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(54) **HEATING CABLE ROUTING FOR ANTI-ICING CASSETTES**

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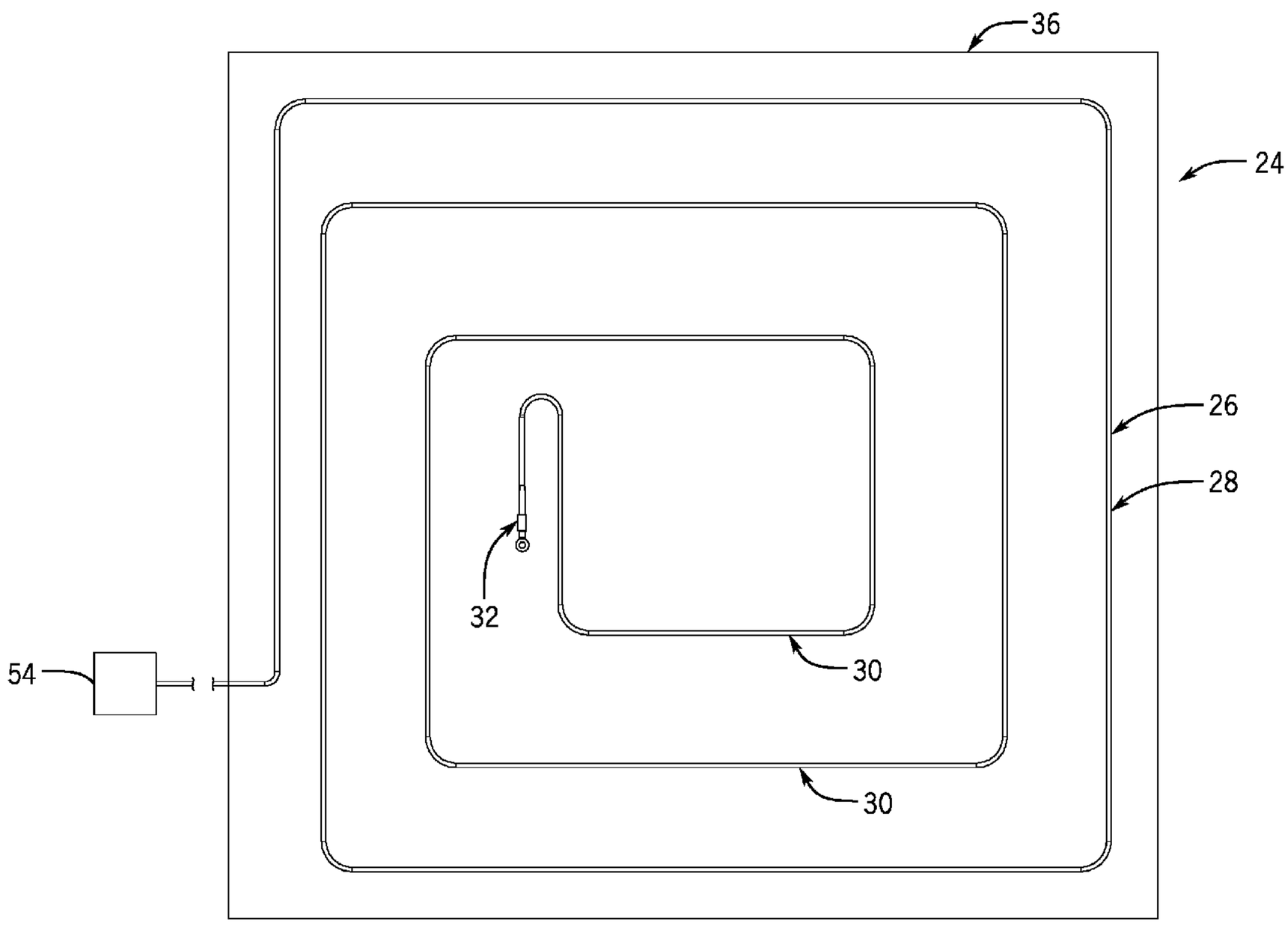
(57) **ABSTRACT**

A system and method of heating cable routing for anti-icing cassettes is provided. An anti-icing cassette includes a panel, a plurality of channel segments arranged on an underside of the panel, and a heating cable routed through the plurality of channel segments and arranged in a concentric manner, including an outer loop and at least one concentric inner loop inside the outer loop.



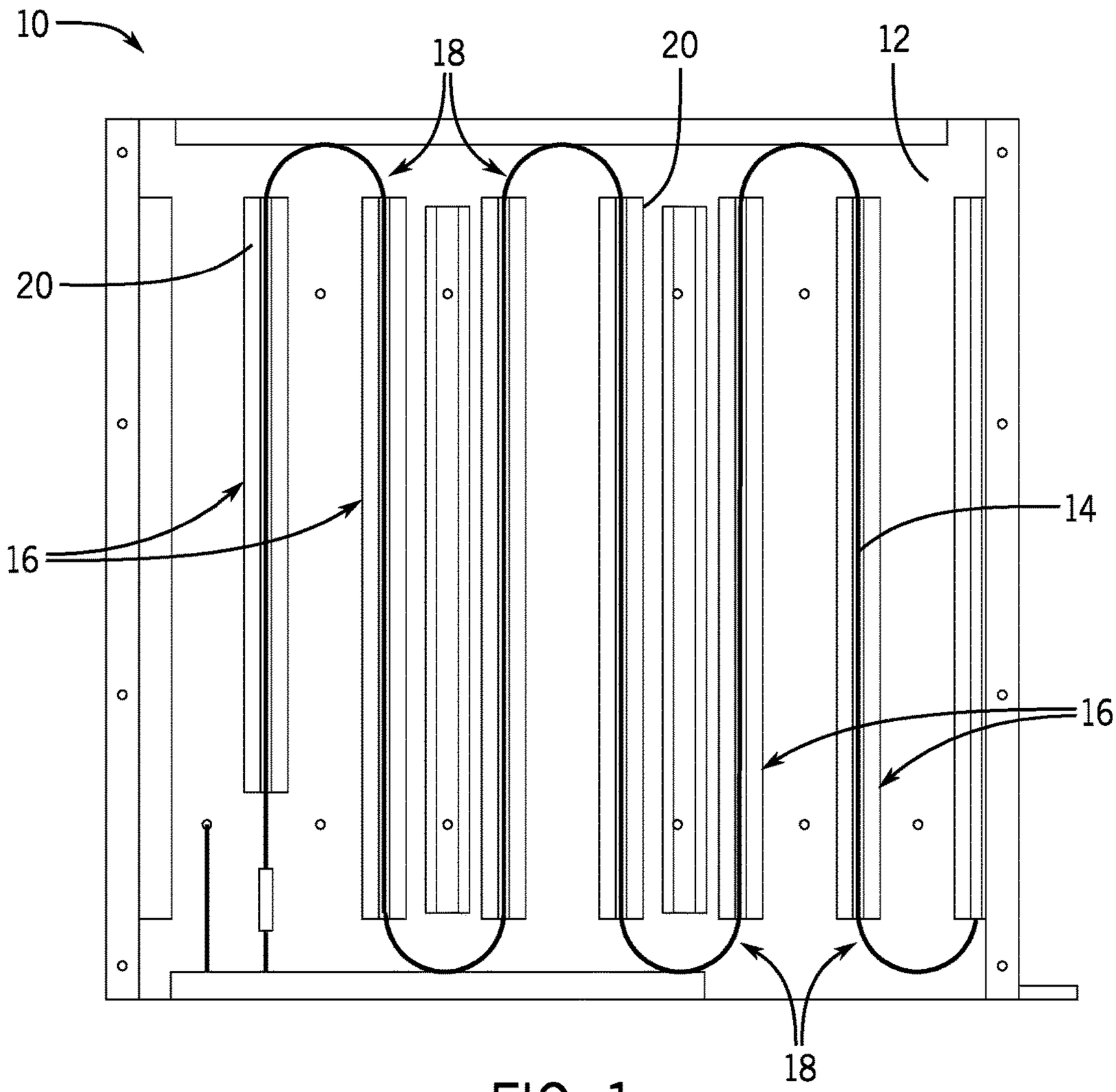


FIG. 1

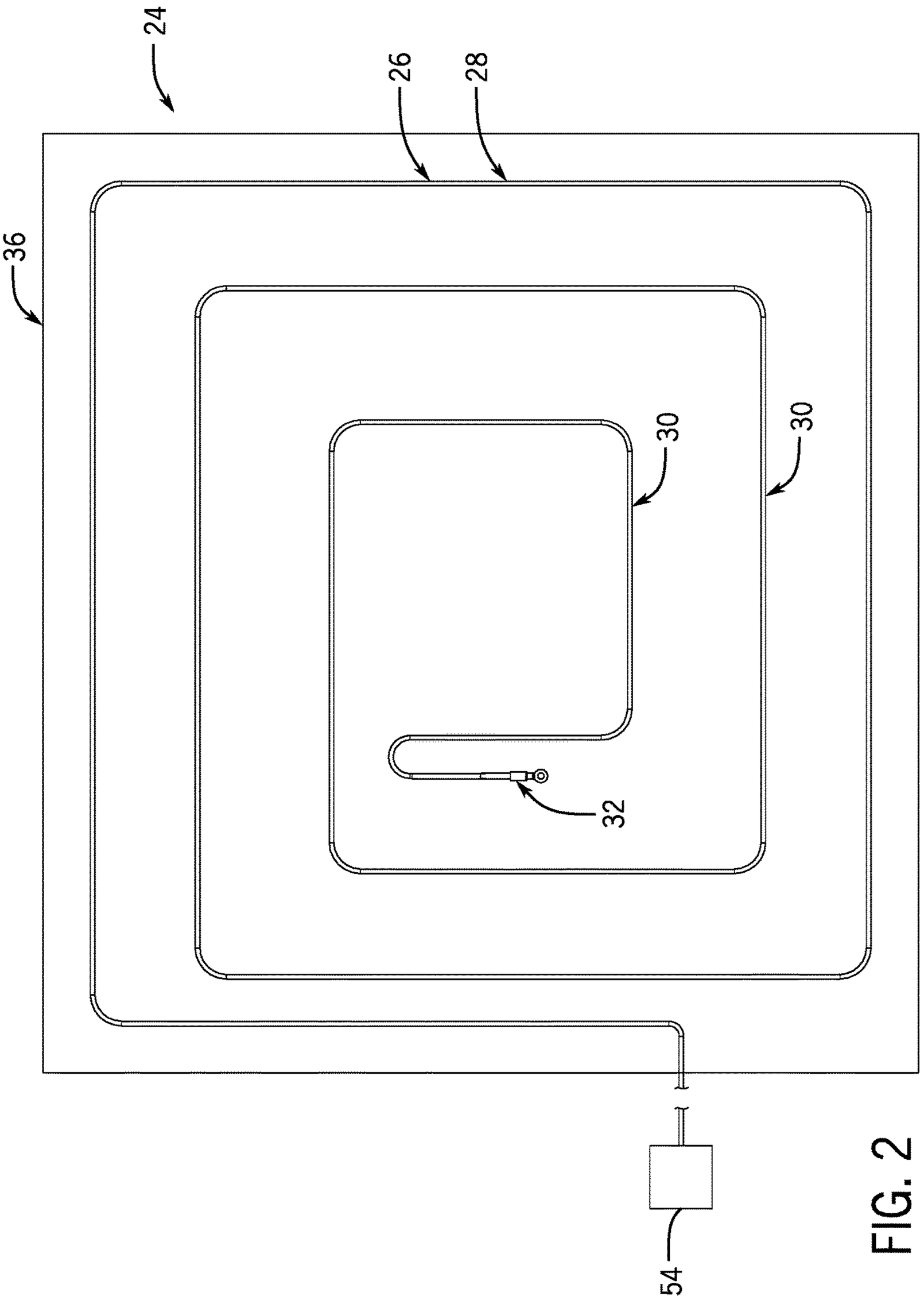


FIG. 2

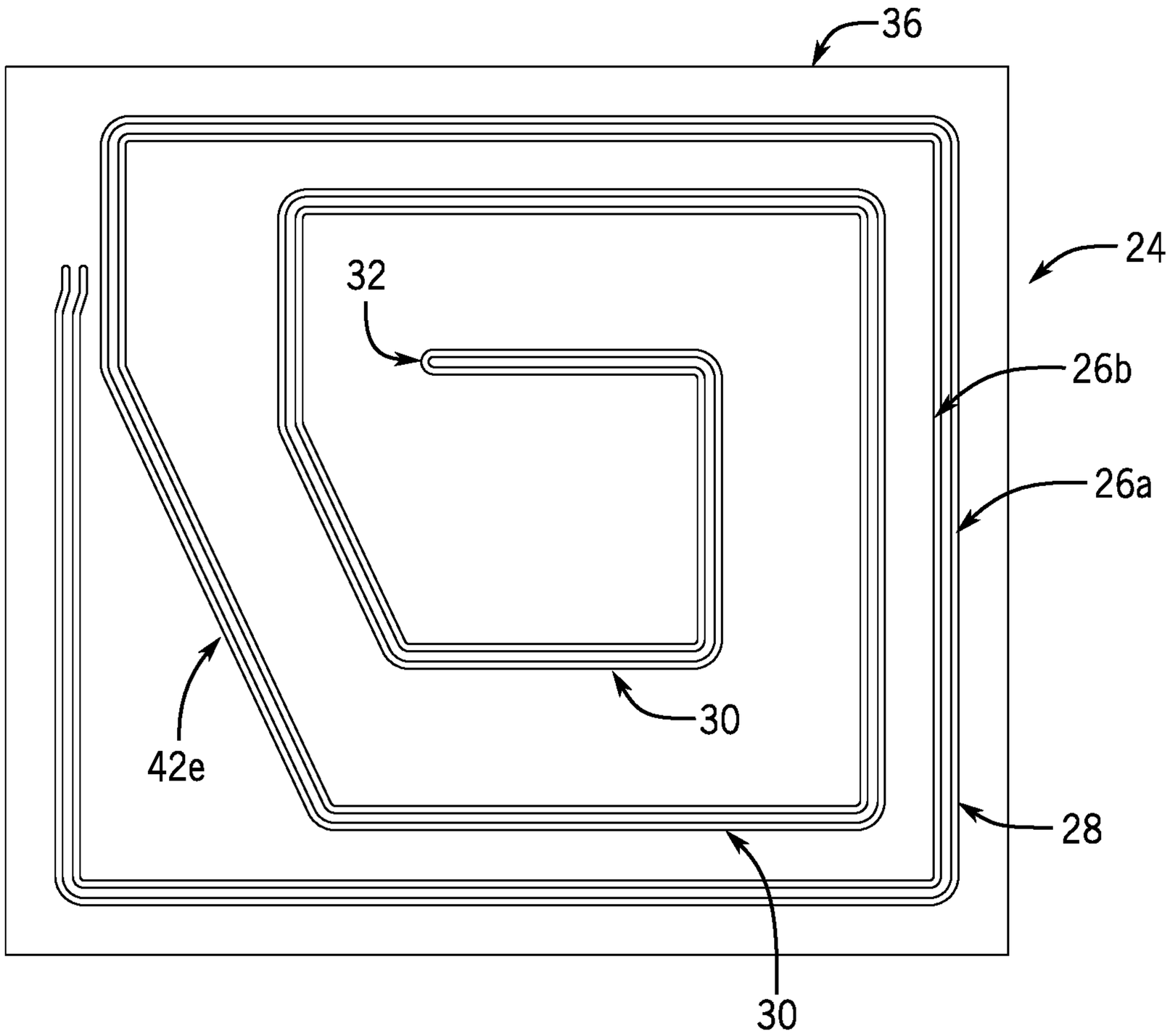


FIG. 3

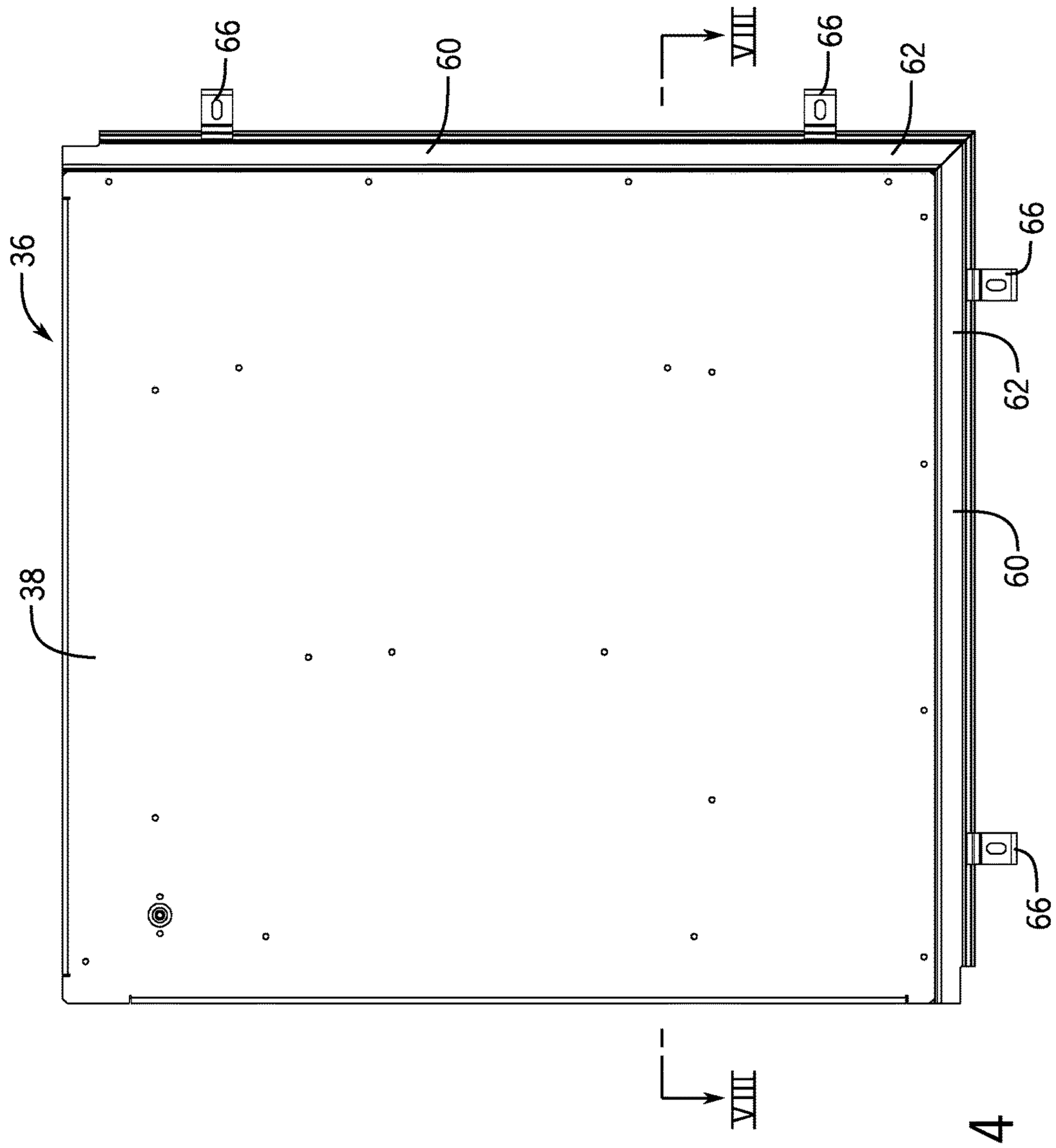


FIG. 4

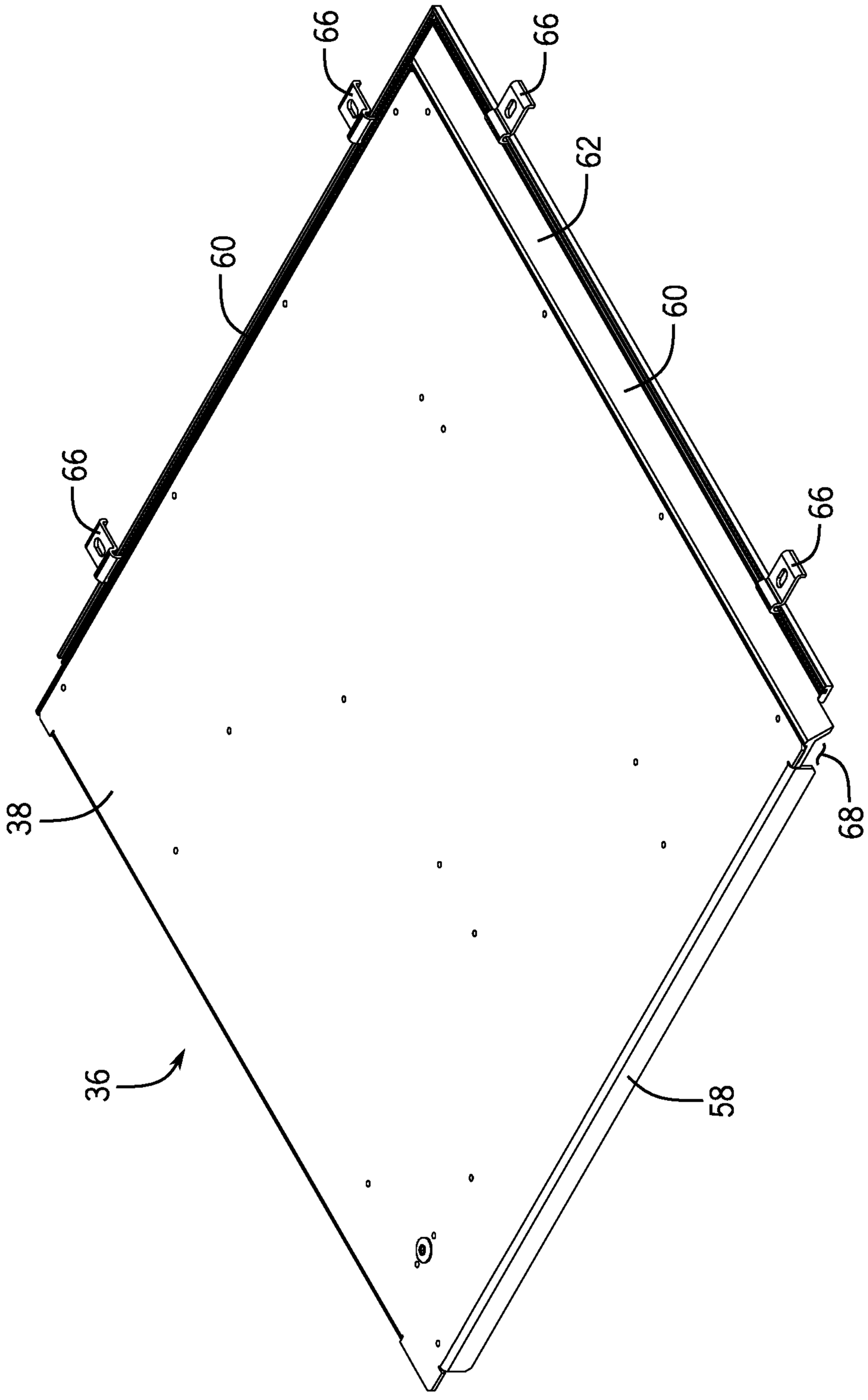


FIG. 5

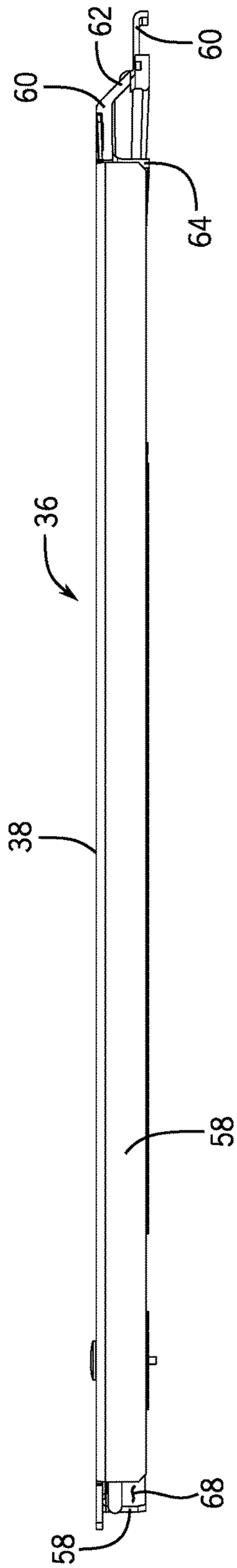


FIG. 6

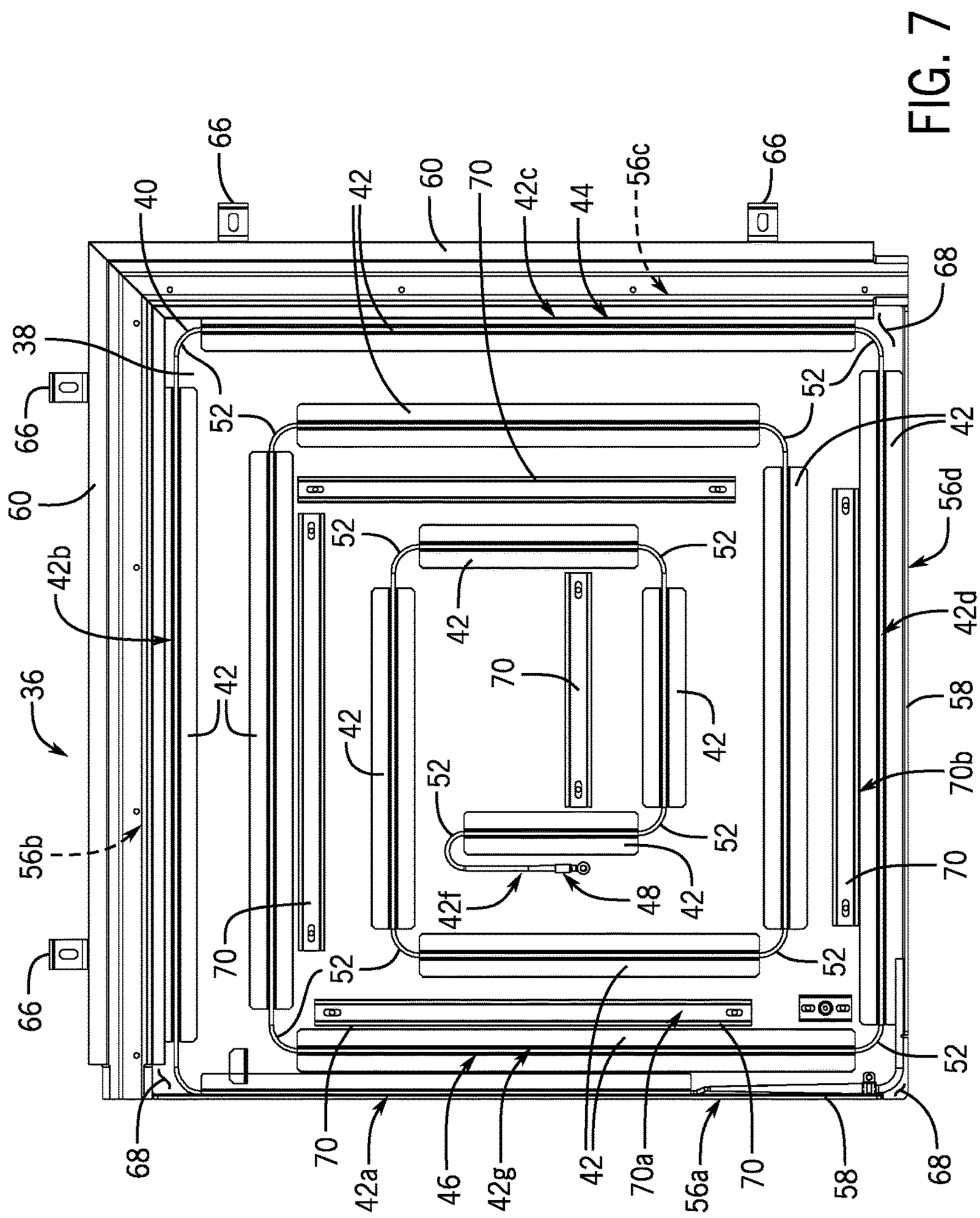

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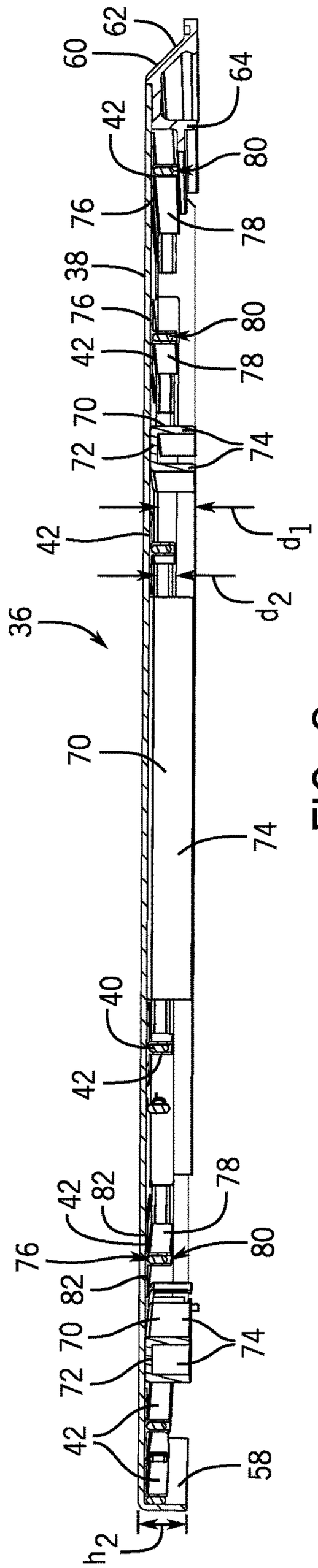
FIG. 7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h_2

FIG. 8

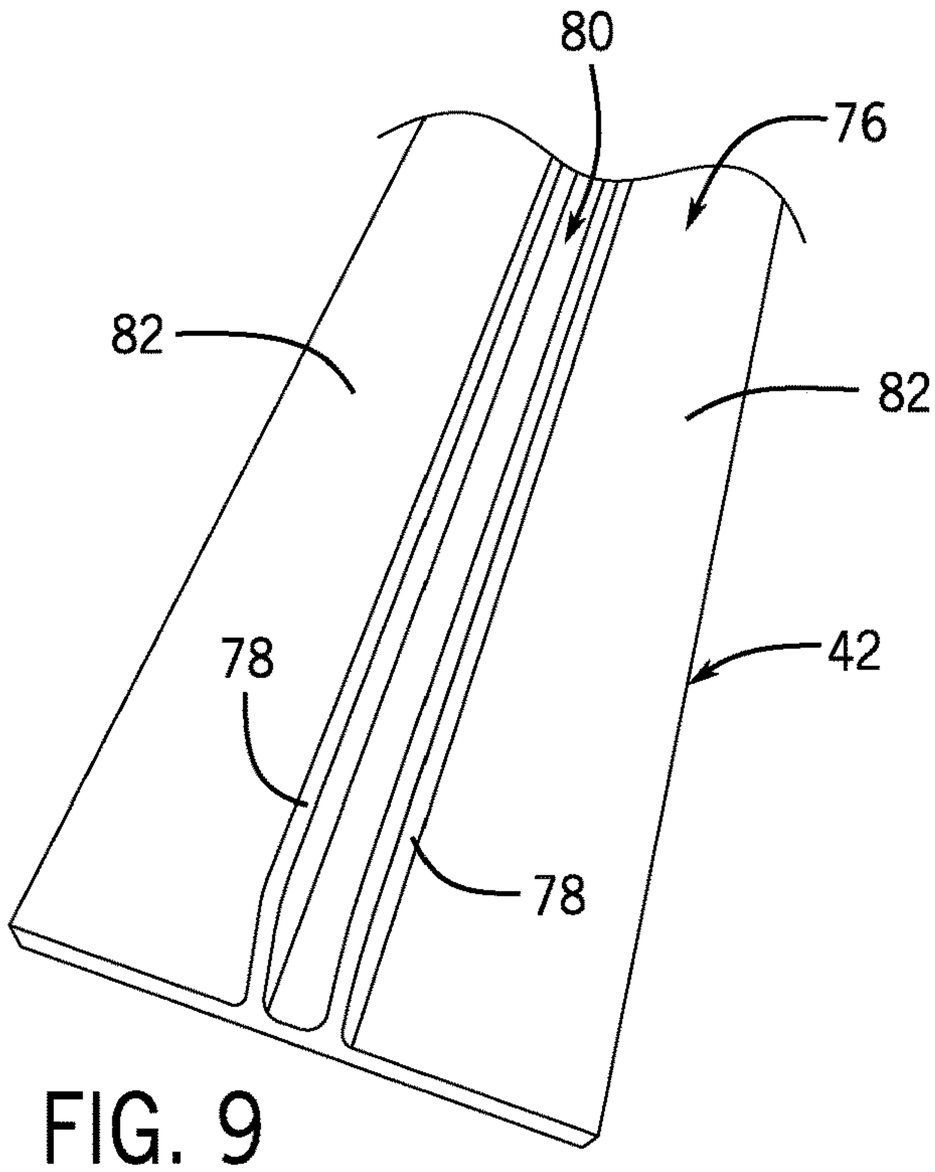

FIG. 9

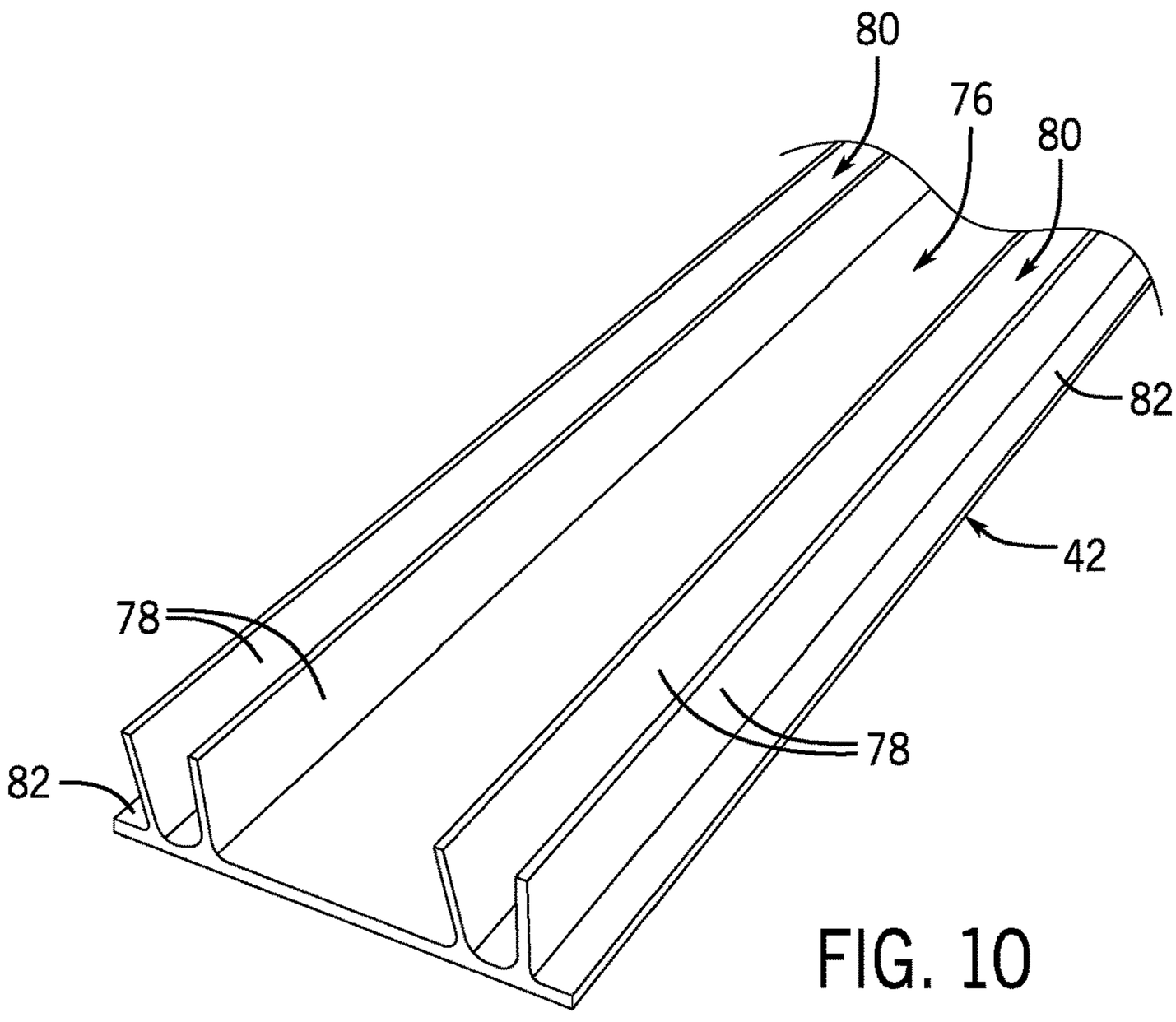

FIG. 10

HEATING CABLE ROUTING FOR ANTI-ICING CASSETTES

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a non-provisional claiming the benefit of U.S. Prov. Pat. App. Ser. No. 62/658,365, filed under the same title on Apr. 16, 2018, and incorporated fully herein by reference.

BACKGROUND OF THE INVENTION

[0002] Ships and offshore platforms used in cold-weather environments often include "anti-icing" panels, also known as cassettes, for preventing ice formation along walking paths and escape ways. The panels are typically made of a metal (such as aluminum) or rubber substrate and electrical heating cables. For example, the panels are fastened to the decks of ships and platforms so that the panel surfaces form walking paths, and heat generated by the cables helps reduce ice formation on the panel surfaces. The electrical heating cables are embedded in or coupled to an underside of the panel and are typically arranged in a serpentine nature. More specifically, a typical cassette includes a heating cable routed back and forth, forming parallel lines with looped ends traversing across the panel.

SUMMARY OF THE INVENTION

[0003] In some embodiments of the present disclosure, an anti-icing cassette is provided that includes a panel and a plurality of channel segments arranged on an underside of the panel. A heating cable is routed through the plurality of channel segments and is arranged in a concentric manner, including an outer loop adjacent an outer perimeter of the panel and at least one concentric inner loop inside the outer loop. Embodiments of the anti-icing cassette can include any one or a combination of the following features provided herein.

[0004] In some embodiments, the heating cable can terminate inside the outer loop. Moreover, in some embodiments, the heating cable can be bent at a substantially 90-degree angle to be routed from a first channel segment of the plurality of channel segments to an adjacent second channel segment of the plurality of channel segments.

[0005] In some embodiments, the plurality of channel segments can include a first channel segment, a second channel segment, a third channel segment, and a fourth channel segment arranged relative to each other to form the outer loop. The plurality of channel segments can include extruded metal slots defined by a base structure and a pair of projections extending from the base structure. The plurality of channel segments can each include at least one flange positioned laterally outward of the pair of projections. The first channel segment can be substantially parallel to a first section of a perimeter of the panel, the second channel segment can be substantially parallel to a second section of the perimeter of the panel, the third channel segment can be substantially parallel to a third section of the perimeter of the panel, and a fourth channel segment can be substantially parallel to a third section of the perimeter of the panel.

[0006] In some embodiments, one or more supports can extend further from the panel than the plurality of channel segments arranged on an underside of the panel. Additionally or alternatively, a transition member operably coupled with the panel, the transition member having a chamfered outer surface and a vertical inner surface.

[0007] In some embodiments of the present disclosure, an anti-icing cassette is provided that includes a panel and a plurality of channel segments arranged on an underside of the panel. The plurality of channel segments include a first channel segment parallel to a first section of a perimeter of the panel and a second channel segment parallel to a second section of the perimeter. A first heating cable is routed through the plurality of channel segments and is arranged in a concentric manner. The first heating cable defines a bend portion between the first and second channel segment. Embodiments of the anti-icing cassette can include any one or a combination of the following features provided herein.

[0008] In some embodiments, the first channel segment can be arranged about 90 degrees relative to the second channel segment. The first heating cable can be biased towards the vertical members and away from the transition members.

[0009] In some embodiments, the panel can include a panel and a pair of side members extending downwardly from the panel, the side members disposed on adjacent sides of the panel and separated from one another. Additionally or alternatively, a pair of transition members can be operably coupled with two adjacent sides of the panel, the transition members including a chamfered outer surface.

[0010] In some embodiments, a second heating cable, wherein the first and second cables are disposed in respective first and second slots within at least one of the plurality of channel segments.

[0011] In some embodiments of the present disclosure, a method of routing a heating cable on an underside of an anti-icing cassette is provided. The method includes routing the heating cable through a first plurality of channel segments coupled to the underside of the anti-icing cassette to form an outer loop adjacent to a perimeter the anti-icing cassette. The method also includes routing the heating cable through a second plurality of channel segments coupled to the underside of the anti-icing cassette to form an inner concentric loop inside the outer loop. In addition, the method includes terminating the heating cable at a location inside the outer loop. Embodiments of the method of routing a heating cable on an underside of an anti-icing cassette can include any one or a combination of the following features provided herein.

[0012] In some embodiments, the routing the heating cable through a first plurality of channel segments and the routing the heating cable through a second plurality of channel segments can bias the cable in an offset position from a center point of the cassette. The routing the heating cable through a first plurality of channel segments step can include positioning the heating cable within first and second channel segments within the first plurality of channel segments, the first and second channel segments offset from one another by less than 180 degrees. The routing the heating cable through a second plurality of channel segments step can include biasing the inner concentric loop towards a perimeter section of a panel of the anti-icing cassette.

[0013] In some embodiments, the method can further include attaching a support to a panel of the anti-icing cassette between the outer loop and the inner loop.

[0014] These and other aspects of the invention will become apparent from the following description. In the description, reference is made to the accompanying draw-

ings which form a part hereof, and in which there is shown embodiments of the invention. Such embodiments do not necessarily represent the full scope of the invention and reference is made, therefore, to the claims herein for interpreting the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The present invention will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements.

[0016] FIG. **1** is an underside view of an anti-icing cassette including a serpentine cable-routing configuration.

[0017] FIG. **2** is a schematic view of a concentric cable routing configuration utilizing a single cable, according to some embodiments.

[0018] FIG. **3** is a schematic view of a concentric cable routing configuration utilizing more than one cable, according to some embodiments.

[0019] FIG. **4** is a top plan view of an anti-icing cassette, according to some embodiments.

[0020] FIG. **5** is a top perspective view of the anti-icing cassette, according to some embodiments.

[0021] FIG. **6** is a side plan view of the anti-icing cassette, according to some embodiments.

[0022] FIG. **7** is a bottom plan view of the anti-icing cassette, according to some embodiments, including a concentric cable-routing configuration.

[0023] FIG. **8** is a cross-sectional view of the anti-icing cassette taken along the line VIII-VIII of FIG. **4**.

[0024] FIG. **9** is a bottom perspective view of a channel segment of the anti-icing cassette having a single slot.

[0025] FIG. **10** is a bottom perspective view of a channel segment of the anti-icing cassette having a pair of segregated slots.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0026] Before the present invention is described in further detail, it is to be understood that the invention is not limited to the particular aspects described. It is also to be understood that the terminology used herein is for the purpose of describing particular aspects only, and is not intended to be limiting. The scope of the present invention will be limited only by the claims. As used herein, the singular forms "a", "an", and "the" include plural aspects unless the context clearly dictates otherwise.

[0027] It should be apparent to those skilled in the art that many additional modifications beside those already described are possible without departing from the inventive concepts. In interpreting this disclosure, all terms should be interpreted in the broadest possible manner consistent with the context. Variations of the term "comprising", "including", or "having" should be interpreted as referring to elements, components, or steps in a non-exclusive manner, so the referenced elements, components, or steps may be combined with other elements, components, or steps that are not expressly referenced. Aspects referenced as "comprising", "including", or "having" certain elements are also contemplated as "consisting essentially of" and "consisting of" those elements, unless the context clearly dictates otherwise. It should be appreciated that aspects of the invention that are described with respect to a system are applicable to the methods, and vice versa, unless the context explicitly dictates otherwise.

[0028] Numeric ranges disclosed herein are inclusive of their endpoints. For example, a numeric range of between 1 and 10 includes the values 1 and 10. When a series of numeric ranges are disclosed for a given value, the present disclosure expressly contemplates ranges including all combinations of the upper and lower bounds of those ranges. For example, a numeric range of between 1 and 10 or between 2 and 9 is intended to include the numeric ranges of between 1 and 9 and between 2 and 10.

[0029] Embodiments of the present invention are generally directed toward anti-icing cassettes. According to some embodiments, rather than routing cables back and forth in a serpentine configuration, one or more heating cables may be routed in concentric loops. This concentric routing of the heating cables may provide multiple benefits over serpentine routing such as, but not limited to, more efficient heating of the cassette, more uniform heating profile across the cassette by providing additional heat proximate heat sinks, and better thermal coupling of the heating cable to the surface to be heated. In addition, the cassette provided herein can utilize less electrical power usage during operation than conventional cassettes, which can lead to energy savings and less component degradation over time. Some embodiments of the invention may be used in certain environments, such as ship or oil platform environments. These environments encounter extreme temperatures that quickly become hazardous when surfaces, such as decks, walkways, and stairs, are not adequately maintained free of ice and snow. Additionally, some embodiments may be used in other environments, such as roadways, driveways, sidewalks, roofs, gutters, and so on.

[0030] For example, FIG. **1** illustrates a cassette **10** having a serpentine cable configuration. The cassette **10** includes a panel **12** and a heating cable **14** routed back and forth across an underside of the panel **12**, forming parallel lines **16** with looped ends **18**. Also, conduits **20** can be used to arrange the heating cable **14** in this layout and to thermally couple the heating cable **14** to the panel **12**. As shown in FIG. **1**, the extruded conduits **20** are typically installed on or integrated with the underside of the panel **12** to receive straight sections of the heating cable **14** (e.g., along the parallel lines **16**).

[0031] FIGS. **2** and **3** illustrate various concentric routing patterns **24** according to some embodiments. Unlike the serpentine configuration of FIG. **1**, the patterns **24** include at least one cable **26** routed in a first outer loop **28** and one or more concentric inner loops **30** inside the outer loop **28** until reaching a termination point **32** inside the outer loop **28**. The loops **28**, **30** may be considered concentric because they generally share a center and the inner loop **30** can be substantially completely surrounded by the outer loop **28**. In some embodiments, the heating cable **26** can be terminated using a terminator or termination kit. Herein, a "loop" may be a substantially square, rectangular, or polygonal loop. Furthermore, in some embodiments, a "loop" may be a substantially circular or oblong loop. Also, in some embodiments, the concentric pattern may be considered a spiral pattern.

[0032] As illustrated in FIG. **3**, in some embodiments, first and second cables **26***a*, **26***b* are powered in series. The heating cables **26***a*, **26***b* can be coupled to one or more controllers **54** that manage power application to the cables

26*a*, **26***b* (e.g., by applying an electrical current to the cable conductors, causing heat generation along the cable length). In some instances, the power application to the cables **26***a*, **26***b* may additionally or alternatively be provided through a cassette **36** that is proximate to the cassette **36**, such that multiple cassettes **36** may be electrically connected in series, or in parallel, where an alternating current (AC) signal applied at the cable of a first cassette **36** in the series will cause current to flow through the heat tracing cables of each of the cassettes in the series, thereby heating each of the cassettes **36** in the series. Any number of cables **26***a*, **26***b* may be used in the routing pattern **24** depending on the desired amount of heat transfer, cable properties such as heater type (e.g., self-regulating, constant wattage, hazardous environment rated, etc.), diameter and bend radius of the cable, type of power attachment, and size and material of the cassette **36**, etc. In embodiments having a single cable **26**, the cable **26** may be similarly powered by any method provided herein.

[0033] In embodiments having more than one cable **26** powered in series, the pair of cables **26***a*, **26***b* may be a single cable that is folded at the termination point **32**. Accordingly, the termination point **32** may be free of joints, and thus may not need a terminator or an end seal kit. Herein, a "joint" may be an end of a cable or wire. By forming a system that is free of joints at the termination point **32**, the cassette **36** may be less expensive to manufacture due to the need for fewer components. Likewise, due to the need for fewer components, the cassette **36** may be more robust than conventional cassettes. The removal of the joint may also create a more efficient heating system.

[0034] As illustrated in FIGS. **4-6**, the cassette **36** can be relatively portable in size, measuring between about one and about three square meters in some embodiments, allowing for customized placement in existing walkways. For example, the sizing permits positioning multiple cassettes **36** in a variety of different configurations, such as any suitable abutting configuration, forming a walkway with minimal gaps in between cassettes **36**. As such, one or more cassettes **36** may be of uniform or varying size and/or dimension and may be arranged so that all or a portion of at least one side of each cassette **36** can abut an adjacent cassette **36**. Additionally, while the illustrated cassette **36** has a generally square perimeter, rectangular, circular, trapezoidal, irregular, and other shapes are contemplated. Further, adjacently arranged cassettes may have a corresponding shape to such that gaps between the cassettes may be minimized without regard for the geometrical shape of the cassette **36**.

[0035] In some embodiments, variously sized cassettes **36** may be used based on the design of the walkway. In some instances, the cassette **36** may be configured as a corner member in which two adjacent sides of the cassette **36** are operably coupled with other cassettes. In such instances, the cassette **36** may include a panel **38** that includes a panel **38** and a pair of side members **58**. The panel **38** and the side members **58** may be integrally formed with one another. The panel **38** may include any number of side members **58** based on the shape of the panel **38** and the number of the cassettes that are to be coupled with the corner cassette **36**. The sides of the cassette **36** that are not coupled with adjacent cassettes may be coupled transition members **60**. In some embodiments, the transition members **60** may be angled such that transition members **60** are non-parallel to the side members **58**. For example, the transition member **60** can have a chamfered outer surface **62** and a generally vertical inner surface **64**. In addition, the transition members **60** can include anchors **66** thereon for retaining the cassette **36** in position. The transition members **60** may be formed from a varied or common material as the panel **38**. For example, in some embodiments, the transition members **60** may be formed from fiberglass material while the panel **38**, and side members **58**, may be formed from a metallic material.

[0036] In various embodiments, the end portions of the side members **58** and the transition members **60** may be separated by gaps **68**. The gaps **68** may allow environmental debris, such as water, dirt, etc. to drain from a position under the panel **38** to a position outwardly of the panel **38**. In some embodiments, water may be trapped under the cassette **36** that then freezes forming ice. When power is supplied to the cable, the ice may melt and then drain through the gaps **68**.

[0037] FIG. **7** illustrates an underside of a heat-traced anti-icing cassette **36** having a concentric cable routing arrangement, according to some embodiments. Generally, as shown in FIG. **7**, the cassette **36** can include a panel **38** and one or more heating cables **40** (e.g., heat tracing cables) in thermal contact with an underside of the panel **38**. A top side of the panel **38** can form a walking surface to be heated by the heating cable **40**. Additionally, thermal insulation can be coupled to the underside of the panel **38**, over the heating cable **40**, to thermally insulate the underside of the cassette **36**.

[0038] In some embodiments, the heating cable **40** may be any suitable heating cable for heating a metal or other corrosion-resistant walkway panel in extreme environments. Generally, any heat tracing cable with known applications in underfloor heating may be used, provided such heat tracing cable has weather-resistant properties. Similarly, heating cables **40** used in industrial heat tracing applications may be used, provided they have a suitable diameter, bend radius, and power requirements for use in the cassette **36**. For example, in some embodiments, an unshielded heating cable **40** can be used (e.g., along with a component that grounds the cassette **36**). In some embodiments, the heating cable **40** may be a shielded heating cable and may be a self-regulating cable (e.g. Raychem BTV, Raychem QTVR, or similar), a constant wattage cable (e.g. Raychem XPI or similar), a hazardous environment-rated cable, or another suitable type of cable. In some embodiments, the heating cable **40** can be a series resistance heating cable, such as a single-, double-, or triple-conductor series resistance heating cable.

[0039] The heating cable **40** can be in thermal contact with the underside of the panel **38** in any suitable manner. In some embodiments, such as the example shown in FIG. **7**, the underside of the panel **38** can include one or more extruded channel segments **42**, such as extruded aluminum channel segments **42**, through which the heating cable **40** is routed. The channel segments **42** can be coupled to or integral with the panel **38** and can serve to transfer heat from the heating cable **40** to the panel **38**. In some embodiments, as shown in FIG. **7**, the extruded channel segments **42** can be straight-line channel segments **42** arranged along the underside of the panel **38** to accommodate a specific cable routing configuration, as further described below.

[0040] In some embodiments, the heating cable **40** may be fastened in place under the panel **38** with clips, and the clips can assist transferring heat from the heating cable **40** to the panel **38**. In some embodiments, the heating cable **40** is fastened in place against the underside of the panel **38** using

a suitable adhesive tape. In some embodiments, the tape can include properties that improve heat transfer from the heating cable **40** to the panel **38**, such as a high thermal conductivity. In some embodiments, the tape may be an aluminum tape that helps improve heat transfer and minimize temperature gradients.

[0041] While some embodiments may implement clips or tape, the extruded channel segments **42** can provide improved heat transfer over these options. For example, the extruded channel segments **42** can provide better heat transfer compared to clips because extrusions provide more contact surface between the heating cable **40** and heat transfer surfaces compared to clips. More specifically, clips, being discrete objects, tend to concentrate force locally. Therefore, lengths of cable **40** not directly under clips tend to have low contact force, and poor heat transfer. In some examples, the extruded channel segments **42** may be superior to tape because they are much thicker than tape (for example, channel segments **42** are about **1.5** mm thick versus a tape thickness of about **0.1** mm). Thus, the channel segments **42** have a much wider thermal conduction path and lower thermal resistance compared to tape.

[0042] As shown in FIG. **7**, the heating cable **40** may be routed in a concentric configuration along the underside of the panel **38**. In other words, the channel segments **42** may be arranged along the underside of the panel **38** so that a heating cable **40** routed through the channel segments **42** is arranged in a concentric configuration. For example, in some embodiments, the heating cable **40** can be routed around an outer perimeter of panel **38** (e.g., forming the outer loop **44**), then routed inside itself in a concentric manner (e.g., forming one or more inner loops **46**) until terminating inside the perimeter (i.e., at the termination point **48**).

[0043] In some embodiments, such as the example illustrated in FIG. **7**, a first channel segment of the outer loop **44** is substantially parallel to a first section of the perimeter of the panel **38**. A second channel segment is substantially parallel to a second section of the perimeter of the panel **38**. Similarly, a third channel segment of the outer loop **44** is substantially parallel to a third section of the perimeter of the panel **38**. A fourth channel segment of the outer loop **44** is substantially parallel to a fourth section of the perimeter of the panel **38**. The heating cable **40** is positioned within each of the first, second, third, and fourth channel segments **42***a*, **42***b*, **42***c*, **42***d* and defines bend portions **50** between each respective channel segment **42***a*, **42***b*, **42***c*, **42***d*. Once positioned within the first, second, third, and fourth channel segments **42***a*, **42***b*, **42***c*, **42***d*, the cable **40** traverses substantially the entire outer perimeter of the panel **38**. While the panel **38** of FIG. **7** has a generally square perimeter, some embodiments include a heating cable **40** that traverses an outer perimeter of a rectangular, circular, trapezoidal, irregular, or other shaped panel **38**. Additionally, in some embodiments, the heating cable **40** may traverse less than the entire outer perimeter of the panel **38**.

[0044] To accomplish concentric routing, the heating cable **40** can be bent at uniform or varying angles. For example, the heating cable **40** can be routed through a first channel segment **42**, then bent and routed through a second, adjacent channel segment **42** at the bend portion **50**. Generally, the heating cable **40** can be bent at any angle equal to, greater than, or less than 90 degrees, e.g., limited by the diameter and bend radius characteristics of the specific heating cable **40**. In some examples, such as the outer loop **44** of FIG. **7**, the first channel segment **42** is arranged about 90 degrees relative to the second channel segment **42**. Thus, to accomplish cable **40** routing through the channel segments **42**, the heating cable **40** can include substantially 90-degree angle bend portions **50**. More specifically, the heating cable **40** can be routed straight through the channel segment **42**, then bent about 90 degrees to be routed through the second channel segment **42**. In some examples, the heating cable **40** is positioned within first and second channel segments **42** of the outer loop **44** that are offset from one another by less than 180 degrees. In some embodiments, the bend portions **50** may be external of the channel segments **42**. However, in other embodiments, the bend portions **50** may be disposed within any of the channel segments **42**, or otherwise coupled, with the panel **38**.

[0045] In some embodiments, the routing configuration can include a loop **44**, **46** having all substantially 90-degree bend portions **50**. For example, all channel segments **42** in a loop **44**, **46** may be relative to adjacent channel segments **42** at substantially 90-degree angles, where at least one channel segment **42** of the loop **44**, **46** is shorter than an opposite channel segment **42** to permit the heating cable **40** to be routed inside itself to form a concentric inner loop **46**. As shown in FIG. **7**, the outer loop **44**, for example, can include a first channel segment **42***a* along a first perimeter edge, a second channel segment **42***b* along a second perimeter edge, a third channel segment **42***c* along a third perimeter edge, and a fourth channel segment **42***d* along a fourth perimeter edge. The heating cable **40** can thus enter the first channel segment **42***a*, and be routed through the first channel segment **42***a*, the second channel segment **42***b*, the third channel segment **42***c*, and the fourth channel segment **42***d* to form the outer loop **44**. The fourth channel segment **42***d* can be shorter than the opposite, second channel segment **42***b* to permit the heating cable **40** to be routed inside of the first channel segment **42***a* to begin forming one of the inner loops **46**.

[0046] Additionally or alternatively, in some embodiments, one or more channel segments **42** in a loop **44**, **46** can be angled less than or more than 90 degrees relative to adjacent channel segments **42**, thus creating diagonal channel segments **42***e*, as shown in FIG. **2**, to permit the heating cable **40** to be routed inside itself to form an inner loop **46**. As such, as shown in FIG. **2**, the configuration can include cable bend portions **50** inside the perimeter that are greater than 90 degrees.

[0047] In some embodiments, a final channel segment **42***f* of the cable **40** that defines the termination point **48** may extend in a direction that is opposite from an adjacent channel segment **42**. In some examples, the final channel segment **42***f* may assist in biasing more heating cable **40** towards the sides of the panel **38** having the vertical members than the transition members **60**. Herein, "biased" may be an orientation in which one or more of the concentric loops **44**, **46** are offset from a center point of the panel **38**.

[0048] Concentric routing, as described above, has a number of advantages compared to conventional serpentine routing. For example, when routed concentrically, the heating cable **40** can be located to optimize thermal uniformity and promote higher energy efficiency. More specifically, a concentrically arranged heating cable **40** does not need to traverse across the center of the cassette **36**, unlike a serpentine arrangement. Therefore, excess heating of the center of the cassette **36**, which often occurs with serpentine

routing, can be avoided. Additionally, the concentric configuration can enable more efficient positioning of the heating cable **40** where heat loss is the greatest. More specifically, heat losses are greater at the outer perimeter of a cassette **36** (e.g., along its edges), so a higher density of heating cable **40** around the outer perimeter can be beneficial. The concentric arrangement provides higher flexibility for getting more heat to the outer perimeter. For example, the concentric arrangement of some embodiments more easily allows for the creation of loops **44**, **46** that are biased to the outer perimeter of the cassette **36**. Thus, by including one or more loops **44**, **46** around the outside perimeter, a larger portion of heat transfer occurs along the perimeter to help counter these heat losses. In some examples, in order to provide an area that is heated sufficiently to remove ice from a walkway, the coldest area of the panel **38** may be heated to a minimum temperature. The amount of power needed to heat the coldest area of the panel **38** determines the amount of power usage by the cassette **36**. In many cases, the coldest area is proximate to the perimeter of the panel **38**. Thus, by biasing the cable **40** to the areas likely to have the lowest temperatures, less energy may be needed to heat the cassette **36**, which may lead to lower operating costs.

[0049] Furthermore, the above-described concentric configuration promotes better thermal coupling of a heating cable **40** to the panel **38**. As described above, an extruded aluminum channel segment **42** can be used to thermally couple the heating cable **40** to the panel **38**. The channel segments **42** are generally installed on straight sections of heating cable **40**. Therefore, thermal efficiency is improved if more of the heating cable **40** is straight and captured by the channel segments **42**. As shown in FIG. **7**, only minimal bend portions **50** are outside the extruded channel segments **42** and, thus, a majority of the heating cable **40** is thermally coupled to the panel **38** via the channel segments **42**. In contrast, in the serpentine configuration shown in FIG. **1**, the half-round looped ends **18** cannot be routed through straight channel segments **42** and, thus, less of the heating cable **14** is thermally coupled to the panel **12**. In other words, when comparing the concentric configuration of FIG. **7** to the serpentine configuration of FIG. **1**, more of the heating cable **40** in the concentric configuration can be routed through straight channel segments **42**, thus promoting better thermal coupling of the heating cable **40** to the panel **38**.

[0050] As illustrated in FIGS. **7-10**, one or more supports **70** can be arranged between various channel segments **42** of the cable **40**. In the example illustrated in FIG. **7**, some of the supports **70** generally extend in a common direction with adjacently positioned channel segments **42**. Moreover, the one or more supports **70** may be biased towards various portions of the perimeter. For example, similarly to the cable **40**, the supports **70** may be generally biased towards the vertical members and away from the transition members **60**.

[0051] The number of channel segments **42** between the perimeter of the panel **38** and the supports **70** may be varied. For example, in the embodiment shown in FIG. **7**, a pair of channel segments **42***a*, **42**g are arranged between a first side member **58***a* and a first support **70***a* while a second channel segment **42***b* is arranged between a second side member **58***b* and a second support **70***b*. Accordingly, the cable **40** and the supports **70** may be arranged in any fashion based on a desired heating profile, cable arrangement, weight support requirement, and so on.

[0052] As illustrated in FIG. **8**, in some embodiments, the panel **38** can be supported by the side members **58**, the transition members **60**, and the supports **70**. In this manner, the supports **70** may extend a first distance d_1 from the panel **38** and the channel segments **42** may extend a second distance d_2 from the panel **38**, wherein the first distance is greater than the second distance. Moreover, the height h_1 of the side members **58** may be substantially equal to the first distance d_1.

[0053] As illustrated in FIGS. **8-10**, in some embodiments, the supports **70** may each define a substantially u-shaped profile in that each support **70** can include a central body **72** and two parallel side protrusions **74** extending from opposing sides of the central body **72**. The channel segments **42** may include a base structure **76** and a pair of projections **78** extending from intermediate portions of the base structure **76** that together define a slot **80**. One or more flanges **82** can be disposed laterally outward of the slot **80**. The flanges **82** can increase an area upon which the channel segment **42** is thermally coupled with the panel **38** to increase thermal conductivity therewith. In some examples, some channel segments **42**, such as the first channel segment **42***a* includes a single flange **82**, while other channel segments **42**, such as the second channel segment **42***b*, includes a pair of opposing flanges **82**, while other channel segments **42** may not include any flanges **82**.

[0054] As illustrated in FIGS. **9** and **10**, the channel segments **42** may include any number of projections **78**. For example, when a single cable **40** is wound along the panel **38**, the channel segments **42** may include a single pair of projections **78**. In other examples, the cassette **36** may include first and second cables **40** may be aligned proximate on another and powered in series, or in parallel. In such examples, two pairs of projections **78** may be formed within each channel segment **42** so that each wire may be independently positioned within a respective pair of projections **78**.

[0055] In some embodiments, a thermal compound may be disposed in between two projections **78** in addition to the cable **40**. The thermal compound may further assist in directing heat from the cable **40** through the channel segments **42** and to the panel **38**. The thermal compound may also seal the area between the projections **78** from the external environment. In one embodiment, the thermal compound can be a silicone type-gel that may include additives for increasing thermal conductivity. The thermal compound can prevent the ingress of an external contaminate into the area between the projections **78** and can also isolate the cable **40** away from the external atmosphere to prevent any electrical arcing from reaching the external atmosphere. The thermal compound can provide sufficient isolation of the electronic circuitry from the external atmosphere to satisfy regulatory requirements for hazardous environment, such as, for example, CSA, FM, PTB, DNV, IECEx, and InMetro Zones **1** and **2**.

[0056] In light of the above, embodiments provide an anti-icing cassette including a concentric cable routing configuration that can provide improved heating of the cassette surface for, for example, preventing snow and ice formation on walkways.

[0057] While the invention has been illustrated and described in detail in the foregoing drawings and description, the same is to be considered as illustrative and not restrictive in character, it being understood that only illus-

trative embodiments thereof have been shown and described and that all changes and modifications that come within the spirit of the invention are desired to be protected. For example, any of the features or functions of any of the embodiments disclosed herein may be incorporated into any of the other embodiments disclosed herein.

What is claimed is:

1. An anti-icing cassette, the cassette comprising:

a panel;

a plurality of channel segments arranged on an underside of the panel; and

a heating cable routed through the plurality of channel segments and arranged in a concentric manner, including an outer loop adjacent an outer perimeter of the panel and at least one concentric inner loop inside the outer loop.

2. The cassette of claim **1**, wherein the heating cable terminates inside the outer loop.

3. The cassette of claim **1**, wherein the plurality of channel segments includes a first channel segment, a second channel segment, a third channel segment, and a fourth channel segment arranged relative to each other to form the outer loop.

4. The cassette of claim **1**, wherein the heating cable is bent at a substantially 90-degree angle to be routed from a first channel segment of the plurality of channel segments to an adjacent second channel segment of the plurality of channel segments.

5. The cassette of claim **1**, wherein the plurality of channel segments include extruded metal slots defined by a base structure and a pair of projections extending from the base structure.

6. The cassette of claim **5**, wherein the plurality of channel segments each include at least one flange positioned laterally outward of the pair of projections.

7. The cassette of claim **3**, wherein the first channel segment is substantially parallel to a first section of a perimeter of the panel, the second channel segment is substantially parallel to a second section of the perimeter of the panel, the third channel segment is substantially parallel to a third section of the perimeter of the panel, and a fourth channel segment is substantially parallel to a third section of the perimeter of the panel.

8. The cassette of claim **1**, further comprising:

one or more supports extending further from the panel than the plurality of channel segments arranged on an underside of the panel.

9. The cassette of claim **1**, further comprising:

a transition member operably coupled with the panel, the transition member having a chamfered outer surface and a vertical inner surface.

10. An anti-icing cassette, the cassette comprising:

a panel;

a plurality of channel segments arranged on an underside of the panel, the plurality of channel segments including a first channel segment parallel to a first section of a perimeter of the panel and a second channel segment parallel to a second section of the perimeter; and

a first heating cable routed through the plurality of channel segments and arranged in a concentric manner, the first heating cable defining a bend portion between the first and second channel segment.

11. The anti-icing cassette of claim **10**, wherein the first channel segment is arranged about 90 degrees relative to the second channel segment.

12. The anti-icing cassette of claim **10**, wherein the panel includes a panel and a pair of side members extending downwardly from the panel, the side members disposed on adjacent sides of the panel and separated from one another.

13. The anti-icing cassette of claim **12**, further comprising:

a pair of transition members operably coupled with two adjacent sides of the panel, the transition members including a chamfered outer surface.

14. The anti-icing cassette of claim **13**, wherein the first heating cable is biased towards the vertical members and away from the transition members.

15. The anti-icing cassette of claim **10**, further comprising:

a second heating cable, wherein the first and second cables are disposed in respective first and second slots within at least one of the plurality of channel segments.

16. A method of routing a heating cable on an underside of an anti-icing cassette, the method comprising:

routing the heating cable through a first plurality of channel segments coupled to the underside of the anti-icing cassette to form an outer loop adjacent to a perimeter the anti-icing cassette;

routing the heating cable through a second plurality of channel segments coupled to the underside of the anti-icing cassette to form an inner concentric loop inside the outer loop; and

terminating the heating cable at a location inside the outer loop.

17. The method of routing a heating cable of claim **16**, wherein the routing the heating cable through a first plurality of channel segments and the routing the heating cable through a second plurality of channel segments biases the cable in an offset position from a center point of the cassette.

18. The method of routing a heating cable of claim **16**, further comprising:

attaching a support to a panel of the anti-icing cassette between the outer loop and the inner loop.

19. The method of routing a heating cable of claim **16**, wherein the routing the heating cable through a second plurality of channel segments step includes biasing the inner concentric loop towards a perimeter section of a panel of the anti-icing cassette.

20. The method of routing a heating cable of claim **16**, wherein the routing the heating cable through a first plurality of channel segments step includes positioning the heating cable within first and second channel segments within the first plurality of channel segments, the first and second channel segments offset from one another by less than 180 degrees.

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