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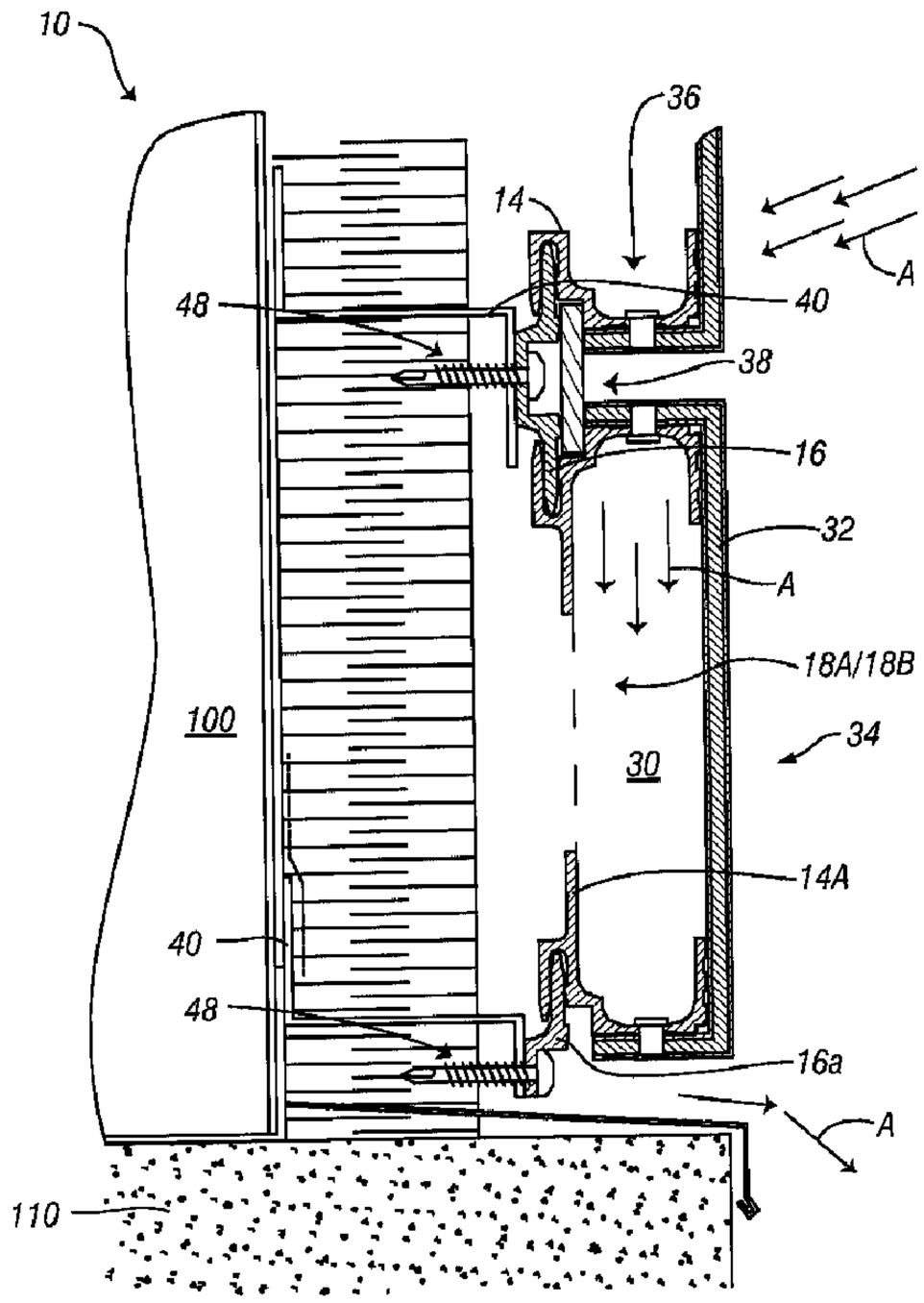
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(72) Inventeurs/Inventors:
MACDONALD, ROBERT B., CA;
MACDONALD, PHILIP A., CA

(73) Propriétaires/Owners:
MACDONALD, ROBERT B., CA;
MACDONALD, PHILIP A., CA

(74) Agent: DEETH WILLIAMS WALL LLP

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(54) Title: WALL PANEL SYSTEMS FOR RIGID WALL PANELS



(57) Abrégé/Abstract:
A wall panel attachment system is provided for attaching rigid wall panels to an exterior building wall. Interlocking components are used to support solar panels, ceramic tiles, or other rigid wall panels to the wall. The rigid wall panels are adhesively connected to planar surfaces of aluminum tile perimeter strips. The tile perimeter strips, in turn, are mechanically or operatively connected to the exterior wall.

ABSTRACT

A wall panel attachment system is provided for attaching rigid wall panels to an exterior building wall. Interlocking components are used to support solar panels, ceramic tiles, or other rigid wall panels to the wall. The rigid wall panels are adhesively connected to planar surfaces of aluminum tile perimeter strips. The tile perimeter strips, in turn, are mechanically or operatively connected to the exterior wall.

WALL PANEL SYSTEMS

FOR RIGID WALL PANELS

[0001]

[0002]

[0003]

BACKGROUND OF THE INVENTION

[0004] This section is intended to introduce various aspects of the art, which may be associated with exemplary embodiments of the present disclosure. This discussion is believed to assist in providing a framework to facilitate a better understanding of particular aspects of the present disclosure. The Background section should be read in this light, and not necessarily as admissions of prior art.

Field of the Invention

[0005] The present disclosure relates to wall panel attachment systems which include photovoltaic (PV, or solar) panels and porcelain ceramic tile (PCT) panels. The present disclosure also pertains to methods of attaching rigid wall panels to exterior wall surfaces.

Discussion of Technology

[0006] Attachment systems for exterior walls of buildings are known. These attachment systems are used for attaching aluminum wall panels along an exterior surface.

[0007] The known aluminum wall panel attachment systems have obstacles. Conventionally, these systems rely upon adhesive or caulk to "seal" the aluminum panel from the elements. However, under exposure to heat and cold and moisture, the adhesive or caulk breaks down. This, in turn, compromises the stability of the system and creates an undesirable appearance.

[0008] Even when such a seal is functional, there may be undesirable effects on the aluminum panels. In this respect, the interior environment can trap heat which affects the individual panels, creating "oil-canning" or popping in response to the pressure differential. In spite of such seals, such systems can also trap moisture in the wall cavity. This, in turn, results in oxidation of parts and staining or deterioration of exterior wall surfaces.

[0009] More recently, systems have been developed according to the "rainscreen principle." This means that the wall cavity is vented, resulting in a temperature and pressure equalized system with moisture drainage. However, such systems can be difficult to install, relying on many components to be milled or adapted on-site, and requiring excessive labour costs and specialty materials. Therefore, a need exists for an improved wall panel attachment system which permits the ingress and egress of moisture behind the panels. Further, a need exists for an attachment system in which the wall panels can be attached to a wall in any sequence.

[0010] It is also desirable to modify an aluminum wall panel attachment system for use with other types of panels. For example, it is desirable for such attachment systems to accommodate photovoltaic (PV, or solar) panels. Given the increasing prevalence of solar energy use in commercial buildings, the vertical wall surfaces present a logical location for the placement of such panels. While solar panels are manufactured in a wide range of sizes and shapes, a need exists to incorporate solar panels into an innovative panel attachment system that permits flush assembly with non-solar panels and reliable operation of the solar energy collection system.

[0011] It is further desirable to modify an aluminum wall panel attachment system to accommodate the use of stiff or non-bendable panels, such as porcelain or other ceramic panels.

SUMMARY OF THE INVENTION

[0012] Wall panel systems for attaching wall panels to an exterior building wall are provided herein. In one aspect, the wall panel system provides a plurality of solar (or PV) panels that are attached to the building wall side-by-side. In another aspect, the wall panel system provides solar panels placed adjacent to aluminum (or other non-solar) wall panels. In yet another aspect, the wall panel system provides a plurality of ceramic panels that are attached to the building wall side-by-side.

[0013] First, a wall panel system is provided. The system allows for the attachment of two or more adjacent rigid wall panels to an exterior building wall. The rigid wall panels are either PV wall panels or ceramic wall panels. In one embodiment, the system includes a plurality of rigid wall panels, a plurality of bracket assemblies configured to be fastened to the exterior building wall; and a plurality of attachment clips configured to be fastened to respective bracket assemblies by a fastener and to carry the dead loads of the respective rigid wall panels. Preferably, the bracket assemblies are fabricated from steel for strength.

[0014] Each attachment clip has a central fastening surface fastened to the bracket assembly. Further, each attachment clip has a pair of integrally formed wing members. The

wing members extend from a central fastening surface, preferably in a substantially symmetrical manner.

[0015] The rigid wall panel system also includes a plurality of tile perimeter strips. Each tile perimeter strip comprises a generally C-shaped member having a planar surface configured to extend along a rear surface of a respective wall panel. Each tile perimeter strip further comprises a receiving member integrally attached to the C-shaped member and having a slot adapted to engage and interlock one of the wing members of the attachment clip.

[0016] The rigid wall panels are adhesively connected to respective planar surfaces of the tile perimeter strips. The adhesive connection may be through a high-strength bonding tape, a structural silicone adhesive and sealant, or a combination of both. It is noted that while the adhesive connection may provide a substantially water-proof seal along a perimeter of the panel, the C-shaped member may have a through-opening to permit the ingress of air behind the rigid wall panels.

[0017] In a preferred embodiment using PV wall panels, the system further includes one or more cable guides. The cable guides may be attached to respective bracket assemblies. Each of the cable guides is configured to receive an electrical cable extending from the rear surface of the respective PV wall panels.

[0018] In an alternate embodiment, and as noted above, a PV wall panel may be placed on an exterior building wall adjacent to a non-PV wall panel, such as an aluminum composite panel. For this arrangement, an alternate wall panel system is provided that is a hybrid wall panel system.

[0019] The hybrid wall panel system first includes a plurality of PV (or other rigid) wall panels. In the case of solar wall panels, each PV wall panel defines a plurality of photovoltaic cells configured to convert solar energy into electrical energy. Further, each PV wall panel comprises an exterior flat surface as noted above.

[0020] In addition, the hybrid wall panel system includes a non-PV wall panel. The non-PV wall panel has an exterior flat surface and at least two side surfaces bent generally perpendicularly to the exterior flat surface. In this way, a hollow interior portion is defined inside each non-PV wall panel. Preferably, each non-PV wall panel comprises an aluminum composite material.

[0021] The hybrid wall panel system may also include a plurality of bracket assemblies. Each bracket assembly is configured to be fastened to the exterior wall. In one aspect, each bracket assembly comprises two back-to-back L-angle brackets fastened to each other to form a generally Z-shaped assembly. A first end is for attachment to the wall, and a second end is for fastening to an attachment clip.

[0022] The wall panel system also has a plurality of attachment clips. Each clip is preferably fabricated from aluminum, and is configured to be fastened to a respective bracket assembly by a fastener. Preferably, each fastener comprises a threaded fastener. The attachment clips carry the dead loads of the various wall panels.

[0023] Each attachment clip has a central fastening surface configured to be fastened to the bracket assembly. Each attachment clip further has a pair of integrally formed wing members. Each wing member extends outwardly from the central fastening surface, preferably in a substantially symmetrical manner. Preferably, isolation tape is applied between the attachment clips and the respective bracket assemblies.

[0024] The hybrid wall panel system also includes a plurality of perimeter strips. Preferably, each perimeter strip is fabricated from aluminum. Perimeter strips that support the solar or PV wall panels are referred to as tile perimeter strips; perimeter strips that support the non-PV wall panels are referred to as panel perimeter strips.

[0025] Each tile perimeter strip is configured as the tile perimeter strips described above. In this respect, each tile perimeter strip is configured to adhesively connect to a rear surface of a

respective PV panel. At the same time, each panel perimeter strip is configured to be fastened to one side surface of a respective wall panel.

[0026] Each tile perimeter strip comprises a generally C-shaped member having a planar surface configured to extend along a rear surface of a respective PV wall panel. Each tile perimeter strip further comprises a receiving member integrally attached to the C-shaped member and having a slot adapted to engage and interlock one of the wing members of the attachment clip. At the same time, each panel perimeter strip comprises a generally C-shaped member configured to reside inside of and extend along an inside portion of a side surface of a respective wall panel. Further, each panel perimeter strip has a slot integrally attached to the C-shaped member adapted to engage and interlock one of the wing members of the attachment clip, thus connecting a respective non-PV wall panel to the attachment clip and, thereby, to the wall.

[0027] The hybrid wall panel system also includes one or more rivets. The rivets are placed along the side surface of the non-PV wall panels to connect the side surface of a respective wall panel to a receiving member of a panel perimeter strip.

[0028] The wall panel system may optionally include panel stiffeners. The panel stiffeners are positioned behind or on the rear surface of the PV wall panels. Panel stiffeners may also be placed behind or inside the hollow interior portion of the respective aluminum wall panels. The panel stiffeners reinforce the aluminum wall panels and prevent deforming or popping of the aluminum wall panels.

[0029] The wall panel system may further include a plurality of infill strips. Each infill strip is preferably fabricated from a substantially rigid material comprising aluminum, or a combination of aluminum and polyethylene, or of fire-retardant polyvinyl. Each of the infill strips is non-sealingly disposed within respective slots of adjoining panel perimeter strips.

[0030] With the exception of the adhesive connection of the rigid panels to the tile perimeter strips, the hybrid wall panel system is held together non-adhesively. Further, the

system is ventilated at least partially through the one or more rivets to permit ingress and egress of air and moisture to provide a pressure-balanced and moisture-drained interior environment.

[0031] The above-described systems are configured to allow panels to be secured to respective bracket assemblies along the wall in any sequence. Additional wall panels may be attached to the exterior wall using additional bracket assemblies, attachment clips and panel perimeter strips.

BRIEF DESCRIPTION OF THE FIGURES

[0032] So that the manner in which the above recited features of the present invention can be better understood, certain drawings are appended hereto. It is to be noted, however, that the appended drawings illustrate only selected embodiments of the inventions and are therefore not to be considered limiting of scope, for the inventions may admit to other equally effective embodiments and applications.

[0033] Figure 1 shows a cross-sectional view of a wall panel attachment system, in one embodiment. Here, the wall panels are aluminum panels having edges that are bent inward for connection to panel perimeter strips.

[0034] Figure 2 is a cross-sectional view of a panel perimeter strip used in the attachment system, in one embodiment.

[0035] Figure 3 is a cross-sectional view of an attachment clip used in the attachment system, in one embodiment.

[0036] Figure 4 is a cross-sectional view of a panel stiffener optionally used in the attachment system, in one embodiment.

[0037] Figure 5 shows a cross-sectional view of aluminum composite material (ACM) as may be used in the wall panels.

[0038] Figures 6, 7, and 8 show progressive steps in the formation of an ACM panel for use in the present system, in one embodiment. In Figure 8, it can be seen that the opposing edges of the aluminum wall panel have been bent and then secured to respective panel perimeter strips using rivets.

[0039] Figure 9 shows a cross-sectional view of an infill strip as may be used in the attachment system of Figure 1.

[0040] Figure 10 shows an enlarged cross-sectional view of an infill strip having been received within adjacent panel perimeter strips. The infill strip covers the attachment clip and fastener.

[0041] Figure 11 is an elevational view of sub-framing or bracket assemblies used for mounting a plurality of ACM panels in the present system, in one arrangement.

[0042] Figure 12 is a cross-sectional view of a wall panel attachment system with bracket assemblies, in one embodiment.

[0043] Figures 13, 14 and 15 show progressive steps in the installation of an infill strip in a wall panel attachment system, according to a first method.

[0044] Figure 16 shows a view of the installation of lengths of infill strip in a wall panel attachment system, according to a second method.

[0045] Figure 17 shows a view of a finished wall paneled exterior, in one embodiment. A plurality of wall panels is shown.

[0046] Figure 18 shows a cross-sectional view of a panel perimeter strip, in an alternate arrangement.

[0047] Figures 19 and 20 show cross-sectional views of two versions of an alternative panel stiffener.

[0048] Figure 21 is a cross-sectional view of a photovoltaic (PV) wall panel attachment system adjacent a non-PV wall panel attachment system, wherein the exterior surfaces remain flush with one another.

[0049] Figures 22 and 23 provide enlarged views of upper and lower portions of wall panel attachment systems for supporting a PV panel. Separate tile perimeter strips are shown.

[0050] Figure 24 is a plan view of a panel placed on panel perimeter strips.

[0051] Figure 25 is a top (or, optionally, side) view of another photovoltaic (PV) wall panel attachment system. Here, two solar wall panels are placed on an exterior wall adjacent to one another. The two solar wall panels are flush.

[0052] Figure 26 shows cross-sectional views of a plurality of alternative attachment clips that may be used in the attachment systems herein, depending on location of the panel to be installed.

[0053] Figure 27 shows cross-sectional views of a plurality of alternative panel perimeter strips that may be used with the attachment systems herein, depending on location of the panel to be installed.

[0054] Figure 28 provides cross-sectional views of alternative infill strips as may be used in the attachment systems herein.

[0055] Figure 29 is a perspective view of a rigid panel that may be adhered to an alternative tile perimeter strip. The rigid panel may be a porcelain ceramic tile (PCT) wall panel.

[0056] Figure 30 is a top (or, optionally, a side) view of a porcelain ceramic tile (PCT) wall panel attachment system, in one embodiment. Here, two porcelain ceramic wall panels are placed on an exterior wall adjacent to one another.

[0057] Figure 31 is a cross-sectional view of a wall panel assembly, wherein the assembly utilizes a porcelain ceramic tile (PCT) wall panel attached to panel perimeter strips. The assembly is ready for hanging.

[0058] Figure 32 is a cross-sectional view of a PCT wall panel attachment system at an end of a wall. A porcelain ceramic tile is shown placed along the exterior of the wall. The attachment system in this view is ideally suited for use with a curtain wall sill.

[0059] Figure 33 is a cross-sectional view of a PCT wall panel attachment system at an end of a wall, in an alternate embodiment. A porcelain ceramic tile is again shown placed along the exterior of the wall. The attachment system in this view is ideally suited for use with a curtain wall head.

[0060] Figure 34 is still another cross-sectional view of a PCT wall panel attachment system at an end of a wall, in an alternate embodiment. A porcelain ceramic tile is again shown placed along the exterior of the wall. The attachment system in this view is ideally suited for use with a ceramic window sill.

DETAILED DESCRIPTION

[0061] Wall panel attachment systems are provided herein. The wall panel attachment systems employ an extruded aluminum attachment system for fastening a plurality of panels to a building surface. The components may be fabricated from a milled or anodized aluminum. Each system's strength is enhanced by the use of an extruded perimeter frame design which carries the dead load for the various panels.

[0062] In the present disclosure, different types of panels are employed. These include aluminum composite material (ACM) panels, solar or photovoltaic (PV) panels, and porcelain ceramic tile (PCT) panels.

[0063] **Figure 1** presents a cross-sectional view of a wall panel attachment system **10**, according to one embodiment. Here, the attachment system **10** is used to attach ACM panels **32** to the exterior surface of a wall **100**.

[0064] The system **10** is designed to operate in accordance with the rainscreen principle. This means that the system **10** is designed so that a wall cavity formed under the individual panels is vented, resulting in a pressure-equalized system. Controlled moisture drainage within the system, coupled with this equalized pressure, contributes to effective, maintenance-free construction. The flow of air through a wall panel **32** and into a hollow interior **30** behind the ACM panel **32** is shown at arrows "**A**."

[0065] The attachment system **10** may be fabricated through an extrusion process. The extrusion process begins with an aluminum billet, which is the material from which the profiles are preferably extruded. The billet must be softened by heat prior to the extrusion process. The heated billet is placed into an extrusion press, which represents a powerful hydraulic device wherein a ram pushes a dummy block. The dummy block, in turn, forces the softened metal through a precision opening, known as a die. The die produces the required shapes.

[0066] The extruded parts are cut to specific lengths. The extruded parts may have a milled or an anodized finish. It is, of course, understood that the system **10** is not limited by the specific extrusion process or other method by which the component parts are manufactured.

[0067] The system **10** includes a panel perimeter strip. **Figure 2** provides a cross-sectional view of an illustrative panel perimeter strip **14**. **Figure 10** provides a cross-sectional view of a pair of panel perimeter strips **14**. In **Figure 10**, the panel perimeter strips **14** have been connected to corners of wall panels **32**. Connection is by means of counter-sunk rivets **36**. **Figure 10** will be discussed in further detail below.

[0068] Referring back to **Figure 1**, three panel perimeter strips are seen, with one being marked as **14A**. The panel perimeter strips **14/14A** are attached to side surfaces of wall panels **32**. The wall panels **32** are preferably fabricated from an aluminum composite material (ACM).

Hollow rivets (numbered as **36** in **Figure 10**) are also shown in **Figure 1**, connecting the panel perimeter strips **14/14A** to the panels **32**.

[0069] The system **10** also includes an attachment clip **16**. **Figure 3** provides a cross-sectional view of an illustrative attachment clip **16**. The attachment clip **16** has a central fastening surface, and a pair of integrally formed wing members. Each wing member extends outwardly from the central fastening surface in a substantially symmetrical manner.

[0070] **Figure 10** provides another cross-sectional view of an attachment clip **16**. In **Figure 10**, each wing member of the attachment clip **16** is received by an opposing panel perimeter strip **14**. Thus, the panel perimeter strips **14** are designed to mate together with the wing members of the attachment clips **16**. The custom-designed extrusion allows for maximum attachment area without foregoing structural integrity.

[0071] The attachment clip **16** is used on-site to attach the panel perimeter strips **14** to a building. An exterior building surface is shown in **Figure 1** at **100**. The exterior building surface **100** is above a building foundation or ground surface **110**.

[0072] To install the panel system **10**, sub-framing may be constructed. Preferably, the sub-framing comprises two back-to-back galvanized steel "L" angles, referred to sometimes herein as bracket assemblies. **Figure 12** is an enlarged cross-sectional view showing the system **10** of **Figure 1**. In **Figure 12**, two "L" angles are seen at **40**. The L-angles **40** serve as brackets that allow the installer to level the substrate in all three axes before installation of panel assemblies **34**. Preferably, stainless steel screws **44** are used to connect the L-brackets **40** to the building surface **100**. Further, the L-brackets **40** themselves may be connected to each other through one or more stainless steel screws **46**.

[0073] The bracket assemblies **40** are preferably installed horizontally at each horizontal joint. **Figure 11** shows a cut-away elevational view of the sub-framing, or L-brackets **40**, as installed on an exterior building surface **100**. It can be seen that a series of finished ACM panel assemblies **34** have been mounted onto the exterior building surface **100**. Preferably, panel

assemblies **34** are mounted from the bottom of the exterior building surface **100**, and moves up. In this way, the installer may make sure that each row is level relative to the previous row installed. However, it is observed here that the finished panel assemblies **34** may beneficially be installed in any direction or sequence.

[0074] This aspect of the inventions deserves further discussion. As can be seen in **Figure 11**, the L-angle brackets **40** have been placed along the exterior building surface **100** in horizontal rows. The finished panel assemblies **34** may be secured to the brackets **40** from left-to-right, from right-to-left, or even out of order provided the correct spacing is maintained. Similarly, the L-angle brackets **40** may be placed along the exterior building surface **100** in vertical rows. The finished panel assemblies **34** may then be secured to the brackets **40** from bottom-to-top, from top-to-bottom, or out of order provided the correct spacing is maintained.

[0075] Referring back to **Figure 12,** a thin layer of isolation tape **42** may be applied to the back of the aluminum attachment clips **16**. This prevents direct contact between the galvanized steel sub-framing (bracket assemblies **40**) and the corresponding aluminum attachment clip **16**. Thus, in turn, prevents galvanic action (electrolytic decay of the aluminum) over time. Preferably, stainless steel self-drilling screws **48** are used to fasten the aluminum attachment clips **16** to steel sub framing **40**. After determining a logical order of installation, each panel assembly **34** is plumbed and leveled to ensure a tight and concise fit from panel to panel.

[0076] The individual panels **32** may optionally be supported by a panel stiffener. **Figure 4** provides a cross-sectional view of a panel stiffener **18**, in one embodiment. In this embodiment, the panel stiffener **18** comprises a hollow tube having a square profile.

[0077] Such a panel stiffener **18** is desirable on large-sized panels. The panel stiffeners **18** may be used to prevent the popping or "oil canning" of the finished panel assemblies **34**. As the individual panels **32** heat up, the panels **32** may expand and make a popping sound. The stiffeners **18** reinforce the panels **32** to reduce this effect.

[0078] **Figures 19** and **20** provide cross-sectional views of panel stiffeners **18A, 18B,** in alternate embodiments. In these arrangements, the panel stiffeners **18A, 18B** are internally reinforced. This provides greater stability between the exterior building surface **100** and the panel assemblies **34**.

[0079] Where panel stiffeners **18, 18A, 18B** are used, the panel perimeter strip **14** may be adapted to better locate and secure the stiffener component. A panel perimeter strip **14A** having a profile as shown in **Figure 18** may be advantageous for this purpose. An extended interior lip **15** of the panel perimeter strip **14A** operates to secure the panel stiffener component.

[0080] Panel stiffeners may be provided in different sizes depending on the wind pressures to which the panels **34** will be exposed. A larger width panel stiffener **18B** may be advantageous where there are greater wind loads on the attachment system **10** or if less deflection on the individual panels **34** is desired. It will be appreciated that the construction of the panels **32** themselves also provides a basic level of rigidity, and stiffeners are not necessarily required.

[0081] The attachment system **10** also includes an infill strip. An infill strip **38** is shown in the cross-sectional views of **Figures 1, 10,** and **12**. An infill strip **38** is also shown in cross-sectional isolation in **Figure 9**. The infill strip is preferably cut to a width of approximately 1-1/4" (32 mm) for a ½" (13 mm) joint. The infill strip **38** replaces the conventional caulk joint, giving the panel system a clean, maintenance free appearance. The infill strip **38** also is used to hide the fasteners **48** for the attachment clip **16**.

[0082] Each attachment clips **16** is designed so as to interlock with a pair of panel perimeter strips **14** while holding an infill strip **38** securely in place.

[0083] Both the infill strips **38** and the panels **32** are preferably fabricated from an aluminum composite material ("ACM"). **Figures 5** through **7** present illustrative cross-sectional views of an ACM panel **32** undergoing fabrication. The panel **32** may be fabricated from several layers as described below.

[0084] As shown in **Figure 5**, ACM **20** consists of a core of low density polyethylene **24** sandwiched between two sheets of aluminum **22** (each approximately 0.5 mm thick). The finish face of the aluminum sheets **22** is coated with a polyvinylidene fluoride coating. The inner aluminum layer is typically coated with chrome or polyester coatings. The standard thickness of the panel **32** is 5/32" (4 mm) but thickness may range from 1/8" (3 mm) to ¼" (6 mm), depending on customer preference or structural requirements.

[0085] A finished ACM panel **32** may be fabricated from a flat sheet of ACM **26** using different types of router and cutting bits **28** (seen in **Figure 6**). After the sheet of ACM **26** has been cut and routed, the sheet **26** is then bent along the router lines to form the finished panel **32** (seen in **Figure 7**). The newly-shaped panel **32** is then assembled with the panel perimeter strip **14** using a panel rivet **36** to complete the finished panel assembly (seen in **Figures 8** and **10**). A standard panel rivet for this application may be 3/16" diameter.

[0086] **Figure 8** shows a finished panel assembly **34**. Panel perimeter strips **14** are shown supporting a panel **32**. Two rivets **36** are also shown, preserving through-openings through the panel perimeter strips **14** and connected panels **32**.

[0087] There are various methods to accomplish the routing and cutting process:

[0088] **Method 1**

Handheld router (not shown): A handheld router is used more often when reworking a panel to a different size. This method requires the simplest tool set up, but is the most labor-intensive method of fabrication due to the lengthy time for setup and layout of each different panel.

[0089] **Method 2**

Vertical table saw (not shown): A vertical table saw can also be used, both to cut and rout the panels. Custom "V" routing blades can be purchased to rout the panels. Panel design is limited using the vertical table saw in itself. Using it in combination with the hand held router has its advantages, but it is still a costly way to manufacture panels.

[0090] **Method 3**

CNC-Machine (not shown): The computer numerically controlled (CNC) machine is a complete and concise way to manufacture panels. Once the panel has been designed by a CAD operator it is then sent directly to the machine. This machine has been found to be very useful and economical for manufacturing panels. This is the applicants' preferred method for cutting and routing panels.

[0091] **Figures 13** through **16** demonstrate the installation of an infill strip **38** into an attachment system **10**. The infill strips **38** are preferably shipped to a construction site in long lengths, and are cut to fit on-site. The strips **38** may have a protective plastic coating, which is then removed from the face of the infill strips **38** before installation.

[0092] The infill strips **38** may be installed one of two ways:

[0093] First, as shown in **Figures 13** through **15**, individual infill strips **38** may be slipped into a slot **37** before the adjacent panel is installed. This is of benefit when the edge of the joint is not accessible, or when the infill strip **38** has a curve or bend in it. The infill strip **38** is fitted into the space between the panel **32** and the attachment clip **16** as illustrated in **Figures 13** and **Figure 14**. Then, an adjacent panel **32'** is installed so that the infill strip **38** and attachment clip **16** engage into the slots **37** in the panel edge at the perimeter strip **14A' (Figure 15)**.

[0094] Second, and as an alternative method of installation, the installer can slide the infill strip **38** in from the end. This is shown in **Figure 16**. This allows for a simplified installation of the finished panels **34**. The infill strips **38** are not installed until an area is complete. This means that panel assemblies **34** can be adjusted for straightness and position even after adjacent panels have been installed. The difficulty with this method is that the end of the joint will not always be accessible (i.e. wall or window frame) and the infill strip **38** may have a tendency to catch on the attachment clips **16** as it is being slid into the joint. To aid in the sliding of the strips **38**, a tool may be used to pull the leading edge of the strips **38** over the clips (not shown in **Figure 16**).

[0095] **Figure 17** presents a perspective view of a finished wall panel exterior. The finish faces of the panels **32** may have a protective film **50** to protect against minor abrasions that may occur during handling and installation. The protective film **50** may be peeled back from the returns of the panels **32** before installing. To keep the panels **32** clean and free of construction debris, generally the protective plastic film **50** is only removed from the faces of the panels once the landscaping has been completed.

[0096] As can be seen, a dry joint aluminum wall panel attachment system **10** for attaching wall panels to an exterior building wall is provided. The attachment system includes a plurality of individual aluminum-based wall panels **32**. Each wall panel has an exterior flat surface and four side surfaces. At least two of the side surfaces are bent generally perpendicularly to the exterior flat surface. In this way, a hollow interior portion **30** is defined.

[0097] The attachment system **10** also includes a plurality of bracket assemblies. Each bracket assembly is configured to be fastened to the exterior wall **100**. In one aspect, each bracket assembly comprises two back-to-back L-angle brackets **40** fastened to each other via connectors **46** to form a generally Z-shaped assembly. A first end is for attachment to the exterior wall surface **100**, and a second end is for fastening to an attachment clip **16**. Preferably, the bracket assemblies **40** are fabricated from steel for strength.

[0098] The attachment system **10** also has a plurality of attachment clips **16**. Each clip **16** is preferably fabricated from aluminum and is configured to be fastened to a respective bracket assembly by a fastener **48**. Preferably, each fastener **48** comprises a threaded fastener. The attachment clips **16** carry the dead load of the wall panels **32**.

[0099] Each attachment clip **16** has a pair of integrally formed wing members. Each wing member extends outwardly from the central fastening surface in a substantially symmetrical manner. Preferably, isolation tape **42** is applied between the attachment clips **16** and the respective bracket assemblies.

[00100] The attachment system **10** also includes a plurality of panel perimeter strips **14**. Preferably, each panel perimeter strip **14** is fabricated from aluminum. Each panel perimeter strip **14** (or, optionally, **14A**) is configured to be fastened to one side surface of a respective wall panel **32**. Further, each panel perimeter strip **14** comprises a generally C-shaped member configured to reside inside of and extend along an inside portion of a side surface of a respective wall panel **32**, and a receiving member integrally attached to the C-shaped member configured to extend beyond the side surface of a wall panel **32** and provide a slot **37** adapted to engage and interlock one of the wing members of the attachment clip **16**, thus operatively connecting a respective wall panel assembly **34** to the attachment clip **16** and thereby to the wall **100**.

[00101] The attachment system **10** also includes rivets **36**. The rivets **36** are placed along the side surface of the wall panels **32** to connect the side surface of a respective wall panel **32** to a receiving member of a panel perimeter strip **14**. The rivets **36** are hollow to permit the ingress and egress of air and moisture through the hollow interior area **30** behind the panels **32**.

[00102] The attachment system **10** further includes a plurality of infill strips **38**. Each infill strip **38** is preferably fabricated from a substantially rigid material comprising aluminum or aluminum composite material. Each of the infill strips **38** is non-sealingly disposed within respective slots **37** of adjoining panel perimeter strips **14**.

[00103] The infill strips **38** are placed between a corresponding attachment clip **16** and the one or more rivets **36** so as to cover the fasteners **48**. In one aspect, each infill strip **38** is engaged with the slot **37** of a panel perimeter strip prior to installing an adjacent wall panel assembly **34**. Alternatively, each infill strip **38** may be introduced to the slots **37** of two adjacent panel perimeter strips **32** after two adjacent wall panel assemblies **34** have been installed.

[00104] The attachment system **10** is held together non-adhesively. In addition, the attachment system **10** is configured to allow panel assemblies **34** to be secured to respective panel attachment clips **16** in any sequence.

[00105] The wall panel attachment system **10** may be modified for use with stiff or rigid panels. In this instance, an adhesive is applied to a flat surface of a tile perimeter strip. The rigid panels may be, for example, fabricated from ceramic.

[00106] In one embodiment, it is desirable to integrate the wall panel attachment system **10** with the ability to generate clean energy for the building on which the wall panels are mounted. **Figure 21** provides a cross-sectional view of a photovoltaic (PV) wall panel attachment system **60**. The system **60** may be used to attach multiple PV wall panels **61** to an exterior building wall (such as wall **100** of **Figure 1**) adjacent to ACM panels. The system **60** includes a plurality of PV wall panels **61** which are attached to a structural sub-assembly, as will be described below.

[00107] First, bracket assembly **62** is mounted to the exterior building wall **100**. The bracket assembly **62** may comprise one or more L-angle brackets, and can be configured to accommodate adjacent panels, as needed. For example, as shown in **Figure 21**, an installed aluminum composite wall panel **32** is shown residing above or adjacent an installed PV panel **61**. The bracket assembly **62** may be constructed of multiple bracket components affixed to one another to form a unitary structural foundation or sub-framing for the remainder of the system **60**.

[00108] The bracket assembly **62** shown in **Figure 21** comprises a primary base bracket **71**, a secondary base bracket **72**, and a panel mounting bracket **73**, all of which are secured to one another by conventional fasteners, such as stainless steel screws **46**. The primary base bracket **71** and the secondary base bracket **72** are each secured to the exterior building wall **100** by fasteners **63**, which are preferably masonry screws. Optionally, a cable guide **64** is attached to the bracket assembly **62** to permit secure routing of electrical cables **67** extending from each of the PV wall panels **61**. The cables **67** carry electric current generated by the PV panels **61**.

[00109] The wall panel attachment system **60** also includes attachment clips **16**. The attachment clips **16** are configured to be fastened to respective bracket assemblies **62** by a fastener **68** and to carry the dead loads of the respective PV wall panels **61**. The attachment clips

16 may have a single-wing design as shown in **Figure 21**, or a double-wing design as shown in **Figure 21**, depending on the location along the wall **100** in which they are used.

[00110] **Figure 26** shows a series of cross-sectional views of attachment clips that may be used in the attachment system **60**. A double-wing design is shown at **16**. The double-wing design is used when multiple solar (or other stiff) panels **61** are being hung adjacent to one another. The double-wing clips **16** allow panels **61** to be hung in any sequence.

[00111] A single-wing design is shown at **16A**. This is actually the attachment clip used in **Figure 21**. The single-wing design **16A** may be utilized when a panel **61** is being installed at an edge of a wall or adjacent a window sill. The single-wing design **16A** may also be utilized when a panel **61** is being installed adjacent an ACM panel **32**, as shown in **Figure 21**.

[00112] The wall panel attachment system **60** also includes a plurality of tile perimeter strips **74**. The tile perimeter strips **74** provide lateral support for the PV wall panels **61**. The tile perimeter strips **74** may be placed along horizontal edges of the panels **61**, vertical edges of the panels **61**, or both. Further, where the panels **61** are polygonal bodies having edges that are offset from vertical and horizontal, the tile perimeter strips **74** may be angled to support the offset edges.

[00113] Each tile perimeter strip **74** comprises a generally C-shaped member configured to extend along a rear surface **69** of a respective PV wall panel **61**. Each tile perimeter strip **74** also includes a receiving member integrally attached to the C-shaped member having a slot adapted to engage and interlock one of the wing members of the attachment clip **16**, shown best in the enlarged views of **Figures 22** and **23**.

[00114] **Figure 27** shows a series of cross-sectional views of panel perimeter strips that may be used with the attachment system **60**. The panel perimeter strip **74** shown in **Figure 27** is also used in **Figure 21**. The tile perimeter strips **74** provide horizontal support for the PV wall panels **61**.

[00115] The wall panel attachment system **60** may further include one or more panel stiffeners **18.** As shown in **Figure 21**, a panel stiffener **18** may be placed in the C-shaped member of the panel perimeter strip **74** to provide lateral support for an adjacent panel **61**. Each panel stiffener **18** is fixed between the C-shaped members of opposing tile perimeter strips **74**, as shown in **Figures 22** and **23**. Preferably, the panel stiffeners **18** are connected to the tile perimeter strips **74** using conventional fasteners **75**, and are positioned such that the left and right edges of the PV wall panel **61** are substantially flush with the panel stiffeners **18**.

[00116] It is noted that in the views of **Figures 21**, **22**, and **23**, a gap is present between the panel **61** and the stiffener **18**. In reality, this gap is very small, such as only 1 to 7 mm. Therefore, the panels **61** and the stiffeners **18** may be considered to be "attached."

[00117] Each PV wall panel **61** is attached to the panel stiffeners **18** and to the tile perimeter strips **74**. Preferably, the PV wall panel **61** is bonded to the panel perimeter strips **74** using a structural silicone adhesive **66**. An example of a suitable adhesive **66** is the 983 Silicone Glazing and Curtainwall adhesive/sealant product manufactured by Dow Corning.

[00118] In a preferred embodiment, a high-density closed-cell foam tape **65** is applied to either a rear perimeter surface **69** of the PV wall panel **61**, or to the tile perimeter strip **74**. The ¼" wide by 3/8" high, high-density, closed-cell foam tape **65** provides spacing for the necessary thickness of the structural silicone adhesive **66**, as shown in **Figure 24**.

[00119] In operation, the high-density closed-cell foam tape **65** may first be applied to the planar surface of a panel perimeter strip **74**. Thereafter, a PV wall panel **61** is held onto or laid on the panel perimeter strip **74** and, optionally, a panel stiffener **18**. A bead or volume of structural silicone adhesive **66** is then applied to a void formed between the PV wall panel **61** and tile perimeter strip **74** outside of the foam tape **65**. The void is filled until the structural silicone adhesive **66** is flush with the exterior perimeter edges of the tile perimeter strip **74** and the panel **61**, as shown is Figures **22** and **23**. The high-density, closed-cell foam tape **65** confines the structural silicone adhesive **66** to the tile perimeter strip **74**. The tape **65** also maintains a gap

between the panel perimeter strip **74** and the panel **61** to ensure that that the electrically active area on the PV wall panel **61** remains unaffected.

[00120] Structural bonding tape can be used as an alternative to the structural silicone adhesive **66** and the foam tape **65** when utilizing tile perimeter strip **74D**. One such suitable bonding tape is the VBH bonding tape manufactured by 3M Company. Preferably, an additional adhesive **66** is applied to the rear surface periphery of the PV wall panel **61** in the form of a structural silicone adhesive and sealant, such as the 983 Silicone Glazing and Curtainwall adhesive/sealant product manufactured by Dow Corning. In this manner, the PV wall panel **61** is securely bonded to the structural assembly beneath it.

[00121] The PV wall panels **61** may be any desired PV panel that is suitable for use in the desired application. One example of such a PV panel is the ASI OPAK solar panel manufactured by Schott North America, Inc., of Elmsford, New York. It is noted that such solar panels can be very heavy – even up to 60 pounds, depending on dimensions. Therefore, care should be taken to ensure that a quality adhesive is used for securing the panels **61** to the panel perimeter strips **74**.

[00122] It will be understood to those of ordinary skill that the shape and dimensions of the mounting components described above should permit mounting of the PV wall panels **61** so that their exterior surfaces may be flush with the adjacent non-solar wall panels **32**. Thus, in **Figure 21**, a solar wall panel **61** is placed on an exterior wall **100** adjacent a non-PV wall panel, e.g., the ACM panel **32**.

[00123] It is also understood that the panel systems **60** herein may also be used with solar wall panels being adjacent to one another. **Figure 25** is a top view of another photovoltaic (PV) wall attachment system **60**. Here, two solar wall panels **61** are placed on an exterior wall **100** adjacent to one another. An attachment clip **16** having a central fastening member and two symmetrically extending wing members is provided. Further, two tile perimeter strips **74** are provided. The tile perimeter strips **74** are adhesively connected to the rear surfaces of the respective solar panels **61** using adhesive **66**.

[00124] Through-openings may optionally be provided in the tile perimeter strips **74**. These are shown in **Figure 25** at **77**. The through-openings **77** permit the ingress and egress of air and moisture behind the solar wall panels **61** to provide a pressure-balanced and moisture-drained environment.

[00125] The description above for **Figures 22** through **25** pertain to the use of solar wall panels with an attachment system **60**. The attachment system **60** allows for the installation of PV panels **61** wherein panel assemblies (panels **61** with panel perimeter strips **74**) may be hung in any sequence. It is noted that modifications of certain components to the attachment systems **60** may be made. These include the attachment clip **16**, the panel perimeter strip **74**, and the infill strip **38**.

[00126] **Figure 26** shows a series of cross-sectional views of attachment clips that may be used in the attachment system **60**. The first attachment clip **16** is the attachment clip shown in **Figure 3**. The attachment clip is also shown in the attachment system of **Figure 25**. The second attachment clip **16A** is the attachment clip shown in the attachment system of **Figure 21**. This attachment clip **16A** is also seen at the bottom of **Figure 1**.

[00127] It is understood that where panels **61** are placed along a corner or edge of a wall, some modification of the attachment clip **16** is necessary. The half-clip of **16A** is noted above. Additional attachment clips **16B** and **16C** are shown. Attachment clip **16B** is illustratively shown being used in **Figure 33**, while attachment clip **16C** is illustratively shown being used in **Figure 34**. Attachment clips **16B** and **16C** are useful where panels **61** are being installed along a corner or edge of a wall or adjacent a door frame or window sill.

[00128] **Figure 27** shows a series of cross-sectional views of panel perimeter strips that may be used with the attachment system **60**. The first panel perimeter strip **74** is the panel perimeter strip shown in the attachment systems of **Figures 21** and **25**. However, modifications to the panel perimeter strip **74** are shown at **74A**, **74B**, **74C**, and **74D**. These alternate embodiments may be used to provide additional structural security to the PV panels. For example, the panel

perimeter strip **74D** may be used where the installer uses structural bonding tape in lieu of the structural silicone adhesive **66**.

[00129] The various panel perimeter strips **74, 74A, 74B, 74C, 74D** may be used to secure stiff panels or tiles to exterior surface of a building. In this instance, the perimeter strips may be referred to as tile perimeter strips.

[00130] **Figure 28** provides a series of cross-sectional views of infill strips as may be used in the attachment system **60**. Infill strip **38** is the infill strip shown in **Figure 9**. This infill strip is also seen in the attachment system of **Figure 15**. However, modifications to the infill strip may be made where a different profile for a panel perimeter strip is employed. Alternate infill strip profiles are shown at **38Ai, 38Aii, 38B**, and **38C**.

[00131] Infill strips **38Ai** and **38Aii** are used when access and removal panels are required. Infill strip **38B** is used when the panel revealed joint is filled – to various depths or widths – utilizing the slots created by the tile perimeter strip **74** and the attachment clips **16**. Infill strip **38C** is used when the panel revealed joint is desired to be enclosed, utilizing the two adjoining tile perimeter strips **74** only.

[00132] The description above for **Figures 1, 12, 21** and **25** relate to a wall panel attachment system that may be used for the installation of ACM **32** and solar **61** wall panels, and combinations thereof. However, the wall panel attachment systems described above may be used with rigid, non-solar wall panels.

[00133] **Figure 29** provides a perspective view of a flat panel **90** that may be fastened or adhered to perimeter strips and panel stiffeners. The illustrative panel **90** is fabricated from a ceramic material. For purposes of the present disclosure, the terms "ceramic" or "ceramic material" may include oxides such as alumina and zirconia. Specific examples include bismuth strontium calcium copper oxide, silicon aluminium oxynitrides, uranium oxide, yttrium barium copper oxide, zinc oxide, and zirconium dioxide. "Ceramic" may also include non-oxides such as carbides, borides, nitrides and silicides. Specific examples include titanium carbide, silicon

carbide, boron nitride, magnesium diboride, and silicon nitride. The term "ceramic" also includes composites, meaning particulate reinforced, combinations of oxides and non-oxides. Additional specific examples of ceramics include barium titanate, strontium titanate, ferrite, and lead zierconate titanate.

[00134] A wall panel attachment system **80** is offered herein, wherein the panels are fabricated from ceramic. A preferred ceramic material is porcelain. Porcelain is a ceramic material made by heating raw materials, generally including clay in the form of kaolin, in a kiln to temperatures between 1,200 °C (2,192 °F) and 1,400 °C (2,552 °F). Porcelain may be fabricated as tiles, referred to as porcelain ceramic tile, or PCT. In this instance, PCT may also be referred to herein as a "cladding material."

[00135] **Figure 30** is a top (or, alternatively, a side) cross-sectional view of a porcelain ceramic tile (PCT) wall panel attachment system **80**, in one embodiment. Here, two porcelain ceramic wall panels **81** are placed on an exterior wall **100** adjacent to one another.

[00136] In the attachment systems **80** of **Figure 30**, a plurality of ceramic tiles **81** may be installed onto a wall in any sequence. However, it is noted that the system **80** of **Figure 30** is essentially the same as the system **60** shown in **Figure 25**, but without the electrical cables **67**, and wherein the panels are ceramic rather than solar wall panels.

[00137] Each ceramic tile, or panel **81**, may be 2.5 mm to 3.00 mm in width. Each panel **81** may further be reinforced using a 0.5 mm to 1.0 mm laminate of fiberglass on one side, and a 0.5 mm to 1.0 mm laminate of fiberglass on the opposing side.

[00138] As with the photovoltaic (PV) wall panel attachment system **60**, the PCT attachment system **80** utilizes a bracket assembly **62** to support the panel **81**. The bracket assembly **62** is mounted to the exterior building wall **100**. The bracket assembly **62** may comprise one or more L-angle brackets **72**, **73**, and can be configured to accommodate adjacent panels, as needed. The brackets **72**, **73** may be two back-to–back galvanized steel "L" angles. The bracket assembly **62** may be constructed of multiple bracket components affixed to one

another to form a unitary structural foundation or sub-framing for the remainder of the system **80**.

[00139] The bracket assembly **62** shown in **Figure 30** comprises a wall bracket **72** and a panel mounting bracket **73**. These brackets **72, 73** are secured to one another by conventional fasteners, such as stainless steel screws **46**. The L-angle brackets **72, 73** serve as brackets that allow the installer to level the substrate in three axes before installation of PCT panels **81**. The sub-framing installation may be the same as for the ACM panels **32**.

[00140] Attachment clips **16** are configured to be fastened to respective panel attachment systems **80** by a fastener **68** and to carry the dead loads of the respective PCT wall panels **81**. The attachment clip **16** shown in **Figure 30** uses a double-wing design. Tile perimeter strips **74** are also shown in **Figure 30**, attached to the ceramic panels **81**. The perimeter strips **74** include a through-opening **77**. The through-opening permits the ingress and egress of air and moisture behind the ceramic wall panel **81** to provide a pressure-balanced and moisture-drained environment. However, the hollow rivets **36** from ACM system **10** are not needed.

[00141] The PCT wall panel attachment system **80** also includes a high-density, closed-cell foam tape **85**. The tape **85** is, and acts in the same manner as, the foam tape **65** as shown in **Figure 25**. The tape **85** may be applied to either the rear perimeter surface **89** of the PCT wall panel **81** or to the planar surface of the tile perimeter strip **74**. The high-density, closed-cell foam tape **85** creates spacing for the necessary thickness needed for the adhesive **86**. This, again, is in the form of a structural silicone adhesive and sealant, such as the 983 Silicone Glazing and Curtainwall adhesive/sealant product manufactured by Dow Corning. In this manner, the PCT wall panel **81** is securely bonded to the structural assembly beneath it. The foam tape **85** also acts as a backstop as silicone adhesive is squeezed into the gap between the panel perimeter strip **74** and a rear surface **89** of the ceramic panel **81**. This assembly process is essentially identical to that of the PV wall panel attachment system **60**.

[00142] It is noted that in most cases, the use of the peripheral structural silicone adhesive **66** is adequate. For some panels, the operator may choose to add a bonding tape (shown at **95** in

Figure 33). For larger panels, the operator may further add structural silicone adhesive **86** in the gap between the stiffeners **18** and the rear **89** of the panels **81**. Also, structural bonding tape may be used as an alternative to the silicone adhesive **86** and the high-density closed foam tape **85** when utilizing tile perimeter strip **74A**.

[00143] **Figure 31** provides a cross-sectional view of a wall panel assembly **84**. The assembly **84** utilizes a porcelain ceramic tile (PCT) wall panel **81** attached to panel perimeter strips **74**. The assembly **84** is ready for hanging as part of the system **80** of **Figure 30**.

[00144] **Figures 30** and **31** demonstrate the use of porcelain ceramic tile (PCT), as a cladding material that can be integrated in a wall panel attachment system **80.** The attachment system **80** allows individual panels to be hung on the exterior wall of a building in any sequence. The attachment system **80** is generally used for placing tiles in the center portion of a wall, as indicated with panel assemblies **34** in **Figure 11**. Where placing panel assemblies along an edge, corner, or window, a modification is made to the attachment clip, as shown below in **Figures 32**, **33** and **34**.

[00145] **Figure 32** is a cross-sectional view of a PCT wall panel attachment system **80'** at an end of a wall **100**. A porcelain ceramic tile **81** is shown placed along the exterior of the wall **100**. Flashing is indicated at **92** at the end of the wall **100**. The attachment system **80'** is ideally suited for use with a curtain wall sill (not shown).

[00146] The attachment system **80'** uses several of the same items as the photovoltaic (PV) wall attachment system **60** of **Figure 21**. In this respect, the PCT attachment system **80'** includes a bracket assembly **62**. The bracket assembly **62** may comprise one or more L-angle brackets. Here, the bracket assembly **62** comprises a wall bracket **72** and a panel mounting bracket **73**. The brackets **72, 73** are affixed to one another by connector screws **46** to form a unitary structural foundation or sub-framing for the remainder of the system **81'**.

[00147] The wall bracket **72** and the panel mounting bracket **73** are each secured to the exterior building wall **100** by one or more fasteners **63**. Fastener **63** seen in **Figure 32** is preferably a masonry screw.

[00148] The PCT wall panel attachment system **80'** utilizes an attachment clip and a panel perimeter strip. The attachment clip is the attachment clip **16A** from **Figure 26**, while the panel perimeter strip is the panel perimeter strip **74** from **Figure 27**. It can be seen that the panel perimeter strip **74** includes a through-opening 77. The through-opening permits the ingress and egress of air and moisture behind the ceramic wall panel **81** to provide a pressure-balanced and moisture-drained environment.

[00149] The PCT wall panel attachment system **80'** also includes a closed-cell foam tape **85**, such as neoprene. The tape is **85** is applied to the rear perimeter surface **89** of the PCT wall panel **81** to create spacing. The PCT wall panel attachment system **80'** further includes an additional adhesive **86** applied to the rear surface periphery **89** of the PCT wall panel **81**. This, again, is in the form of a structural silicone adhesive and sealant, such as the 983 Silicone Glazing and Curtainwall adhesive/sealant product manufactured by Dow Corning. In this manner, the PCT wall panel **81** is securely bonded to the structural assembly beneath it.

[00150] **Figure 33** is a cross-sectional view of a PCT wall panel attachment system **80''** at an end of a wall **100**, in yet another alternate embodiment. A porcelain ceramic tile **81** is again shown placed along the exterior of the wall **100**. The attachment system **80''** is ideally suited for use with a curtain wall head (not shown).

[00151] The PCT attachment system **80''** also includes the wall mounting brackets **72**, **73**, the one or more fasteners **63**, and the connector screws **46**. The PCT wall panel attachment system **80''** also utilizes an attachment clip and a panel perimeter strip. The attachment clip is the attachment clip **16B** from **Figure 26**, while the panel perimeter strip is the tile perimeter strip **74A** from **Figure 27**. The tile perimeter strip **74A** includes the through-opening **77** to permit the ingress and egress of air and moisture behind the ceramic wall panel **81**.

[00152] The PCT attachment system **80''** shown in **Figure 33** does not use tape **85** and structural silicone adhesive **86**; instead, an optional thin sheet **94** is placed along the outside flat surface of the tile perimeter strip **74A**. The sheet is fabricated from anodized aluminum or other metallic material. The sheet **94** may be, for example, pre-painted galvanized steel. The sheet **94** is secured to the perimeter strip **74A** by counter-sunk rivets (not shown). Strips of bonding tape **95** are then placed between the sheet **94** and the ceramic tile **81** in order to adhere the ceramic tile **81** to the attachment system **80''**.

[00153] The use of the sheet steel **94** is particularly beneficial when the tiles **81** are large, such as greater than 25 square feet in area. The sheet steel **94** is "picture framed" along and within the perimeter strip 74A, and provides back support for the ceramic tiles **81**. This, in turn, prevents the tile **81** from shattering in the unlikely (but nevertheless possible) event that some object strikes the tile **81** after the attachment system has been installed on the side of a building, and breaks the tile **81**.

[00154] **Figure 34** is still another cross-sectional view of a PCT wall panel attachment system **80'''** at an end of a wall **100**, in an alternate embodiment. A porcelain ceramic tile **81** is again shown placed along the exterior of the wall **100**. The attachment system **80'''** is ideally suited for abutment with a ceramic window sill (not shown).

[00155] The PCT attachment system **80'''** also includes the wall mounting bracket **72**. Tape **85** and adhesive **86** are also employed. The PCT wall panel attachment system **80'''** also utilizes an attachment clip and a panel perimeter strip. The attachment clip is the attachment clip **16C** from **Figure 26**, while the panel perimeter strip is the panel perimeter strip **74** from **Figure 27**. The panel perimeter strip **74** need not include the through-opening **77**.

[00156] As can be seen, different attachment clips **16A, 16B, 16C** are used in **Figures 32, 33, and 34**. Each of these attachment clips **16A, 16B, 16C** is configured to be fastened to respective panel attachment systems **80', 80'', 80'''** by a fastener **68** and to carry the dead loads of the respective PCT wall panels **81**.

[00157] The scope of the claims that follow is not limited by the embodiments set forth in the description. The claims should be given the broadest purposive construction consistent with the description as a whole.

CLAIMS

What is claimed is:

1. A wall panel system for attaching multiple wall panels to an exterior building wall, each wall panel having a dead load, and the system comprising:

a plurality of rigid wall panels;

a plurality of bracket assemblies configured to be fastened to the exterior wall;

a plurality of attachment clips configured to be fastened to respective bracket assemblies by a fastener and to carry the dead loads of the respective wall panels, each attachment clip having a central fastening surface fastened to the bracket assembly and a pair of integrally formed wing members extending outwardly from the central fastening surface;

a plurality of tile perimeter strips configured to reside along a rear surface of a respective wall panel, each tile perimeter strip comprising:

a generally C-shaped member having a planar surface configured to reside along a rear surface of a respective wall panel, and

a receiving member integrally attached to the C-shaped member and having a slot adapted to engage and interlock one of the wing members of the attachment clip, thus operatively connecting a respective wall panel to the attachment clip and, thereby, to the wall;

wherein the system is configured to allow wall panels to be secured to respective bracket assemblies in any sequence,

wherein an adhesive is applied to the rear surface of each wall panel and adhered to each tile perimeter strip along the planar surface, wherein the adhesive comprises structural silicone adhesive, bonding tape, or combinations thereof, wherein each wall panel is attached to the C-shaped member only by the adhesive.

2. The attachment system of claim 1, wherein each panel comprises a plurality of photovoltaic cells for converting solar energy to electrical energy.

3. The attachment system of claim 2, wherein each panel further comprises:

a substantially flat exterior surface; and

an electrical cable for delivering electrical current from the plurality of photovoltaic cells.

4. The attachment system of claim 1, wherein each panel is fabricated from a ceramic material.

5. The attachment system of claim 4, wherein:

each panel further comprises a substantially flat exterior surface; and

each panel is fabricated from a porcelain material to form a porcelain ceramic tile.

6. The attachment system of claim 4, further comprising:

a plurality of thin metallic sheets placed along and connected to the planar surface of the panel perimeter strips, wherein each of the plurality of ceramic panels is adhesively connected to a corresponding metallic sheet.

7. The attachment system of claim 1, wherein:

each bracket assembly comprises two back-to-back L-angle brackets fastened to each other to form a generally Z shaped assembly, a first end of which is for attachment to the wall and a second end of which is for fastening to an attachment clip; and

the pairs of wing members of the attachment clips extends outwardly from the central fastening surface in a substantially symmetrical manner.

8. The attachment system of claim 1, wherein each C-shaped member further comprises a through-opening to permit the ingress and egress of air and moisture behind the rigid wall panels to provide a pressure-balanced and moisture-drained environment.

9. The attachment system of claim 1, further comprising:

a plurality of infill strips non-sealingly disposed within respective slots of the tile perimeter strips so as to cover the fastener, each infill strip being fabricated from a substantially rigid material comprising aluminum, aluminum and polyethylene, polyvinyl chloride (PVC), or

combinations thereof.

10. The attachment system of claim 1, wherein each fastener comprises a threaded fastener.

11. The attachment system of claim 1, wherein each panel perimeter strip is pre-adhered to a wall panel before installation to the building wall.

12. The attachment system of claim 1, further comprising:

an isolation tape applied between each attachment clip and a corresponding bracket assembly.

13. The attachment system of claim 1, wherein:

each attachment clip comprises aluminum; and

each bracket assembly comprises steel.

14. The attachment system of claim 1, wherein each tile perimeter strip is fabricated at least partially from anodized aluminum.

15. The attachment system of claim 1, further comprising:

a panel stiffener placed between opposing tile perimeter strips along the rear surface of each wall panel to reinforce each wall panel.

16. The attachment system of claim 1, wherein:

the adhesive is a structural silicone adhesive applied to the rear surface of each wall panel; and

the adhesive on each rear surface resides adjacent a strip of foam tape.

17. A photovoltaic (PV) wall panel system for attaching multiple PV wall panels to an exterior building wall, each PV wall panel having a dead load, and the system comprising:

a plurality of PV wall panels, each PV wall panel comprising a plurality of photovoltaic cells for converting solar energy to electrical energy;

a plurality of bracket assemblies configured to be fastened to the exterior building wall;

a plurality of attachment clips configured to be fastened to respective bracket assemblies by a fastener and to carry the dead loads of the respective PV wall panels, each attachment clip having a central fastening surface fastened to the bracket assembly and at least one integrally formed wing member, each wing member extending from the central fastening surface;

a plurality of tile perimeter strips, each tile perimeter strip comprising:

a generally C-shaped member having a planar surface configured to reside along a rear surface of a respective PV wall panel, and

a receiving member integrally attached to the C-shaped member having a slot adapted to engage and interlock one of the wing members of the attachment clip; and

an adhesive for connecting the wall panels to the planar surfaces of the C-shaped members at least along selected edges, wherein each wall panel is attached to the C-shaped members only by the adhesive; and

wherein the system is configured to allow the PV wall panels to be secured to respective bracket assemblies in any sequence.

18. The attachment system of claim 17, further comprising:

one or more cable guides attached to each bracket assembly, wherein each of the cable guides is configured to receive electrical cables extending from the rear surface of the PV wall panels for delivering electrical current from the plurality of photovoltaic cells.

19. The attachment system of claim 17, further comprising:

at least one panel stiffener fixed between the C-shaped members of opposing tile perimeter strips to provide support for each PV wall panel along the rear surface.

20. The attachment system of claim 17, wherein the adhesive comprises structural silicone adhesive, strips of bonding tape, or combinations thereof.

21. The attachment system of claim 17, wherein:

the adhesive is a structural silicone adhesive applied to the rear surface of each wall panel; and

the adhesive on each rear surface resides adjacent a strip of foam tape.

22. A hybrid wall panel system for attaching multiple wall panels to an exterior building wall, each wall panel having a dead load, and the system comprising:

a plurality of bracket assemblies configured to be fastened to the exterior wall;

a plurality of attachment clips configured to be fastened to respective bracket assemblies by a fastener and to carry the dead loads of the respective wall panels, each attachment clip having a central fastening surface fastened to the bracket assembly and a pair of integrally formed wing members, each wing member extending from the central fastening surface;

a plurality of solar wall panels, each solar wall panel having a plurality of photovoltaic cells for converting solar energy to electrical energy;

a plurality of tile perimeter strips configured to be adhesively connected to a rear surface of a respective solar wall panel, each tile perimeter strip comprising:

a generally C-shaped member having a planar surface configured to reside along a rear surface of a respective wall panel, and

a receiving member integrally attached to the C-shaped member and having a slot adapted to engage and interlock one of the wing members of the attachment clip, thus operatively connecting a respective wall panel to the attachment clip and, thereby, to the wall;

an adhesive for connecting the solar wall panels to the planar surfaces of the C-shaped members at least along selected edges, wherein each solar wall panel is attached to the C-shaped member only by the adhesive;

a plurality of non-PV wall panels, each non-PV wall panel having an exterior flat surface and at least two side surfaces bent generally perpendicularly to the exterior flat surface and defining a hollow interior portion;

a plurality of panel perimeter strips configured to be fastened to one side surface of a respective non-PV wall panel, each panel perimeter strip comprising:

a generally C-shaped member configured to extend reside inside of and reside along an inside portion of a side surface of a respective wall panel, and

a receiving member integrally attached to the C-shaped member configured to extend beyond the side surface of a wall panel and having a slot adapted to engage and interlock one of the wing members of the attachment clip, thus operatively connecting a respective wall panel to the attachment clip and, thereby, to the wall;

one or more rivets provided along the side surface of respective non-PV wall panels to connect the side surface to the receiving member of a respective panel perimeter strip; wherein:

the hybrid system is configured to allow non-PV wall panels to be secured to respective bracket assemblies in any sequence;

at least one solar wall panel is adjacent to at least one non-PV wall panel; and

the tile perimeter strips and the panel perimeter strips are dimensioned and configured such that the exterior surfaces of the solar wall panels and the non-PV wall panels are substantially flush with one another.

23. The attachment system of claim 22, further comprising:

at least one panel stiffener fixed between the C-shaped members of opposing tile perimeter strips to provide support for each PV wall panel along the rear surface.

24. The attachment system of claim 22, wherein the adhesive comprises structural silicone adhesive, bonding tape, or combinations thereof.

25. The attachment system of claim 22, wherein:

the adhesive is a structural silicone adhesive applied to the rear surface of each wall panel; and

the adhesive on each rear surface resides adjacent a strip of foam tape.

26. The attachment system of claim 22, wherein the system is configured to allow the solar wall panels to be secured to respective bracket assemblies in any sequence.

27. A wall panel system for attaching multiple wall panels to an exterior building wall, each wall panel having a dead load, and the system comprising:

a plurality of rigid wall panels;

a plurality of bracket assemblies configured to be fastened to the exterior wall;

a plurality of attachment clips configured to be fastened to respective bracket assemblies by a fastener and to carry the dead loads of the respective wall panels, each attachment clip having a central fastening surface fastened to the bracket assembly and an integrally formed first wing member and an integrally formed second wing member, each

of the wing members extending outwardly from the central fastening surface;

a plurality of tile perimeter strips configured to reside along a rear surface of a respective wall panel, each tile perimeter strip comprising:

a generally C-shaped member having a generally planar surface configured to reside along a rear surface of a respective wall panel, and

a receiving member integrally attached to the C-shaped member and having a slot adapted to engage and interlock one of the wing members of the attachment clip, thus operatively connecting a respective wall panel to the attachment clip and, thereby, to the wall;

wherein at least a portion of the planar surface of each tile perimeter strip is adhered to the rear surface of its respective wall panel only by a structural adhesive.

28. The wall panel system of claim 27, wherein the adhesive is applied in the form of a tape bearing the adhesive.

29. The wall panel system of claim 27, wherein the adhesive comprises structural silicone.

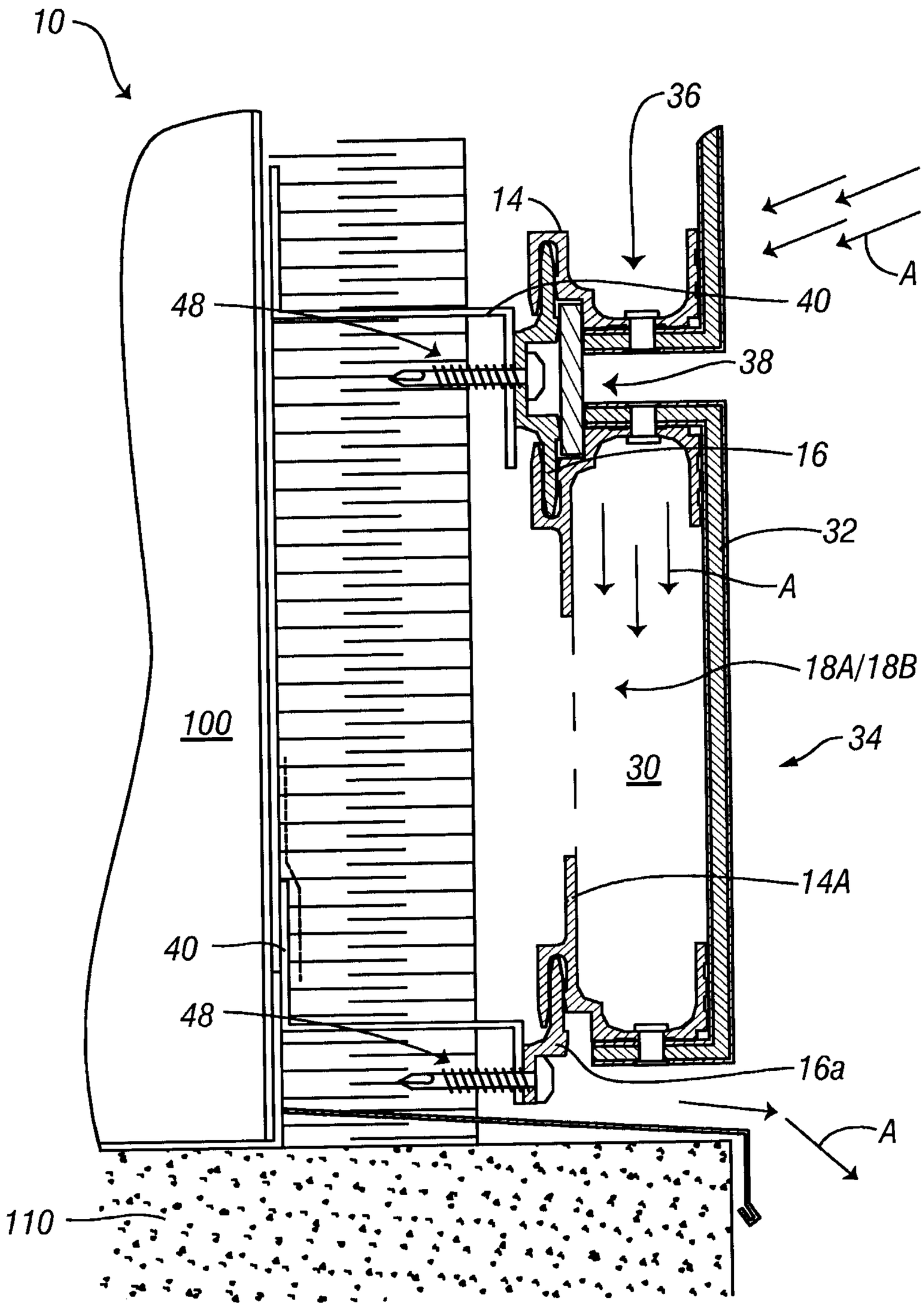


FIG. 1

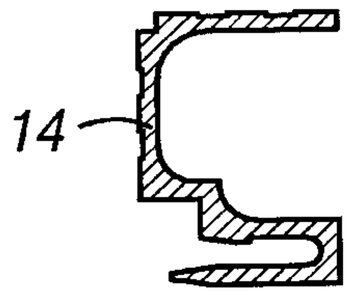


FIG. 2

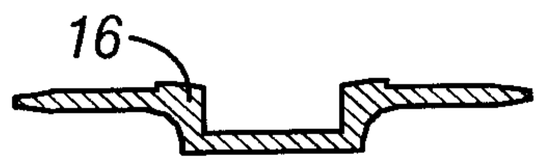


FIG. 3

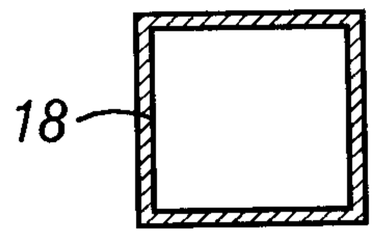


FIG. 4

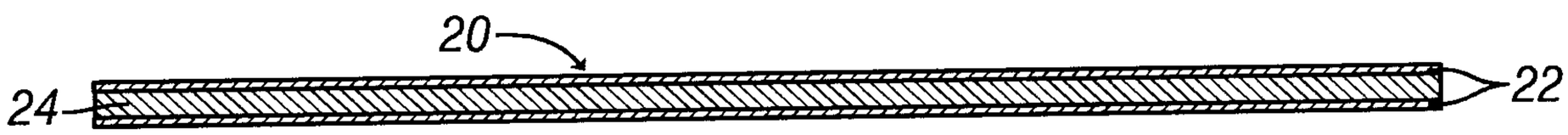


FIG. 5

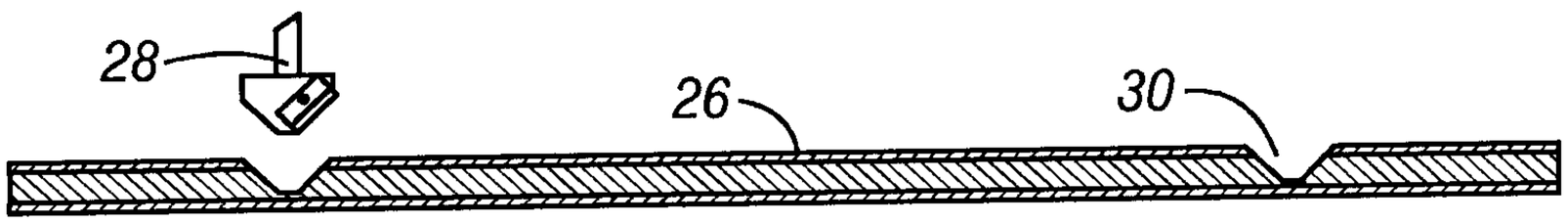


FIG. 6

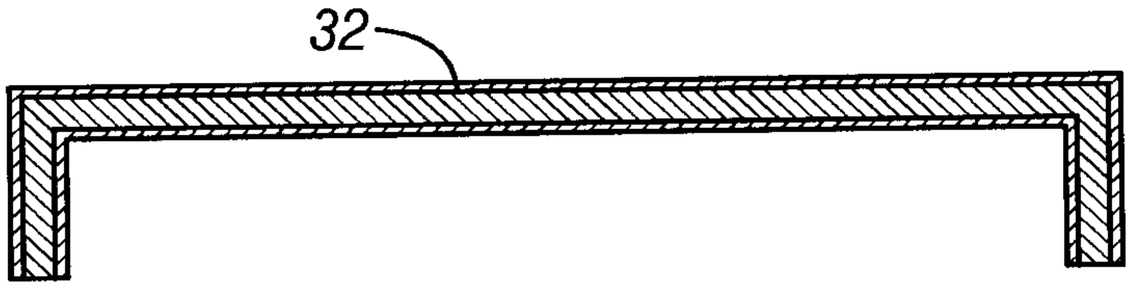


FIG. 7

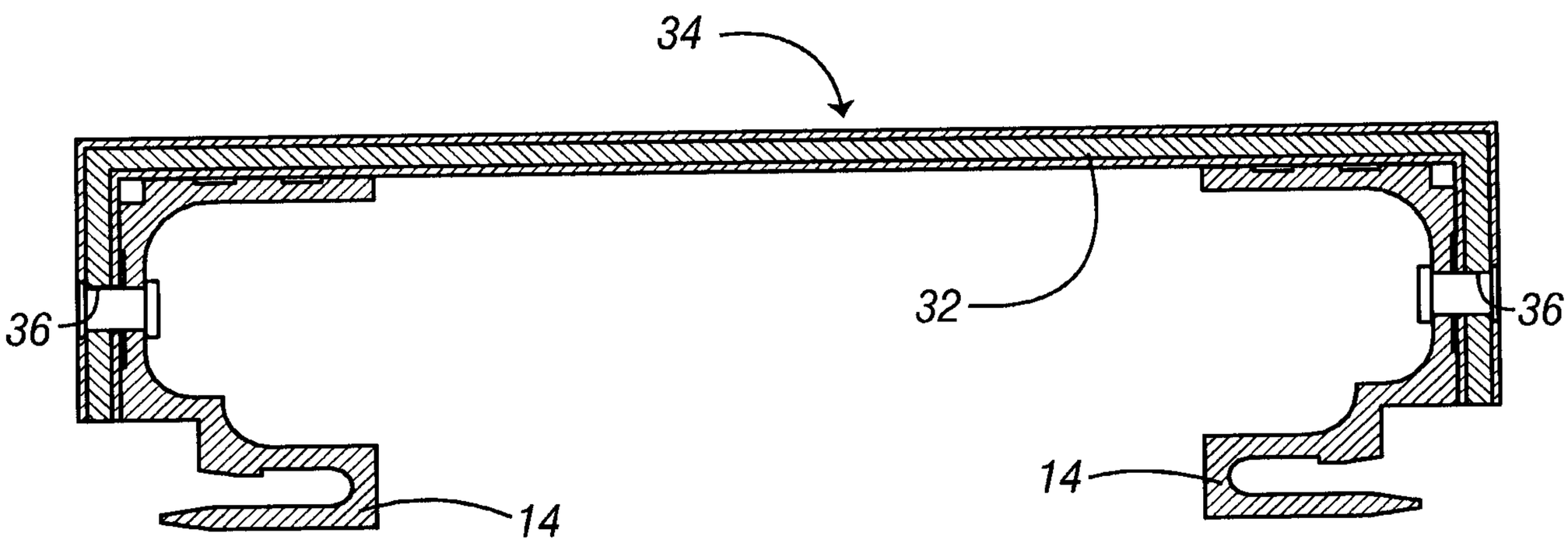


FIG. 8

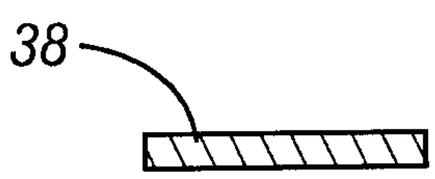


FIG. 9

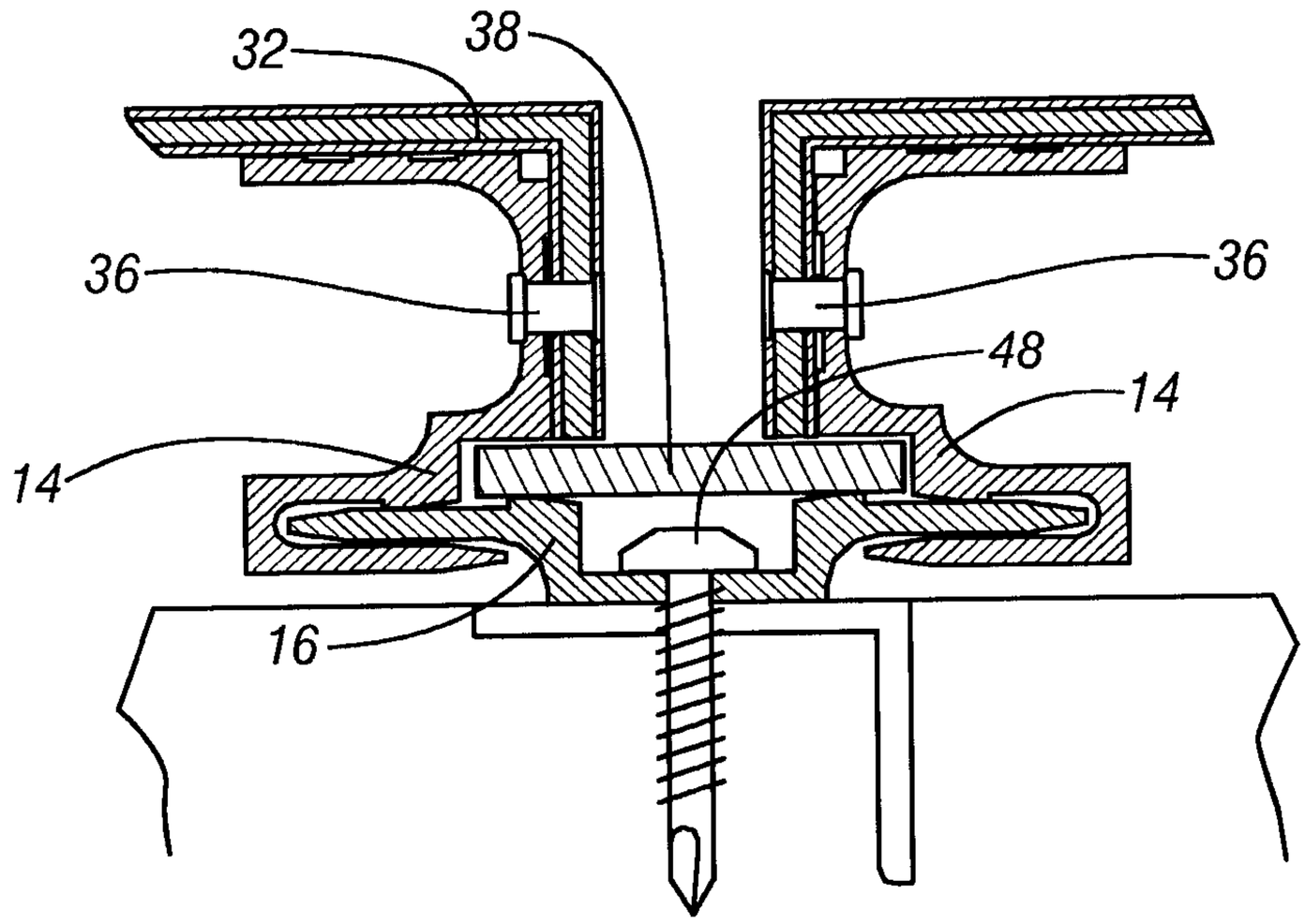


FIG. 10

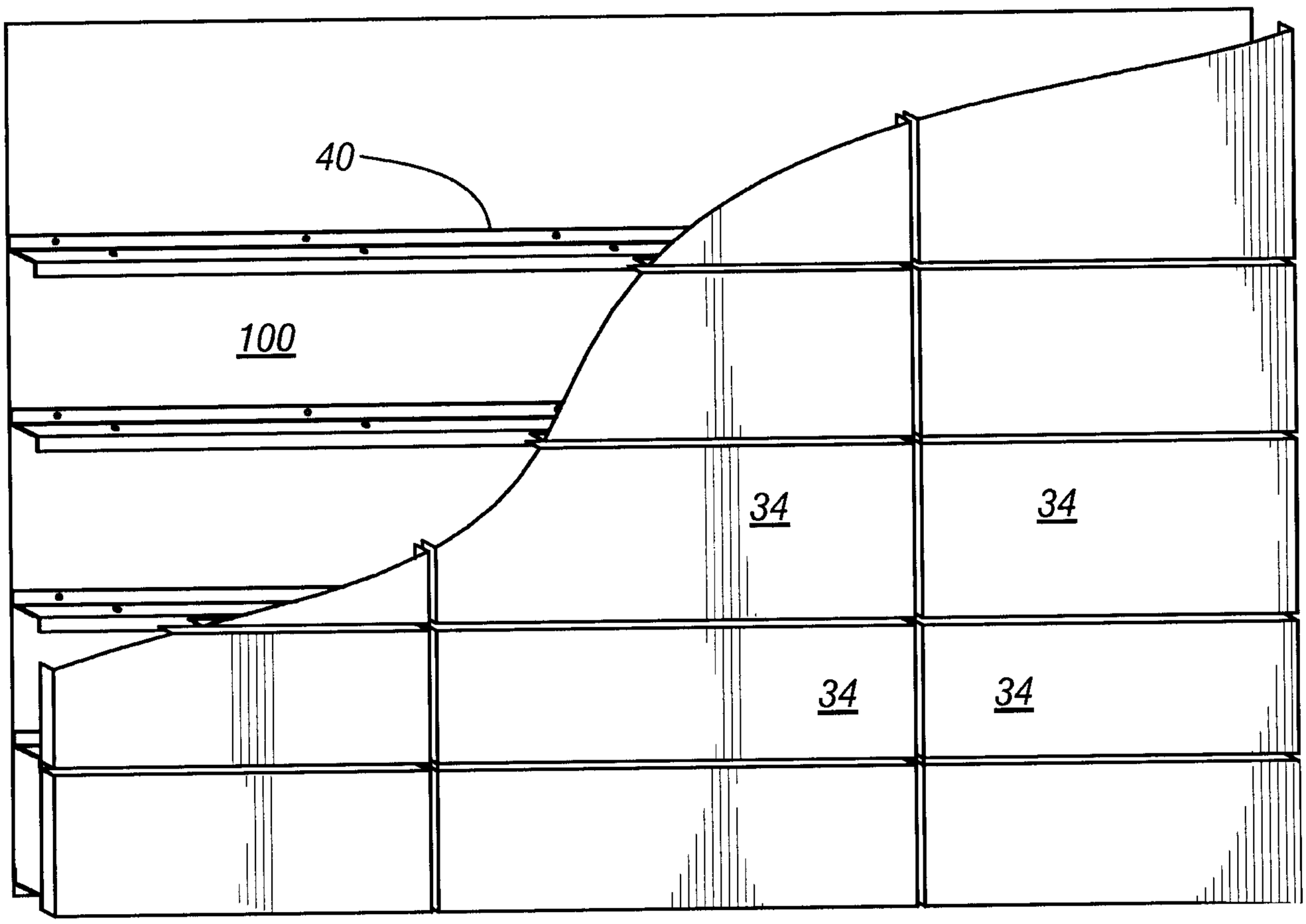


FIG. 11

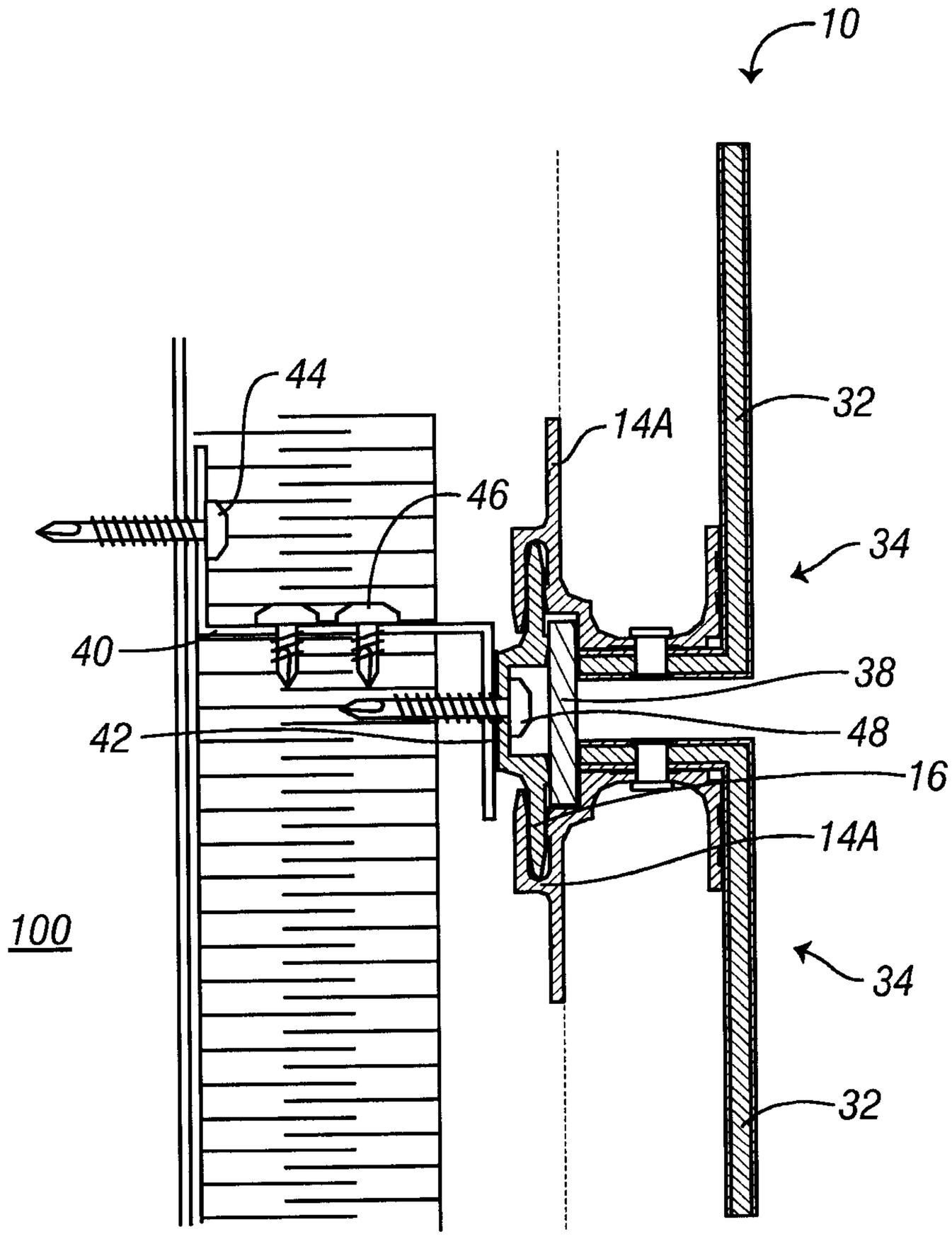


FIG. 12

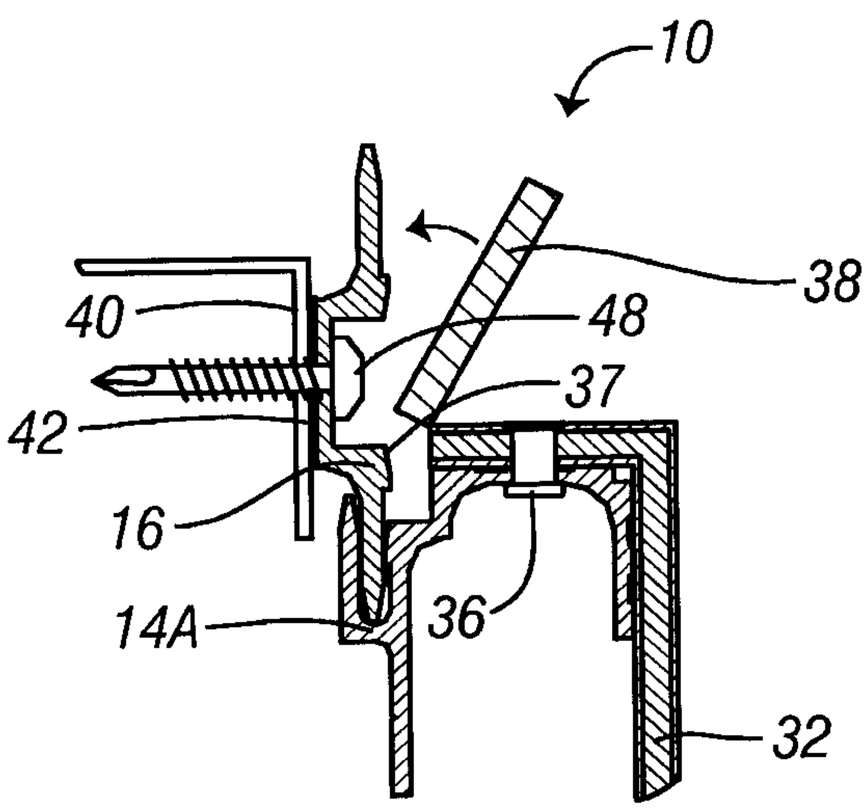


FIG. 13

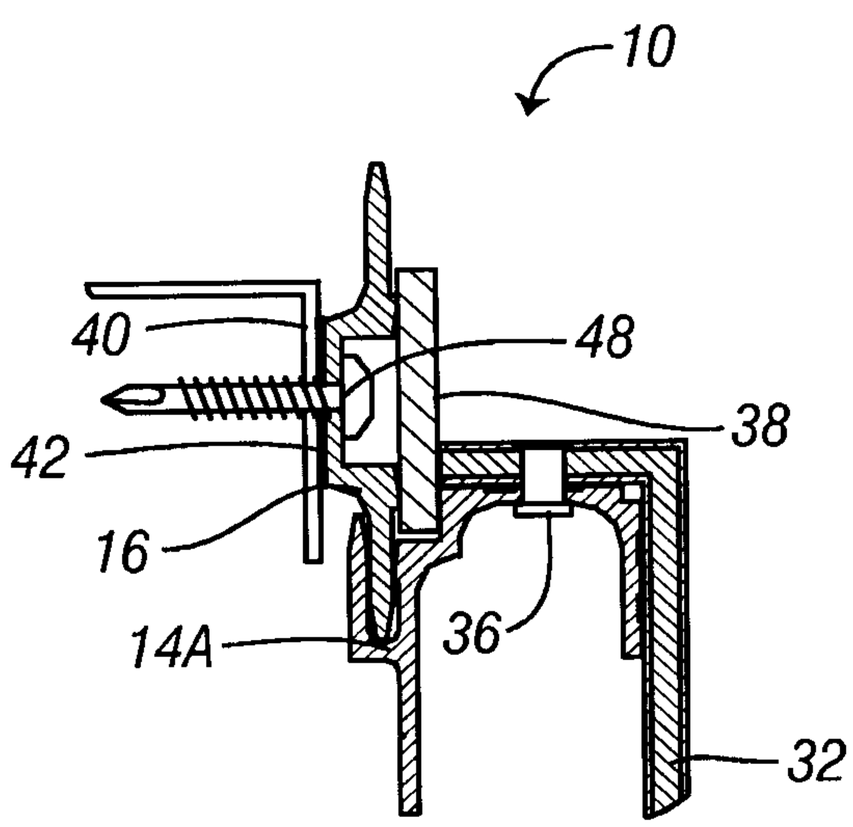


FIG. 14

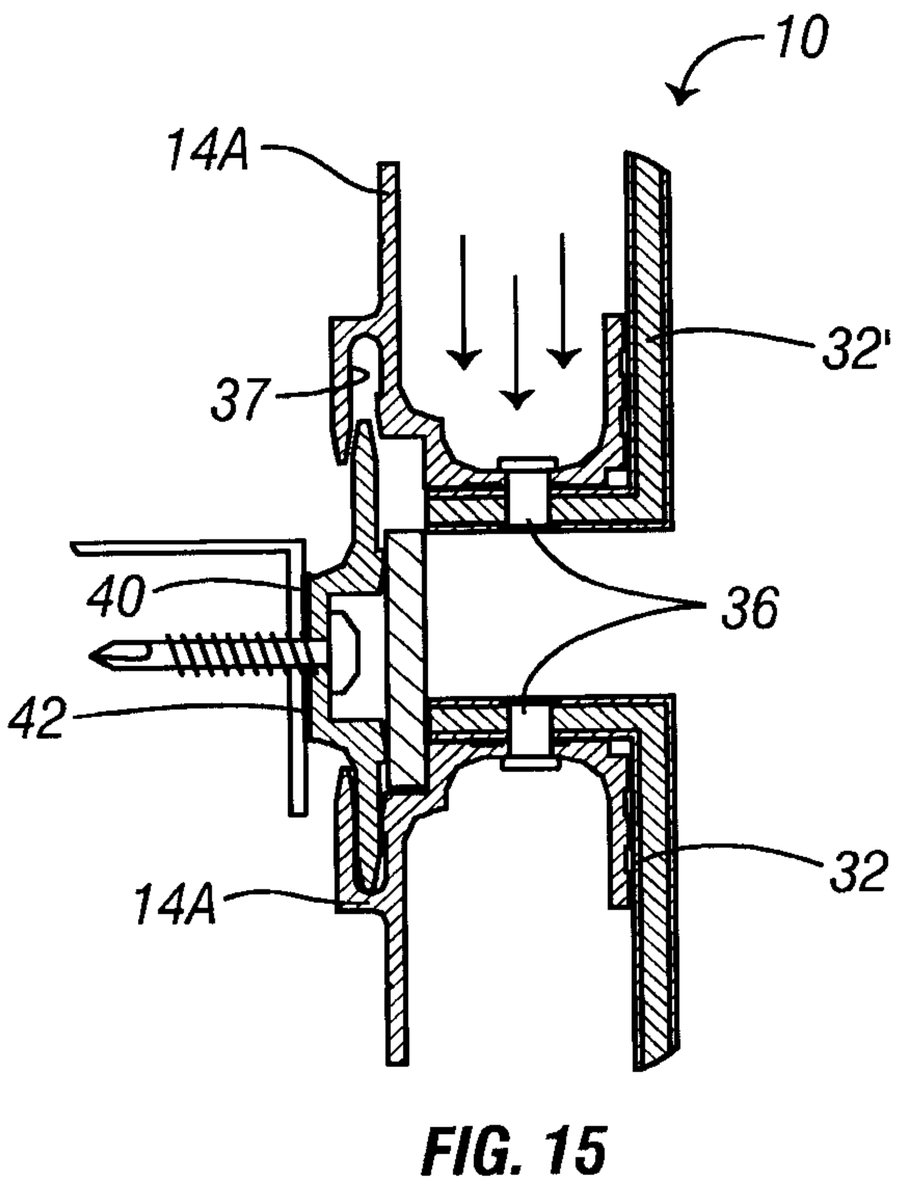


FIG. 15

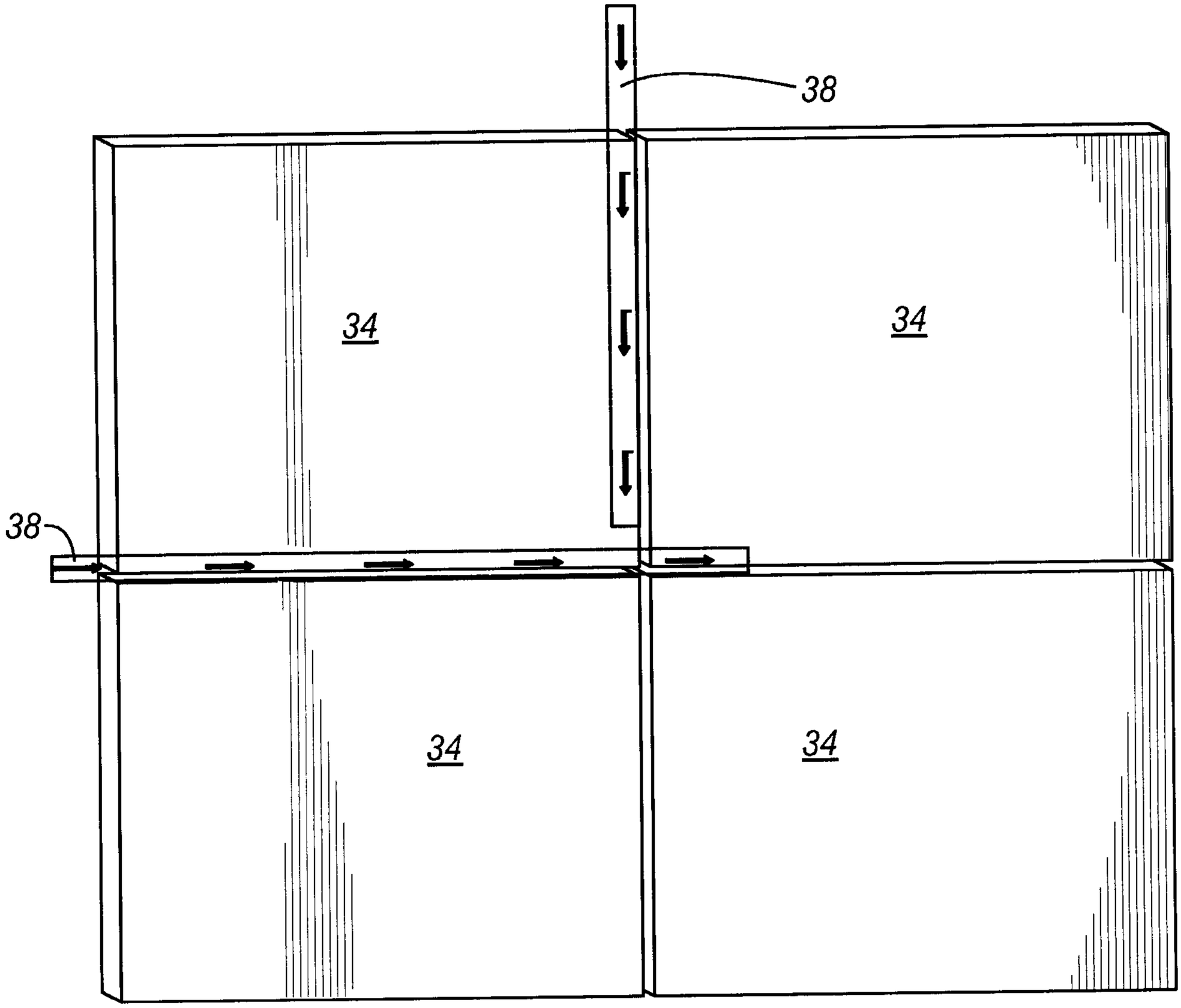


FIG. 16

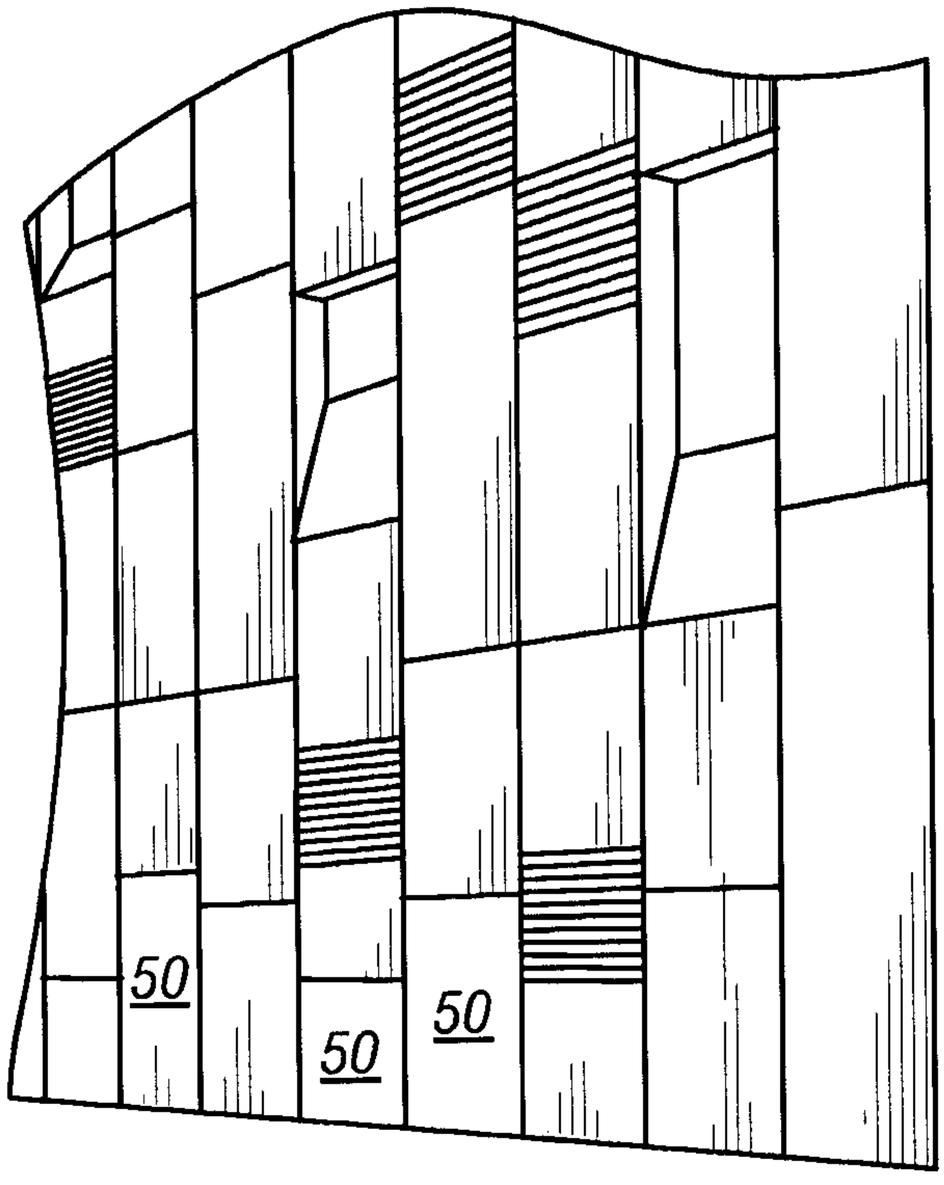


FIG. 17

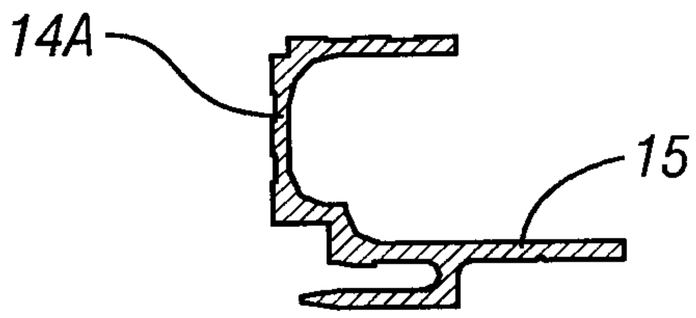


FIG. 18

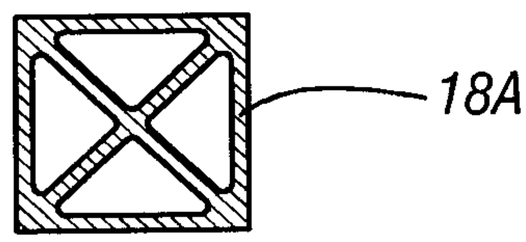


FIG. 19

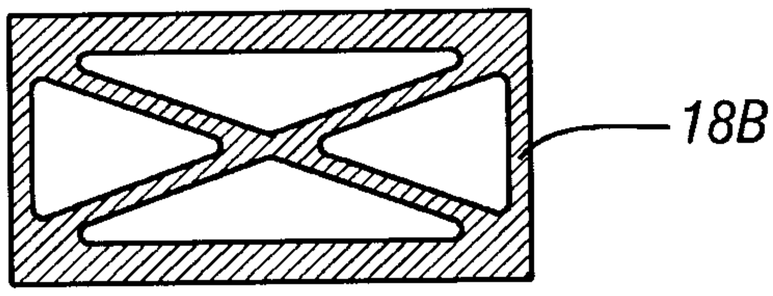


FIG. 20

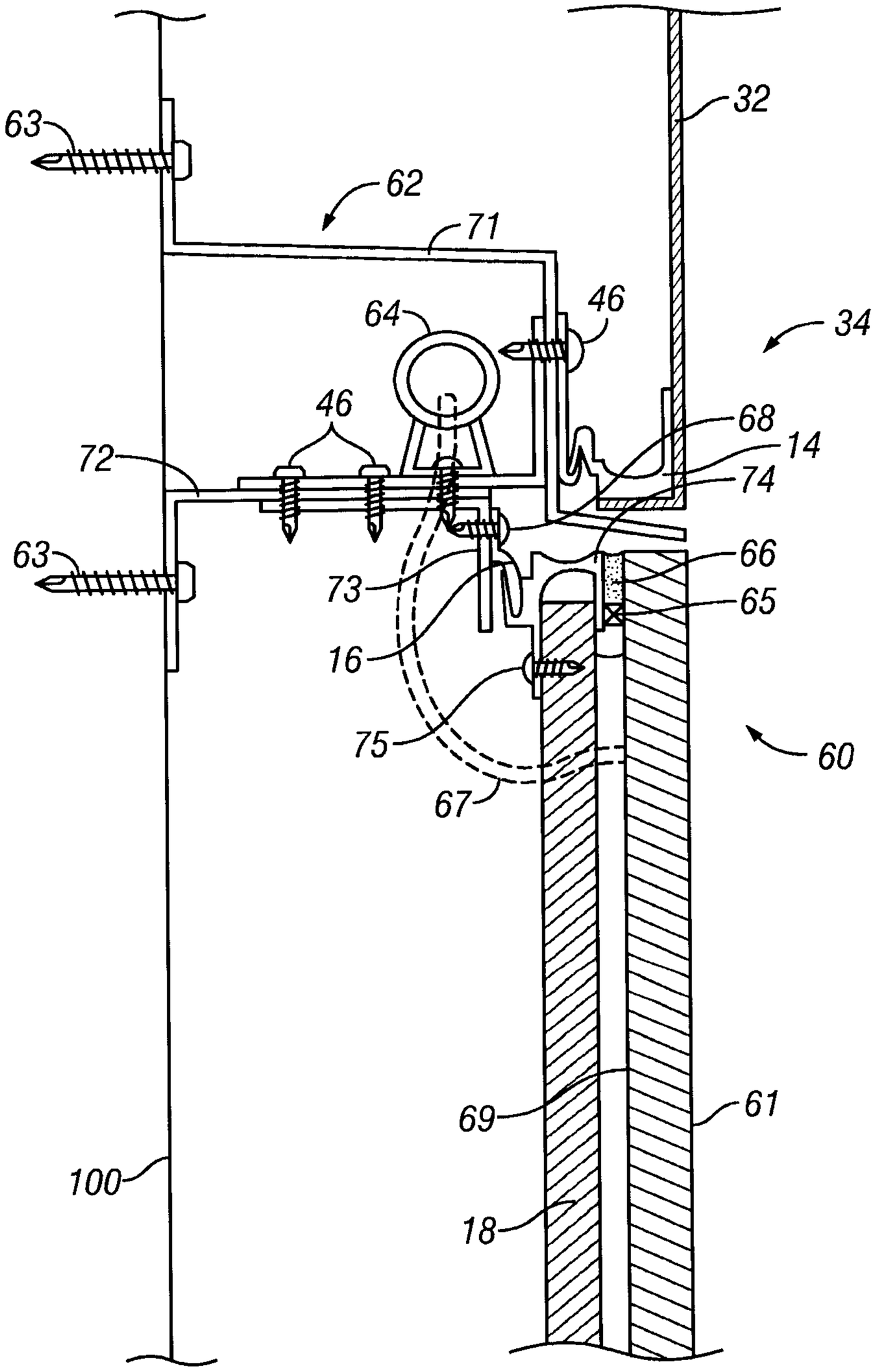


FIG. 21

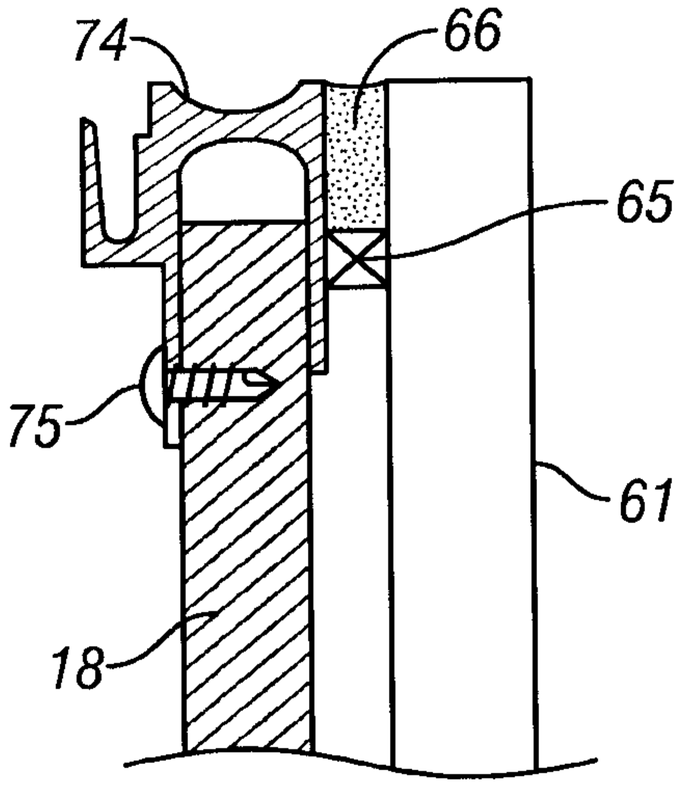


FIG. 22

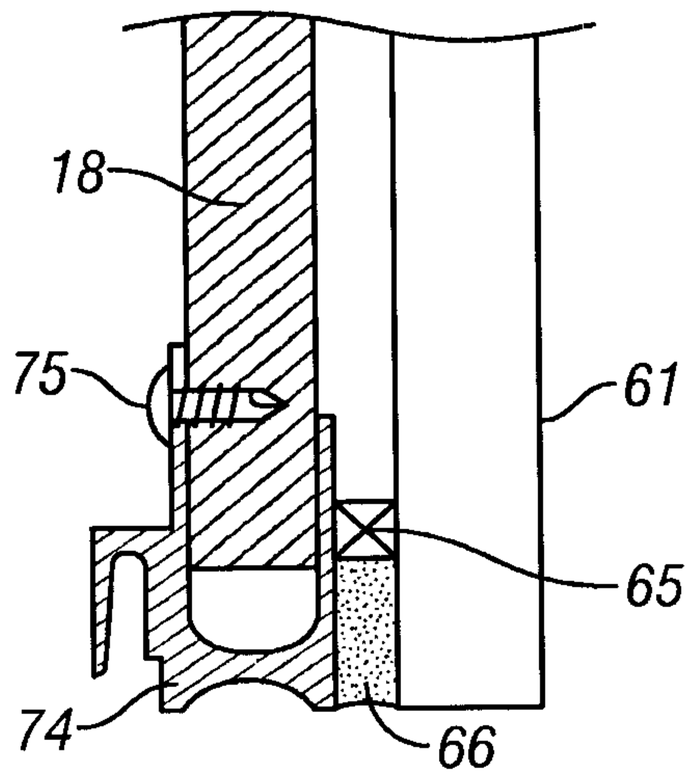


FIG. 23

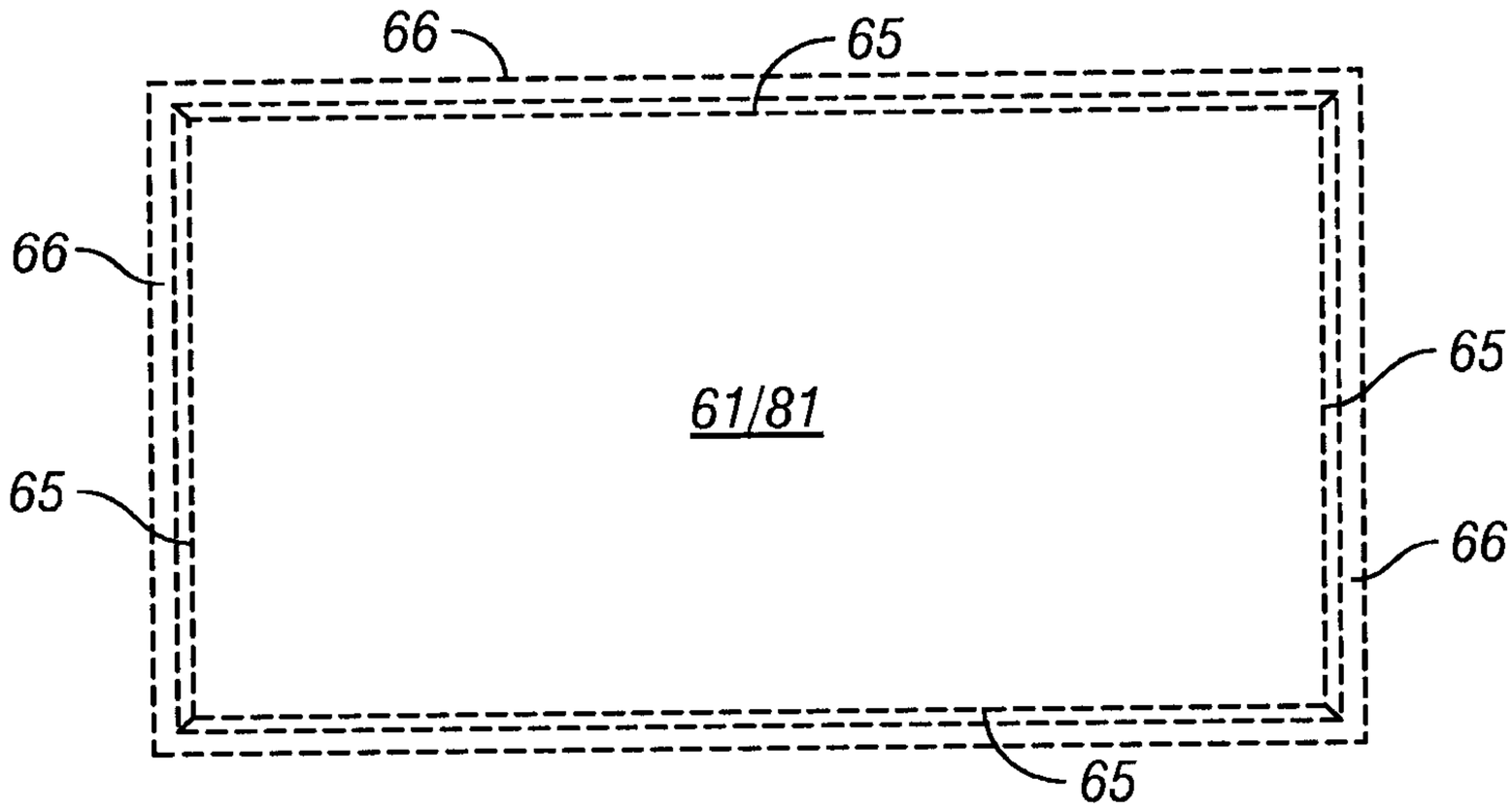


FIG. 24

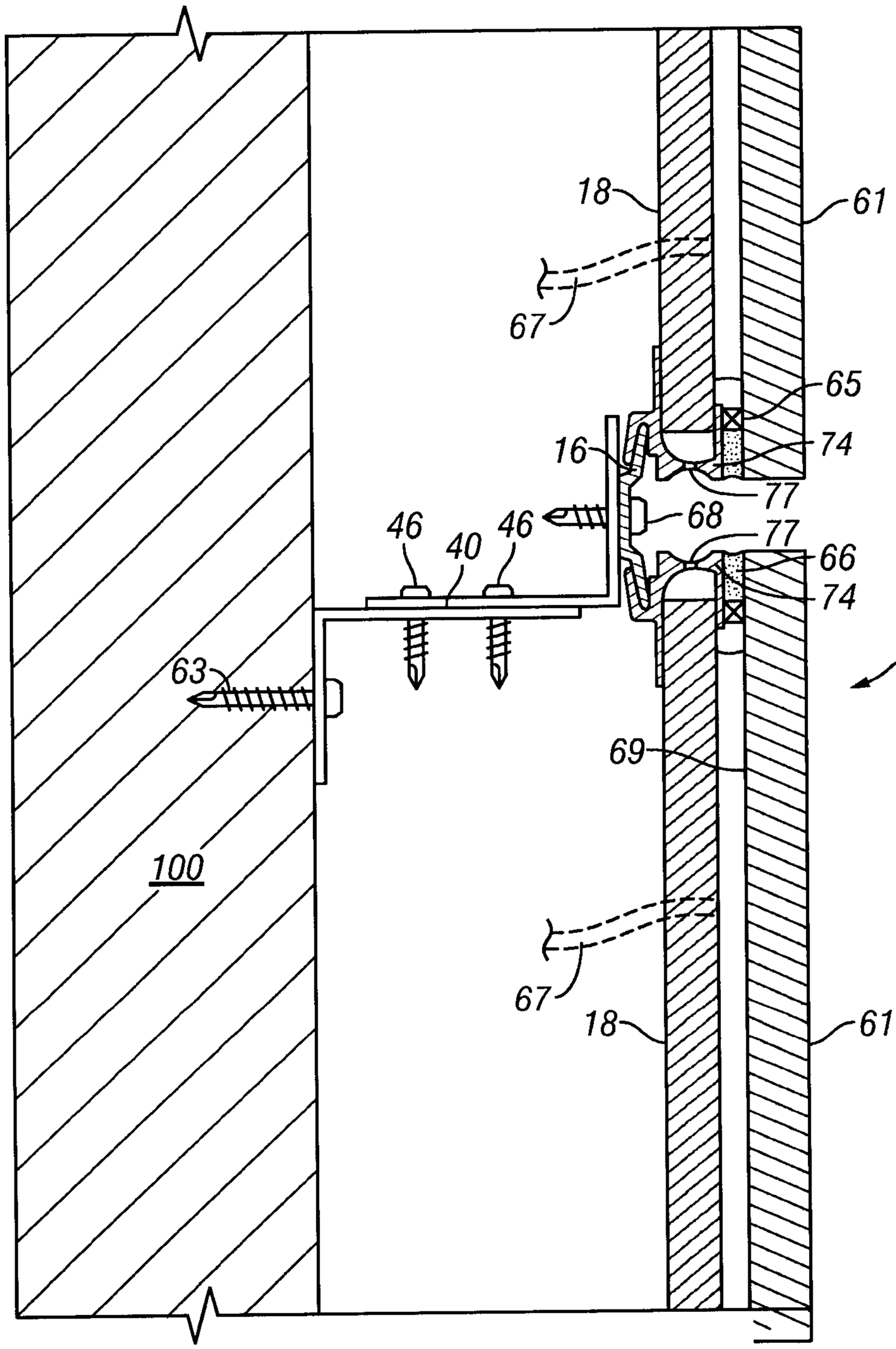


FIG. 25

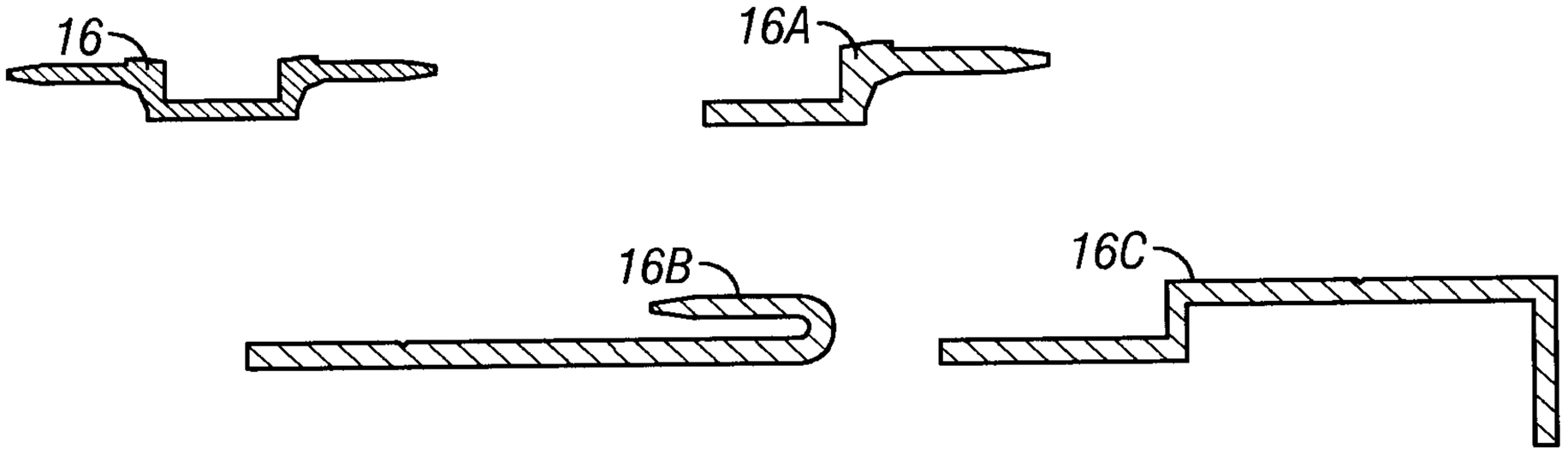


FIG. 26

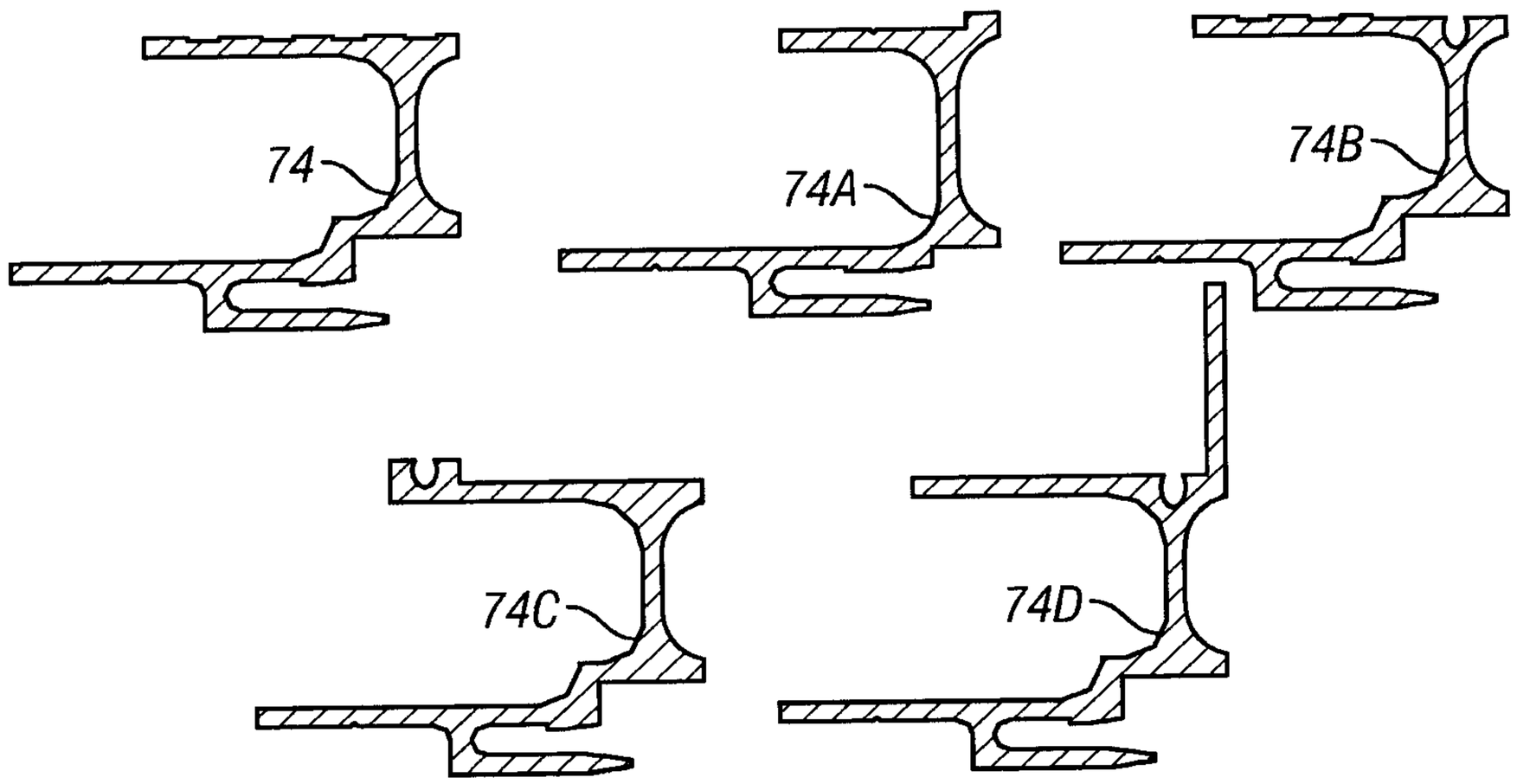


FIG. 27

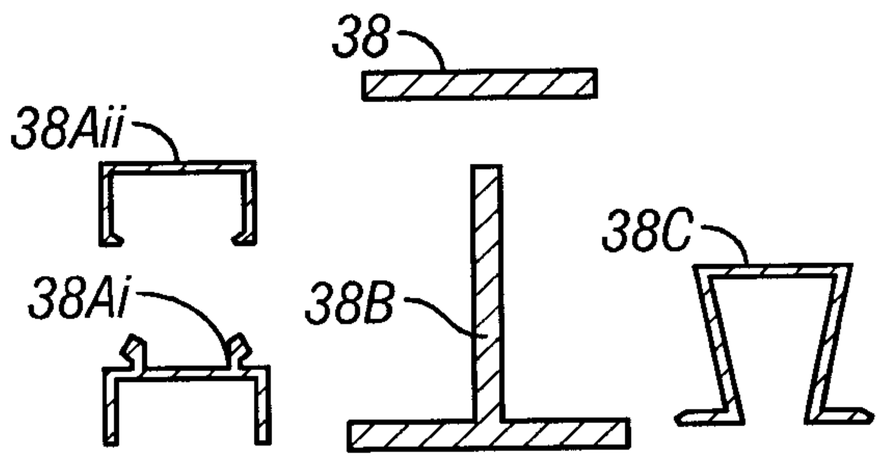


FIG. 28

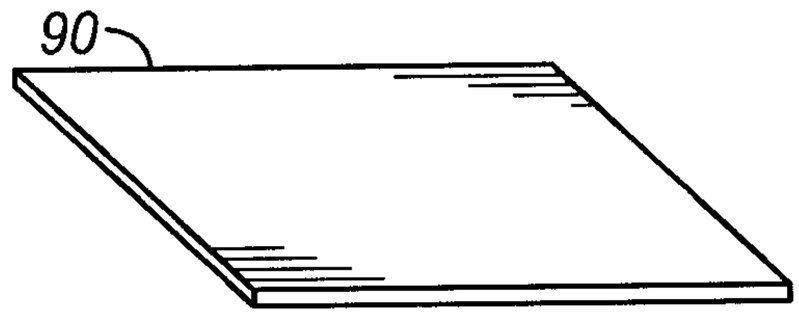


FIG. 29

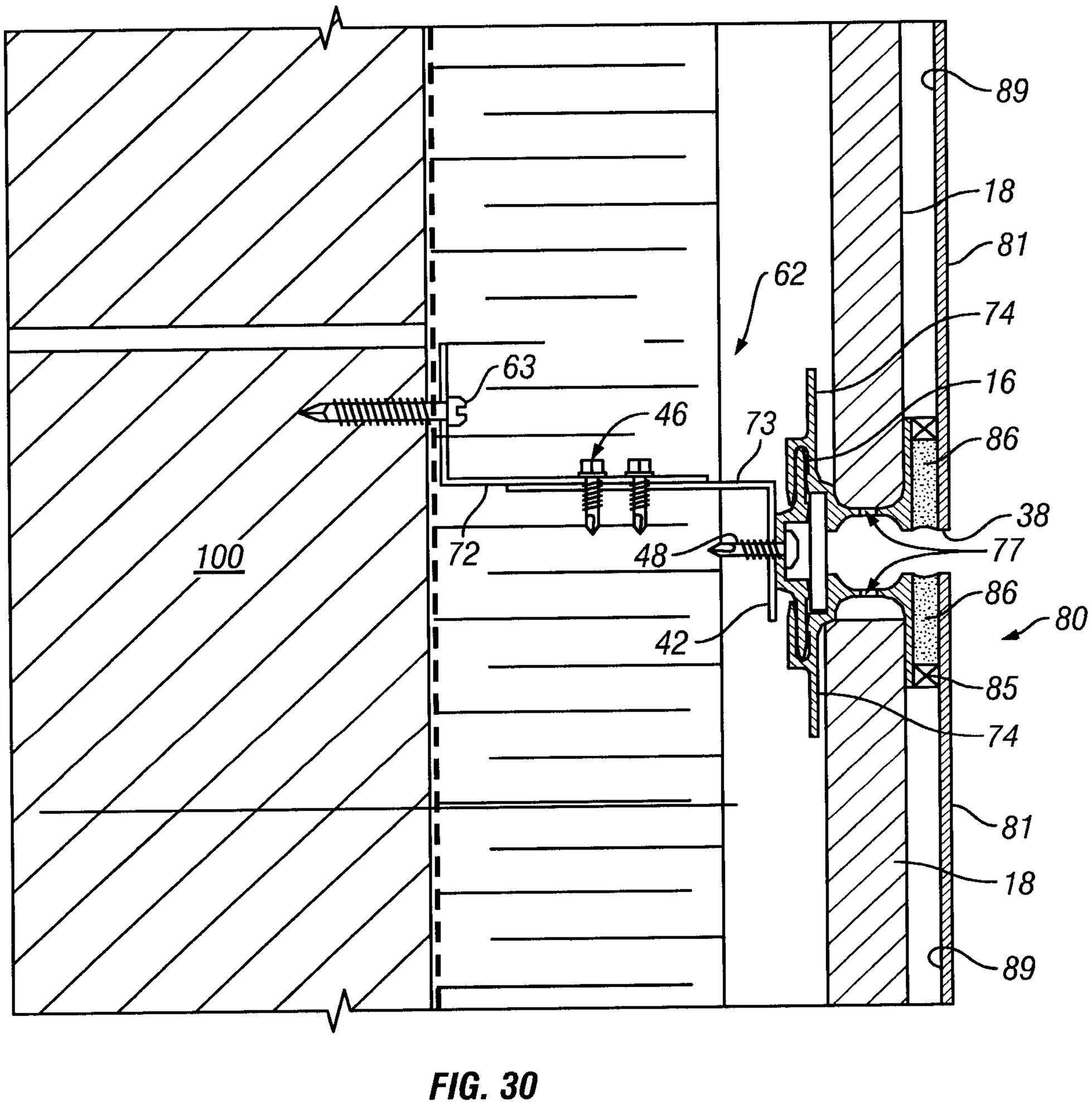


FIG. 30

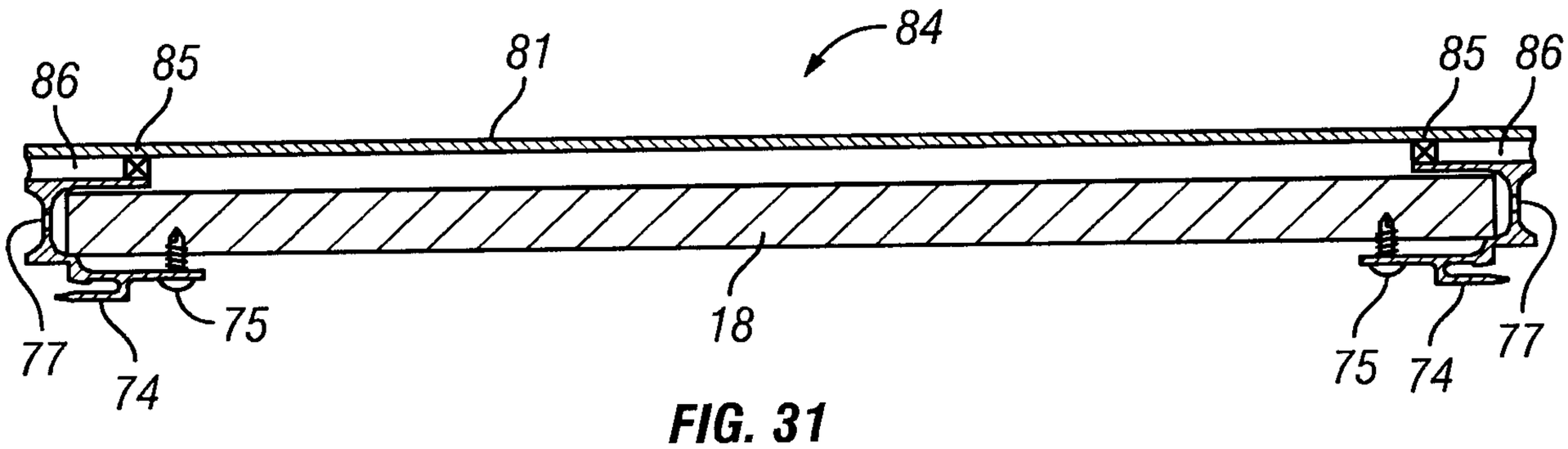

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FIG. 31

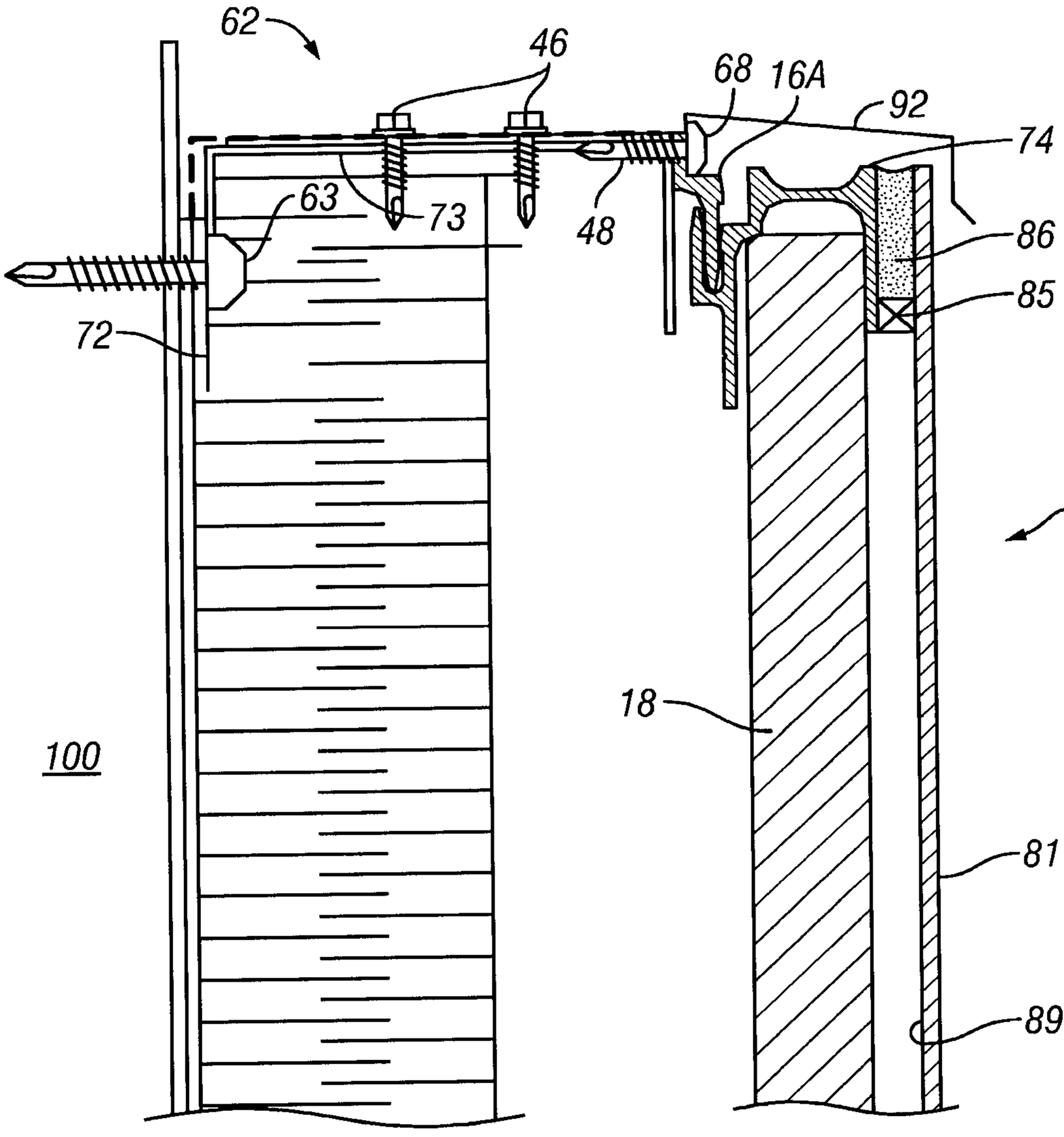

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FIG. 32

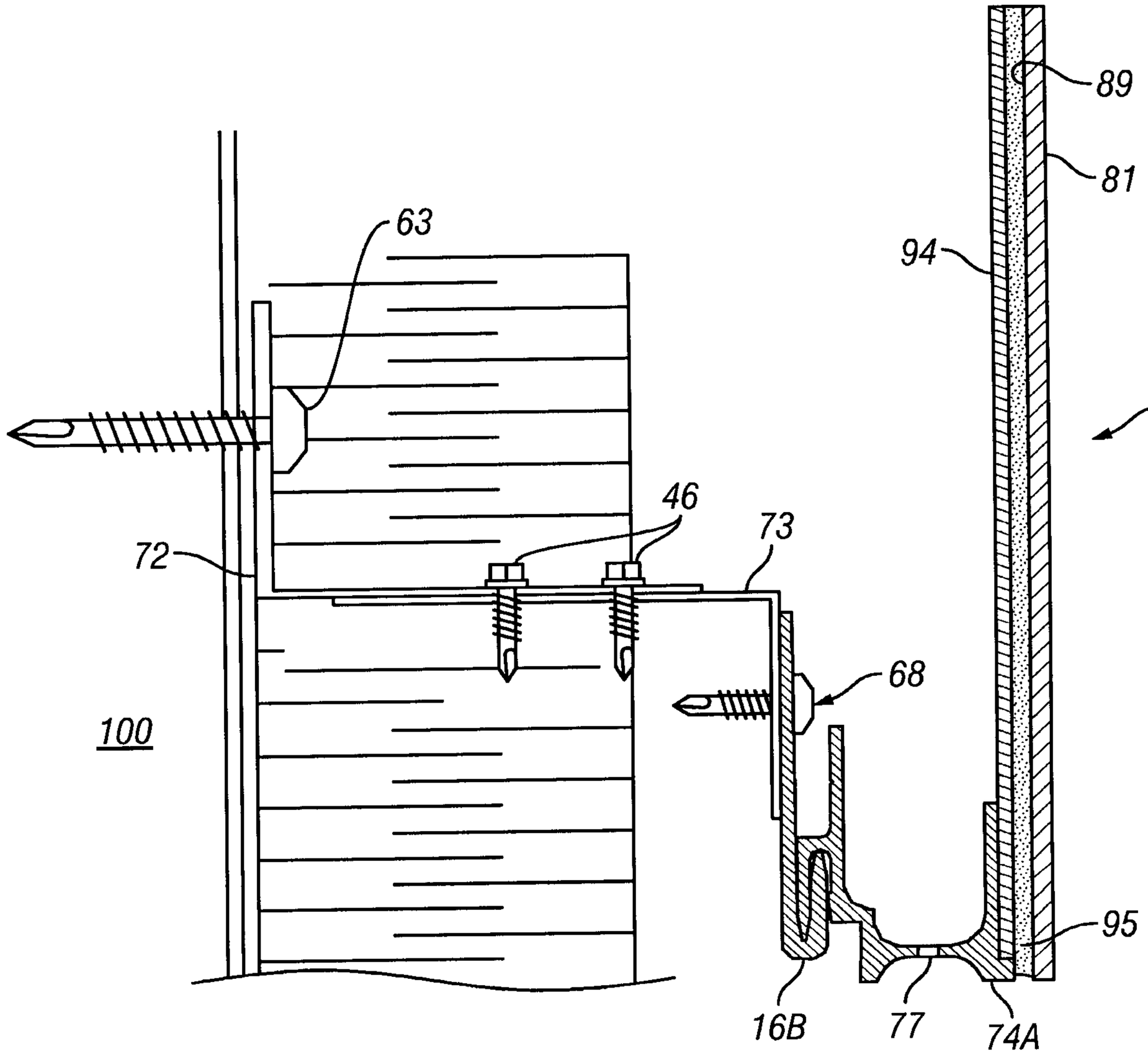


FIG. 33

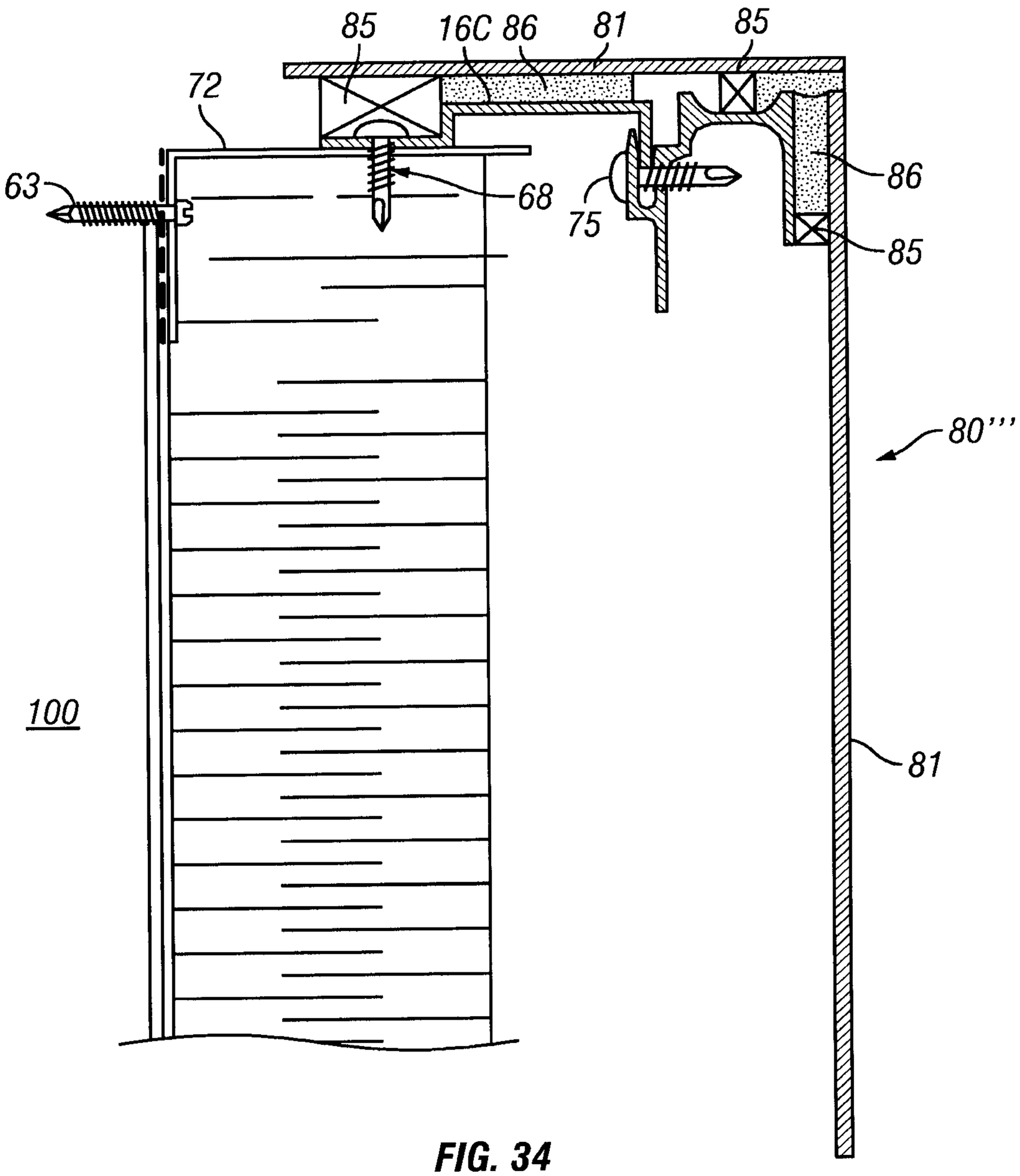
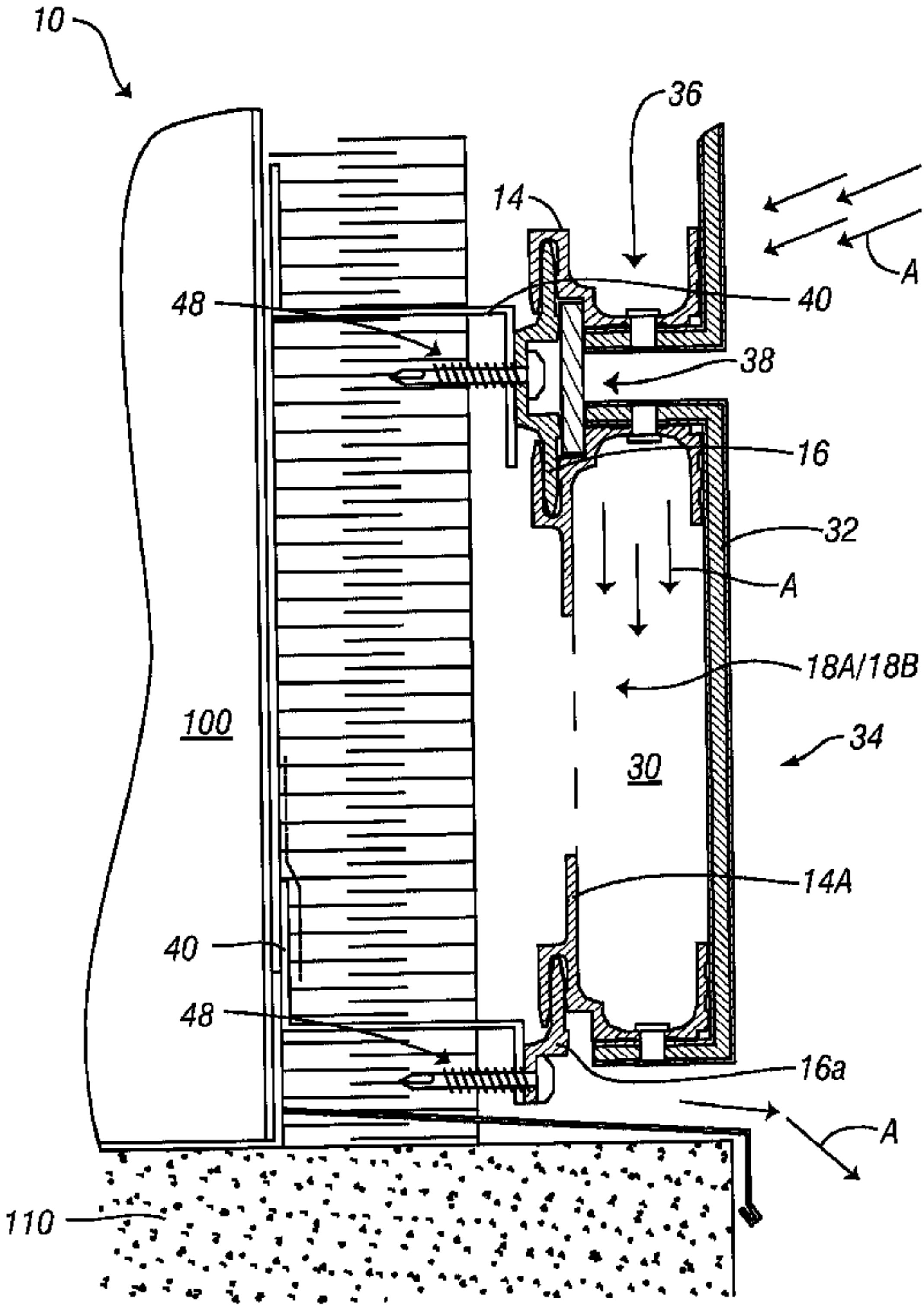


FIG. 34


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