed to in-mold substrate binding while resting on meshes of different size. Figure 23A shows a tape that has not been exposed to in-mold binding (control). Figures 23B, 23C and 23D show tapes that have been exposed to in-mold binding while resting on meshes with mesh sizes of approximately 150, 180 and 250 mesh respectively. The progression of increasing white speckles from 150 mesh (least) to 250 mesh (most) indicates increasing fiber flattening as the size of the pores diminishes. It will be appreciated that depending on the characteristics of the tape, such as but not limited to, fibers density, there may be an optimum size of mesh below or above which flattening may increase.

**[00100]** It is to be understood that the singular forms "a", "an" and "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to "a device" includes reference to one or more of such devices, i.e. that there is at least one device. The terms "comprising", "having", "including", "entailing" and "containing", or verb tense variants thereof, are to be construed as open-ended terms (i.e., meaning "including, but not limited to,") unless otherwise noted. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of examples or exemplary language (e.g. "such as") is intended merely to better illustrate or describe embodiments of the invention and is not intended to limit the scope of the invention unless otherwise claimed.

**[00101]** While several embodiments have been provided in the present disclosure, it should be understood that the disclosed systems and methods might be embodied in many other specific forms without departing from the scope of the present disclosure. The present examples are to be considered as illustrative and not restrictive, and the intention is not to be limited to the details given herein. For example, the various elements or components may be combined or integrated in another system or certain features may be omitted, or not implemented.

**[00102]** This invention has been described in terms of specific embodiments, implementations and configurations which are intended to be exemplary only. Persons of ordinary skill in the art will appreciate, having read this disclosure, that many obvious variations, modifications and refinements may be made without departing from the inventive concept(s) presented herein. The scope of the exclusive right sought by the Applicant(s) is therefore intended to be limited solely by the appended claims.

**WHAT IS CLAIMED IS:**

1. An injection mold for manufacturing an injection-molded article to which a substrate is bound in-mold during injection, the substrate having an adhering surface for binding to the article and a leading edge at an upstream end of the substrate, the injection mold comprising:

a first mold component and a second mold component together defining a cavity into which a molten plastic material is injected to form the article; and

a flow deflector disposed on at least one of the first and second mold components, wherein the flow deflector deflects a flow of the molten plastic material over the leading edge of the substrate such that the flow makes first contact with the adhering surface of the substrate downstream of the leading edge, thereby forming a temporary air pocket at the leading edge of the substrate which is then back-filled by the subsequent flow of the molten plastic material.

2. The injection mold of claim 1 wherein the flow deflector comprises an overhang.

3. The injection mold of claim 1 or 2 wherein the flow deflector comprises a curved ramp.

4. The injection mold of claim 1 or 2 wherein the flow deflector comprises a linear ramp.

5. The injection mold of any one of claim 1-4 wherein the flow deflector comprises an angled undercut.

6. The injection mold of claim 1 wherein the flow deflector comprises a step.

7. The injection mold of claim 1 or 2 wherein the flow deflector comprises a dual angled ramp having a first angled ramp-like portion having a first angle and a second angled ramp-like portion having a second angle different from the first angle.

8. The injection mold of any one of claims 1 to 7 wherein the flow deflector is movable.

9. The injection mold of any one of claims 1 to 8 further comprising a flow-directing structure downstream of the flow deflector for directing the flow toward the substrate.

10. The injection mold of claim 9 wherein the flow-directing structure is movable.

11. The injection mold of any one of claims 1 to 10 further comprising an angled injection port upstream of the flow deflector.

12. The injection mold of any one of claims 1 to 11 wherein the lower mold component comprises a substrate cavity for receiving the substrate.

13. The injection mold of any one of claims 1 to 12 further comprising at least one substrate stabilizer to restrain the substrate in its position in the mold.

14. The injection mold of claim 13 wherein the at least one substrate stabilizer comprises a substrate retention member.

15. The injection mold of claim 13 or 14 wherein the at least one substrate stabilizer comprises a vacuum source.

16. The injection mold of any one of claim 1-15 wherein the substrate is a flock tape and wherein the mold further comprises flocking fibers protective structure.

17. The injection mold of claim 16 wherein the flocking fibers protective structure comprises flocking fibers receiving channels.

18. The injection mold of claim 17 wherein the flocking fibers protective structure is a mesh.

19. A method of injection-molding an article to which a substrate is bound in-mold during injection, the substrate having an adhering surface for binding to the article and a leading edge at an upstream end of the substrate, the method comprising:

providing a first mold component and a second mold component together defining a cavity;

injecting a molten plastic material into the cavity to form the article; and

deflecting a flow of the molten plastic material over the leading edge of the substrate using a flow deflector deflects such that the flow makes first contact with the substrate downstream of the leading edge, thereby forming a temporary air pocket at the leading edge of the substrate which is then back-filled by the subsequent flow of the molten plastic material.

20. The method of any one of claim 19 further comprising moving the flow deflector.

21. The method of claim 19 or 20 further comprising restraining the substrate using at least one substrate stabilizer.

22. The method of claim 21 wherein restraining the substrate is performed using a vacuum source as the at least one substrate stabilizer.

23. The method of any one of claims 19 to 22 further directing the flow toward the substrate using a flow-directing structure downstream of the flow deflector.

24. The method of any one of claims 19 to 23 further comprising moving the flow-directing structure.

25. The method of any one of claims 19 to 24 wherein injecting the molten plastic material is performed using an angled injection port upstream of the flow deflector.

26. The method of any one of claims 19 to 25 wherein the molten plastic material is a thermoplastic.

27. The method of any one of claims 19 to 26 wherein the substrate is a tape.

28. The method of claim 27 wherein the tape comprises flocking fibers.

29. The method of claim 28 wherein the substrate is restrained by at least one substrate stabilizer and wherein the at least one substrate stabilizer comprises flock receiving channels whereby insertion of the flocking fibers in the flock receiving channels prevent displacement of the tape during injection.

30. An injection mold assembly for manufacturing an injection-molded article to which a substrate is bound in-mold during injection, the substrate having an adhering surface for binding to the article, and flock- fibers on a surface opposite the adhering surface, the injection mold assembly comprising: a first mold component and a second mold component together defining a cavity into which a molten plastic material is injected to form the article; a plurality of fiber-receiving channels in a bottom side of a substrate cavity located in one of the first and second mold components wherein the substrate is placed in the substrate cavity such that at least some of the fibers are within the plurality of fiber-receiving channels during injection.

31. The injection mold of claim 30 further comprising vacuum inlets communicating with the plurality of fiber-receiving channels and connected to a vacuum generator that provides a substrate retention force.

32. The injection mold of claims 30 or 31 wherein the plurality of fiber-receiving channels are contained in a mesh structure disposed in the substrate cavity.

33. The injection mold of any one of claims 30-32 further comprising a flow deflector disposed on at least one of the first and second mold components, wherein the flow deflector deflects a flow of the molten plastic material over the leading edge of the substrate such that the flow makes first contact with the adhering surface of the substrate downstream of the leading edge, thereby forming a temporary air pocket at the leading edge of the substrate which is then back-filled by the subsequent flow of the molten plastic material.

34. A method for manufacturing an injection-molded article to which flock tape having flock fibers is bound in-mold during injection, the method comprising: assessing a degree of flock fiber flattening by matching the degree of flock fiber flattening to the degree of fiber flattening on a separate article on which flock tape has been applied by a method other than in-mold substrate binding, providing an injection mold for in-mold substrate binding as claimed in claim 35 or 36, selecting a mesh structure with a mesh size producing the degree of flock fiber flattening matching that of the separate article.

35. The method of claim 34 wherein the injection molded article is overmolded on the separate article.

36. The method of claim 34 or 35 wherein the step of assessing is performed by comparing the flock fibers to a standardized flock fibers gray scale that is indicative of the degree of fiber flattening.

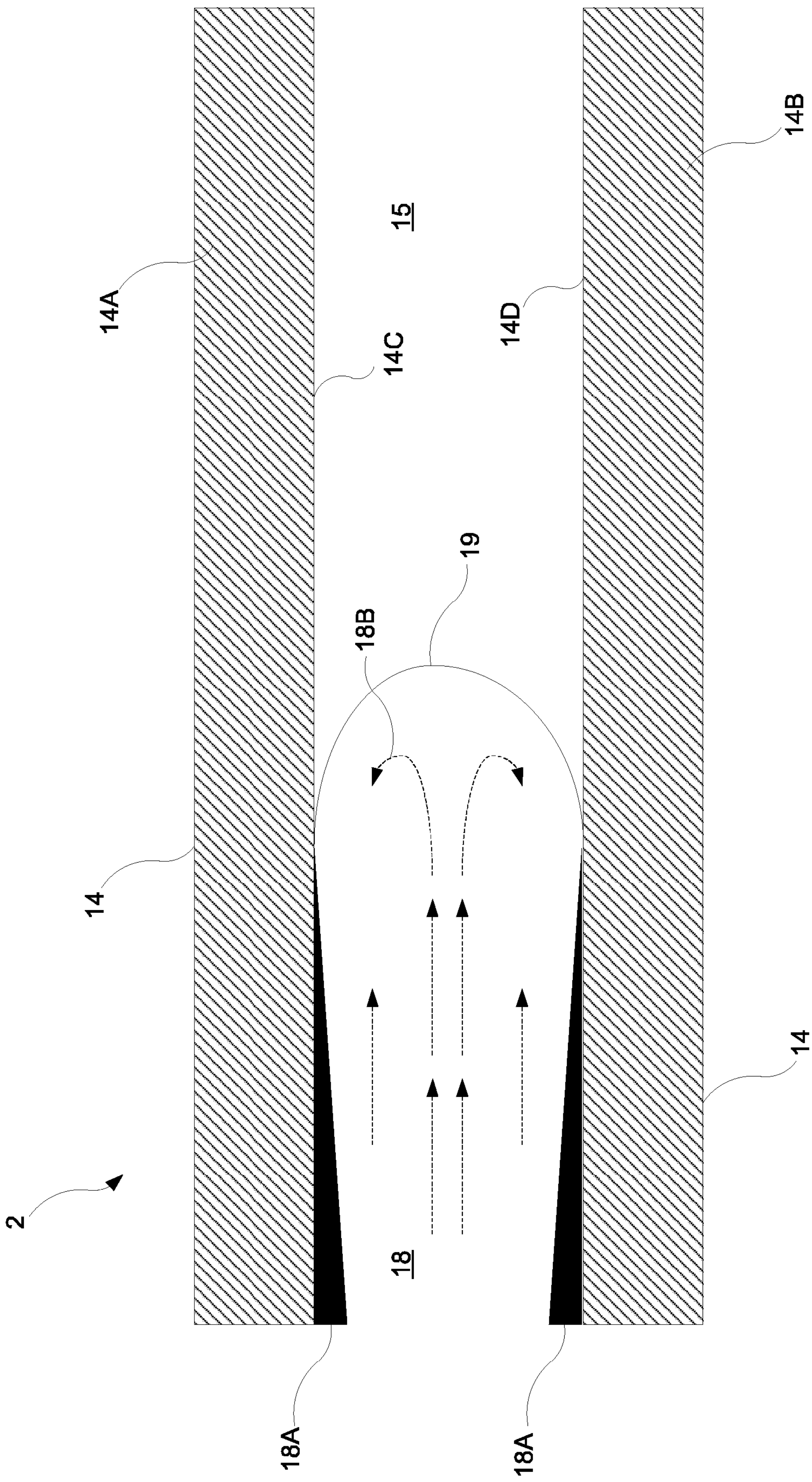


FIG. 1

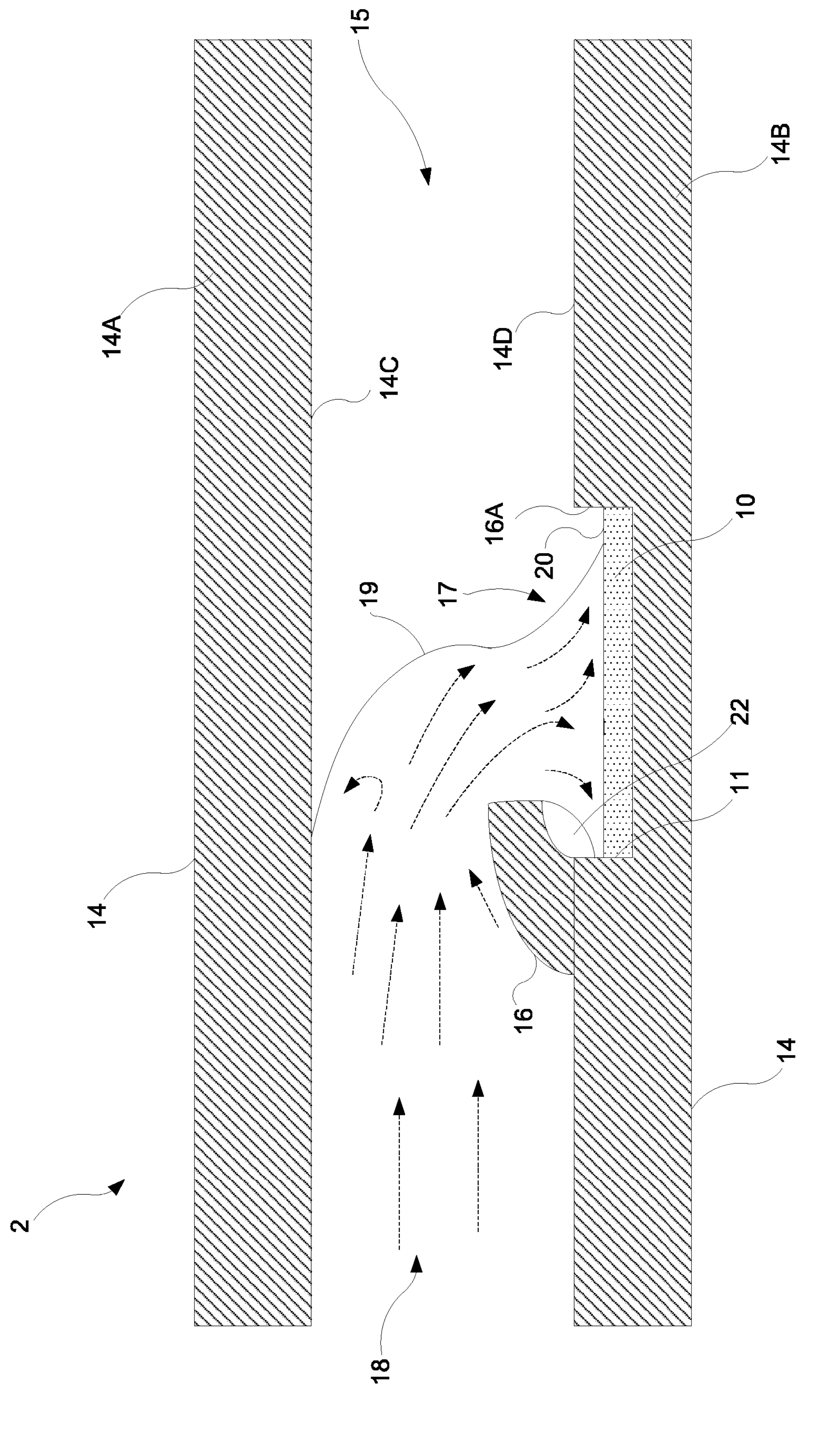


FIG. 2

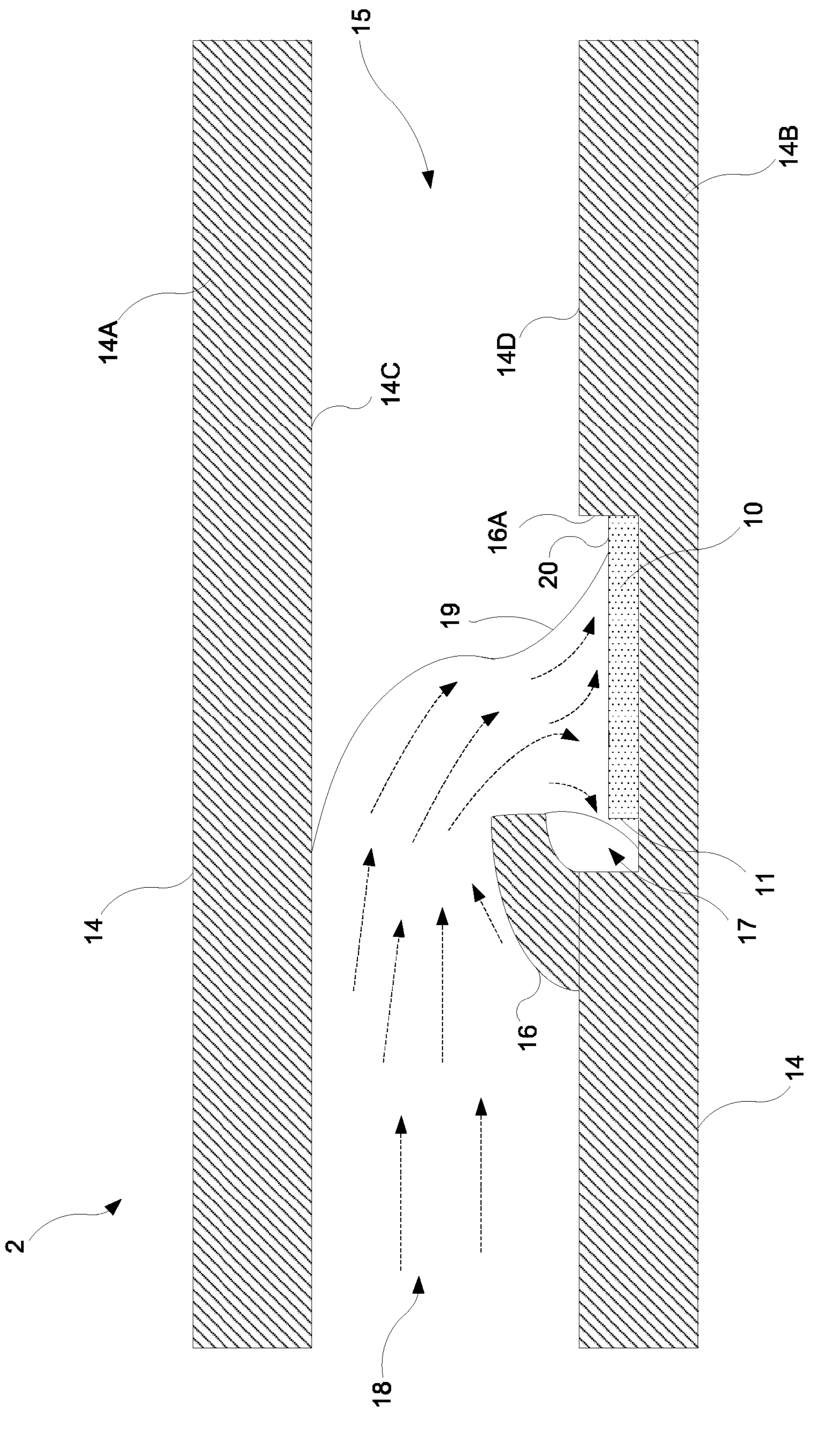


FIG. 3

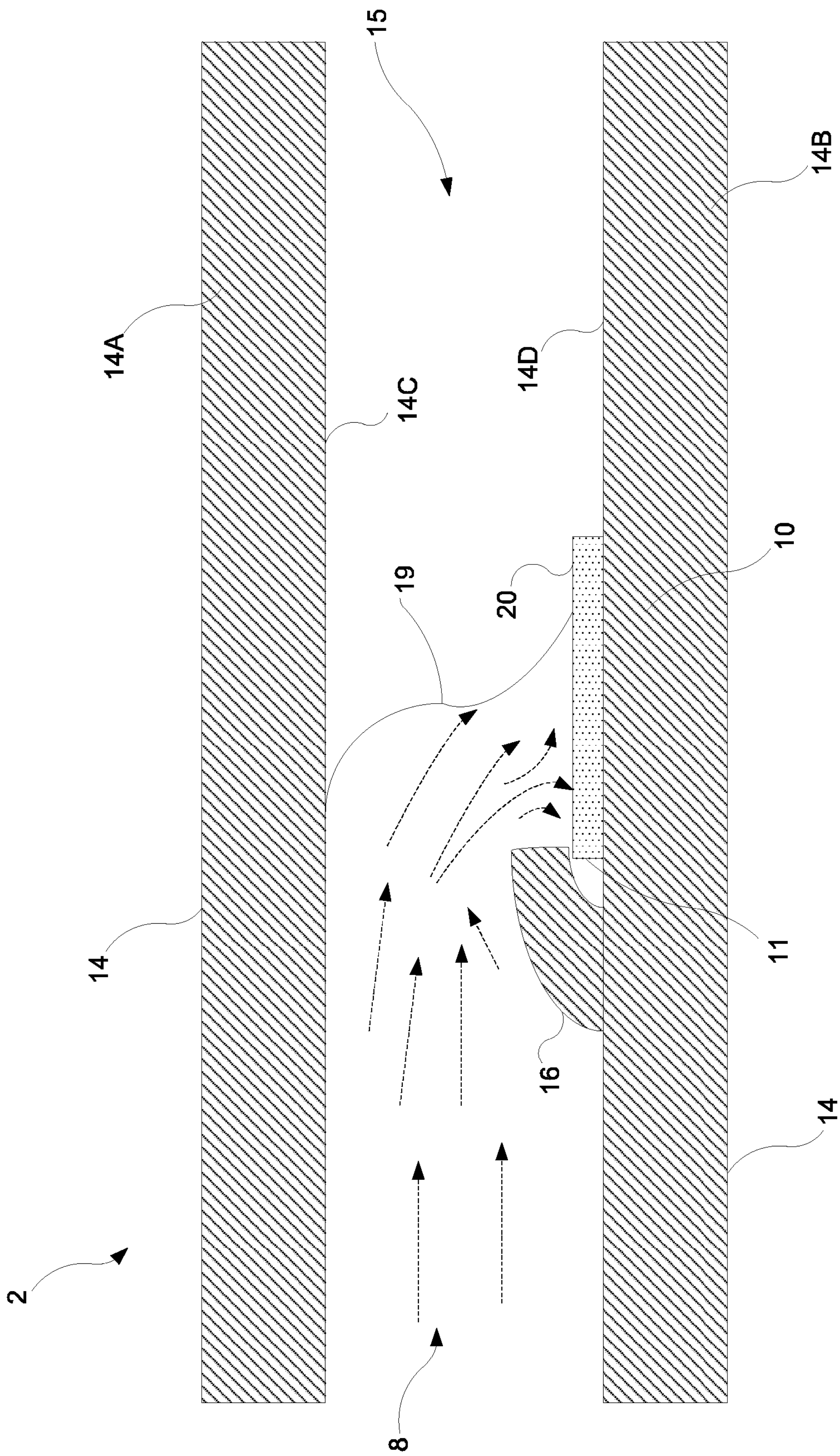


FIG. 4

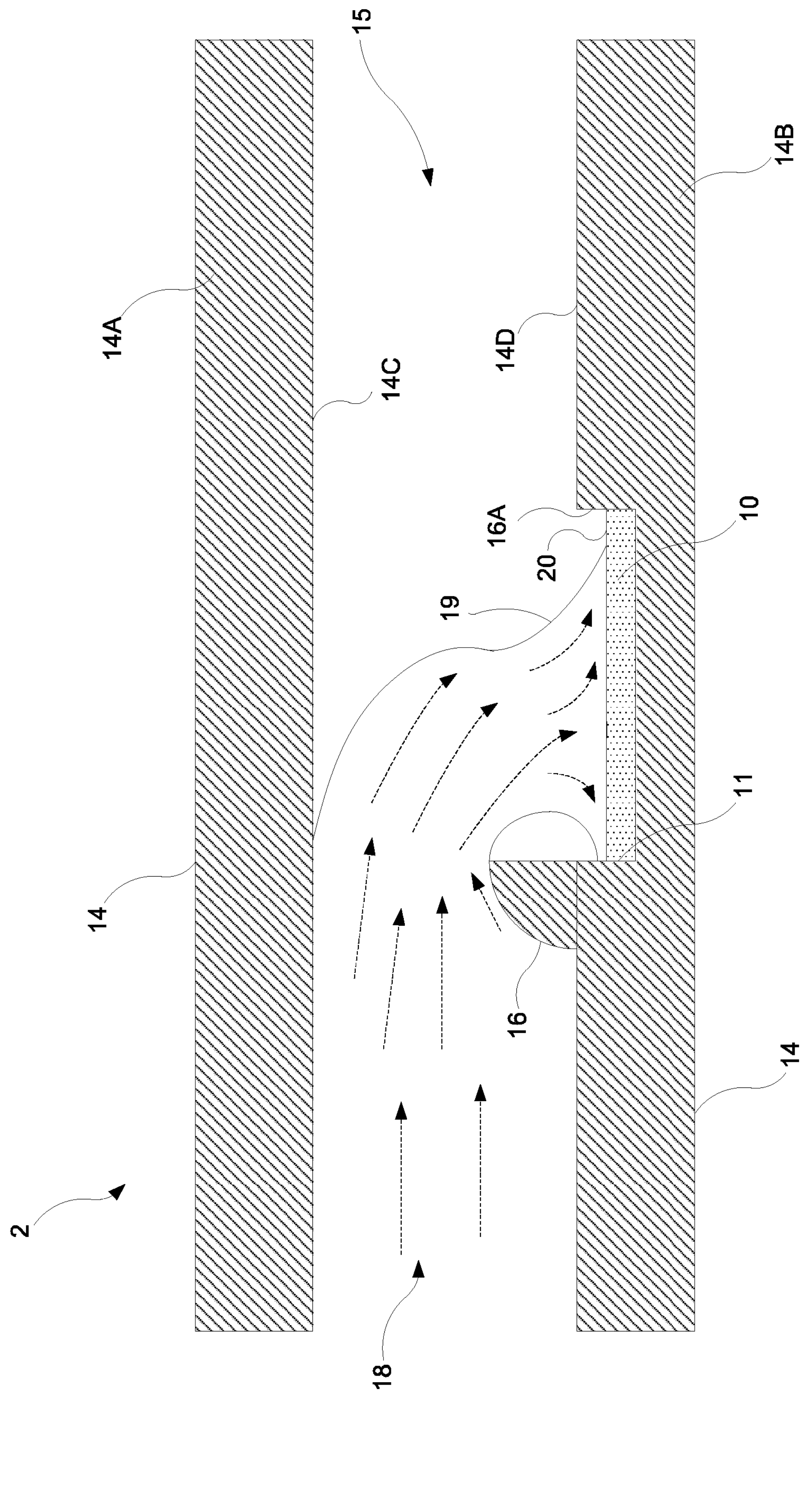


FIG. 5

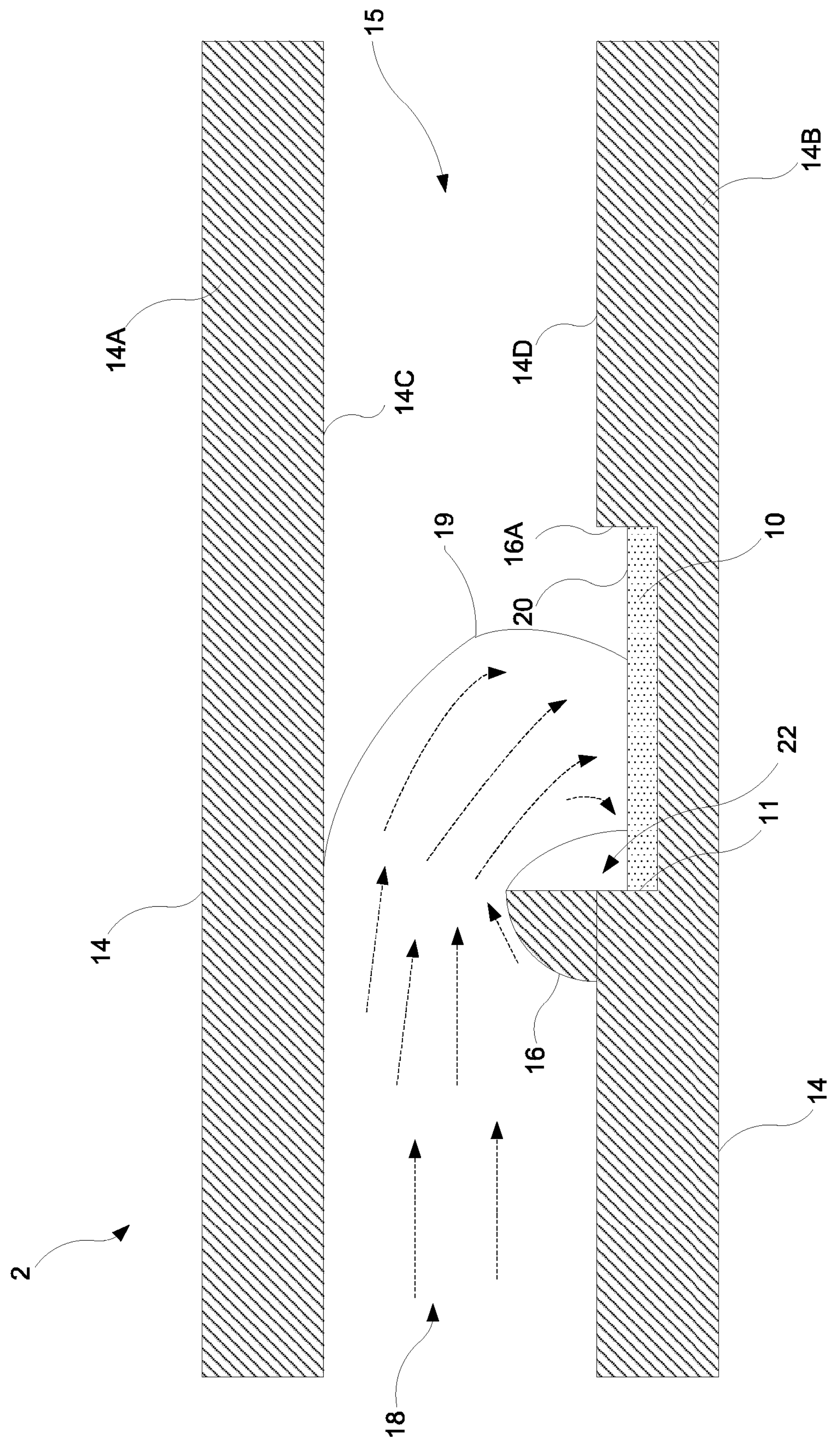


FIG. 6

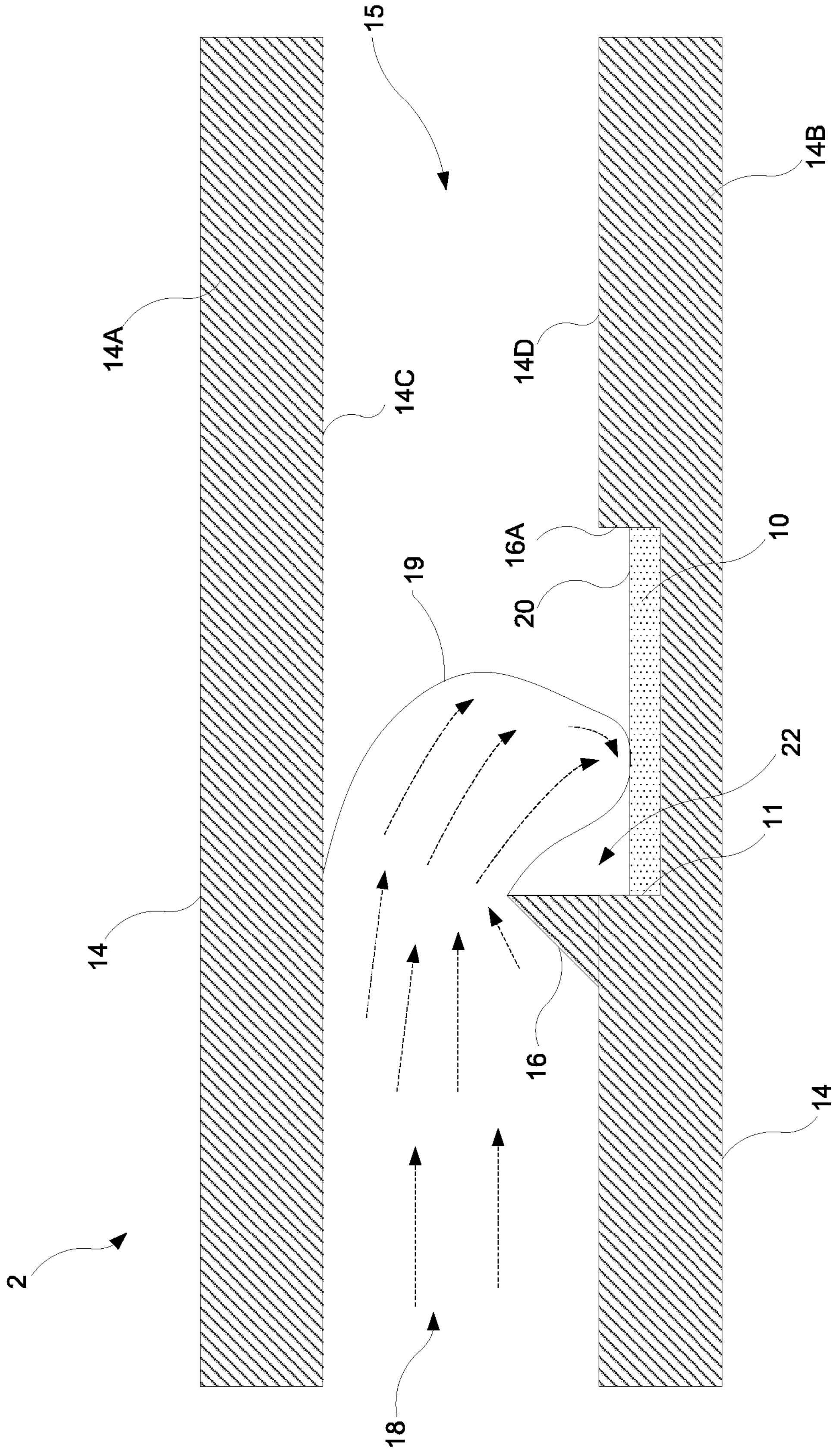


FIG. 7

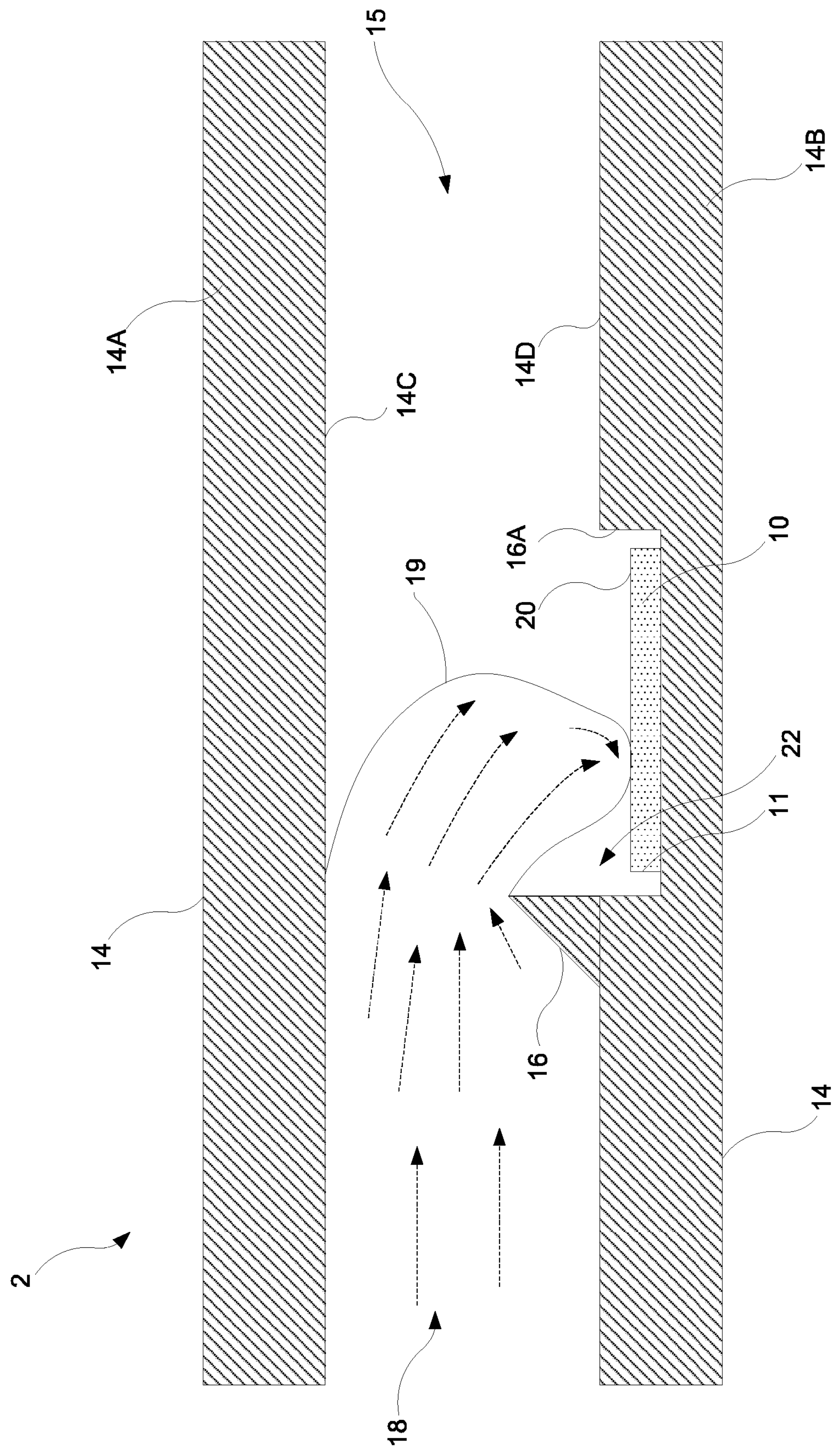


FIG. 8

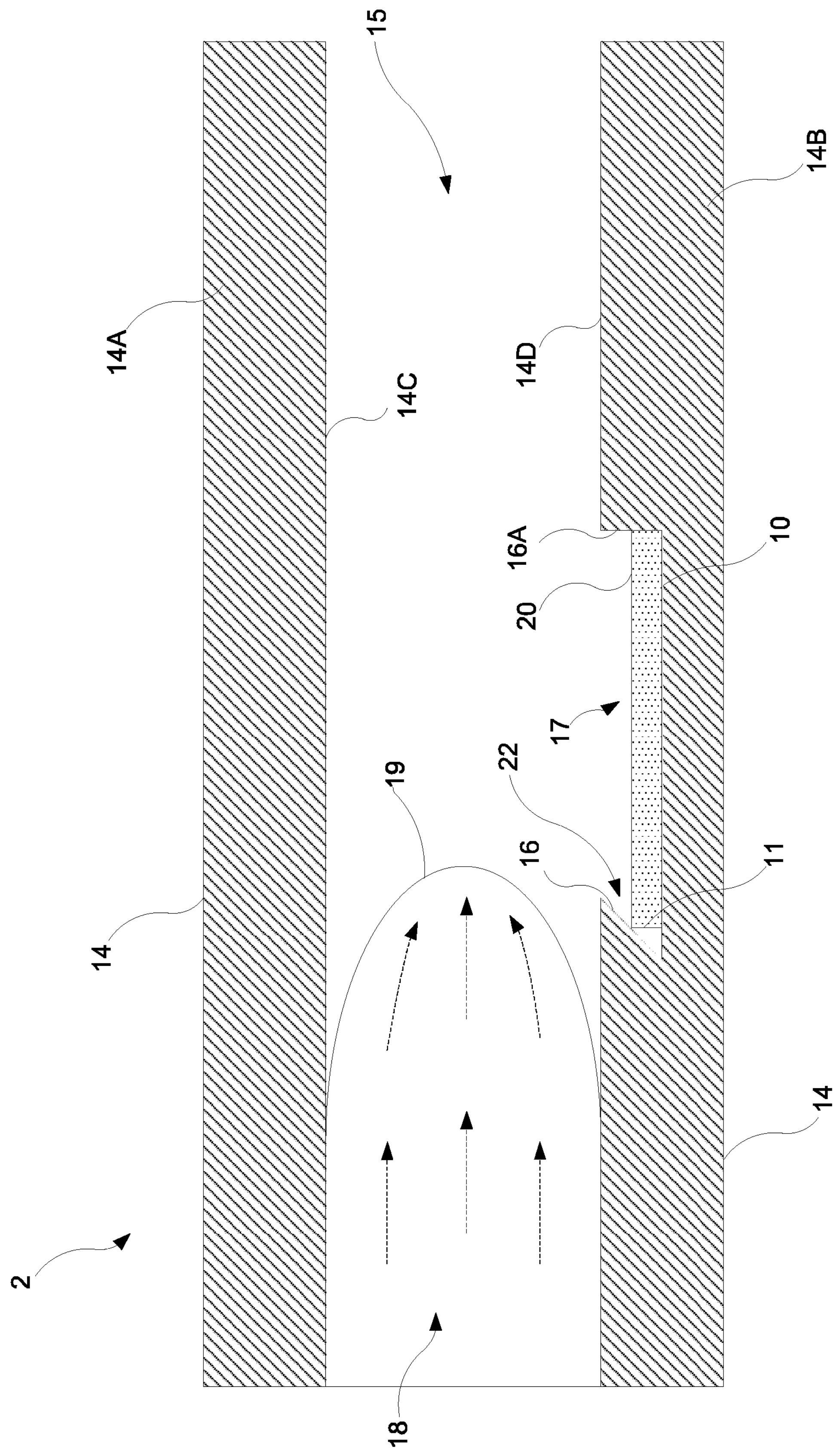


FIG. 9

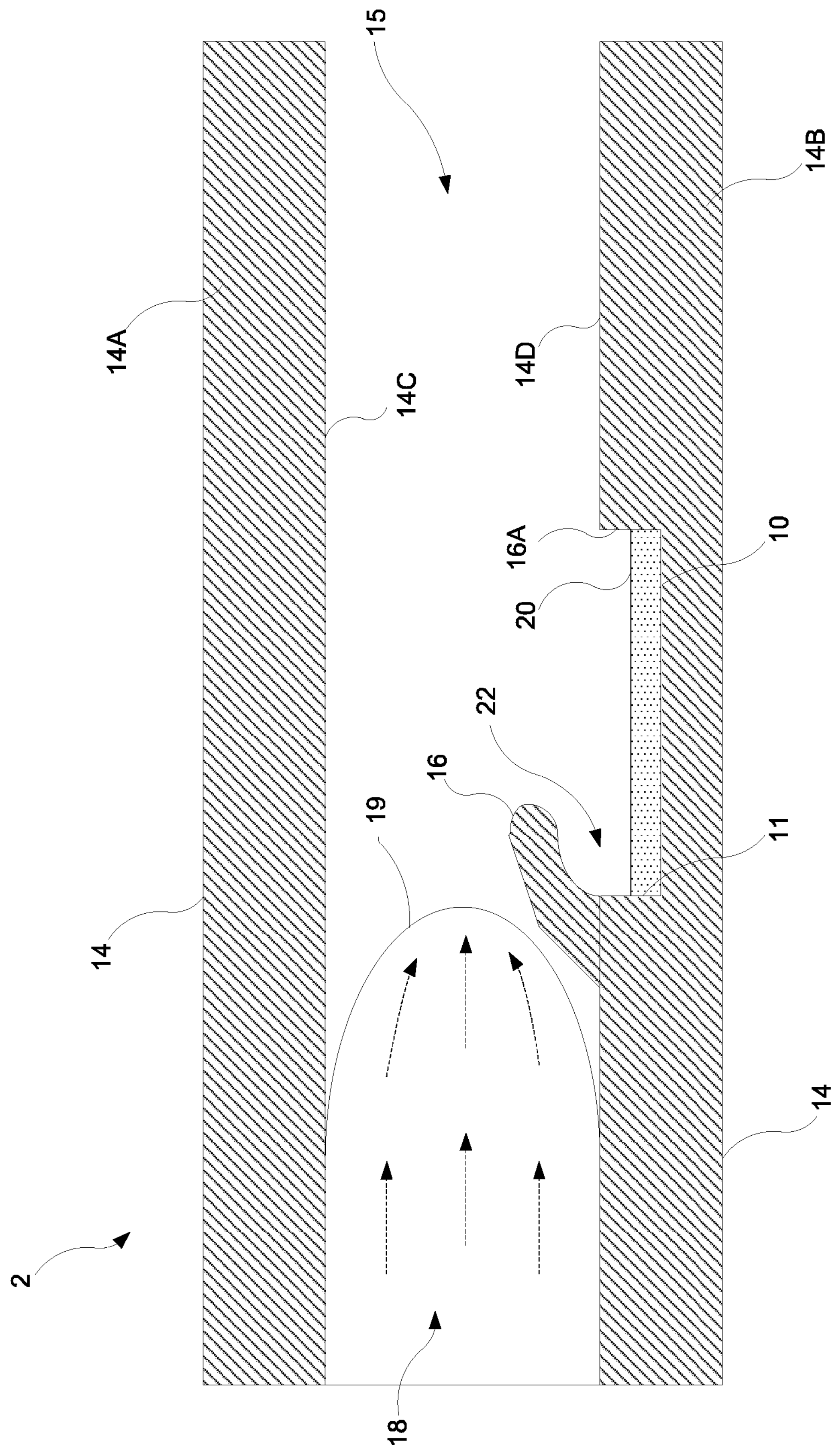


FIG. 10

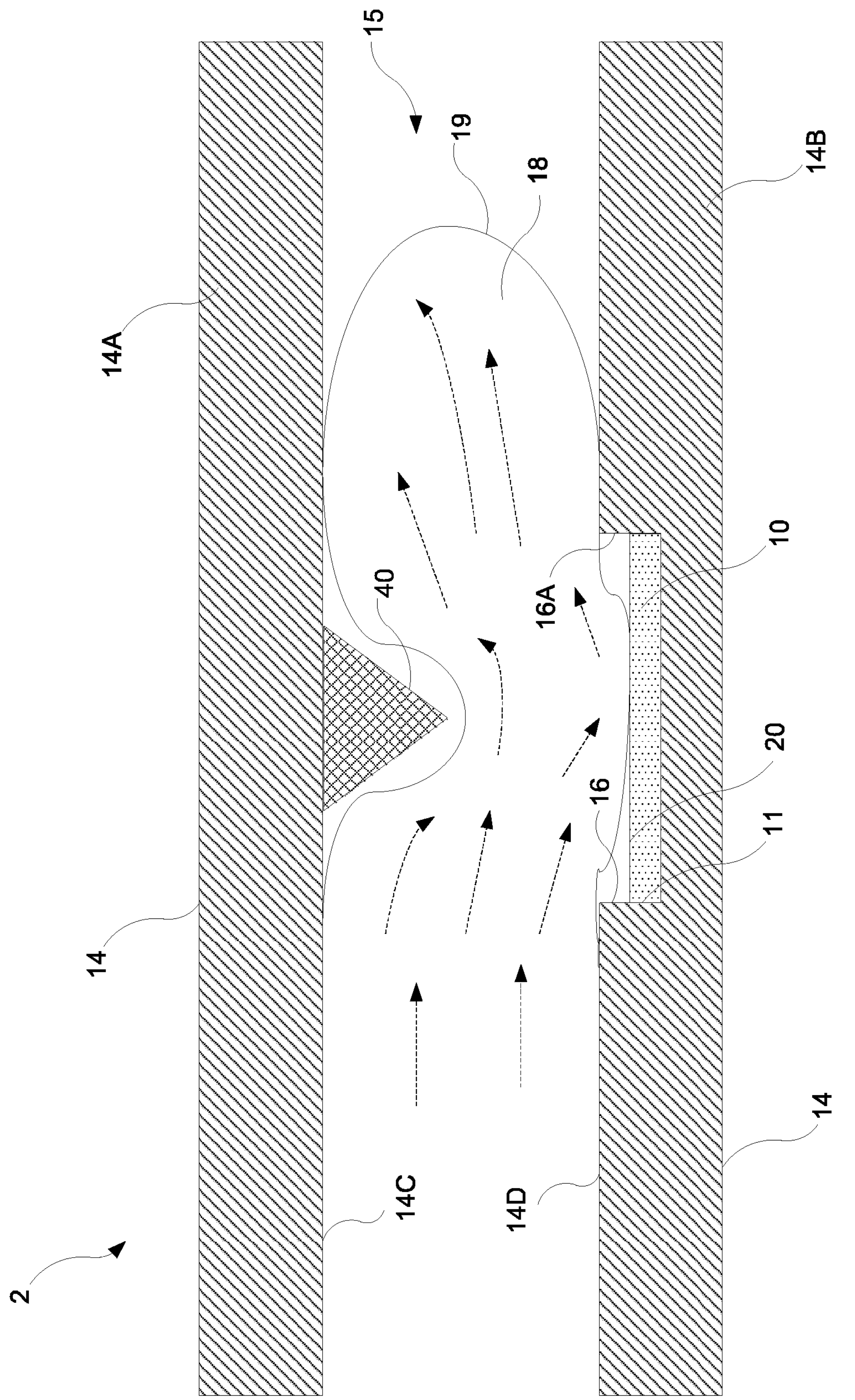


FIG. 11

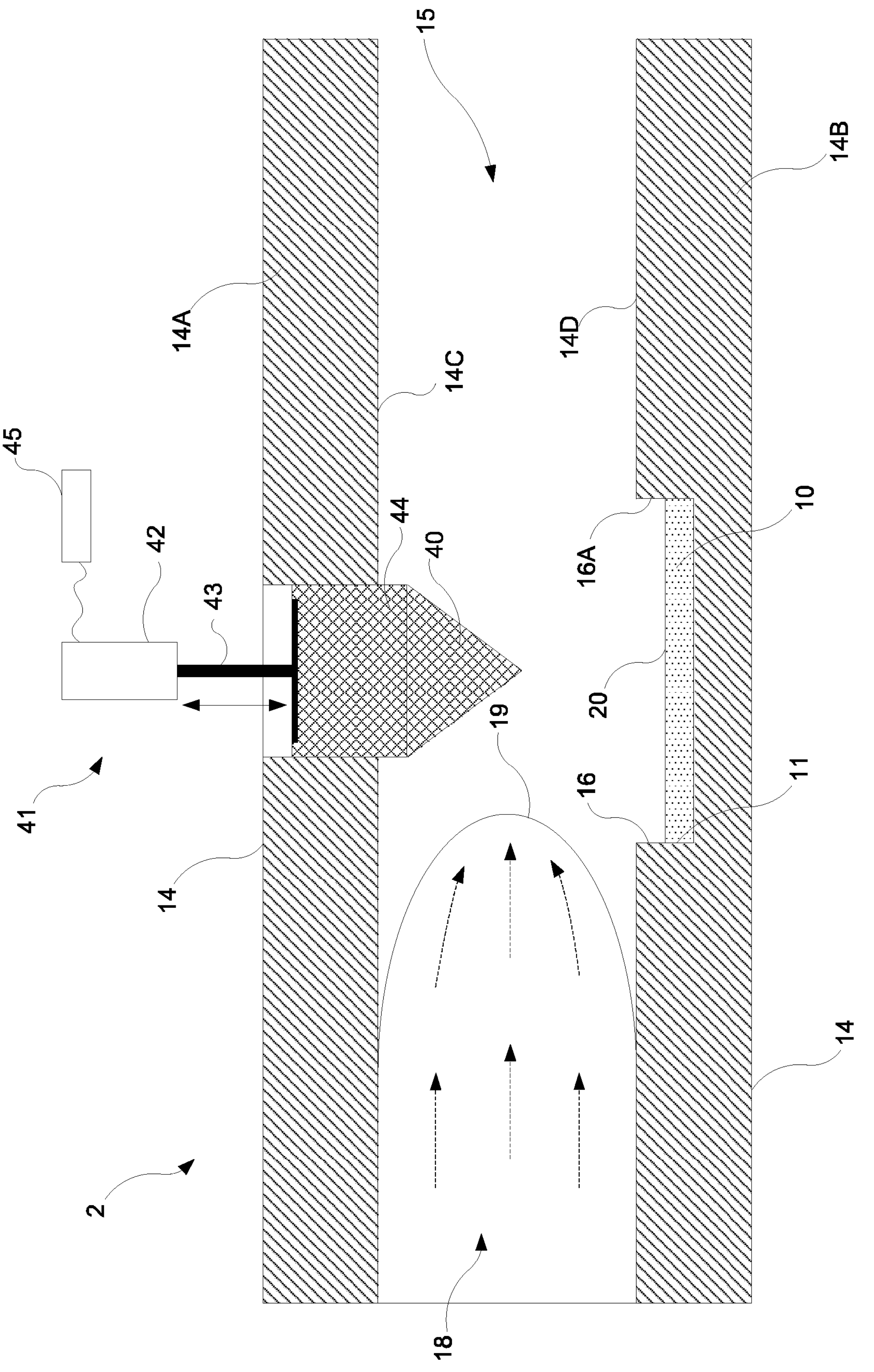


FIG. 12

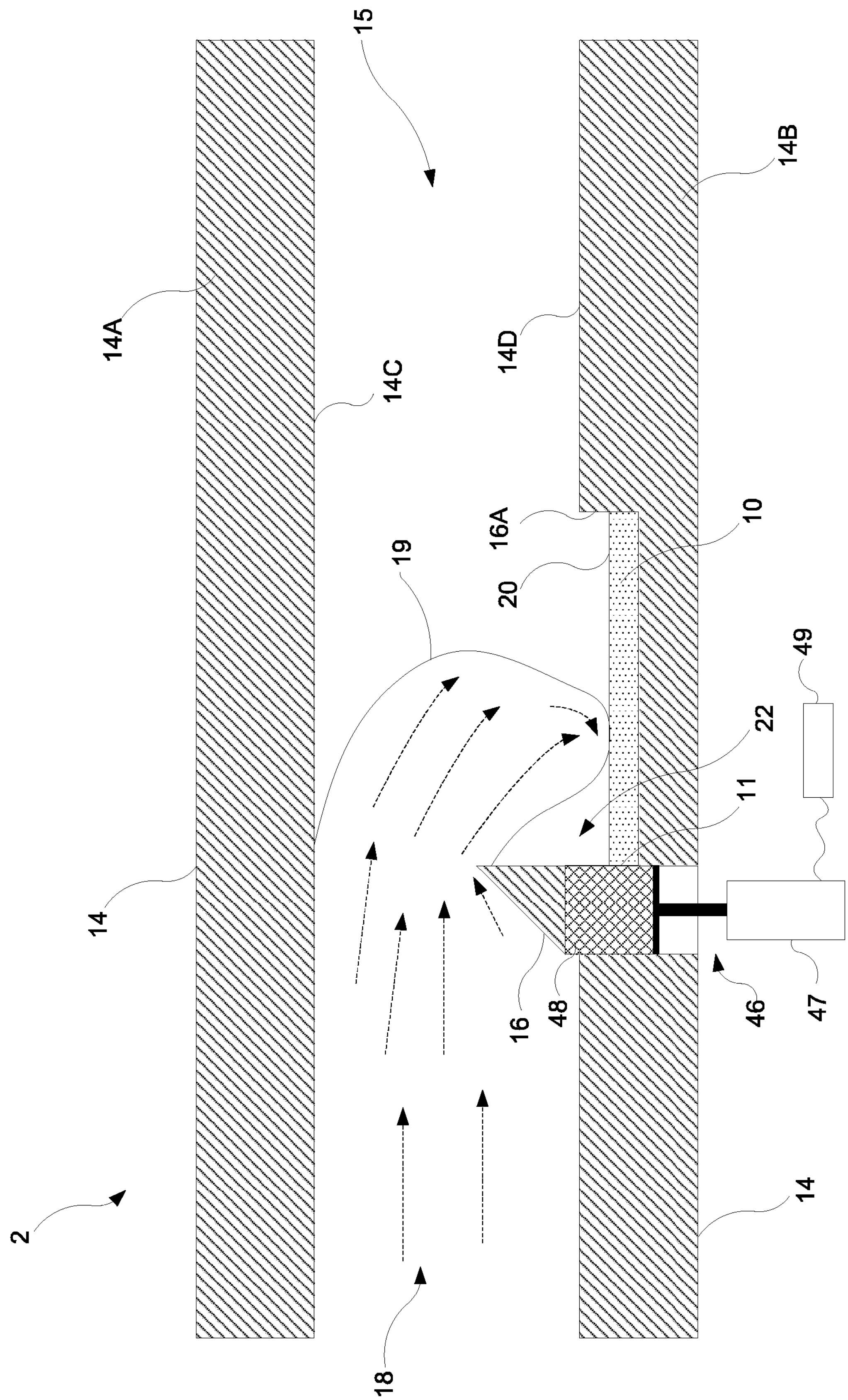


FIG. 13

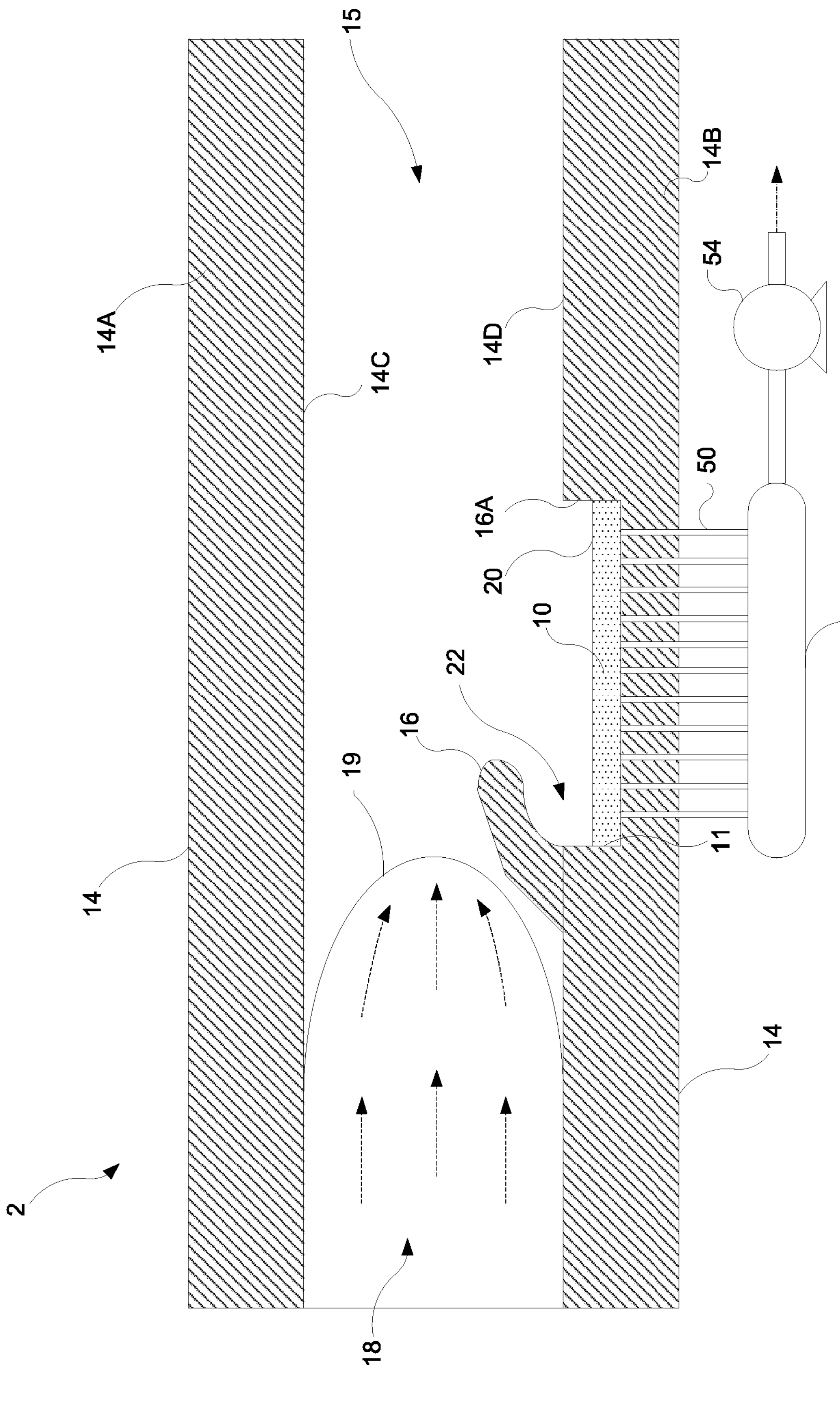


FIG. 14

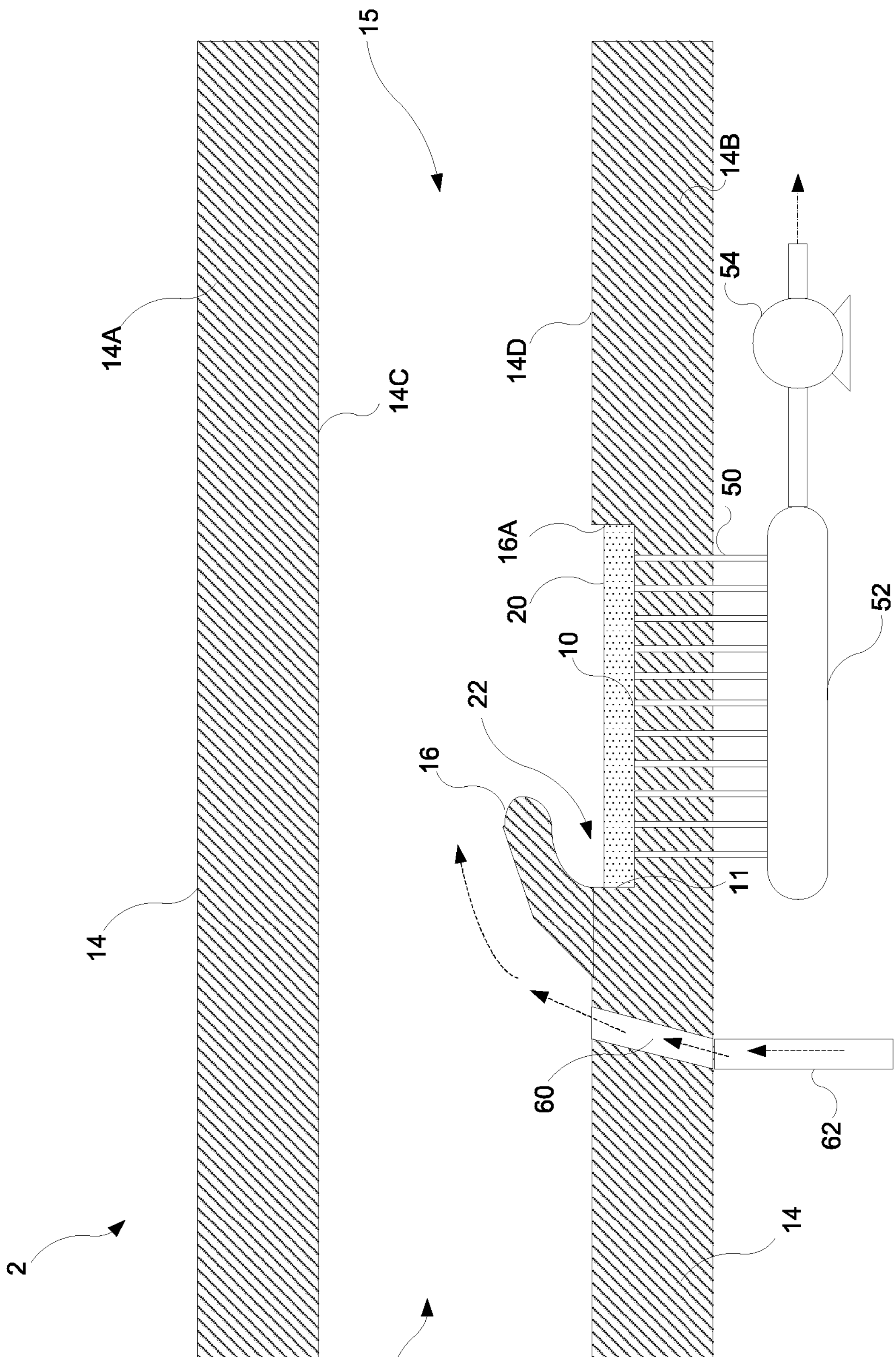


FIG. 15

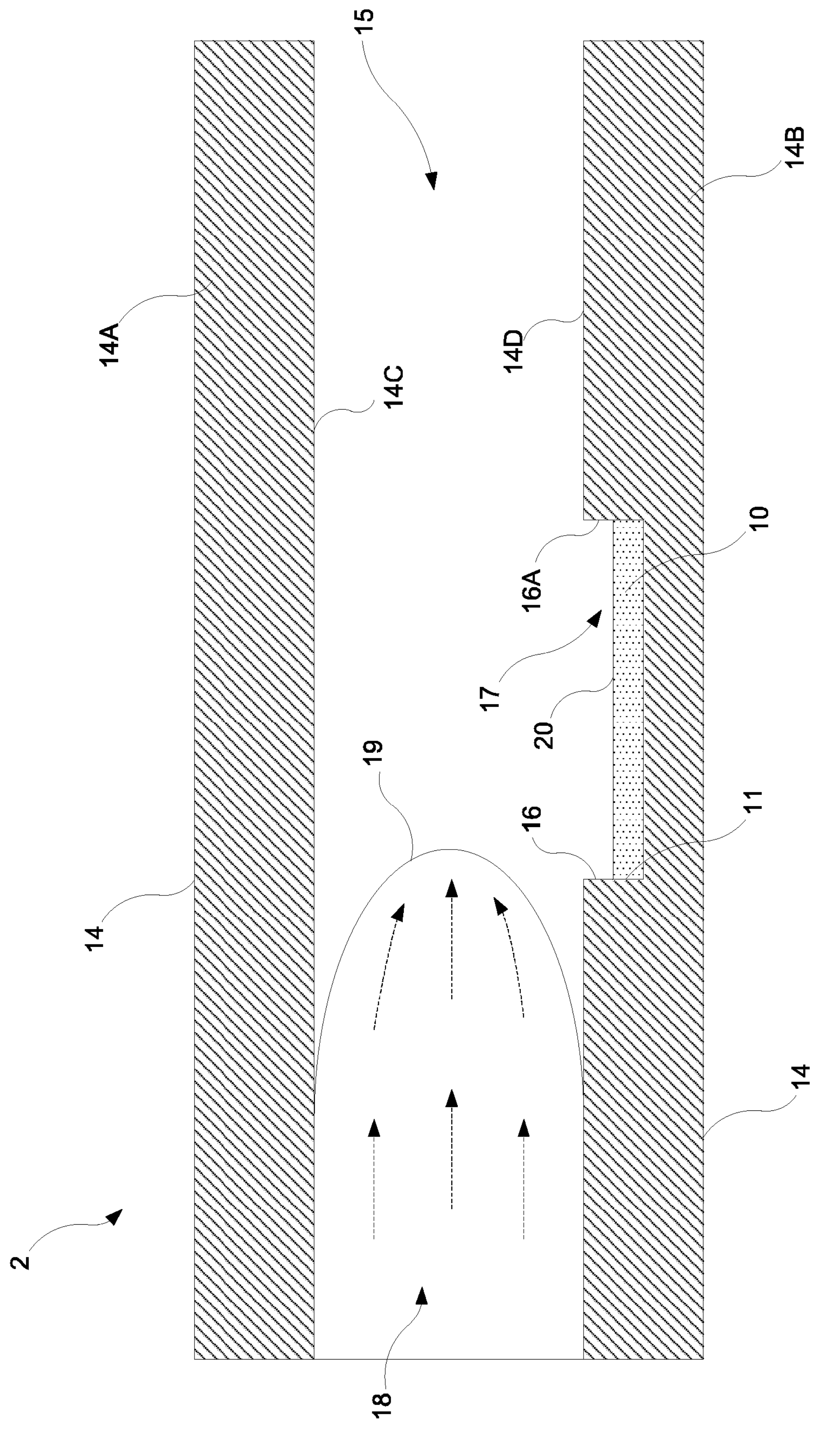


FIG. 16

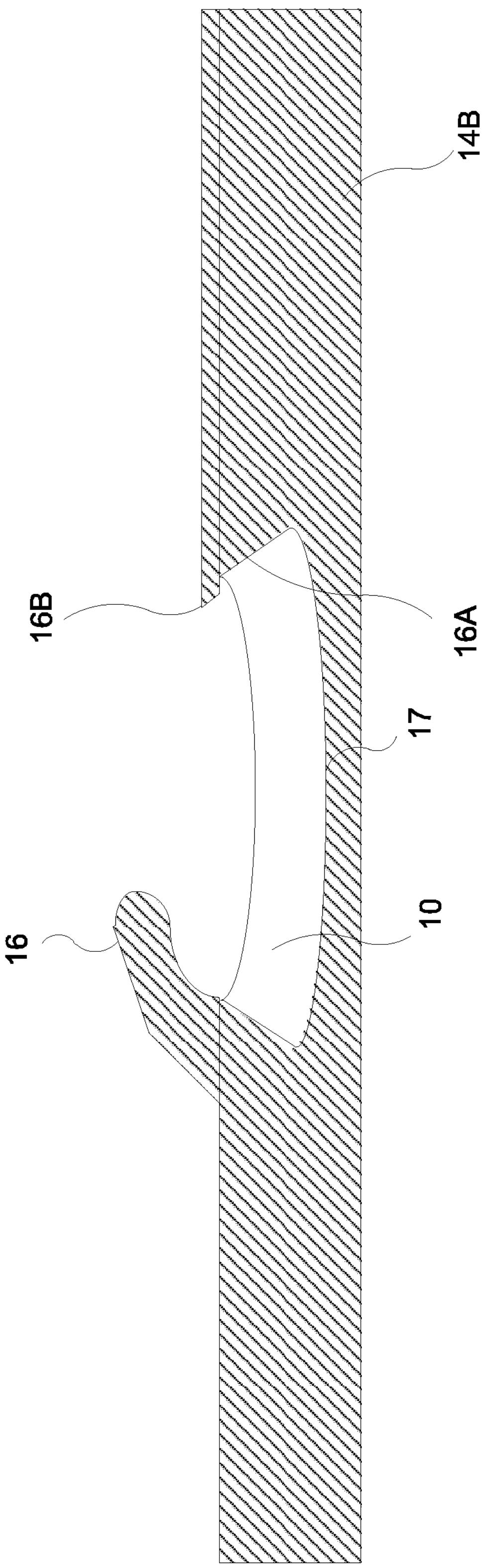


FIG. 17

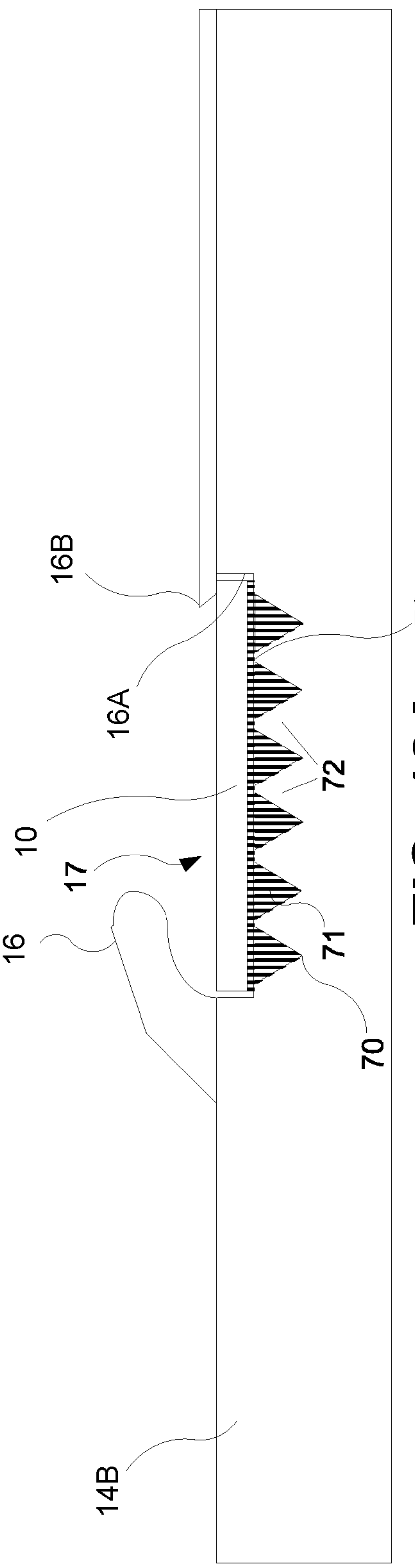


FIG. 18A

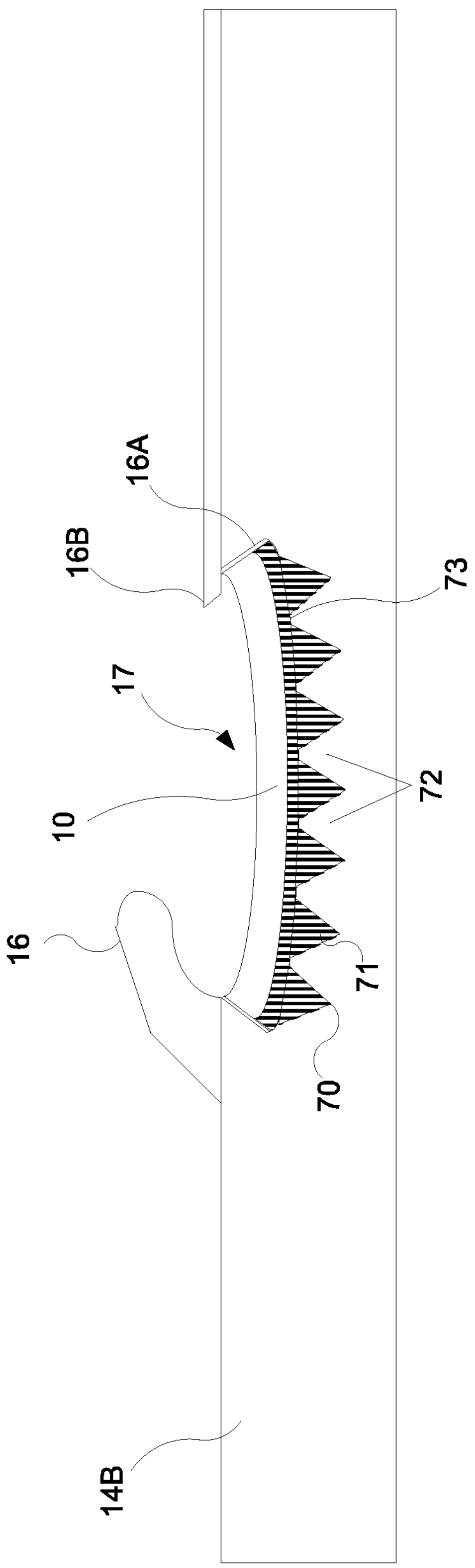


FIG. 18B

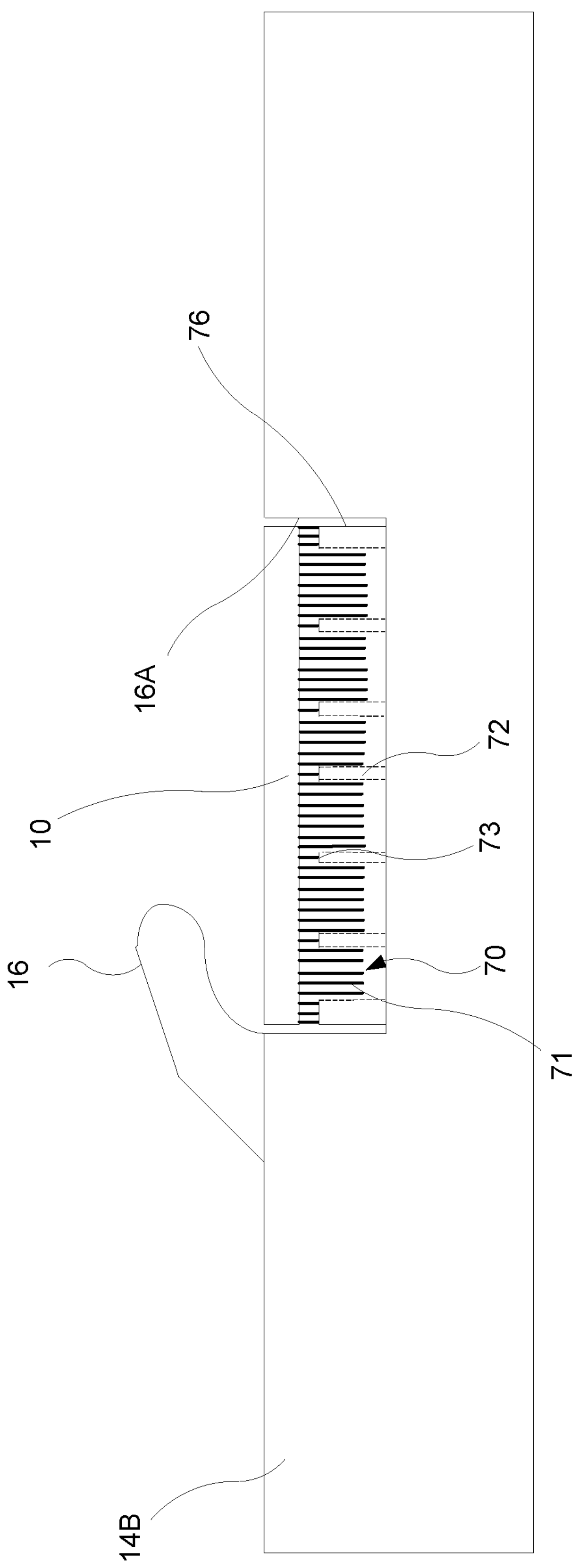


FIG. 19A

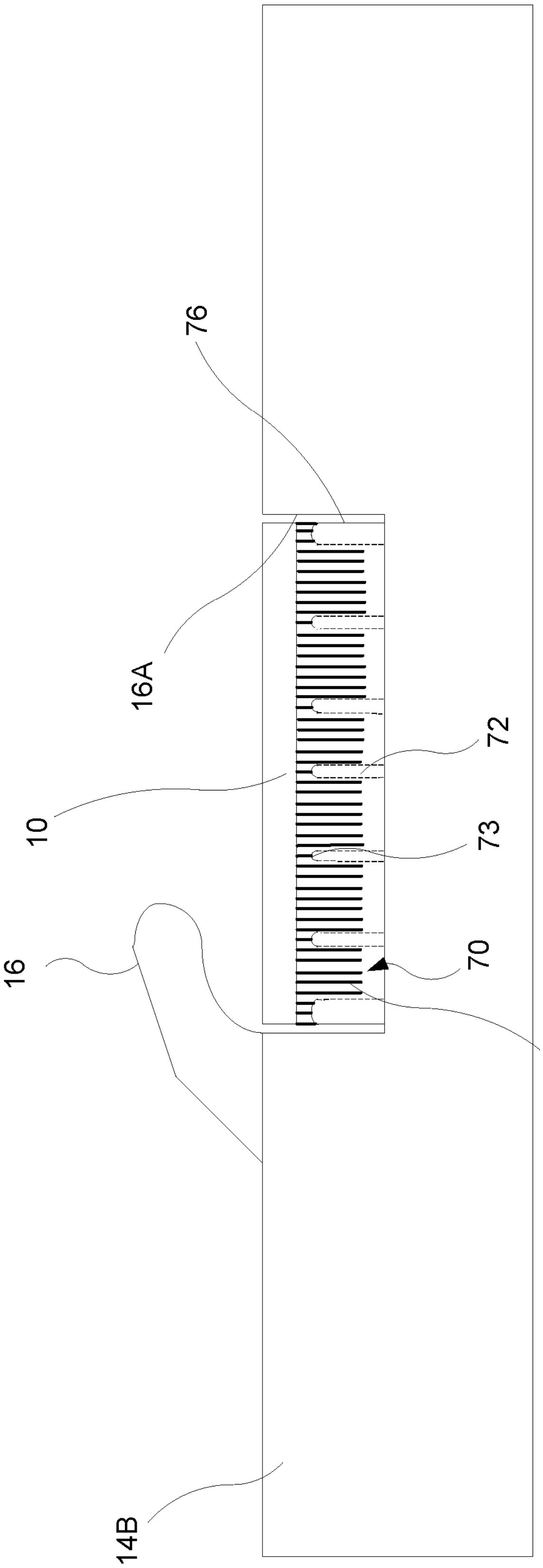


FIG. 19B

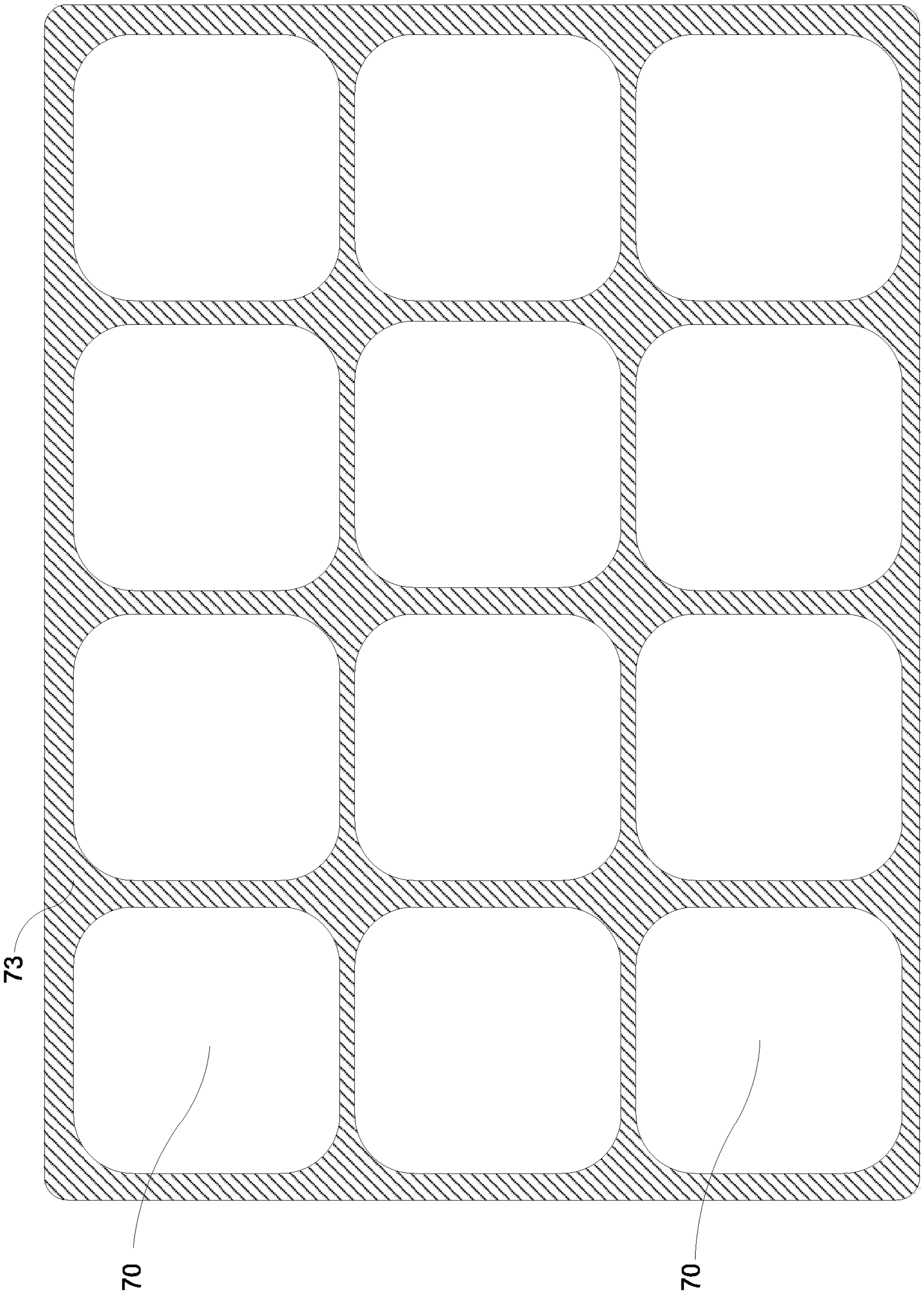


FIG. 20

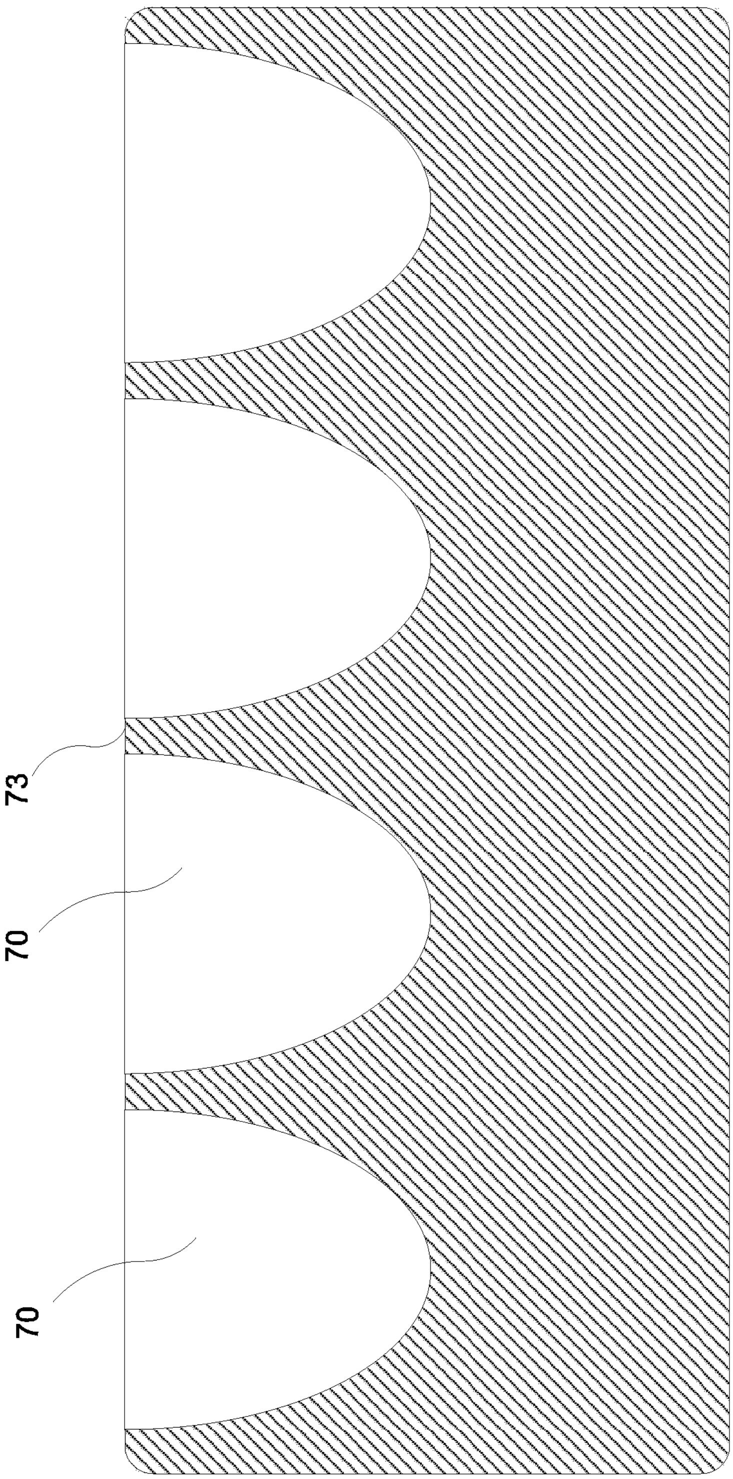


FIG. 21

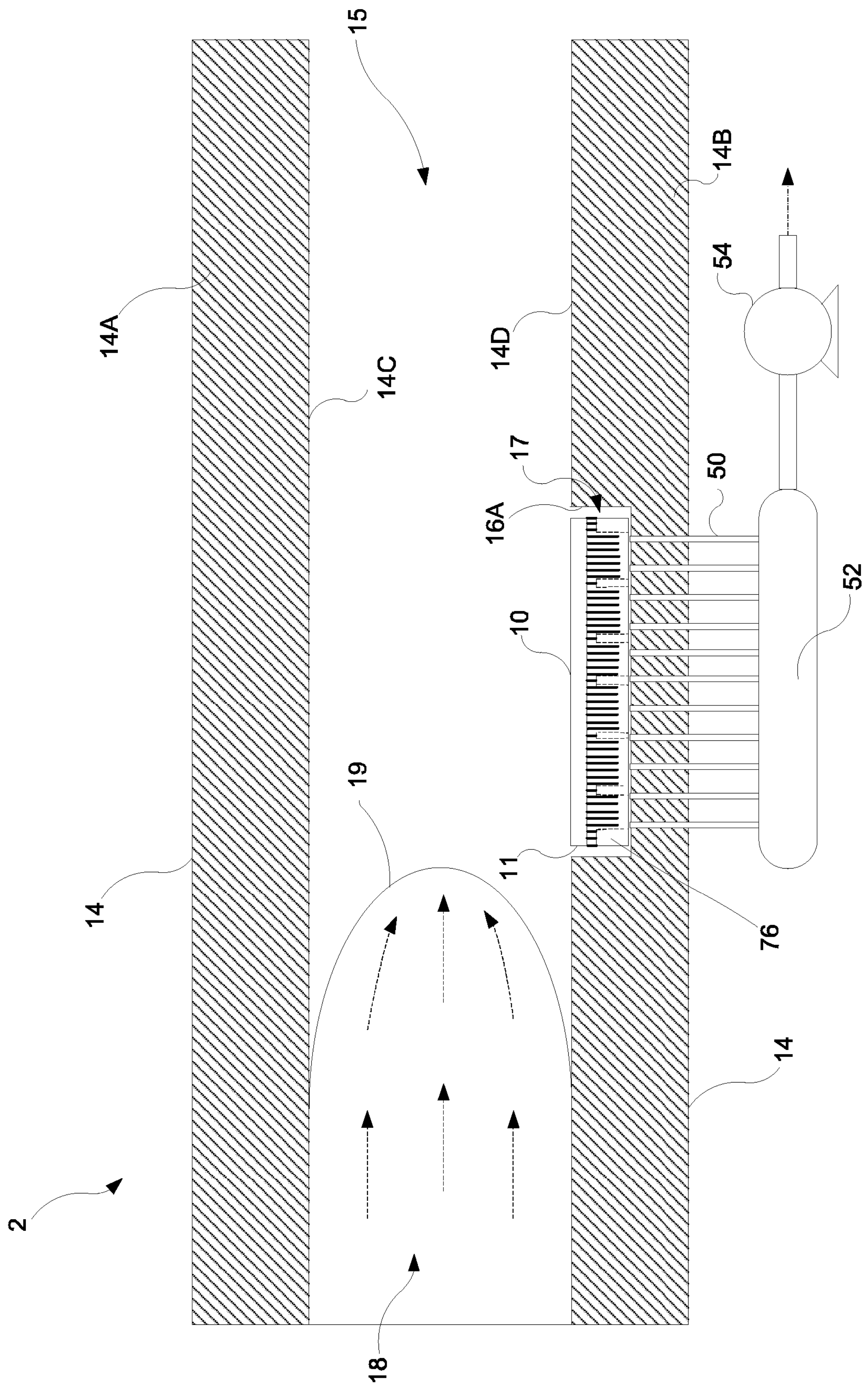


FIG. 22

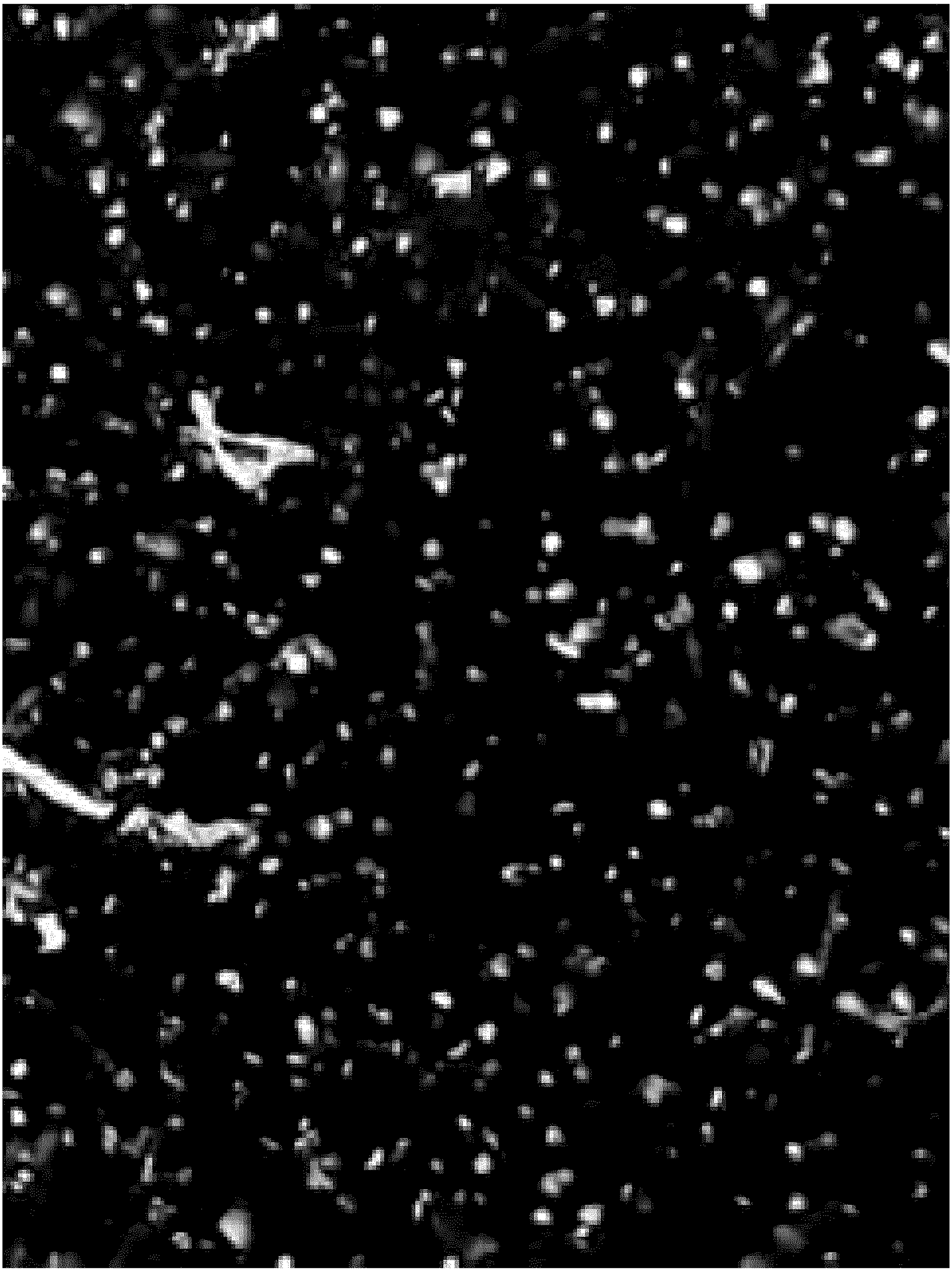

FIG. 23A

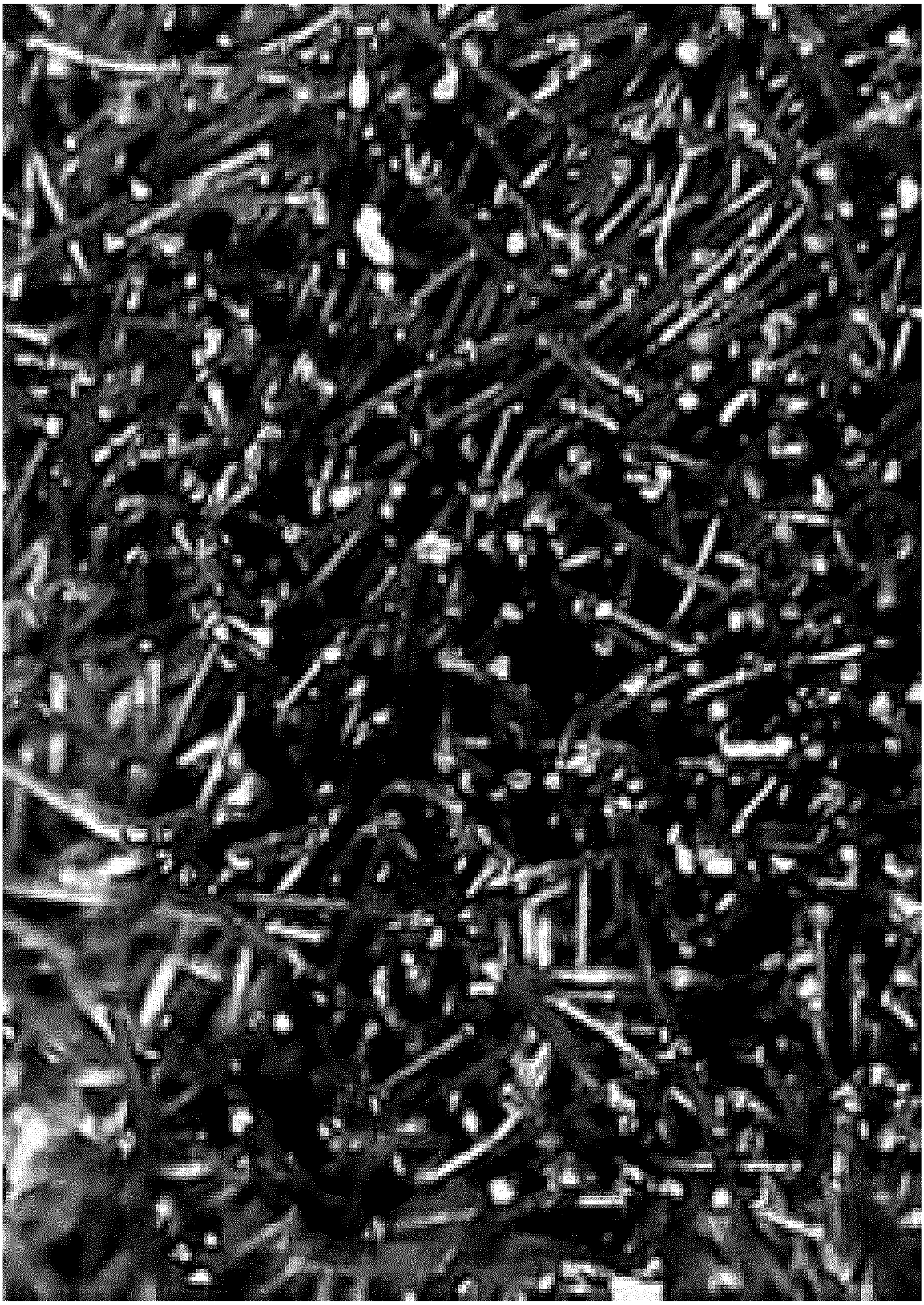

FIG. 23B

FIG. 23C

FIG. 23D

**INTERNATIONAL SEARCH REPORT**

International application No.
**PCT/CA2017/051591**

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***B29C 45/14*** (2006.01) , ***B29C 45/26*** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: ***B29C*** (2006.01) , ***B29B*** (2006.01), ***B32D*** (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Questel-Orbit (Fampat) with key words, such as: injection, mold*, melt, flow, deflect* and cavity

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | CN 103269841 A (LUESEBRINK, U.) 28 August 2013 (28-08-2013)<br>*figs. 3-4* | 30-32 |
| A | CA 2960766 A1 (BACKMANN, M. et al.) 10 March 2016 (10-03-2016)<br>*whole document* | 1-36 |
| A | US 6027328 A (HERBST, R.) 22 February 2000 (22-02-2000)<br>*whole document* | 1-36 |

☐ Further documents are listed in the continuation of Box C.

☑ See patent family annex.

| | | | |
|---|---|---|---|
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| "O" | document referring to an oral disclosure, use, exhibition or other means | | |
| "P" | document published prior to the international filing date but later than the priority date claimed | | |

Date of the actual completion of the international search
03 April 2018 (03-04-2018)

Date of mailing of the international search report
03 April 2018 (03-04-2018)

Name and mailing address of the ISA/CA
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Gatineau, Quebec K1A 0C9
Facsimile No.: 819-953-2476

Authorized officer

Pengfei Zhang (819) 639-7928

| Patent Document Cited in Search Report | Publication Date | Patent Family Member(s) | Publication Date |
|---|---|---|---|
| CN 103269841 A | 28 August 2013 (28-08-2013) | CN103269841A | 28 August 2013 (28-08-2013) |
| | | CN103269841B | 15 February 2017 (15-02-2017) |
| | | EP2502723A1 | 26 September 2012 (26-09-2012) |
| | | WO2012126546A1 | 27 September 2012 (27-09-2012) |
| CA 2960766 A1 | 10 March 2016 (10-03-2016) | CA2960766A1 | 10 March 2016 (10-03-2016) |
| | | CN106660250A | 10 May 2017 (10-05-2017) |
| | | DE102014112715A1 | 03 March 2016 (03-03-2016) |
| | | EP3188887A1 | 12 July 2017 (12-07-2017) |
| | | US2017282408A1 | 05 October 2017 (05-10-2017) |
| | | WO2016034603A1 | 10 March 2016 (10-03-2016) |
| US 6027328 A | 22 February 2000 (22-02-2000) | US6027328A | 22 February 2000 (22-02-2000) |
| | | DE19615029A1 | 28 August 1997 (28-08-1997) |
| | | DE19615029C2 | 02 July 1998 (02-07-1998) |
| | | DE19617768A1 | 28 August 1997 (28-08-1997) |
| | | DE19617768C2 | 22 April 1999 (22-04-1999) |
| | | DE19631209A1 | 16 October 1997 (16-10-1997) |
| | | EP0791448A2 | 27 August 1997 (27-08-1997) |
| | | EP0791448A3 | 12 May 1999 (12-05-1999) |
| | | EP0800908A1 | 15 October 1997 (15-10-1997) |
| | | JPH11939A | 06 January 1999 (06-01-1999) |
| | | JPH09327846A | 22 December 1997 (22-12-1997) |
| | | JP2917267B2 | 12 July 1999 (12-07-1999) |