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(54) **Door handle device**

(57) Provided is a door handle device incorporated with an antenna that can prevent the magnetic flux produced from the electro-conductive members from impairing the performance of the antenna. The door handle device comprises an antenna coil 11 for external communication formed by winding copper wire and a circuit board 10 including a ground pattern 32 and detection electrode patterns 33 and 34 that are received in a door

handle 5, and the ground pattern 32 and detection electrode patterns 33 and 34 are each provided with a plurality of slits 32S, 33S and 34S extending in parallel with an axial line A around which the antenna coil 11 is wound. The provision of the slits prevents generation of eddy current in each electro-conductive pattern which otherwise would interfere with the performance of the antenna.

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Description

TECHNICAL FIELD

[0001] The present invention relates to a door handle device that is suitable for use as a part of a smart entry system for motor vehicles and buildings.

BACKGROUND OF THE INVENTION

[0002] An increasing number of current motor vehicles are fitted with a smart key system that enables a vehicle operator to unlock a door and start the engine simply carrying a smart key (electronic key) on him or her to improve the convenience and security of the vehicle. A main body (onboard unit) of a smart entry system is provided with a capacitive sensor that is configured to detect a vehicle operator's hand holding a door handle or being brought close to the door handle. Upon detecting the vehicle operator's hand, the onboard unit communicates with the smart key via an antenna incorporated in the door handle and unlocks the door when the ID code transmitted from the smart key matches with an ID code stored in ROM of the onboard unit. Typically, in a vehicle fitted with a smart entry system, an antenna is incorporated in a door handle and a trunk lid, and the onboard unit communicates with the electronic key via such an antenna.

[0003] A vehicle fitted with a smart entry system is typically provided with a hollow door handle consisting of a handle main body and an outer cover. The hollow interior of the door handle receives a circuit board that is formed with a pair of detection electrodes serving as proximate sensor electrodes and a detection circuit for detecting changes in the electrostatic capacitance between the two electrodes. Japanese patent laid open publication No. 2005-098030 discloses a door handle that is formed as a highly low-profile component by forming the electrodes as electro-conductive patterns formed on the circuit board. Japanese patent laid open publication No. 2004-324098 discloses a door handle that receives an antenna for communicating with a smart key and proximate sensor electrodes within the hollow interior of the door handle.

[0004] However, in a conventional door handle device incorporated with an antenna and proximate sensor electrodes, when electric current is conducted through the antenna coil formed by winding conductive wire, a magnetic flux produced from the antenna passes through the electrodes consisting of electro-conductive members provided on the circuit board, and this electro-magnetically induces eddy current in the electrodes. The eddy current in turn produces a magnetic flux which tends to cancel the magnetic flux of the antenna, and this impairs the performance of the antenna (or causes such problems as a reduced communication range of the antenna).

BRIEF SUMMARY OF THE INVENTION

[0005] In view of such problems of the prior art, a primary object of the present invention is to provide a door handle device incorporated with an antenna for external communication and an electro-conductive member as a functional component that can provide an adequately functional electro-conductive member without impairing the performance of the antenna.

[0006] A second object of the present invention is to provide a door handle device that is incorporated both with an antenna for external communication and with an electro-conductive member as a functional component as a highly compact unit without impairing the performance of either component.

[0007] A third object of the present invention is to provide a door handle device incorporated with an antenna for external communication and an electro-conductive member as a functional component that is made free from interferences between the two components with a minimum modification to an existing design.

[0008] According to the present invention, at least some of these objects can be accomplished by providing a door handle device, comprising a door handle, an antenna incorporated in the door handle for external radio wave communication and a circuit board incorporated in the door handle and including an electro-conductive member, characterized by that: the electro-conductive member comprises a slit.

[0009] The slit breaks up path for conducting eddy current so that less eddy current is produced in the electro-conductive pattern as compared to an electro-conductive member without such a slit. Therefore, the magnetic flux which is otherwise produced by the eddy current and tends to cancel the magnetic flux of the antenna is minimized. In other words, the impairment of the performance of the antenna is avoided, and a stable communication can be ensured.

[0010] Typically, the antenna comprises a coil of electro-conductive wire, and the door handle defines a hollow interior and the antenna and circuit board are received in the hollow interior of the door handle, as is often the case with door handle devices for smart entry systems. To minimize the generation of eddy current in the electro-conductive member, preferably, the door handle is elongated along an axial line, and the electro-conductive member is elongated along the axial line, the slit extending substantially over an entire length of the electro-conductive member.

[0011] To maximize the effect of preventing eddy current, the electro-conductive member may be provided with a plurality of slits extending in parallel to one another and/or in parallel to an axial line around which the coil is wound. Such slits may be closed at both ends or may be closed at one end and are open at the other end.

[0012] The electro-conductive member may comprise an electrode for a proximity sensor that can be used as a part of a smart entry system. For instance, antenna

may be configured to be used for communication with a key of a smart entry system while the electro-conductive member comprises a detection electrode of an unlock sensor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Now the present invention is described in the following with reference to the appended drawings, in which:

Figure 1 is a front view of the antenna device;
 Figure 2 is a sectional view taken along line II-II of Figure 1;
 Figure 3 is a sectional view taken along line III-III of Figure 1;
 Figure 4 is an exploded perspective view of the door handle device;
 Figure 5 is a front view of the sensor/antenna unit;
 Figure 6 is a simplified, sectional view taken along line VI-VI of Figure 5;
 Figure 7 is a sectional view taken along line VII-VII of Figure 6;
 Figure 8 is a sectional view taken along line VIII-VIII of Figure 6;
 Figure 9 is a simplified sectional view taken along line IX-IX of Figure 5;
 Figure 10 is a front view showing the magnetic flux produced from the antenna;
 Figure 11 is a front view showing the detection electrode patterns according to a modified embodiment of the present invention; and
 Figure 12 is a front view showing the ground electrode pattern according to the modified embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] Referring to Figures 1 and 2, the door handle device 1 comprises a handle base 3 fixedly attached to an outer surface of an outer panel 2 of an automotive door, a door handle 5 pivotally attached to the handle base 3 via a pin 4 and a key slot 6 provided in the handle base 3.

[0015] Referring to Figures 2 to 4, the door handle 5 comprises an antenna/sensor unit 7 and a handle main body 8 and outer cover 9 receiving the antenna/sensor unit 7 therein. The antenna/sensor unit 7 comprises a circuit board 10 disposed on the side of the handle main body 8, an antenna coil 11 and circuit components 12 and 13 that are mounted on the side of the circuit board 10 facing the outer cover 9 and a lock sensor 15 connected to the circuit board 10 via a wire harness 14. In the illustrated embodiment, the circuit board 10 is provided with an elongated rectangular shape having a pair of mutually parallel sides so as to be snugly received in the hollow interior of the door handle 5.

[0016] Referring to Figure 2, the antenna coil 11 and circuit components 12 and 13 as well as a part of the wire harness 14, are sealed in potting material 16 such as polyurethane resin for protection from impact, moisture and corrosion. The lock sensor 15 comprises a lock sensor case 17 and a detection electrode 18 provided inside the lock sensor case 17 and connected to the wire harness 14, and the interior of the lock sensor case 17 is also filled with potting material 19 consisting of such material as polyurethane resin.

[0017] As a vehicle operator's hand is brought close to the handle main body 8, an unlock sensor and circuit component 13 mounted on the circuit board 10 detect the approaching hand, and this initiates a communication with a smart key carried by the vehicle operator via the antenna coil 11 so as to determine if the hand belongs to the authorized vehicle operator. A receiver unit provided on the side of the vehicle receives an ID code transmitted from the smart key, and unlocks the door if the ID code is verified. As the user's hand is brought close to the lock sensor 15, the lock sensor 15 detects the approach of the user's hand whereupon a communication with the smart key is effected via the antenna coil 11. Again, if the ID code is verified, the door is locked.

[0018] Referring to Figures 3 and 4, the antenna/sensor unit 7 is received in the door handle 5, interposed between the handle main body 8 and outer cover 9. The antenna coil 11 comprises a bobbin 22 incorporated with a magnetic core 21 (see Figure 5) made of such magnetic material as ferrite and a coil 23 made of copper wire (electro-conductive wire) wound around the bobbin 22, and is electrically connected to the circuit component 12. Although not shown in Figure 4, the antenna coil 11 and circuit components 12 and 13 as well as a part of the wire harness 14 are sealed in potting material such as polyurethane resin as mentioned earlier.

[0019] Referring to Figures 5 and 6, the antenna/sensor unit 7 comprises a circuit board 10, antenna coil 11 mounted on the circuit board 10 for communication with the smart key, circuit components 12 and 13 mounted on the circuit board 10 and lock sensor 15 connected to an end of the circuit board 10 via the wire harness 14. In Figure 6, for the clarity of illustration, the thickness of the circuit board 10 is exaggerated from the actual thickness.

[0020] As shown in Figures 6 to 9, the circuit board 10 is provided with three layers 10a to 10c each formed by glass fiber reinforced epoxy resin and joined to one another with a bonding agent. The first layer or power source layer 10a adjacent to the antenna coil 11 is formed with a power source pattern 31 for a capacitive proximity sensor that forms a part of an unlock sensor for the smart entry system, the second layer or ground layer 10b is formed with a ground pattern 32 for the capacitive proximity sensor, and the third layer or detection electrode layer 10c is formed with detection electrode patterns 33 and 34 for the capacitive proximity sensor. In the illustrated embodiment, each pattern 31, 32, 33, 34 is made of copper foil having a thickness in the order of several

tens of mm.

[0021] As shown in Figure 7, the detection electrode patterns 33 and 34 are formed in a mutually symmetric pattern with respect to a central axial line of the detection electrode layer 10c. When a vehicle user holds the door handle or a vehicle user's hand is brought close to the door handle, the resulting change in the capacitive value between the two electrodes 33 and 34 is detected by a detection circuit. The circuit component 13 includes a CR oscillator circuit which starts oscillation depending on the change in the capacitive value between the two electrodes 33 and 34 so that an approach of an object may be detected as an increase in the amplitude of the oscillation. As shown in Figure 8, the ground pattern 32 is formed on the ground layer 10b, and protects the detection electrode patterns 33 and 34 from external noises by being kept at the ground voltage. The power source pattern 31 is arranged in such a manner that a bypass capacitor is in effect interposed between the ground pattern 32 and power source pattern 31, and this allows omission of a bypass capacitor for noise suppression.

[0022] As shown in Figure 7, the two detection electrode patterns 33 and 34 extend in parallel with an axial line around which the antenna coil is wound or in parallel with the long sides of the circuit board 10, and are each provided with a plurality of slits 33S, 34S which each extend substantially over an entire length of the detection electrode pattern and are closed at each longitudinal end. More specifically, each detection electrode pattern 33, 34 consists of a plurality of elongated conductive members 33C, 34C which extend in parallel with the axial line around which the antenna coil is wound, and are joined with adjacent ones 33C, 34C at each axial end.

[0023] Similarly, the ground pattern 32 illustrated in Figure 8 is provided with a plurality of slits 32S which each extend substantially over an entire length of the ground pattern and are closed at both longitudinal ends. More specifically, each ground pattern 32 consists of a plurality of elongated conductive members 32C which extend in parallel with the axial line around which the antenna coil is wound, and are each joined with adjacent ones 32C at each axial end.

[0024] As shown in Figures 7 and 8, the detection electrode layer 10c and ground layer 10b are each formed with a plurality of through holes 32H, 33H, 34H extending across the thickness of the circuit board 10. Each through hole 32H, 33H, 34H is connected to a circuit pattern (not shown in the drawings) formed on the surface of the power source layer 10a (see Figure 6) carrying the circuit components 12 and 13, and to the circuit component 13 via this circuit pattern. As shown in Figure 7, the detection electrode pattern 33 receives power via the through hole 33H, and the detection electrode pattern 34 receives power via the through hole 34H. As shown in Figure 8, the ground pattern 32 receives power via the through hole 32H.

[0025] As shown in Figures 7 to 9, as seen on the plan view of the circuit board 10, the two detection electrode

patterns 33 and 34 extend along the long sides of the circuit board 10 in a mutually spaced and parallel relationship. The ground pattern 32 is disposed along the center line of the circuit board 10 substantially without significantly overlapping the detection electrode patterns 33 and 34 so as to minimize the electrostatic capacitance between the ground pattern 32 and each of the detection electrode patterns 33 and 34. If this electrostatic capacitance is significant, it adds to the intrinsic base capacitance of the circuit board 10, and the change in the electrostatic capacitance when a user's hand is brought close to or into contact with the door handle is reduced. If the sensitivity in detecting the change in the electrostatic capacitance between the detection electrode patterns 33 and 34 is increased to compensate for this problem, an excessively high noise level is produced.

<Operation of the Embodiment>

[0026] As illustrated in Figure 10, when electric current is conducted through the copper wire wound around the bobbin 22, a magnetic flux B is produced. The circuit board 10 incorporated with the various electro-conductive members such as the power source pattern 31, detection electrode patterns 33 and 34 and ground pattern 32 is disposed in parallel with the antenna coil 11 so that the magnetic flux B from the antenna coil 11 passes through the electro-conductive members, and eddy current is produced in each of the electro-conductive patterns as a result of electromagnetic induction. The generated eddy current in turn produces a magnetic flux which is opposite in sense to the magnetic flux of the antenna coil 11 so that the magnetic fluxes from the antenna coil 11 and the electro-conductive members cancel each other. The resulting reduction in the magnetic flux of the antenna coil 11 means a reduction in the communication performance of the antenna coil 11.

[0027] However, as shown in Figure 7, the detection electrode patterns 33 and 34 are each configured such that the pattern includes a plurality of slits 33S, 34S extending substantially in parallel with the axial line A around which the antenna coil 11 is wound and terminating or being closed at each axial end. Therefore, the detection electrode patterns 33 and 34 are made less prone to generate eddy current which otherwise would produce a magnetic flux that opposes the magnetic flux of the antenna.

[0028] Also, as shown in Figure 8, the ground pattern 32 is configured such that the pattern includes a plurality of slits 32S extending substantially in parallel with the axial line A around which the antenna coil 11 is wound and terminating or being closed at each axial end. Therefore, the ground pattern 32 is made less prone to generate eddy current which otherwise would produce a magnetic flux that opposes the magnetic flux of the antenna.

<Modified Embodiment(s)>

[0029] The slits 32S, 33S and 34S in the foregoing embodiments extended in parallel with the axial line around which the coil is wound. However, it is also possible to form the slits so as to extend perpendicularly to the axial line or vertically as seen in the drawings such as Figures 7 and 8.

[0030] Referring to Figure 11, the detection electrode patterns 33 and 34 of the modified embodiment are each configured such that the pattern includes a plurality of slits 33S, 34S extending substantially in parallel with the axial line A around which the antenna coil 11 is wound and opening at one of the axial ends. In other words, the detection electrode patterns 33 and 34 each comprise a plurality of elongated conductive members 33C, 34C extending in parallel with the axial line A around which the antenna coil 11 is wound and being merged with adjacent ones at one end so as to define a comb-shaped pattern.

[0031] Referring to Figure 12, the ground pattern 32 of the modified embodiment is configured such that the pattern includes a plurality of slits 32S extending substantially in parallel with the axial line A around which the antenna coil 11 is wound and opening at one of the axial ends. In other words, the ground pattern 32 comprises a plurality of elongated conductive members 32C extending in parallel with the axial line A around which the antenna coil 11 is wound and being merged with adjacent ones at one end so as to define a comb-shaped pattern.

[0032] In this modified embodiment also, if desired, the slits may extend perpendicularly to the axial line or vertically as seen in the drawings such as Figures 11 and 12.

[0033] The description of the specific embodiments of the present invention is now concluded, but the foregoing embodiments are not intended to limit the present invention. For instance, the detection electrode patterns and ground pattern are not necessarily required to be made of copper foil but may also be made of brass or other electro-conductive thin plate. The slits formed in each electro-conductive member may not necessarily extend continually from one lengthwise end to another, but may have breaks in intermediate parts thereof. The antenna coil for external communication of the illustrated embodiments used ferrite for its core, but the core may also be made of other material such as Fe-Al-Si alloy and Fe-Ni alloy having a high magnetic permeability at high frequency, and the antennal coil may have no magnetic core (air core).

[0034] The greater the number of the slits in each detection electrode pattern is or the smaller the width of each electro-conductive member forming each detection electrode pattern is, the higher the communication performance of the antenna coil becomes. However, it suffices if each detection electrode pattern has at least one slit. The same is true with the ground pattern for the purpose of improving the performance of the antenna coil.

[0035] The detection electrode patterns and ground pattern of the illustrated embodiments were each provided

with slits extending in parallel with an axial line A around which the antenna coil is wound in the foregoing embodiments, but the slits are not necessarily required to extend in parallel with an axial line A around which the antenna coil is wound. The slits may extend perpendicularly as briefly mentioned above or obliquely to the axial line A around which the antenna coil is wound.

[0036] The slits formed in each pattern were open at one end of the pattern, but the open end may not necessarily be located on the left side in the drawings as was the case in the foregoing embodiment and may also be located on the right side in the drawings. It is also possible to adopt a staggered arrangement in which the slits change the open side from one slit to the next so that the final pattern may appear as a pair of mutually opposing and interdigitated combs. Alternatively, each pattern may consist of a plurality of elongated strips extending in mutually parallel relationship defining a slit between each pair of adjacent strips and the strips may be commonly connected by a perpendicular strip in an intermediate part thereof. In other words, the slits may be open at both ends but are broken or closed in an intermediate by the perpendicular strip. Also, the slits may not be linear, but may consist of curving lines and may have varying widths.

[0037] Although the present invention has been described in terms of preferred embodiments thereof, it is obvious to a person skilled in the art that various alterations and modifications are possible without departing from the scope of the present invention which is set forth in the appended claims.

[0038] The contents of the original Japanese patent applications on which the Paris Convention priority claim is made for the present application are incorporated in this application by reference.

Claims

1. A door handle device, comprising a door handle (5), an antenna (11) incorporated in the door handle for external radio wave communication and a circuit board (10) incorporated in the door handle and including an electro-conductive member (32, 33, 34), **characterized by that:**

the electro-conductive member comprises a slit (32S, 33S, 34S).

2. The door handle device according to claim 1, wherein the antenna comprises a coil (11) of electro-conductive wire.
3. The door handle device according to claim 2, wherein the electro-conductive member is provided with a plurality of slits extending in parallel to an axial line around which the coil is wound.
4. The door handle device according to claim 1, where-

in the door handle defines a hollow interior and the antenna and circuit board are received in the hollow interior of the door handle.

5. The door handle device according to claim 1, wherein the door handle is elongated along an axial line (A), and the electro-conductive member is elongated along the axial line, the slit extending substantially over an entire length of the electro-conductive member. 5
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6. The door handle device according to claim 1, wherein the electro-conductive member is provided with a plurality of slits extending in parallel to one another. 15
7. The door handle device according to claim 6, wherein the slits are closed at both ends.
8. The door handle device according to claim 6, wherein the slits are closed at one end and are open at the other end. 20
9. The door handle device according to claim 1, wherein the electro-conductive member comprises an electrode for a proximity sensor. 25
10. The door handle device according to claim 1, wherein the antenna is configured to be used for communication with a key of a smart entry system and the electro-conductive member comprises a detection electrode of an unlock sensor. 30

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Fig.1

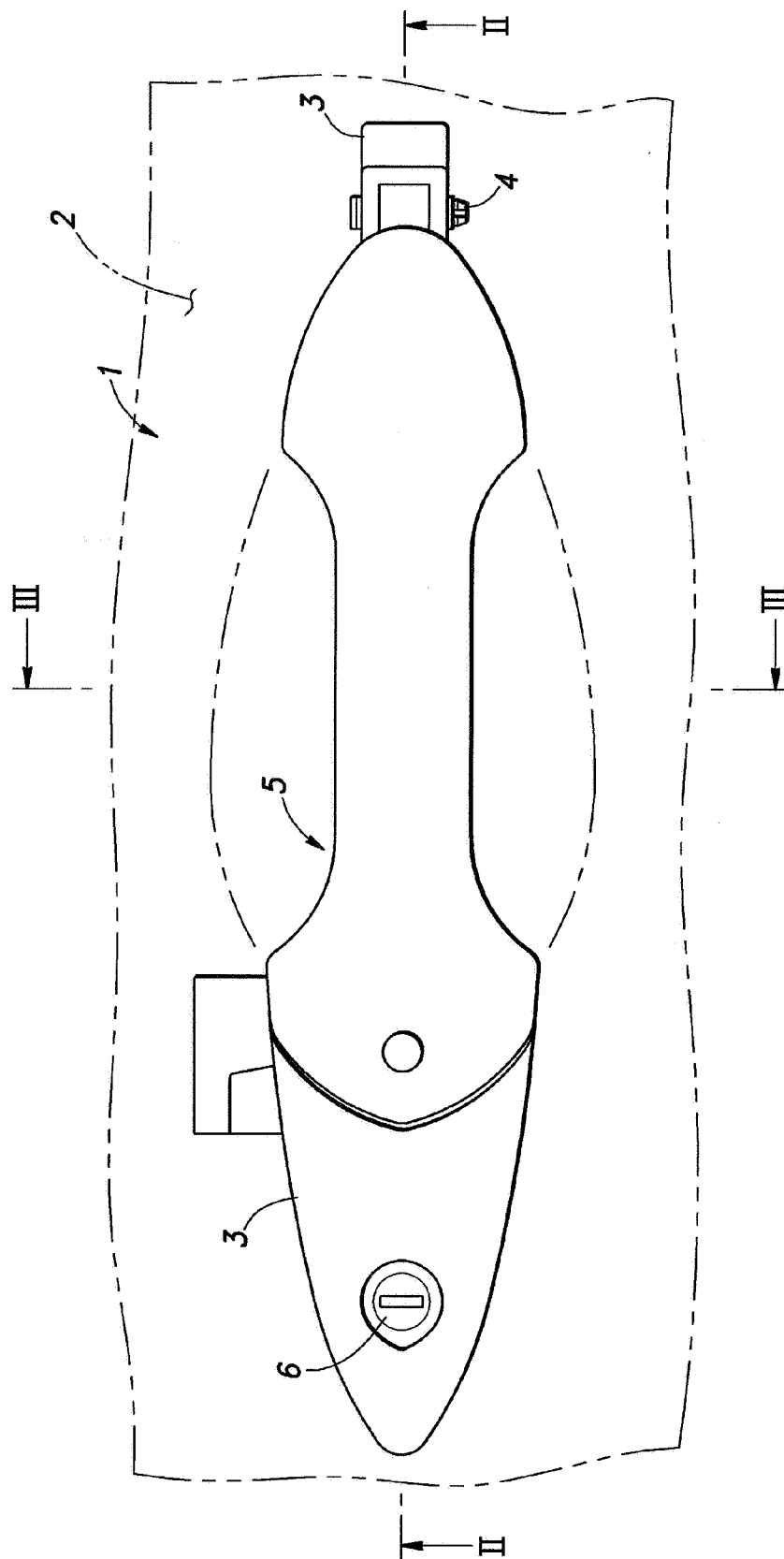


Fig.2

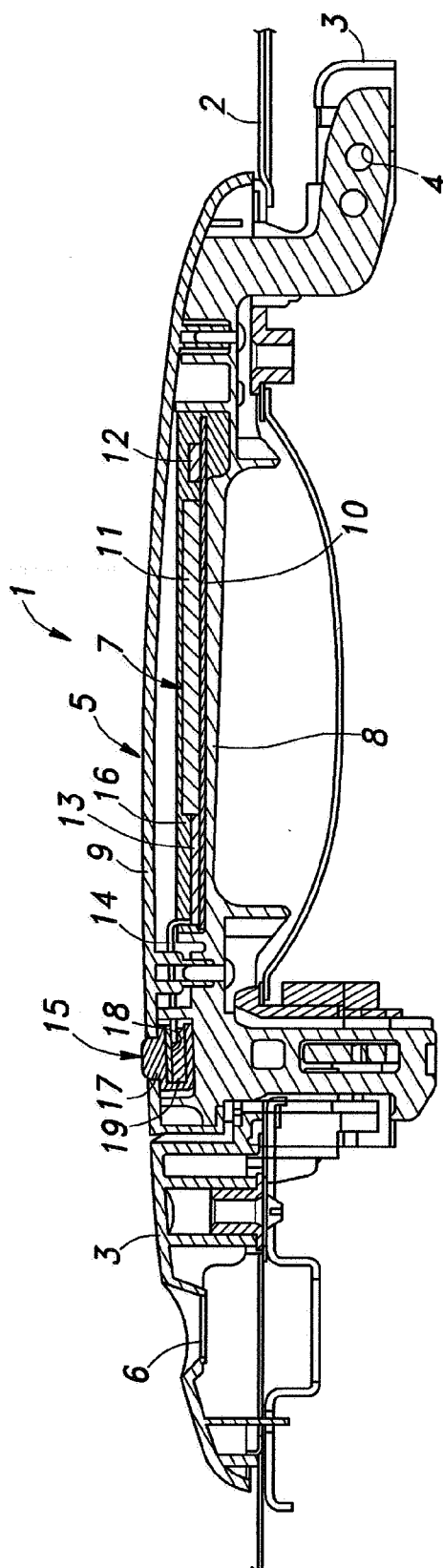


Fig.3

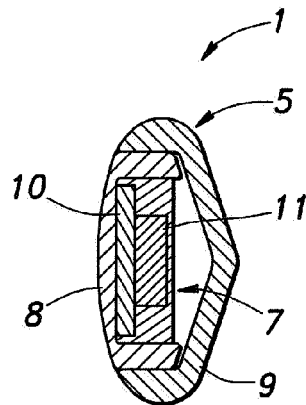


Fig.4

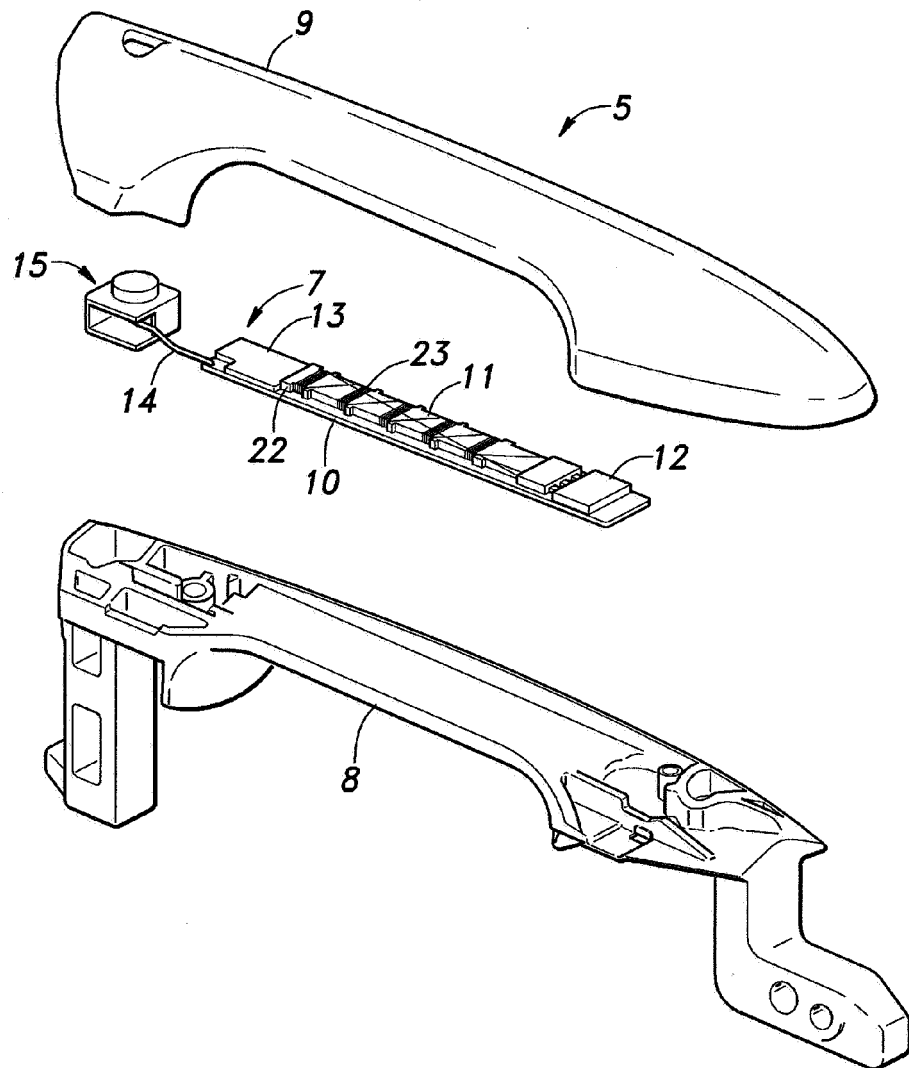


Fig.5

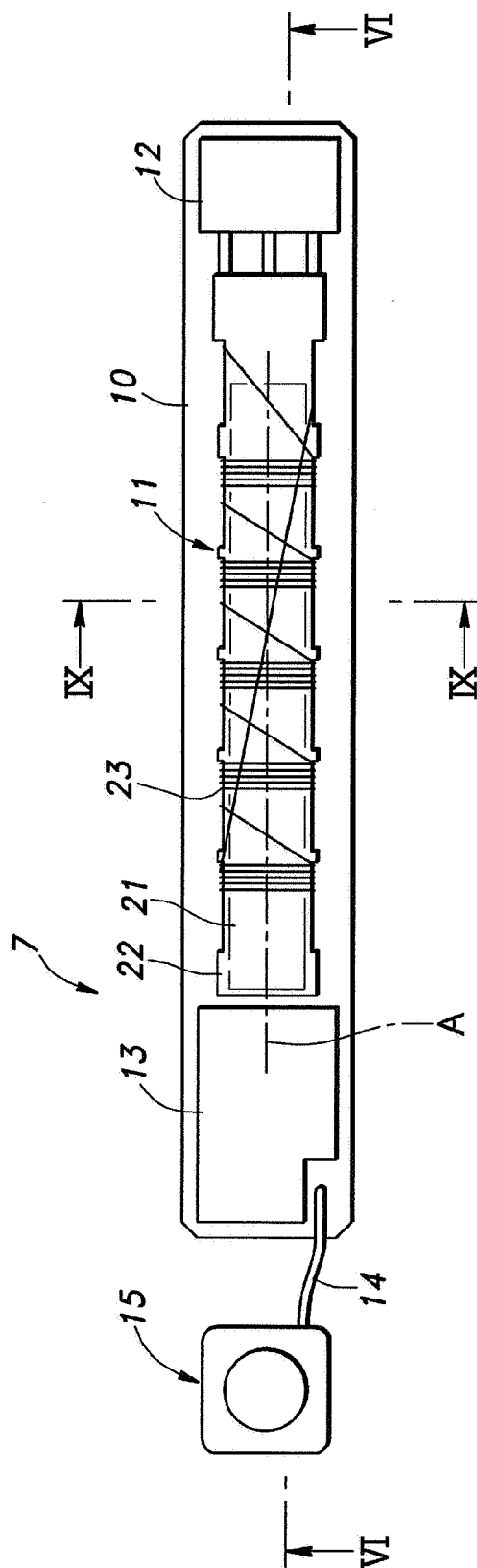
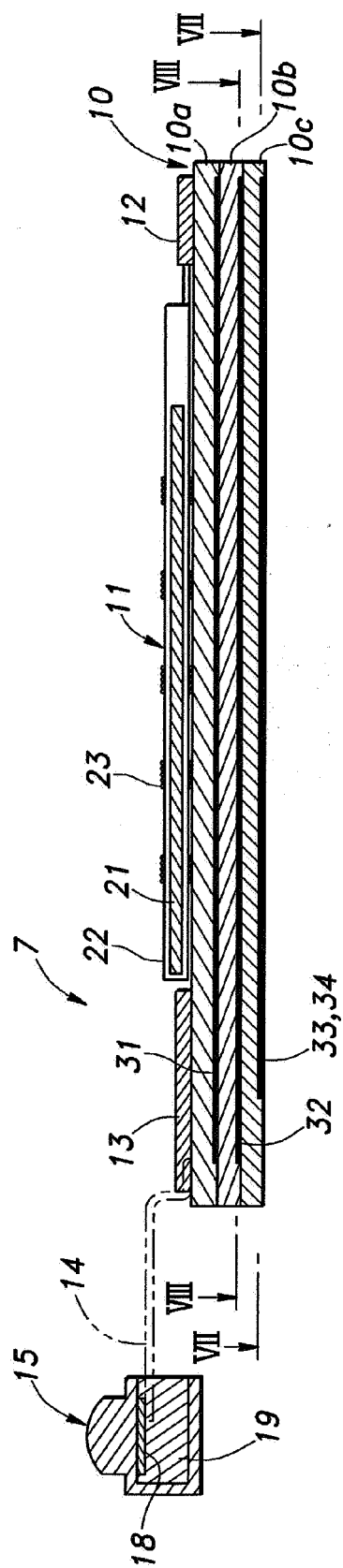


Fig. 6



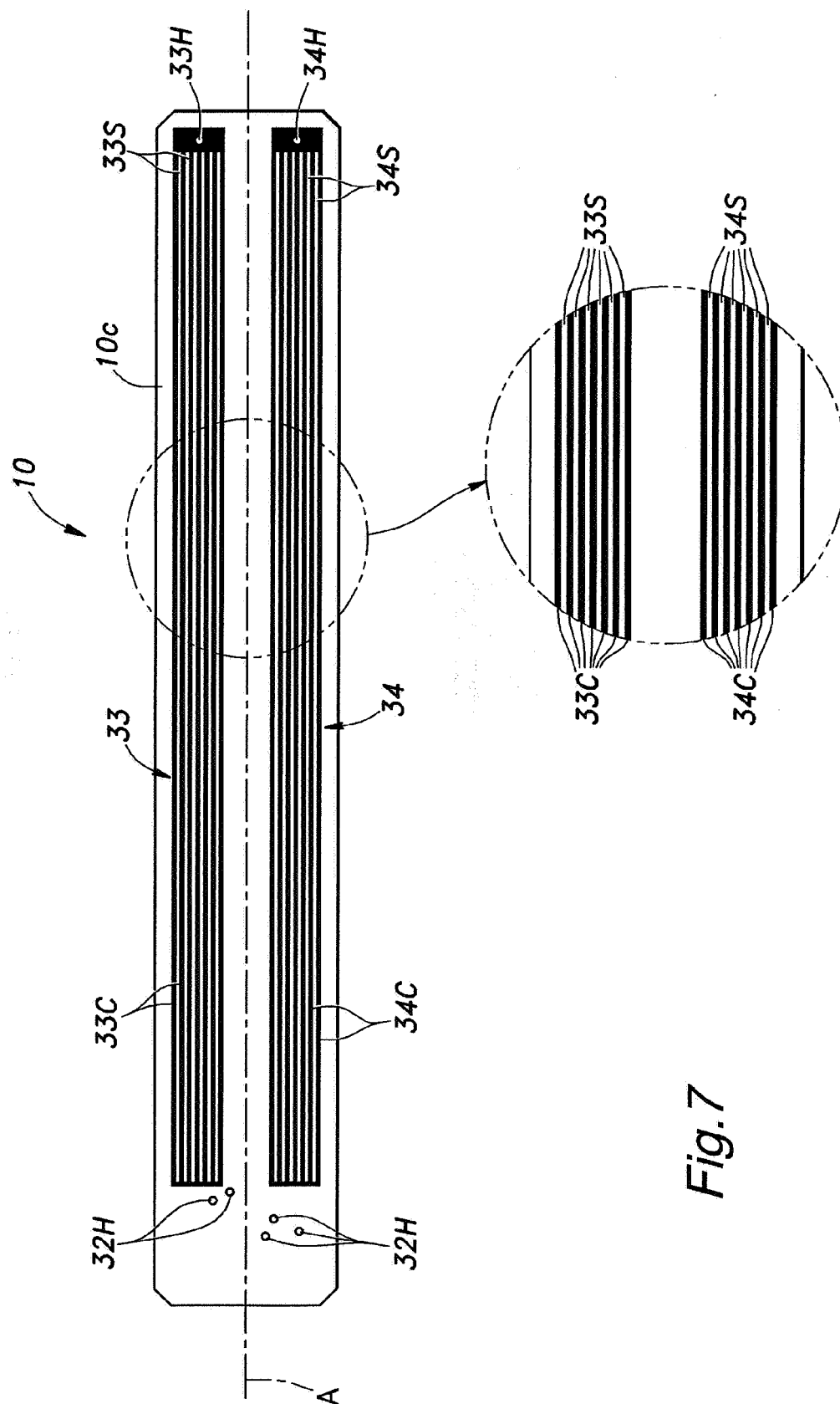


Fig. 7

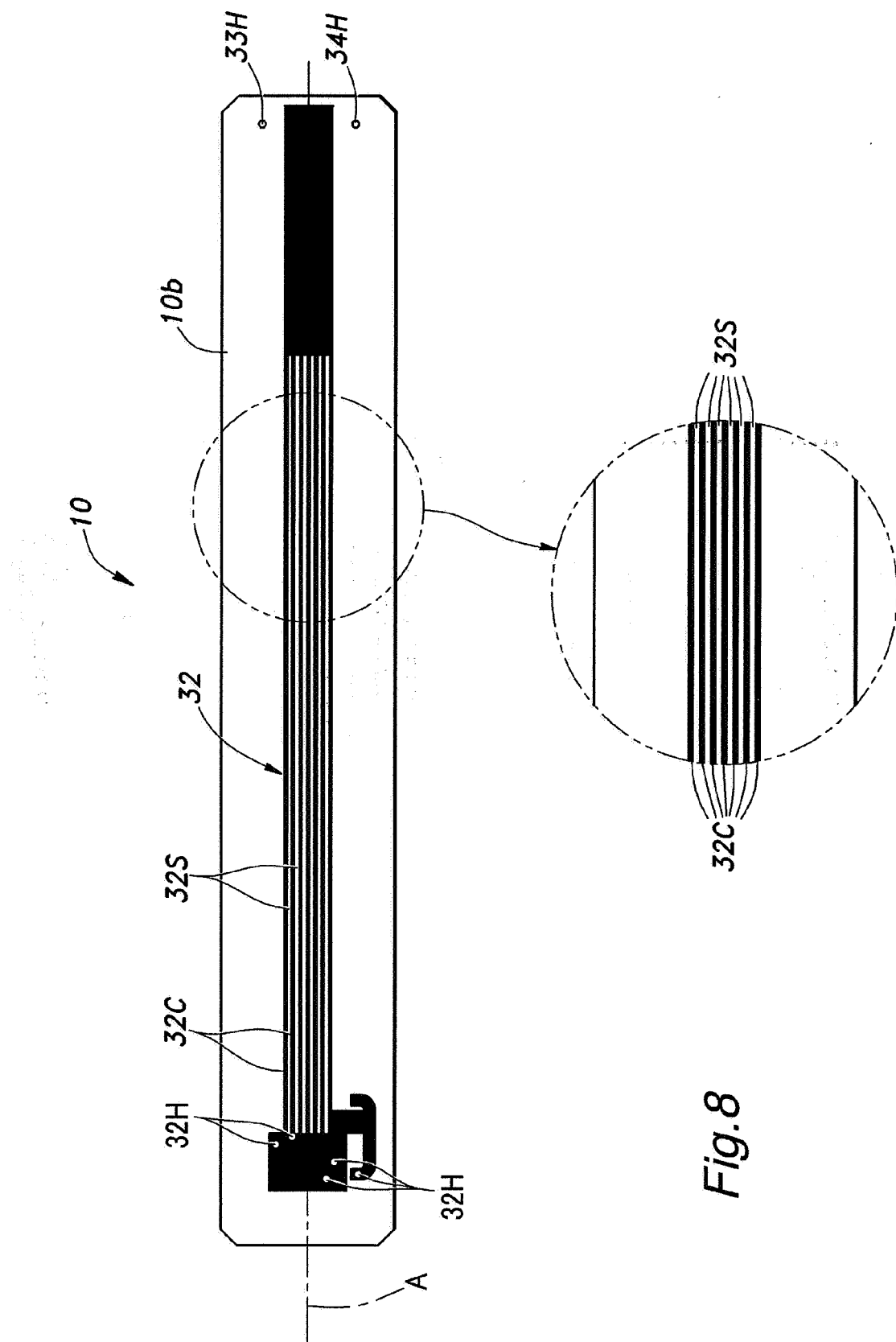


Fig. 8

Fig.9

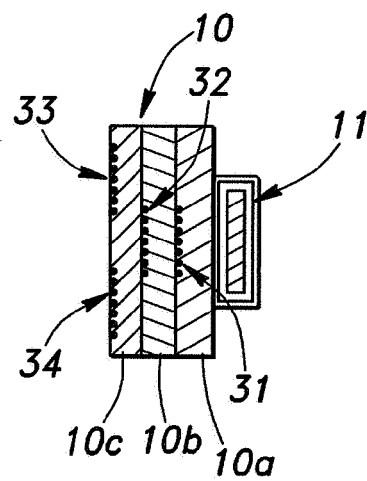
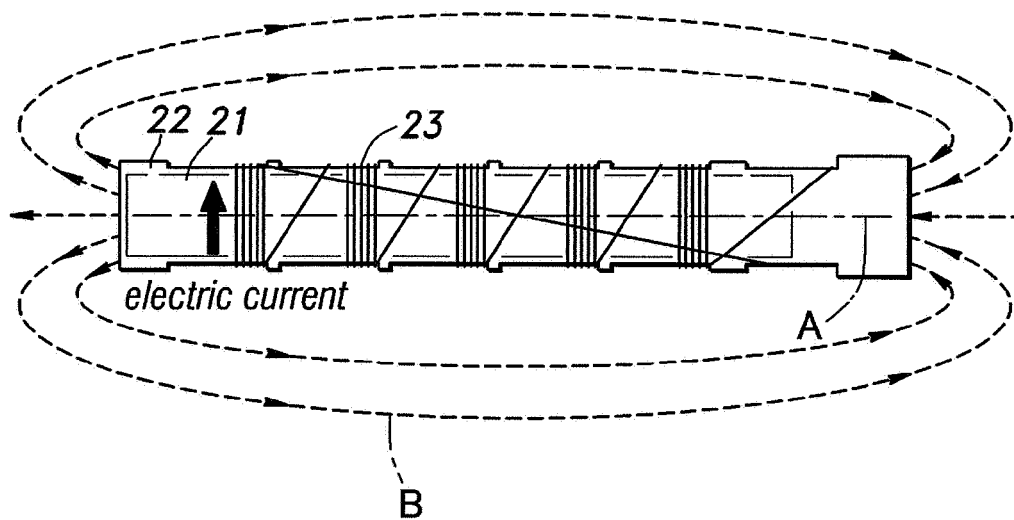


Fig.10



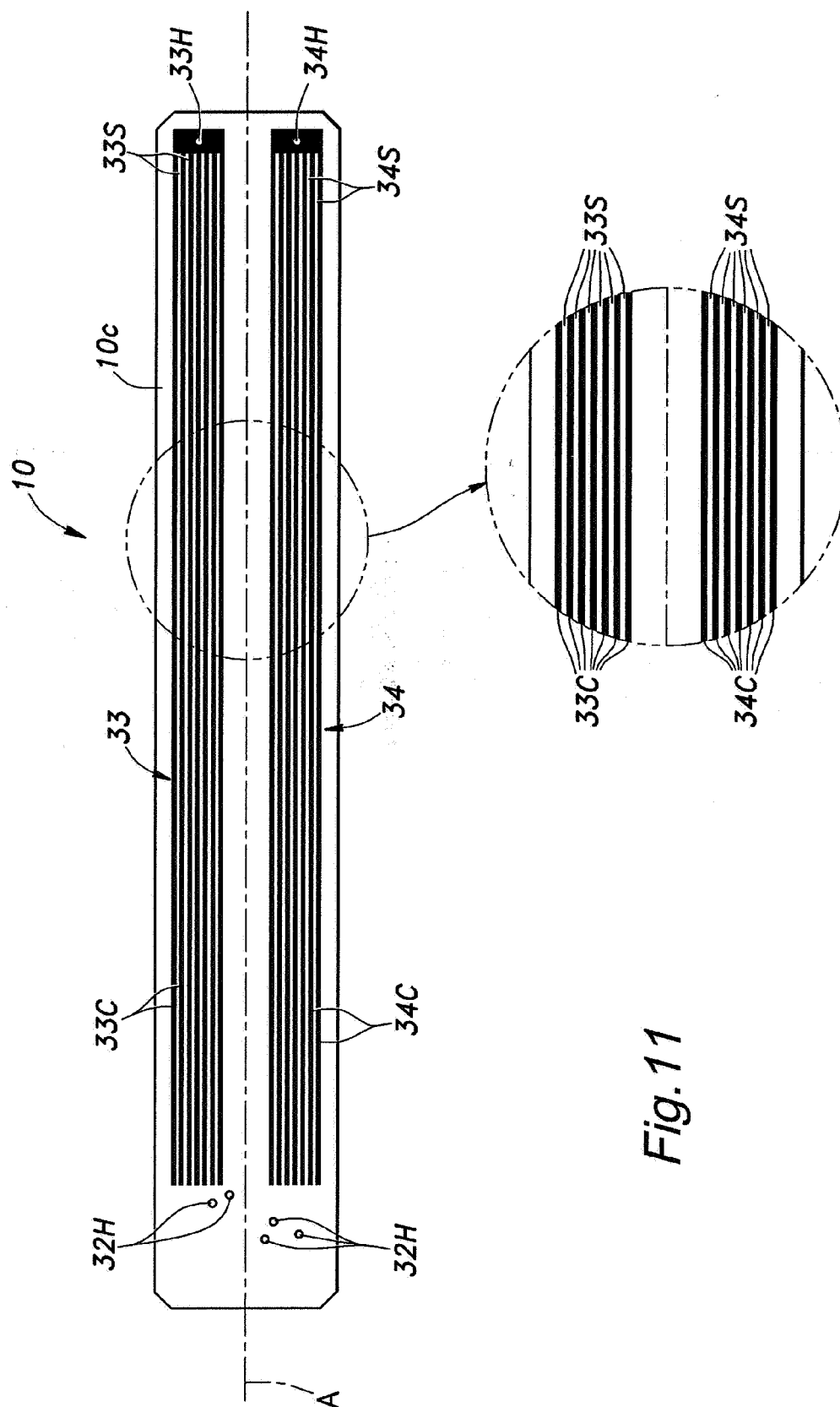


Fig. 11

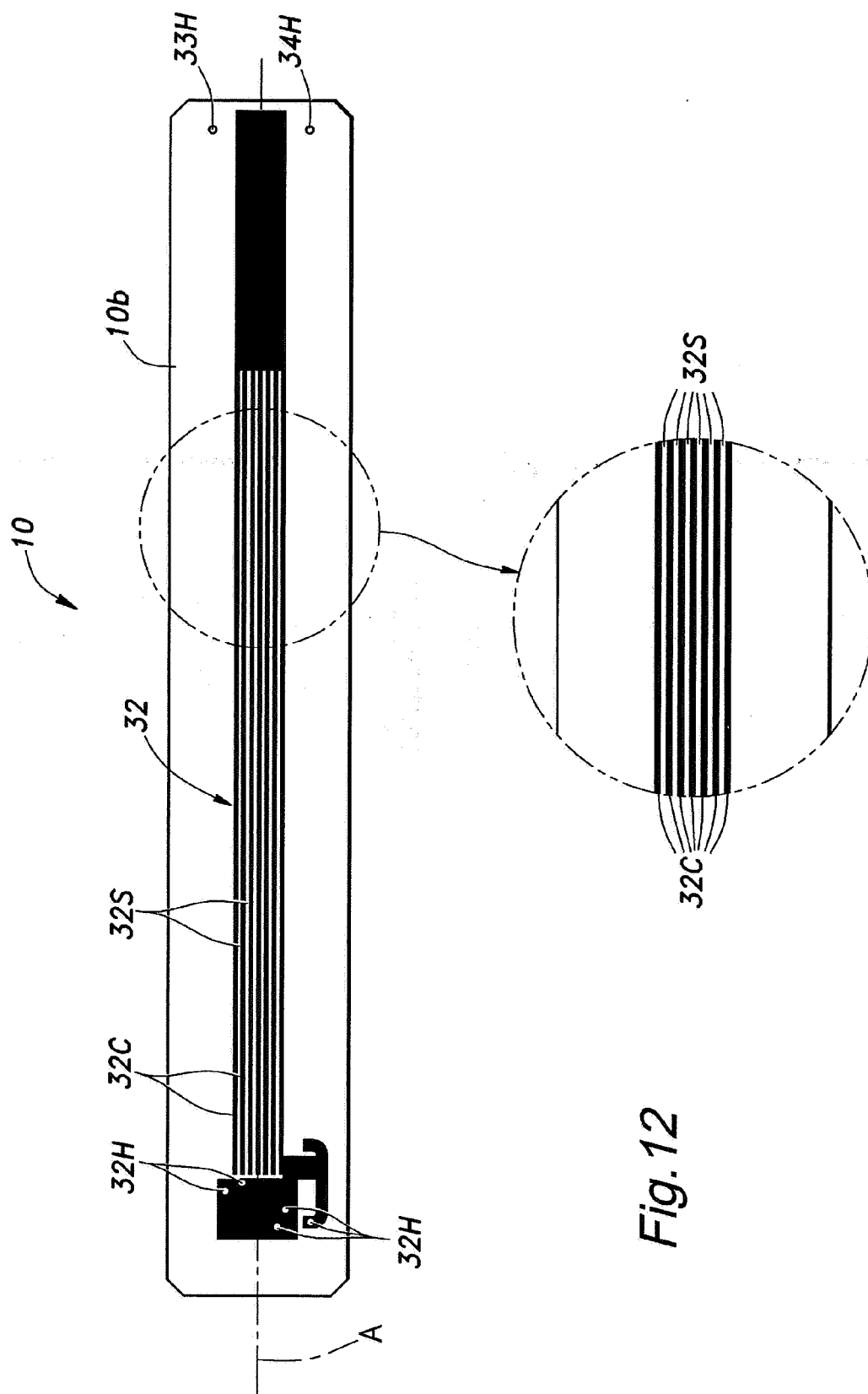


Fig. 12

REFERENCES CITED IN THE DESCRIPTION

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