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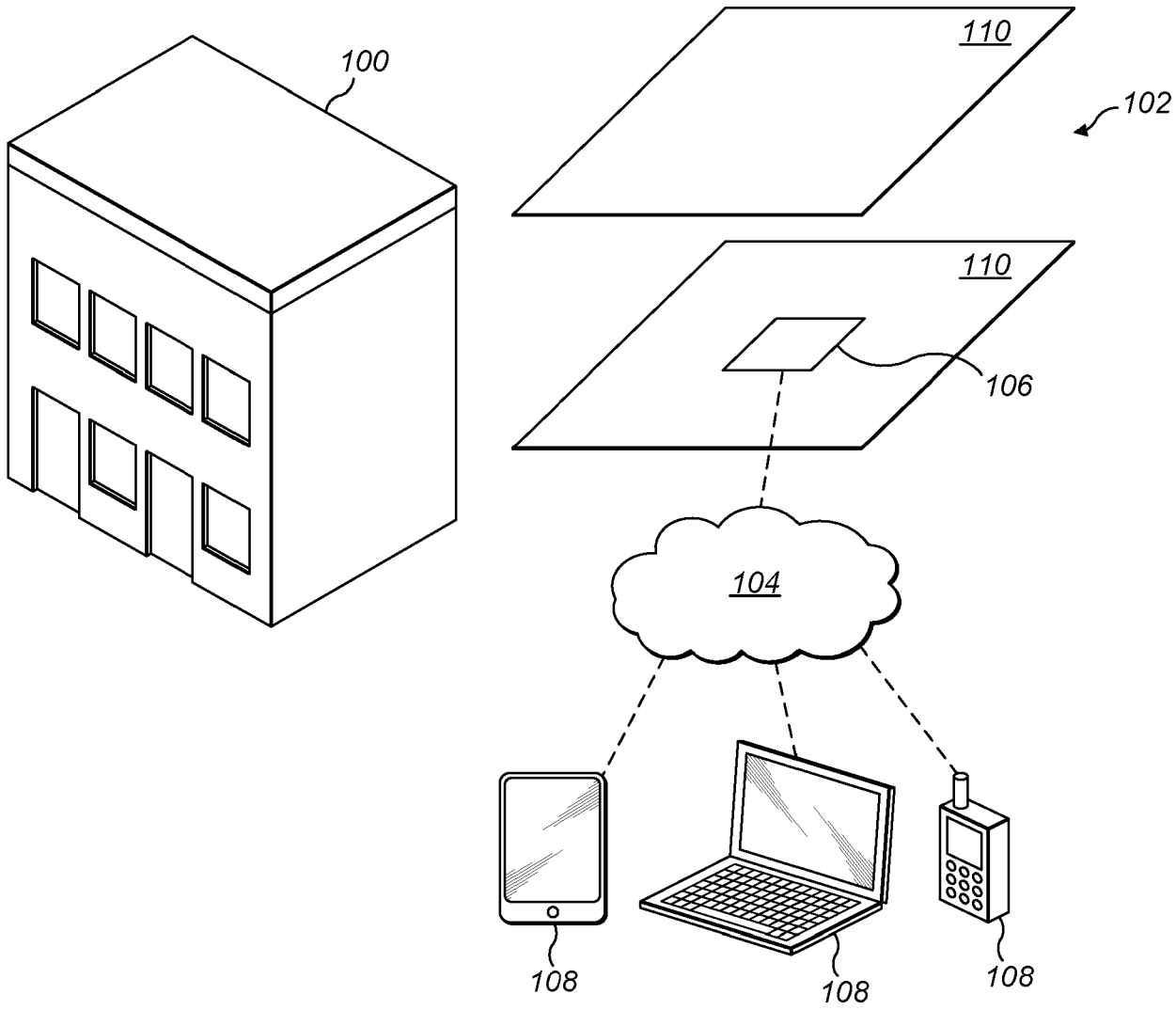

FIG. 1

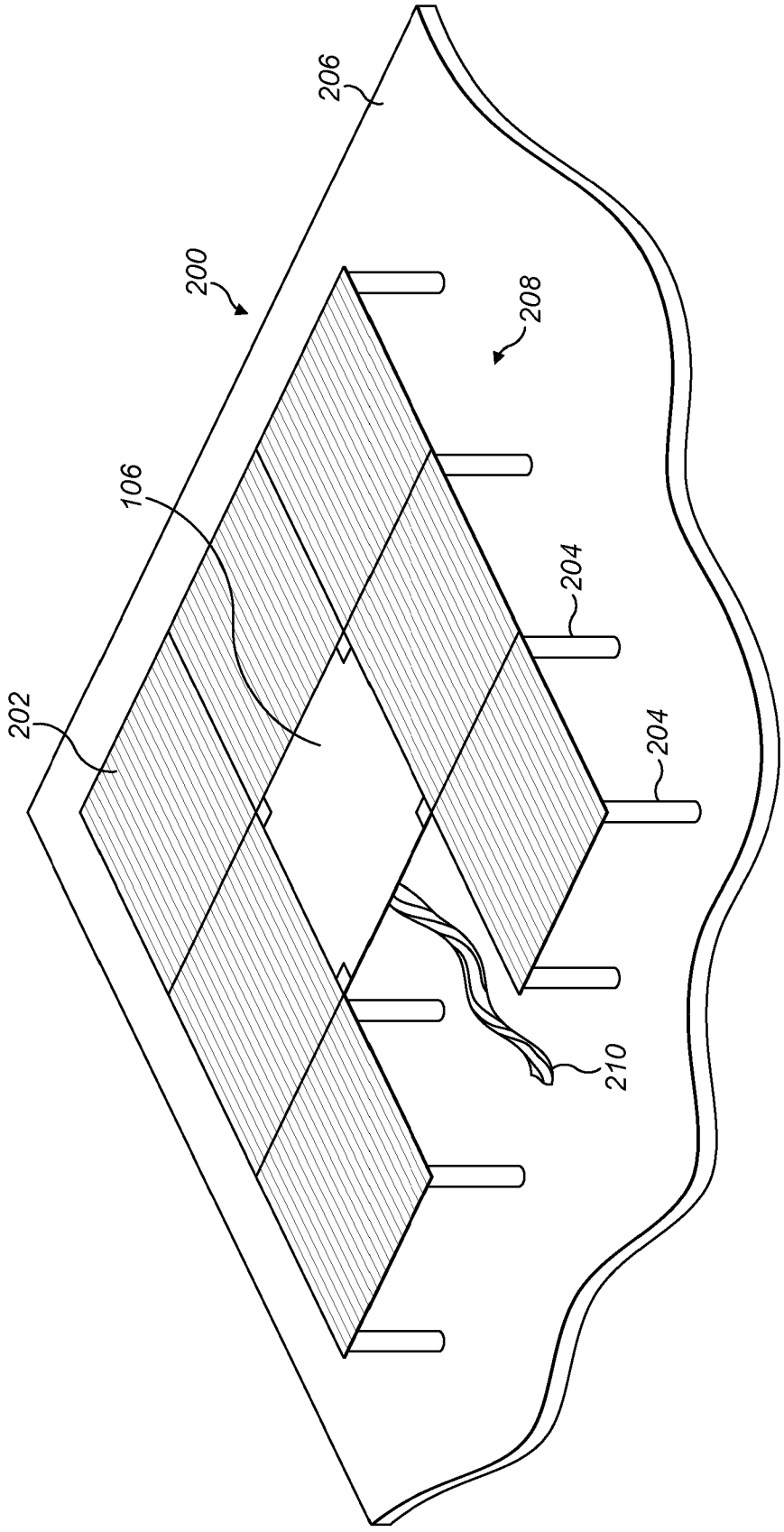

FIG. 2

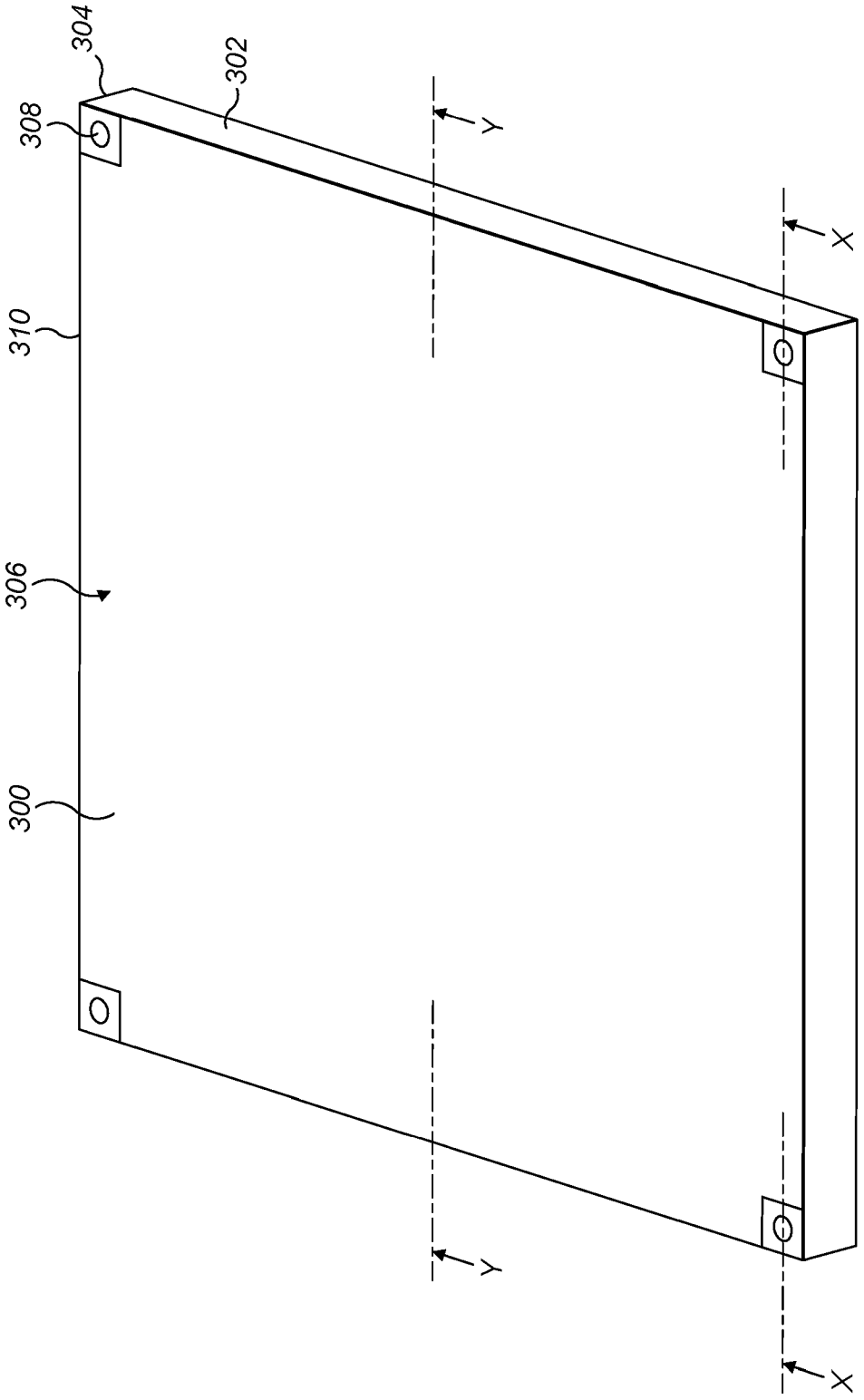

FIG. 3

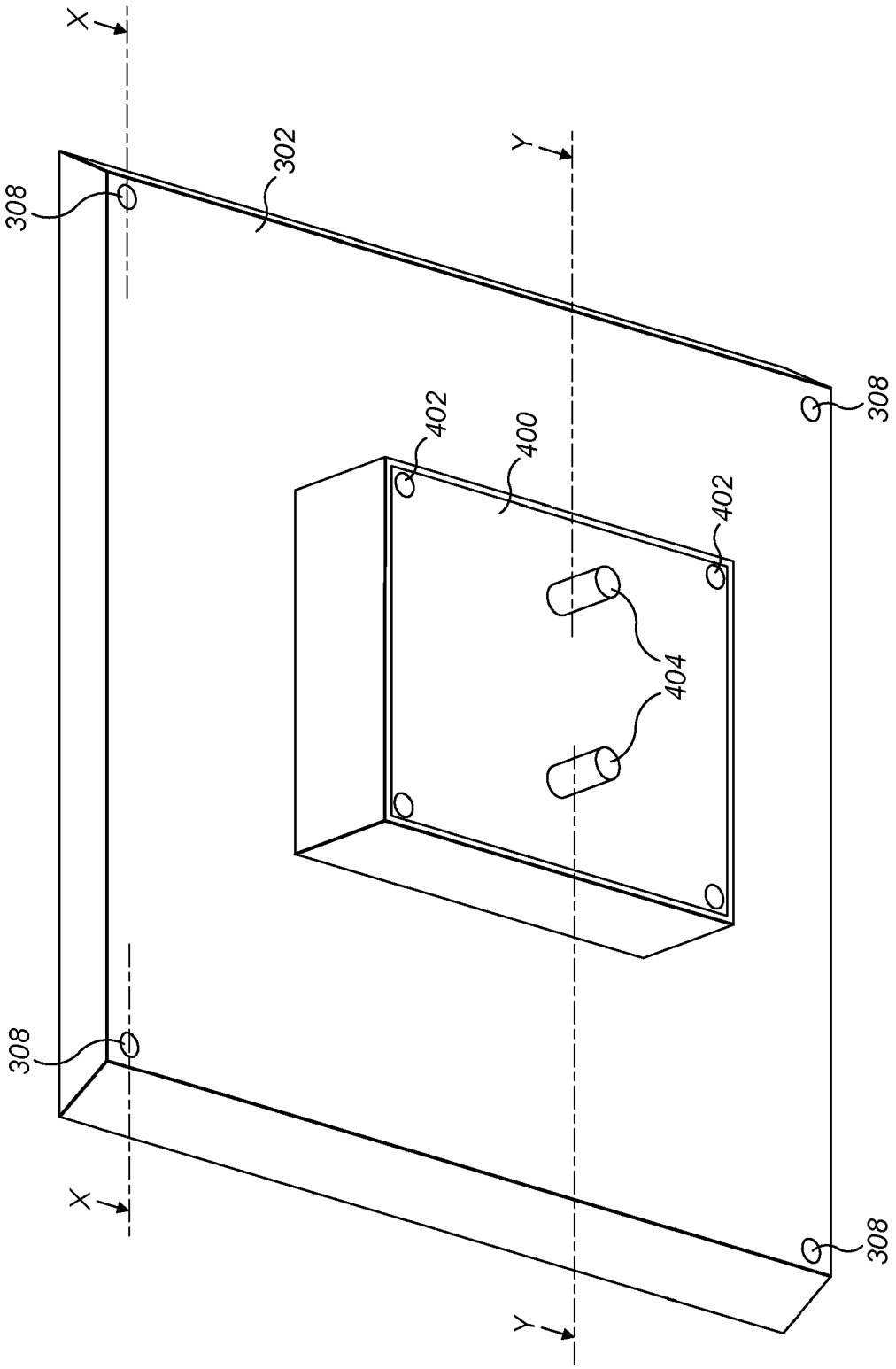

FIG. 4

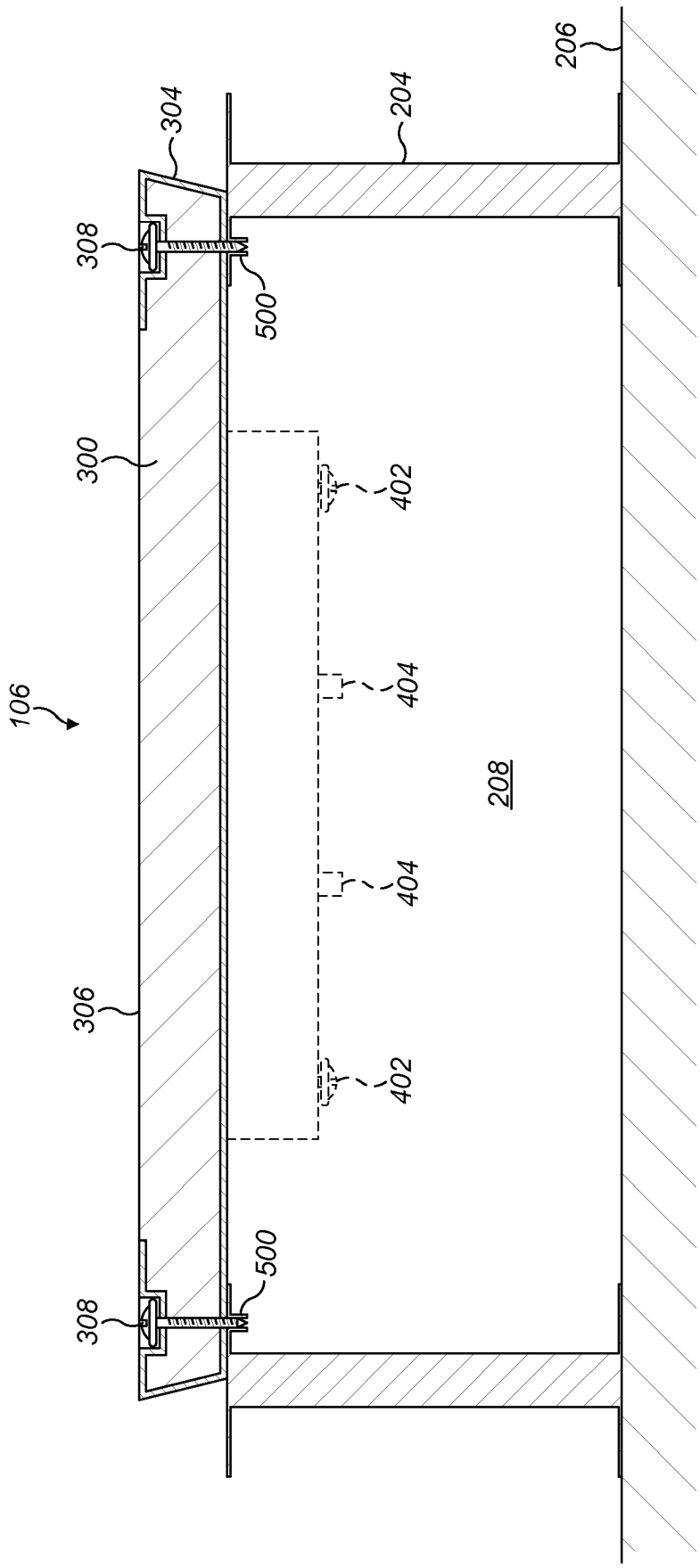

FIG. 5

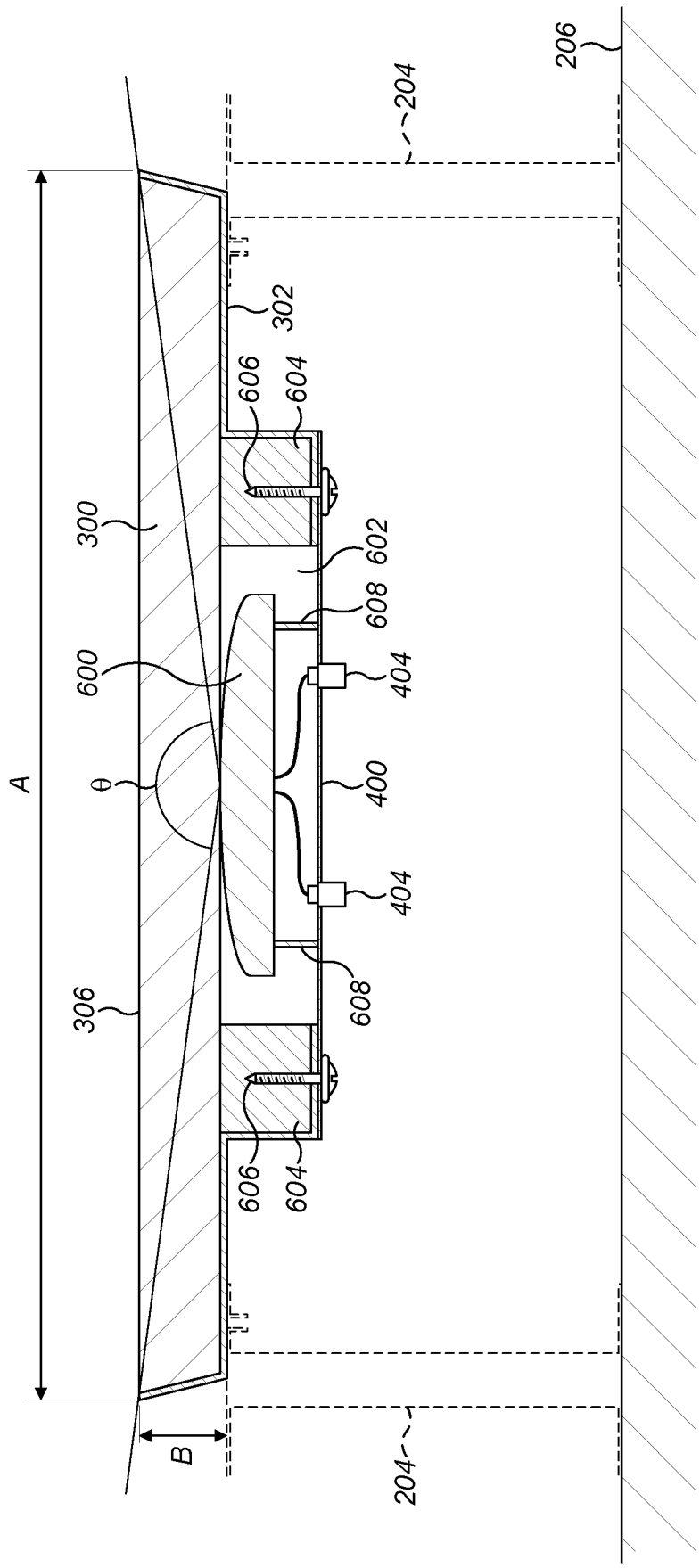
206
204
302
606
604
300
602
608
600
404
θ
400
404
306
608
606
604
A
B
204

FIG. 6

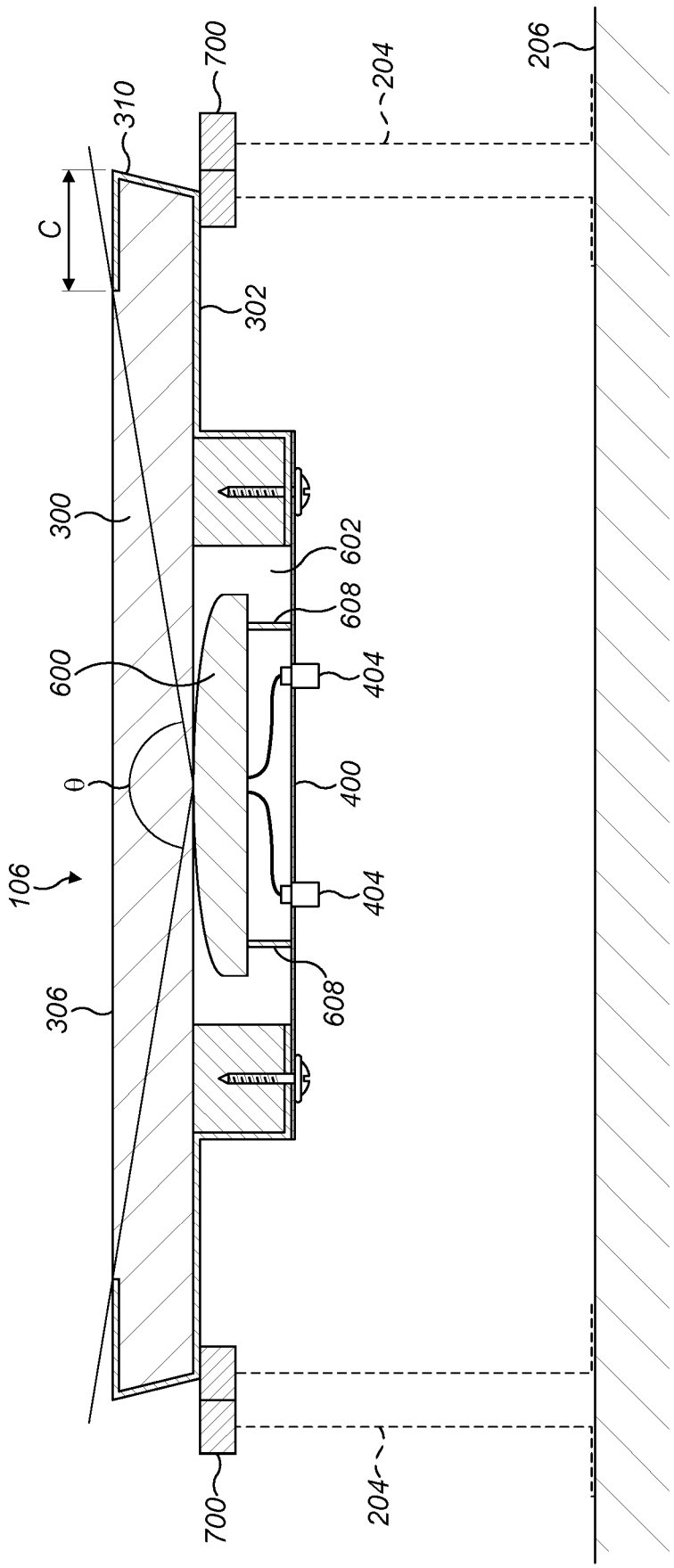
700
204
206
310
C
302
300
602
608
600
404
θ
400
106
404
306
608
700
204

FIG. 7

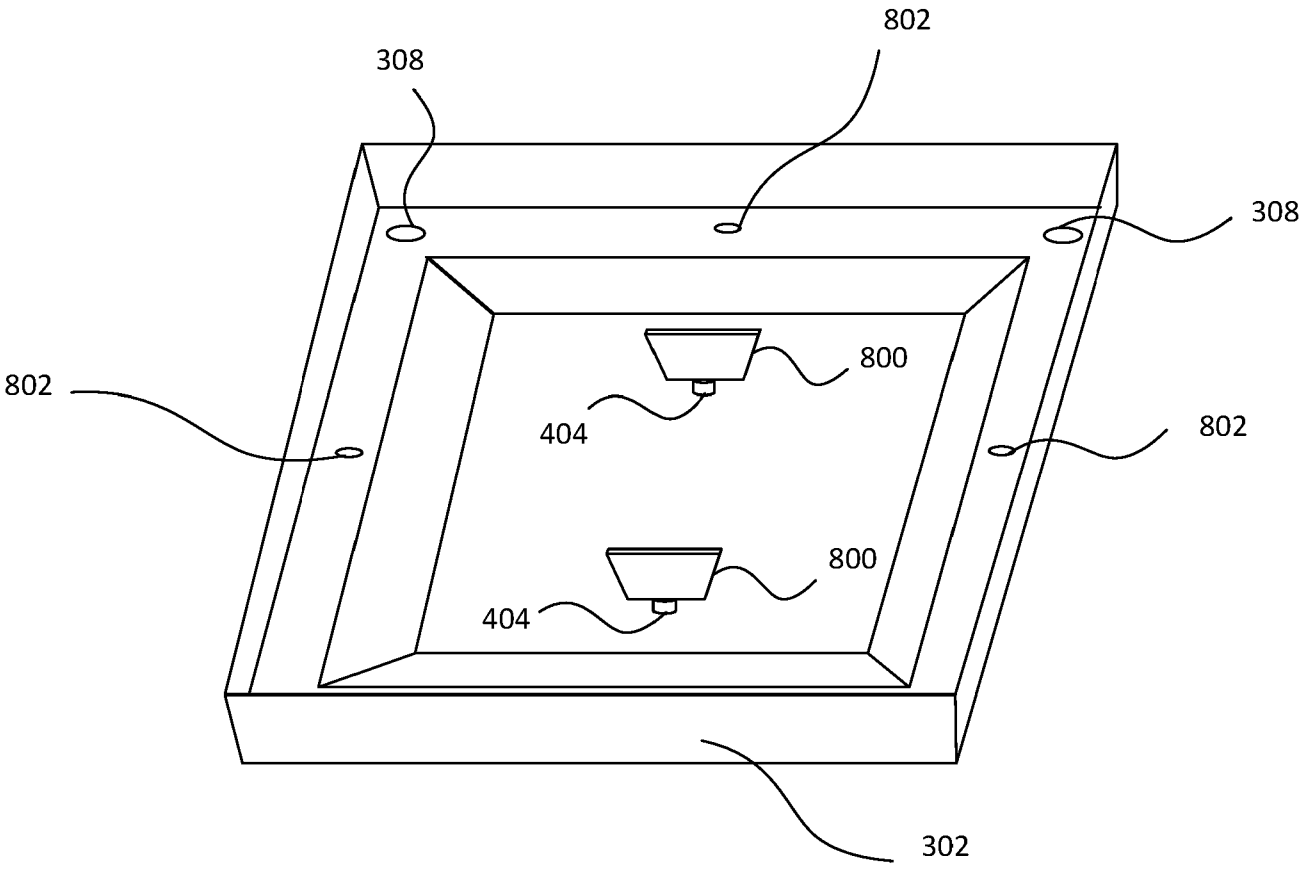

FIG. 8

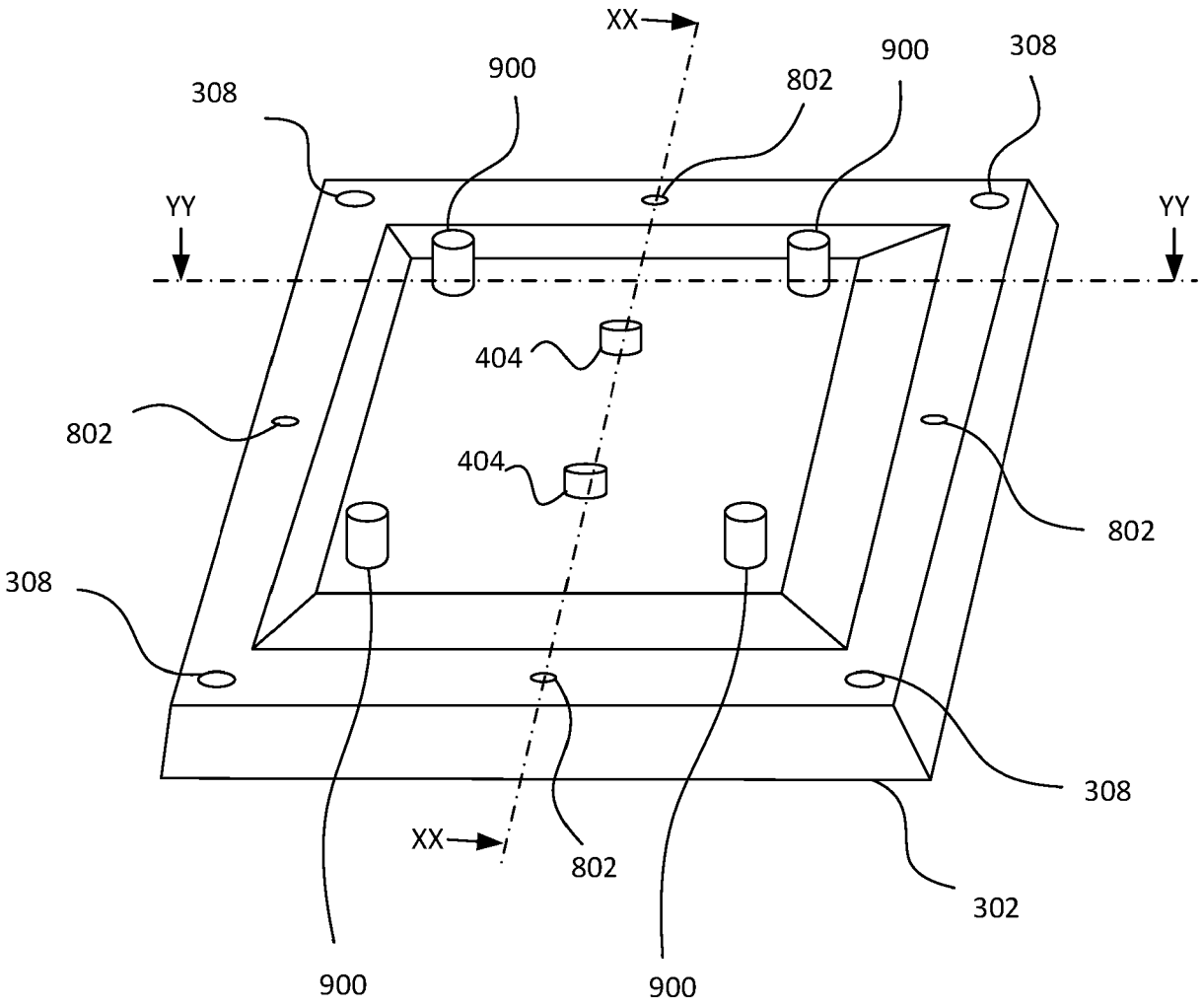
XX
900
802
900
308
308
YY
YY
404
802
404
802
308
308
XX
802
302
900
900

FIG. 9

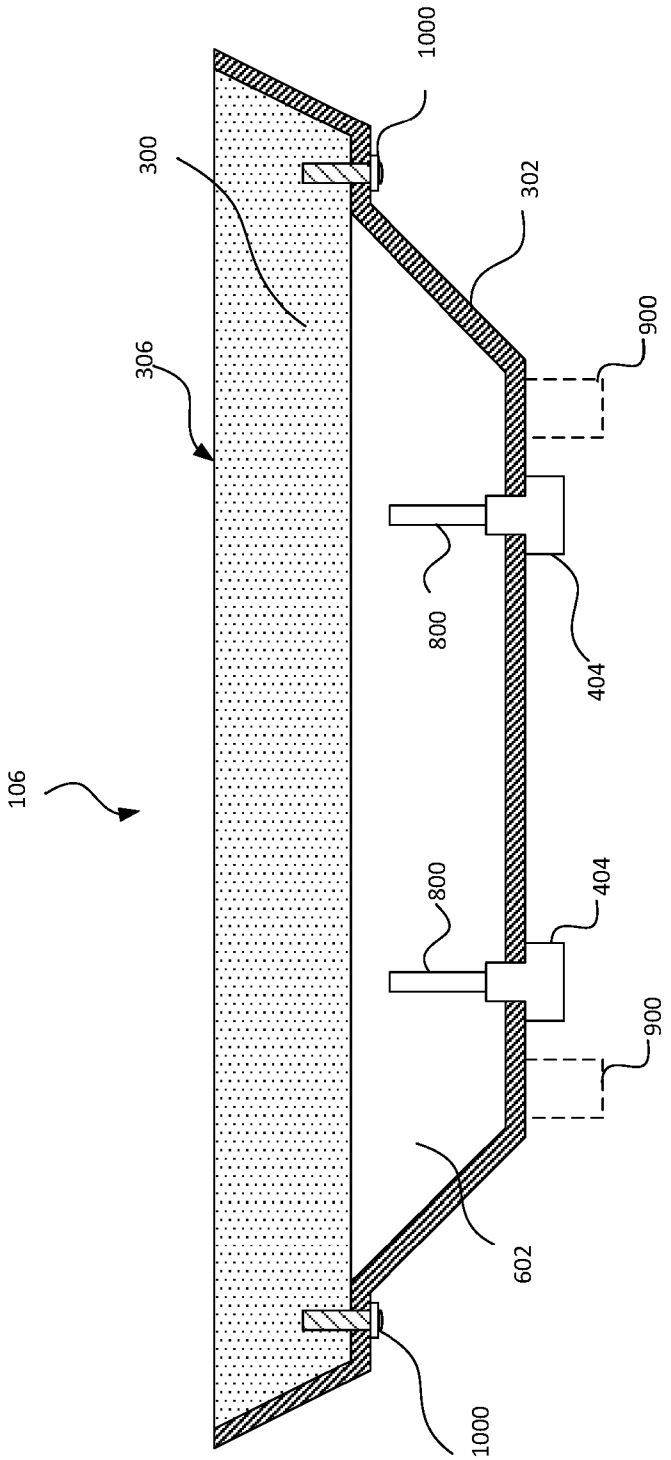

FIG. 10

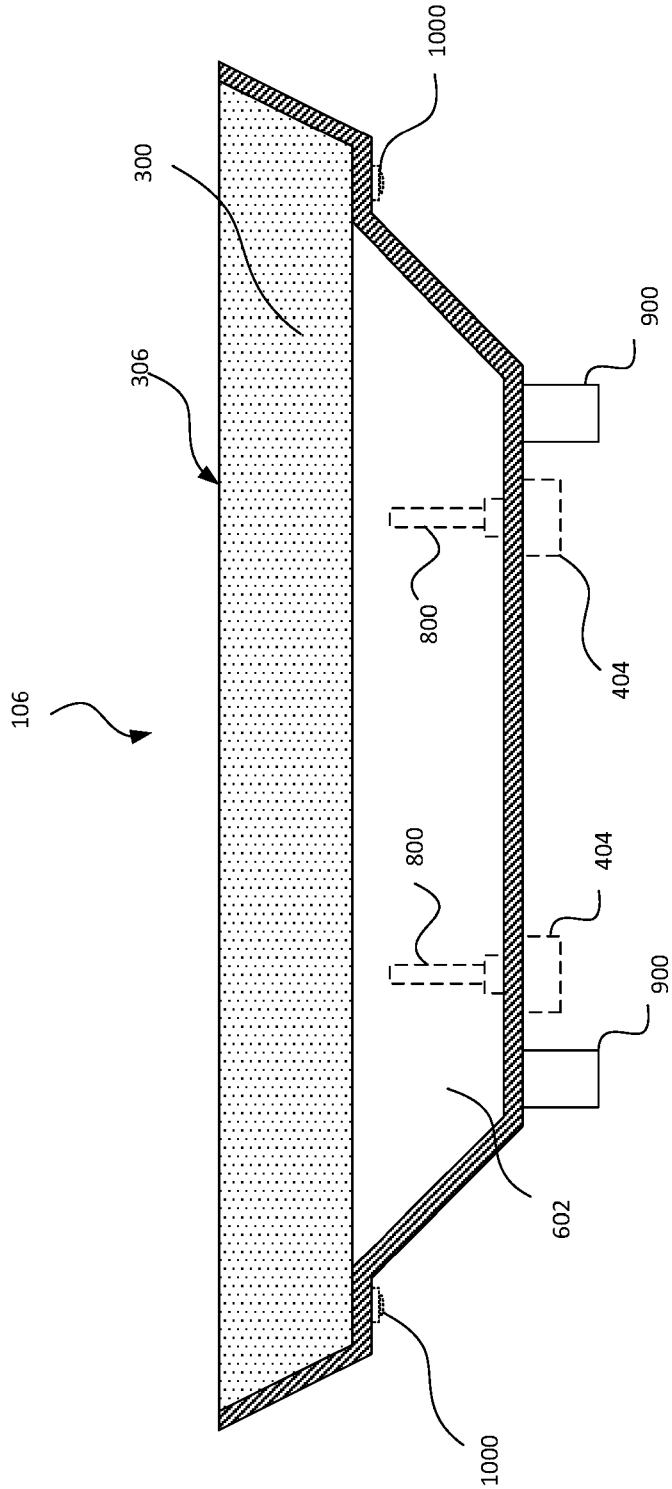

FIG. 11

FLOOR PANEL

Field of the Disclosure

The present disclosure relates to a floor panel. In particular, but not exclusively, the disclosure relates to a floor panel for use inside a building, or "indoors", as part of a raised floor, the floor panel being arranged to provide a wireless communications antenna.

Background to the Disclosure

It is known to provide a wireless communication network inside a building by providing antennas within the building. Antennas are often attached to appropriate wireless networking devices, such as wireless access points or repeaters. In more sophisticated installations, for example in large office buildings, factories or warehouses, antennas are frequently mounted to the underside of the ceiling(s) of the building. In either case, running cables to all the different locations at which antennas are located is complex and expensive. It is also difficult to position the antennas and cables unobtrusively, and this often leads to unsightly installations.

Summary of the Disclosure

Aspects of the present disclosure are set out in the appended claims.

In an aspect of the disclosure, there is provided a floor panel for a raised floor, the floor panel comprising: a core made of an RF-transparent material; an outer casing extending around the core, the outer casing being metal, and wherein a cavity is defined within the outer casing; and, an antenna radiating element for an antenna that is provided by the floor panel, the antenna radiating element being disposed within the cavity such that the core provides a radome for the antenna and being electrically grounded on the outer casing such that the outer casing provides a ground plane for the antenna radiating element.

Optionally, the outer casing has an aperture on a first surface of the floor panel, which first surface faces upwards when the floor panel is installed as part of the raised floor.

Optionally, the aperture extends over a width of the first surface that is greater than a width of the cavity across the floor panel.

Optionally, the aperture extends over the entire first surface of the floor panel.

Optionally, the core is secured to the outer casing by one or more fastening mechanisms on a second surface of the core, which surface faces downwards when the floor panel is installed as part of the raised floor.

Optionally, the aperture has a width sufficient to provide an angular spread of line of sight radiation from the centre of the floor panel, unobstructed by the outer casing, over 150° or more in at least one plane tilted with respect of a plane parallel to the floor panel.

Optionally, the outer casing provides structural support to the core, preferably wherein the ground plane increases the strength of the floor panel with respect to shear forces applied when the floor panel in installed as part of the raised floor.

Optionally, the floor panel further comprises a sensor, preferably, a footfall sensor, humidity sensor, water sensor, noise sensor, temperature, impact or light sensor.

Optionally, the floor panel further comprises an antenna connector coupled to the antenna radiating element.

Optionally, a first portion of the antenna connector is disposed inside the cavity and a second portion of the antenna connector extends through the outer casing to an exterior of the cavity.

Optionally, the antenna radiating element is electrically grounded on the outer casing via the antenna connector.

Optionally, the floor panel further comprising a spacing arrangement extending from the outer casing such that the floor panel can be placed on a substantially flat surface with the floor panel contacting the substantially flat surface only at the spacing arrangement.

Optionally, the antenna radiating element is a bent wire or planar inverted-F antenna radiating element.

Optionally, the floor panel wherein the antenna comprises a plurality of antenna radiating elements disposed within the cavity such that the core provides a radome for the antenna and, electrically grounded on the outer casing such that the outer casing provides a ground plane for the antenna.

Optionally, the core is made of one of: plywood, chipboard, glass fibre reinforced concrete or glass fibre reinforced plastic.

Optionally, the floor panel wherein the antenna is a wireless communications antenna.

Optionally, the wireless communication antenna is an antenna of a cellular telephone network, a private mobile radio network and/or a wireless local area network.

The disclosure also extends to a raised floor comprising the floor panel of any one of the preceding claims; a building comprising the raised floor; a kit of parts for a raised floor comprising: the disclosed floor panel; one or more conventional floor panels; and, pedestals on which the disclosed floor panel and the one or more other conventional floor panels are supported in use. The kit of parts may also comprise a frame, one or more pedestals on which the frame is supported in use and one or more regular floor panels.

The disclosure also extends to a wireless communications network comprising the disclosed floor panel, wherein the wireless communications antenna is arranged to transmit and/or receive wireless communication signals of the wireless communications network.

Optionally, the antenna radiating element(s) are interchangeable. It/they may be an antenna of a cellular telephone network, a wireless local area network, private mobile radio or such like.

Embodiments of the disclosure are now described in further detail, by way of example, with reference to the accompanying drawings.

Brief Description of the Drawings

Figure 1 is an illustration of a building in which a wireless communications network is provided using a floor panel according an embodiment of the disclosure.

Figure 2 is an illustration of the floor panel installed as a part of a raised floor of the building.

Figure 3 is a schematic perspective view of the floor panel according to a first embodiment from above.

Figure 4 is a schematic perspective view of the floor panel according to a first embodiment from below.

Figure 5 is a schematic cross-sectional illustration of the floor panel according to a first embodiment from the line X-X in Figures 3 and 4, proximate to an edge of the floor panel.

Figure 6 is a schematic cross-sectional illustration of the floor panel according to a first embodiment from the line Y-Y in Figures 3 and 4, approximately bisecting the floor panel.

Figure 7 is a schematic cross-sectional illustration, equivalent to the view shown in Figure 6, of a floor panel according to an alternative embodiment.

Figure 8 is a schematic perspective view from above of the floor panel according to a second embodiment, with the core removed.

Figure 9 is a schematic perspective view from below of the floor panel according to a second embodiment.

Figure 10 is a schematic cross-sectional illustration of the floor panel according to a second embodiment from the line XX-XX in Figure 9, proximate to an edge of the floor panel.

Figure 11 is a schematic cross-sectional illustration of the floor panel according to a first embodiment from the line YY-YY in Figure 9, approximately bisecting the floor panel.

Detailed Description of Embodiments

Referring to Figure 1, a building 100 defines an indoor environment 102 in which a wireless communications network 104 is provided by using one or more floor panels 106 configured to provide a wireless communications antenna. In the illustrated embodiment, the building 100 is a multi-story building, such as an office building, in which there is a need to provide such a wireless communications network 104. In any event, it will be appreciated that, in the illustrated embodiment, the floor panel 106 is an indoor floor panel.

The wireless communications network 104 is a Radio Frequency (RF) wireless communication network, such as a cellular telephone network, e.g. using a Universal Mobile Telecommunications System (UMTS) and/or Long-Term Evolution (LTE) and/or 5G protocol, a wireless local area network, e.g. a Wi-Fi network, a Professional Mobile Radio (PMR) network, e.g. Terrestrial Trunked Radio (TETRA) network, a Bluetooth network or such like. The precise technology or protocol is unimportant, although it is believed that the disclosure has particular applicability to the increased prevalence of wireless communication brought about by the advent of the Internet of Things (IoT). Indeed, several different wireless communication networks 104 using different protocols or technology can be implemented in

the building together using the same floor panel(s) 106 configured to provide a wireless communications antenna.

The wireless communications antenna (not shown in Figure 1) is an antenna suitable for use in the cellular telephone network, e.g. using the UMTS or LTE or 5G, the wireless local area network, e.g. the Wi-Fi network, the PMR network, e.g. TETRA network, the Bluetooth network or such like. Indeed, in some embodiments, the wireless communications antenna supports more than one of these types of communication at once, e.g. it is a multi-technology antenna. In some embodiments it acts simply as an antenna, in other embodiments the wireless communications antenna incorporates a signal processing module or such like, e.g. to perform the function of a wireless access point or cellular base station.

Multiple wireless communication devices 108, such as a tablet computer, laptop computer and mobile telephone, are present in the building 100, arranged to communicate over the wireless communication network 104 via the floor panel(s) 106 providing the wireless communication antenna(s).

The building 100 illustrated in Figure 1 has two levels 110: a ground level and an upper level. Referring to Figure 2, a raised floor 200 is installed on each level 110 of the building 100. The floor panel(s) 106 housing the wireless communications antenna(s) are installed as part of the raised floors 200. In Figure 2, just one floor panel configured to provide a wireless communications antenna is shown, installed as part of one of the raised floors 200. However, in a practical implementation, multiple floor panels 106 configured to provide wireless communications antennas are usually installed as part of the raised floors 200 of each level 110 of the building 100.

The raised floors 200 each comprise conventional floor panels 202 and one or more floor panels 106 configured to provide the wireless communications antennas, supported on pedestals 204. The pedestals 204 rest on a structural surface 206 that defines one of the levels 110 of the building 100. The structural surface 206 is typically a plinth of reinforced concrete, or some other suitable material. Alternatively, the structural surface 206 is a planar structure supported on beams between walls of the building 100. The pedestals 204 elevate the conventional floor panels 202 and one or more floor panels 106 above the structural surface 206. The pedestals 204 are usually height adjustable, so that the pedestals 204 can compensate for unevenness in the structural surface 206 to support the conventional floor panels 202 and one or more floor panels 106 configured to provide the wireless

communications antennas of the raised floor 200 such that they are perfectly flat and horizontal.

The conventional floor panels 202 and one or more floor panels 106 configured to provide the wireless communications antennas are usually each squares having width A of around 600mm, and each of the pedestals 204 is positioned so as each to support a corner of one of the conventional floor panels 202 or one or more floor panels 106 configured to provide the wireless communications antennas.

The raised floor 200 defines a void 208 between the conventional floor panels 202 and one or more floor panels 106 configured to provide the wireless communications antennas, and the structural surface 206. Cables 210 are provided in the void 208. In some embodiments, ducting for air conditioning or heating is also provided in the void 208, as well as other components of the infrastructure of the building 100, such as water pipes, sprinkler system components etc.

The cables 210 comprise cables supplying electrical power to the wireless communications antenna(s) and network cables coupling the wireless communications antenna(s) to infrastructure of the wireless communications network 104, such as other wireless communication antennas, routers, computer servers, cellular base stations etc.

First Embodiment

Referring to Figures 3 to 6, in a first embodiment the floor panel 106 configured to provide the wireless communications antenna is a floor panel 106 configured to house a wireless communications antenna 600. The floor panel 106 housing a wireless communications antenna 600 comprises a core 300 and an outer casing 302. The outer casing 302 surrounds the core 300, except at an aperture 306 in the outer casing 302.

The core 300 is made of a first material, which is RF transparent. In the illustrated embodiment, the first material is also fire retardant. It is typically, glass, concrete or, more preferably Glass Reinforced Plastic (GRP), and most preferably Glassfibre Reinforced Concrete (GRC). GRC in particular is likely to meet the relevant structural and fire safety requirements of the relevant building regulations and standards, such as those of the British Standards Institute (BSI) and Property Services Agency (PSA). In some other embodiments, the core 300 is wood, e.g. chipboard, for example when fire retardant properties are less important. In a preferred embodiment the core is comprises solid PSA MOB 08-801/BS EN 12825:2001 compliant, RF-transparent material. The outer casing 302 is made of a second

material, usually metal. In this context, metal may mean a pure metal, such as aluminium, or an alloy, including alloys having non-metal constituents, such as carbon.

Corners 304 of the floor panel 106 housing the wireless communications antenna 600 rest on the pedestals 204 and are releasably attached to the pedestals 204 by a first fixing 308. In the illustrated embodiment, the first fixing 308 is a bolt arranged to mate with a threaded bore 500 of the respective pedestal 204 (as shown in Figure 5). In some embodiments, one or more shims (not shown) are provided between the corners 304 of the floor panel 106 housing the wireless communications antenna 600 and the pedestals 204. The shims assist with levelling the floor panel 106, in particular to ensure that the upwardly facing surface of the floor panel 106 housing the wireless communications antenna 600 is at the same height as the equivalent surfaces of the surrounding conventional floor panels 202.

The aperture 306 in the outer casing 302 is provided on a surface of the floor panel 106 housing the wireless communications antenna 600, which surface faces upwardly when the floor panel 106 housing the wireless communications antenna 600 is installed as part of the raised floor 200. In the illustrated embodiment, the aperture 306 on the upwardly facing surface exposes the core 300, such that the core 300 provides the outermost extent of the floor panel 106 housing the wireless communications antenna 600, through the aperture 306, at the location of the aperture 306. However, this is not essential, and in other embodiments the core 300 is covered by some other material at the location of the aperture 306 in the outer casing 302. In one particular embodiment, in which the first material forming the core 300 is wood, an RF transparent, fire retardant material is provided in the aperture 306 in the outer casing 302.

Referring to Figure 6, the floor panel 106 housing the wireless communications antenna 600 defines a cavity 602 for accommodating the wireless communications antenna 600. In the illustrated embodiment, the cavity 602 is located centrally with respect to the upwardly facing surface. The cavity 602 is defined by the outer casing 302. In more detail, the outer casing 302 extends over another surface of the floor panel 106 housing the wireless communications antenna 600, which surface faces downwardly when the floor panel 106 housing the wireless communications antenna 600 is installed as part of the raised floor 200. This surface can be seen most clearly in Figure 4. A spacer 604 is provided on the downwardly facing surface, between the core 300 and the outer casing 302. The spacer 604 defines the periphery of the cavity 602. That is, it extends around the cavity 602, parallel to the plane of the floor panel 106 housing the wireless communications antenna 600. In this embodiment, the spacer 604 is square. That is, it is in the shape of a square frame. In other

embodiments, the spacer 604 is rectangular, circular or of any other shape suitable for defining the periphery of the cavity 602 so as to accommodate the wireless communications antenna 600. The outer casing 302 extends over the spacer 604, sandwiching the spacer 604 between the outer casing 302 and the core 300. A void between the outer casing 302 and the core 300, within the periphery defined by the spacer 604, provides the cavity 602.

A part 400 of the outer casing 302 is removable to allow access to the cavity 602. In the illustrated embodiment, the removable part 400 is a sidewall of the cavity 602 that is at the bottom of the cavity 602 when the floor panel 106 housing the wireless communications antenna 600 is installed as part of the raised floor 200. Indeed, the removable part 400 is a portion of the outer casing 302 that extends across the spacer 604 to form the cavity 602. The removable part 400 is removably attached to the floor panel 106 housing the wireless communications antenna 106 by a second fixing 402. In the illustrated embodiment, the second fixing 402 mates with the spacer 604 to secure the removable part 400 in position. Analogously to the first fixing 308, the second fixing 402 is a bolt arranged to mate with a threaded bore 606 in the spacer 604. More specifically, there are four bolts, one at each corner of the removable part 400, and four corresponding bores 606 at the corners of the spacer 604.

The wireless communications antenna 600 is mounted within the cavity 602. In the illustrated embodiment, the wireless communications antenna 600 is fixed to the removable part 400 by an antenna mounting 608. In more detail, the wireless communications antenna 600 is removably attached to the removable part 400. The antenna mounting 608 locates the antenna 600 spaced away from the removable part 400 such that the antenna 600 is directly adjacent the core 300 when the removable part 400 is in position on the floor panel 106 housing the wireless communications antenna 600.

The wireless communications antenna 600 has one or more connectors 404 (two in the illustrated embodiment), such as a port for a coaxial cable, an Ethernet port, an optical port or a socket for a power supply cable. The sidewall of the cavity 602 has apertures through which the connectors 404 extend or, alternatively, through which cables connectable to the connectors 404 extend. In the illustrated embodiment, the apertures are in the removable part 400 and the connectors 404 extend through the removable part 400 to the outside of the cavity 602. In one embodiment, the removable part 400 is made of transparent material for easy observation of the wireless communications antenna 600 or other components in the cavity 602. The removable part 400 can also be made of a fire resistant material. However, in the illustrated embodiment, the removable part 400 is made of the same material as the

rest of the outer casing 302. In any event, with the removable part 400 in position, the outer casing 302 completely encapsulates the core 300 except at the aperture 306.

The aperture 306 extends over an area of the upwardly facing surface of the floor panel 106 housing the wireless communications antenna 600, which area is greater than the extent of the cavity 602 across the floor panel 106 housing the wireless communications antenna 600. The aperture 306 terminates at the edge 310 of the floor panel 106 housing the wireless communications antenna 600, except at the corners 304 where the outer casing 302 extends onto the upwardly facing surface. Having the outer casing 302 extending over both the upwardly facing surface and the downwardly facing surface of the floor panel 106 housing the wireless communications antenna 600 proximate to the corners 304 maintains the strength of the floor panel 106 housing the wireless communications antenna 600 where it rests on the pedestals 204. This helps the floor panel 106 housing the wireless communications antenna 600 to resist shear forces adjacent the pedestal 204 when weight is applied to the upwardly facing surface. It also strengthens the floor panel 104 housing the wireless communications antenna 600 in the region of the first fixing 308.

Referring to Figure 6, from the location of the wireless communications antenna 600 at the centre of the floor panel 106 housing the wireless communications antenna 600, and below the core 300, which has a thickness B of around 25mm, there is a field of view through the aperture 306 defined in a direction across the width of the floor panel 106 housing the wireless communications antenna 600 by an angle θ. If the field of view is wide, then the angular spread of a radiation pattern of the wireless communications antenna 600 will tend to be large. In the illustrated embodiment, the angle θ of the field of view is around 170° Having such a wide field of view, and consequently having the radiation pattern spread horizontally as much as possible, allows the wireless communications antenna 600 to cover a larger proportion of the level 110 of the building 100 in which the floor panel 106 housing the wireless communications antenna 600 is located.

The floor panels 106 housing the wireless communications antennas 600 and the conventional floor panels 202 are typically covered with the standard floor finish, such as carpet or vinyl tiles. In some examples, stoneware or wooden finishes may be applied instead of carpet tiles.

It will be appreciated that the floor panel 106 housing the wireless communications antenna 600 and the regular floor panels 202 are interchangeable with one another. Such interchangeability provides for easy replacement of the floor panel 106 housing the wireless

communications antenna 600 during maintenance or in order to change the wireless network coverage provided by the floor panels 106 housing the wireless communications antenna 600 within the indoor environment 102.

In one embodiment, the floor panel 106 housing the wireless communications antenna 600 is provided with one or more sensors, such as a footfall sensor, temperature sensor, humidity sensor, water leakage sensor, noise sensor, temperature sensor, impact sensor, light sensor, etc. Such sensors can be housed in the cavity 602, and take advantage of the provision made for connecting cables 210 to the floor panel 106 housing the wireless communications antenna 600. In one particularly preferred embodiment, the one or more sensors are mounted on the removable part 400. This is particularly convenient, and allows for easy interchangeability of different removable parts 400 having different sensors.

It will be understood that raised floors incorporating only conventional floor panels 202 are already used in some buildings. However, including the floor panel 106 housing the wireless communications antenna 600 in such a raised floor 200, in place of a conventional floor panel 202, to provide the wireless communications network 104 in the building 100, takes advantage of the raised floor 200 in a different way. Cables 210 under the raised floor 200 can be used to save installation costs. Additionally, all installation work can be conducted at floor level, thus negating the requirement for access equipment to reach ceiling or above head height on walls. This hugely simplifies Health and Safety requirements, saves time and further reduces installation costs. Moreover, the disclosure provides a much greater level of efficiency for commissioning, maintenance and future upgrade work, and it is generally much easier to meet the requirements of any Service Level Agreement (SLA) for in-service operation of the wireless communications network 104. The disclosure further provides for fully concealing the wireless communication antennas 600 to improve aesthetics. No wireless communications antenna 600 needs to be mounted on the ceilings of the building 100 or anywhere else in view inside the building 100 to provide sufficient coverage.

Referring to Figure 7, some raised floors 200 have conventional floor panels 202 that rest on stringers 700 extending between the pedestals 204. In an alternative embodiment, the floor panel 106 housing the wireless communications antenna 600 is identical to the floor panel 106 housing the wireless communications antenna 600 described with reference to Figures 1 to 6, except that the outer casing 302 extends around the edge 310 of the floor panel 106 onto the upwardly facing surface all around the panel 106. This means that the aperture 306 in the outer casing is smaller. Typically, the outer casing 302 extends by a distance C of 20mm or more (up to 90 mm in other embodiments). This reduces the angle θ of the

aperture 306, and hence the angular spread of the radiation pattern of the wireless communications antenna 600. Typically, the angle θ is no less than 150º.

Second Embodiment

Referring to Figures 8 to 11, a floor panel 106 configured to provide a wireless communication antenna according to a second embodiment of the disclosure is identical to the floor panel 106 configured to provide a wireless communication antenna according to the first embodiment of the disclosure, except that the floor panel 106 according to the second embodiment may act in and of itself as the antenna. In other words, at least some of the components of the floor panel 106 serve both as floor panel components and act as components of an antenna. In the drawings and the description below, the same reference numerals as used in relation to the first embodiment are used to denote the same or similar features of the second embodiment.

The floor panel 106 according to the second embodiment comprises a core 300, an outer casing 302 and at least one antenna radiating element 800. The outer casing 302 surrounds the core 300, except at an aperture 306 in the outer casing 302. A cavity 602 is defined by the outer casing 302 in which the antenna radiating element 800 is disposed.

The core 300 generally has the properties described in relation to the first embodiment. In the illustrated embodiment, the core 300 is made of a first material, which is RF transparent. In the illustrated embodiment, the first material is also fire retardant. It is typically, glass, concrete or most preferably Glassfibre Reinforced Concrete (GRC). In some other embodiments, the core 300 is wood, e.g. chipboard, for example when fire retardant properties are less important. A portion of the core 300 sits flush with a portion of the outer casing 302, such that that the core 300 is supported by the outer casing 302 in use. In the illustrated embodiment a perimeter of the core 300 sits flush with the outer casing 302, such that the cavity 602 defined between them is completely sealed. It will be appreciated that the core 300 of the floor panel 106, being RF transparent and providing protection to the antenna radiating element(s) 800 disposed within the cavity 602, functions as an antenna radome.

The outer casing 302 is made of an electrically conductive material such as metal. In this context, metal may mean a pure metal, such as aluminium, or an alloy, including alloys having non-metal constituents, such as carbon.

The aperture 306 in the outer casing 302 is provided on a surface of the floor panel 106, which surface faces upwardly when the floor panel 106 is installed as part of the raised floor

200. In the illustrated embodiment, the aperture 306 on the upwardly facing surface exposes the core 300, such that the core 300 provides the outermost extent of the floor panel 106, through the aperture 306, at the location of the aperture 306. However, this is not essential, and in other embodiments the core 300 is covered by some other material at the location of the aperture 306 in the outer casing 302. In one particular embodiment, in which the first material forming the core 300 is wood, an RF transparent, fire retardant material is provided in the aperture 306 in the outer casing 302.

As in the first embodiment, the aperture 306 extends over an area of the upwardly facing surface of the floor panel 106, which area is greater than the extent of the cavity 602 across the floor panel 106. The aperture 306 terminates at the edge 310 of the floor panel, in the illustrated embodiment the outer casing 302 extends around the sides of the floor panel 106 but in the illustrated example does not extend onto the upwardly facing surface. It will be appreciated that, as in the first embodiment illustrated in Figure 7, an alternative arrangement is that the outer casing 302 may extend onto the upwardly facing surface at the corners or around a perimeter of the core 300. Having the outer casing 302 extending around the side walls of the core 300 and the downwardly facing surface of the core 300 (and optionally over the upwardly facing surface) maintains the strength of the floor panel 106 where it rests on the pedestals 204. This helps the floor panel resist shear forces adjacent the pedestal 204 when weight is applied to the upwardly facing surface.

The antenna radiating elements 800 are configured to transmit and/or receive electromagnetic radiation signals. The antenna radiating elements 800 can be of any suitable form, such as bent wire antennas, dipole antennas, rectangular micro strip antennas, helical antennas or reflector antennas, but planar inverted-F antenna radiating elements may be particularly advantageous. In the illustrated embodiment two antenna radiating elements 800 are shown, arranged on either side of a centre (bisecting) line XX-XX of the floor panel 106, preferably symmetrically. It will be appreciated, however, that only a single antenna radiating element 800 may be provided in other embodiments, or a number of antenna radiating elements 800 equal or greater than two. For example, the floor panel 106 may be configured to act as a single input single output (SISO) antenna; or the floor panel 106 may be configured to act as a multiple input multiple output (MIMO) antenna, for example a 4x4 MIMO antenna comprising four antenna radiating elements 800. The arrangement of the one or more antenna radiating elements 800 within the cavity 602 can take any number of different forms to suit the needs of the network users or network providers, and need not be symmetrical as in the illustrated embodiment.

The antenna radiating elements 800 are in electrical connection with the outer casing 302 of the floor panel 106. More specifically, the antenna radiating elements 800 are electrically grounded on the outer casing 302. The outer casing 302 therefore functions as the ground plane for the antenna radiating elements 800. Where there is a plurality of antenna radiating elements 800, this may allow for a shared ground plane for the antenna radiating elements 800.

The outer casing 302 is configured to act as a ground plane of an antenna, the antenna radiating element(s) 800 disposed within the cavity 602 of the outer casing 302 is/are in electrical connection and is/are electrically grounded on the outer casing 302 of the antenna floor panel 106.

In the illustrated embodiment, the antenna radiating elements 800 have one or more connectors 404, such as a port for a coaxial cable, an Ethernet port, an optical port or a socket for a power supply cable. The antenna connectors 404 may also be in electrical contact with the outer casing 302, e.g. the antenna connectors 404 may be grounded on the outer casing 302 of the floor panel 106. So, a connector 404 may provide one electrical path to one (or more) of the antenna radiating elements 800 and another electrical path to the outer casing 302.

The part of the outer casing 302 defining the wall of the cavity 602 has apertures through which the connectors 404 extend or, alternatively, through which cables connectable to the connectors 404 extend. In the illustrated embodiment, the apertures are in lowermost surface (with the floor panel 106 installed as part of a raised floor) of the outer casing and the connectors 404 extend through the apertures to the outside of the cavity 602. In this embodiment, and others, the connectors 404 allow transmission equipment to be connected, for example by a coaxial cable, an Ethernet cable, or an optical cable, so as to transmit their signal through the floor panel 106. Similarly the antenna radiating elements 800 may receive signals and transmit these from the floor panel 106 through along transmission wires connected to the connectors 404.

A spacing arrangement is also provided on the outer casing 302. In the illustrated embodiment the spacing arrangement comprises four spacers 900 which extend from the outer casing 302 by a distance further than that extended by the antenna connectors 404. The floor panel 106 can therefore be placed on a surface to rest on the spacers 900, such that the antenna connectors 404 are not in contact with the surface. This may help to prevent

damage to the antenna connectors 404 when the floor panel 106 is stored or not in use, or not disposed on pedestals.

Referring to Figures 10 and 11, according to the second embodiment the floor panel 106 defines a cavity 602 for accommodating one or more antenna radiating elements 800. In the illustrated embodiment, the cavity 602 is located centrally with respect to the upwardly facing surface. The cavity 602 is defined by the outer casing 302. In more detail, the outer casing 302 extends over another surface of the antenna floor panel 106, which surface faces downwardly when the antenna floor panel 106 is installed as part of the raised floor 200.

The cavity 602 defined by the outer casing 302 may have sloping walls, as in the illustrated embodiment according to Figures 10 and 11, or walls which extend perpendicular to the second surface of the core 300. As in described in relation to the first embodiment, there is a field of view through the aperture 306 defined in a direction across the width of the floor panel 106 by an angle θ. If the field of view is wide, then the angular spread of a radiation pattern of the antenna radiating elements 800 will tend to be large. In the illustrated embodiment, the angle θ of the field of view is around 170°. Having such a wide field of view, and consequently having the radiation pattern spread horizontally as much as possible, allows the floor panel 106 to cover a larger proportion of the level 110 of the building 100 in which the floor panel 106 is located. The field of view can be varied in a number of ways, including, but not limited to: altering the shape of the outer casing 302 (e.g. the width and/or depth of the cavity 602); altering the size of the aperture 306, altering the radiation pattern of the antenna radiating element(s) 800 or selecting alternative antenna radiating elements 800, and the arrangement of the antenna radiating element(s) 800 within the cavity 602.

The dimensions of the floor panel according to the second embodiment may be similar to those described in relation to the first embodiment; that is, a width A of the core 300 of approximately 600mm and a depth B of the core 300 of approximately 30mm.

The outer casing 302 is releaseably attachable to the core 300 by one or more fastening mechanisms 1000. In the illustrated embodiment, four holes 802 are provided in the outer casing 302 through which the surface of the core 300 which faces downwards with the floor panel 106 installed as part of a raised floor is accessible. The fastening mechanism 1000 may be a bolt which can mate with a threaded bore of the core 300 configured to align with the holes 802 in the outer casing 302 in order to affix the core 300 to the outer casing 302. In an alternative, the fastening mechanisms 1000 may be screws which screw into the underside of the core 300 through this hole to affix the core 300 to outer casing 302, which

may be particularly applicable when the core 300 comprises wood or chipboard. By providing the fastening mechanisms 1000 on the underside of the core 300 of the floor panel 106, with the floor panel 106 installed as part of a raised floor, the cavity 602 of the floor panel 106 is sealed and inaccessible from above the raised floor. The cavity 602, containing the antenna radiating elements 800, may only be accessed by removing the floor panel 106 from the raised floor and undoing the fastening mechanisms 1000. This arrangement provides for increased security and a more tamper-proof wireless communications antenna, while allowing qualified or authorised personnel to access the cavity 602 of the floor panel to repair, replace or otherwise access the antenna radiating elements 800.

The floor panel 106 therefore serves both as a floor panel 106 for a raised floor and is also an antenna. The floor panel 106 may be configured to be a wireless communications antenna 600. The floor panel 106 configured as a wireless communications antenna 600 may be an antenna of a wireless communications network.

As in the first embodiment, corners 304 of the floor panel 106 may rest on pedestals 204 and be releasably attached to the pedestals 204 by a first fixing 308. In the second embodiment such fixing may be provided as described in relation to the first embodiment (as shown in Figure 5). In some embodiments, one or more shims (not shown) are provided between the corners 304 of the antenna floor panel 106 and the pedestals 204. The shims assist with levelling the floor panel 106, in particular to ensure that the upwardly facing surface of the antenna floor panel 106 is at the same height as the equivalent surfaces of the surrounding conventional floor panels 202.The illustrated embodiments, and the alternative embodiments that are described, only represent examples of how the ideas and concepts of the present disclosure can be implemented. Those skilled in the art will recognize that other embodiments for carrying out or practicing the ideas and concepts of the present disclosure are also possible. Modifications to illustrated embodiment, and to the alternative embodiments that are described, are possible without departing from the scope of the present disclosure as defined by the accompanying claims.

Expressions such as “including”, “comprising”, “incorporating”, “have”, “is” used to describe and claim the present disclosure are intended to be construed in a nonexclusive manner, namely allowing for items, components or elements not explicitly described also to be present. Reference to the singular is also to be construed to relate to the plural.

Reference numerals appearing in the claims are by way of illustration only and shall have no limiting effect on the scope of the claims.

Each feature disclosed in the description, and, where appropriate, the claims and drawings, may be provided independently or in any appropriate combination.

Claims

1. A floor panel for a raised floor, the floor panel comprising:

a core made of an RF-transparent material;

an outer casing extending around the core, the outer casing being metal;

a cavity between the outer casing and the core; and

an antenna radiating element for an antenna that is provided by the floor panel, the antenna radiating element being disposed within the cavity such that the core provides a radome for the antenna and the antenna radiating element also being electrically grounded on the outer casing such that the outer casing provides a ground plane for the antenna.

2. The floor panel of claim 1, wherein the outer casing has an aperture on a first surface of the floor panel, which first surface faces upwards when the floor panel is installed as part of the raised floor.

3. The floor panel of claim 2, wherein the aperture extends over a width of the first surface that is greater than a width of the cavity across the floor panel.

4. The floor panel of claim 2 or claim 3, wherein the aperture extends over the entire first surface of the floor panel.

5. The floor panel of any one of the preceding claims, wherein the core is secured to the outer casing by one or more fastening mechanisms on a second surface of the core, which surface faces downwards when the floor panel is installed as part of the raised floor.

6. The floor panel of any one of claims 2 to 5, wherein the aperture has a width sufficient to provide an angular spread of line of sight radiation from the centre of the floor panel, unobstructed by the outer casing, over 150° or more in at least one plane tilted with respect of a plane parallel to the floor panel.

7. The floor panel of any one of the preceding claims, wherein the outer casing provides structural support to the core, preferably wherein the outer casing increases the strength of the floor panel with respect to shear forces applied when the floor panel in installed as part of the raised floor.

8. The floor panel of any one of the preceding claims, further comprising a sensor, preferably, a footfall sensor, humidity sensor, water sensor, noise sensor, temperature, impact or light sensor.

9. The floor panel of any one of the preceding claims, further comprising an antenna connector coupled to the antenna radiating element.

10. The floor panel of claim 9, wherein a first portion of the antenna connector is disposed inside the cavity and a second portion of the antenna connector extends through the outer casing to an exterior of the cavity.

11. The floor panel of claim 9 or claim 10, wherein the antenna radiating element is electrically grounded on the outer casing via the antenna connector.

12. The floor panel of any one of the preceding claims, further comprising a spacing arrangement extending from the outer casing such that the floor panel can be placed on a substantially flat surface with the floor panel contacting the substantially flat surface only at the spacing arrangement.

13. The floor panel of any one of the preceding claims, wherein the antenna radiating element is a bent wire or planar inverted-F antenna radiating element.

14. The floor panel of any one of the preceding claims, wherein the antenna comprises a plurality of antenna radiating elements disposed within the cavity such that the core provides a radome for the antenna and electrically grounded on the outer casing such that the outer casing provides a ground plane for the antenna.

15. The floor panel of any one of the preceding claims, wherein the core is made of one of: plywood, chipboard, glass fibre reinforced concrete or glass fibre reinforced plastic.

16. The floor panel of any one of the preceding claims, wherein the as antenna is an antenna of a cellular telephone network, a private mobile radio network and/or a wireless local area network.

17. A raised floor comprising the floor panel of any one of the preceding claims.

18. A kit of parts for a raised floor comprising: the floor panel of any one of claims 1 to 16; one or more other floor panels; and pedestals on which the floor panel and the one or more other floor panels are supported in use.