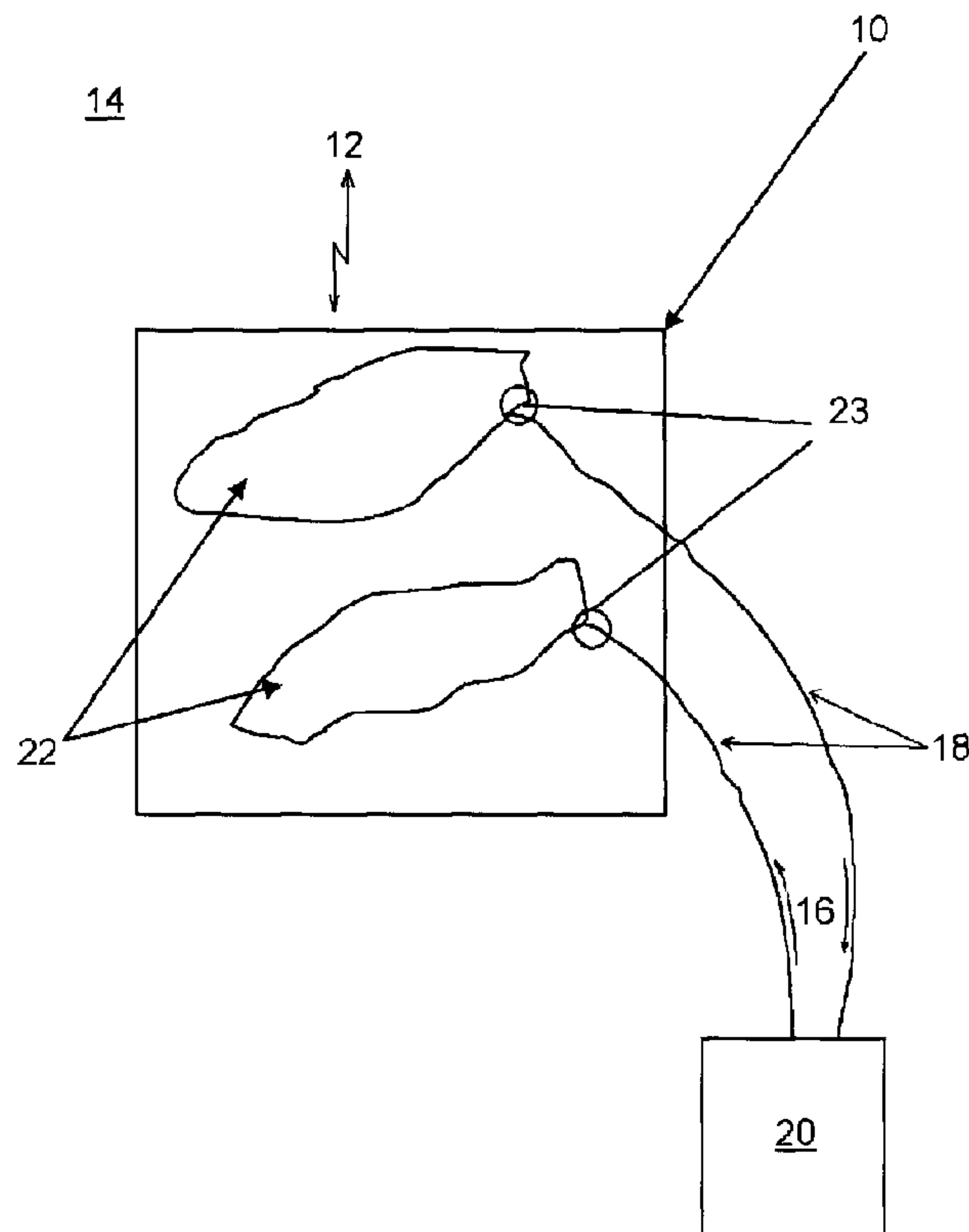




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(54) Titre : ANTENNE SUR CIRCUIT IMPRIME COMPORTANT DES PARTIES SUPPRIMABLES POUR AJUSTER DES FREQUENCES DE RESONANCE
(54) Title: PCB ANTENNA HAVING REMOVAL PORTIONS FOR ADJUSTING RESONANCE FREQUENCIES



(57) Abrégé/Abstract:

A tuneable antenna whose signal element(s) and/or ground element(s) can have their respective areas altered by removing predefined removal portions of the substrate on which the antenna is formed. In this manner, a single antenna can be designed for use in multiple devices, or for use in devices which are subject to multiple configurations and/or for use in devices which operate at different radio frequencies. Preferably, the antenna provides a consistent set of mounting points such that the antenna can be mounted in a variety of devices in the same manner, independently of its tuned state.



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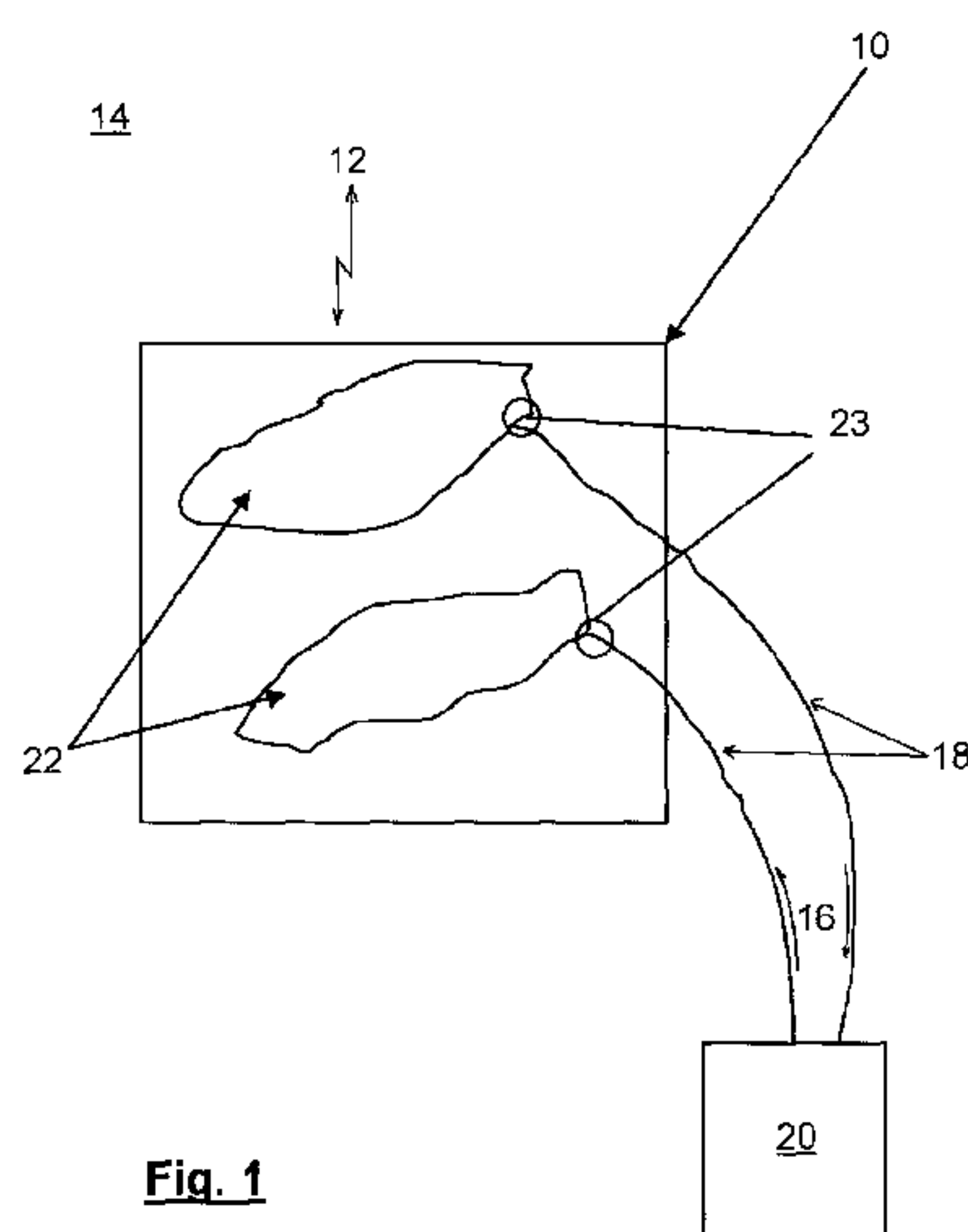


Fig. 1

(57) Abstract: A tuneable antenna whose signal element(s) and/or ground element(s) can have their respective areas altered by removing predefined removal portions of the substrate on which the antenna is formed. In this manner, a single antenna can be designed for use in multiple devices, or for use in devices which are subject to multiple configurations and/or for use in devices which operate at different radio frequencies. Preferably, the antenna provides a consistent set of mounting points such that the antenna can be mounted in a variety of devices in the same manner, independently of its tuned state.

PCB ANTENNA HAVING REMOVAL PORTIONS FOR ADJUSTING RESONANCE FREQUENCIES

RELATED APPLICATIONS

This application claims the benefit of priority from U.S. patent application, serial number 12/765,917, filed April 23, 2010.

TECHNICAL FIELD

The present invention relates to antennas and antenna structures for use in radio communications. More specifically, the present invention relates to antennas and antenna structures fabricated using printed circuit board components, or the like.

BACKGROUND ART

Portable electronic devices, such as personal digital assistants (PDAs), mobile phones, smart phones or mobile data entry terminals can exchange data and/or voice communications with other devices or networks through radio communications. To utilize such radio communications, these portable electronic devices require an appropriate radio component or subsystem (transmitter, receiver or transceiver) and a corresponding antenna. While much innovation has occurred in the last few decades in the area of miniaturizing radios and improving their electrical power efficiencies, the design and construction of antennas has not changed significantly as antenna operation is subject to physical parameters, such as the size, layout and construction of the antenna due to the nature of radio waves and their propagation.

Designing and manufacturing appropriate antennas for use in portable electronic devices is particularly challenging for several reasons. One reason is that the power available for radio transmissions is typically limited in a portable electronic device as such devices are often battery powered. Thus, antennas with relatively high efficiencies are desired. Frustrating this goal, and another reason antenna design is challenging, is the fact that the space/volume into which the antenna must be located within the portable electronic device is typically quite limited.

Compounding these difficulties is the fact that a suitable design for an antenna will change as the desired operating frequency of the radio communications differs and thus a suitable antenna design for use with a radio communication network operating at one

frequency (or range of frequencies) may not be suitable for use with another radio communications network which operates at a different frequency (or range of frequencies).

To date, this has often required manufacturers to create custom/specific antennas for each portable electronic device they manufacture for each expected operating frequency range, thus increasing the manufacturing costs of such devices.

Aggravating this problem further still is the fact that, due to the small volumes within most portable electronic devices, different configurations of the device can change the operation of the antenna. For example, an antenna may be designed which meets the desired performance characteristics for a portable electronic device but when an optional component (i.e. - a barcode scanner or RFID reader) is included in the portable electronic device, the presence of that optional component can affect the performance of the otherwise suitable antenna by reflecting radio waves, altering effective ground planes, etc. Thus, in such cases, the performance of the antenna may be compromised and it is necessary to redesign/retune the antenna to re-obtain the desired level of performance.

DISCLOSURE OF INVENTION

It is an object of the present invention to provide a novel antenna which obviates or mitigates at least one disadvantage of the prior art.

In a first aspect, the present invention provides an antenna for at least one of transmission or reception of electromagnetic waves with respect to a surrounding environment, the antenna having a signal element positioned in metal trace on a substrate, the signal element being isolated from an electrical ground, the antenna comprising: at least one removal portion on the substrate the removal portion for containing a removal element portion of the signal element, such that the substrate located outside of the predefined removal portion contains the remaining balance of the signal element; and a weakness pattern in the substrate about at least part of the periphery of the at least one removal portion, the weakness pattern predisposing the substrate to break along the weakness pattern upon application of a force such that the at least one predefined removal portion and corresponding removal element portion are separated from the remaining balance of the signal element upon application of the

force, the separation of the predefined removal portion and corresponding removal element portion modifies at least one tuning parameter of the antenna having the remaining balance of the signal element as the tuned signal element.

Preferably, the antenna comprises a plurality of the removal portions such that each of the plurality of the predefined removal portions contains a corresponding removal element portion of the signal element. Also preferably, the electrical ground comprises at least one ground element and at least one removal portion on the substrate contains a removal element portion of the ground element, such that the substrate located outside of the predefined removal portion contains the remaining balance of the ground element.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will now be described, by way of example only, which reference to the appended Figures, wherein: Figure 1 is a schematic diagram of an antenna and a portable electronic device, in accordance with the present invention, within an environment; Figure 2 is a another schematic representation of an antenna in accordance with the present invention; Figure 3 another schematic representation of an antenna and a portable electronic device in accordance with the present invention, wherein the antenna includes mounting points; Figure 4 is a schematic side cut away view of a portable electronic device in which the antenna of Figure 1 is mounted; Figure 5a is schematic representation of an antenna in accordance with the present invention including predefined removal portions; Figure 5b shows the antenna of Figure 5a after removal of the predefined removal portions; Figure 5c shows the antenna of Figure 5b after removal of additional predefined removal portions; Figure 6a shows a schematic representation of a slot type antenna in accordance with the present invention; Figure 6b the antenna of Figure 6a after removal of predefined removal portions; Figure 6c shows a schematic representation of another configuration of a slot type antenna in accordance with the present invention; Figure 7a shows a cross sectional view of a patch type antenna in accordance with the present invention; Figure 7b shows a cross section of the antenna of Figure 7b after removal of predefined removal portions; Figure 8a shows a schematic representation of an F-type antenna in accordance with the

present invention; and Figure 8b shows the antenna of Figure 8a after removal of predefined removal portions.

DETAILED DESCRIPTION OF INVENTION

A tuneable antenna in accordance with the present invention is indicated generally at 10 in Figures 1 and 2. Antenna 10, which includes one or more removable portions 32 of a carrier 24, such as a PCB substrate or the like, supporting one or more antenna elements 22, can be employed with a portable electronic device 20 or any other system requiring an antenna for radio communications. As described in more detail below, one or more of removable portions 32 can be removed in order to change the resonance frequency of antenna 10 from a first frequency to a second frequency, as desired. Further, the removable portions 32 can be used to otherwise tune antenna 10 for a selected resonance frequency to facilitate improved performance of antenna 10 when matched/associated to a particularly configured device 20, as is also further described below.

Referring now to Figure 4, device 20 can have antenna 10 coupled via a feed line 18 to a battery 106 and a radio 107 (for example as a radio transmitter, receiver or transceiver) and housed, at least partially if not completely, in a housing 100 of device 20. For example, antenna 10 can be located on the backside of housing 100 opposite a display 104 and/or a keyboard 102 of device 20. In another configuration example, antenna 10 can be located at one end of device 20, adjacent to the display 104 and/or the keypad 102. It is recognised that antenna 10 can be configured to operate as a radio antenna for WAN, WIFI, Bluetooth, GPS or RFID signalling communications.

Referring again to Figures 1 and 2, antenna 10 is a transducer designed to transmit and/or receive electromagnetic (radio) energy 12 from a surrounding environment 14. Accordingly, antenna 10 converts electromagnetic energy 12 into electrical currents 16 (e.g. receive operation) and converts electrical currents 16 into electromagnetic energy 12 (e.g. transmit operation), and any such electrical current 16 is communicated via a transmission lead 18 coupled between antenna 10 and a current source/sink (i.e. - radio receiver, transmitter or transceiver) in device 20.

Antenna 10 is an arrangement of one or more antenna elements 22, which are conductors. Antenna 10 can include one or more antenna element 22a, referred to as a

signal element, and one or more antenna element 22b, referred to as a ground element. In the illustrated embodiment, signal element(s) 22a and ground element(s) 22b are positioned on a carrier/substrate 24 which is used support and to electrically isolate antenna element 22a from ground element 22b and each antenna element 22 includes an antenna terminal 23 which electrically connects the conductors of feed line 18 to respective antenna elements 22.

When transmitting, alternating current 16 is created in the elements 22 by a transmitter applying a voltage at the antenna terminals 23, causing the elements 22 to radiate the electromagnetic energy 12. In reception, the inverse occurs such that the electromagnetic energy 12 from another source induces the alternating current 16 in the elements 22 and a corresponding voltage at the antenna's terminals 23 which is transferred to a receiver. Antenna 10 can have include other elements, such as parabolic and horn elements, or can incorporate shaped reflective surfaces to collect electromagnetic energy 12 and direct or focus that energy onto antenna elements 22.

There are two fundamental types of antenna 10 directional configurations which, with reference to a specific two dimensional plane (usually horizontal - parallel to the Earth's surface - or vertical - perpendicular to the Earth's surface), are either omni-directional or directional. Omni-directional antennas radiate and receive electromagnetic energy more or less equally in all directions about the two-dimensional plane and a common example is a vertical rod which extends orthogonally from the two-dimensional plane. Directional antennas radiate more electromagnetic energy in one direction than in other directions. Directional antennas typically employ additional antenna elements 22 (signal elements 22a and/or ground elements 22b) to direct the electromagnetic energy in the desired direction.

Antenna 10 can also comprise an array including two or more simple antennas 10 positioned on the carrier 24, where the simple antennas 10 are combined to produce a specific directional radiation 12 pattern. Such arrays can be built up from any basic antenna 10 type, such as dipoles, loops or slots, as further described below.

Antenna gain is typically defined as the measure of the performance difference between a directional antenna and an omni-directional antenna. An antenna 10 with a low gain emits electromagnetic energy 12 with about the same power in all directions, whereas a

higher gain antenna 10 will preferentially radiate 12 in one or more particular directions. Specifically, the gain of antenna 10 can be defined as the ratio of the intensity (power per unit surface) of the electromagnetic energy 12 radiated by antenna 10 in a given direction at an arbitrary distance, divided by the intensity of the electromagnetic energy 12 radiated at the same distance by an omni-directional antenna 10.

In any event, antenna 10 can comprise: at least one antenna signal element 22a configured to be isolated from an antenna ground element 22b of antenna 10; an antenna terminal 23 for each antenna signal element 22a and each antenna ground element 22b, the antenna terminals allowing for electrical connection of the respective antenna elements 22 to a respective conductor of a feed line 18; and a carrier/substrate 24 having a selected relative static permittivity, such that the substrate 24 is positioned between the antenna signal element 22a and the antenna ground element 22b and the antenna element 22a is attached to a first surface of the substrate 24.

In telecommunications, there are several types of microstrip antennas 10 (also known as printed antennas), the most common of which is the microstrip patch antenna 10 or patch antenna 10 type. Referring now to Figure 2, the microstrip antenna 10 of the present embodiments is an antenna 10 fabricated by etching or otherwise positioning one or more antenna signal elements 22a, comprising metal traces bonded (e.g. via adhesive, etc) to a suitable substrate 24. Substrate 24 is an electrical insulator and has dielectric properties and, as will be apparent to those of skill in the art, substrate 24 can be a printed circuit board. However, it is also contemplated that special purpose substrates, such as substrates with particular dielectric constants or with other desired characteristics can be employed if desired.

The antenna signal element(s) 22a can be arranged in a variety of patterns on substrate 24, as will be apparent to those of skill in the art, including, without limitation, as a plurality of metallic lines such as a fractal pattern and/or other geometrical shapes such as a circle, square, rectangle, ellipse, or other solid/continuous shapes. Substrate 24 can also include, on the side opposite antenna signal element(s) 22a, a metal layer which can be used as antenna ground element 22b, for establishing a reference potential level for operating antenna 10.

Antenna ground element 22b can be any structure closely associated with (or acting as) the electrical ground for antenna 10 which is directly, or indirectly, connected to the ground conductor of feed line 18. In Figure 2, the illustrated shapes of the signal elements 22a and ground elements 22b are examples only and, as such, signal elements 22a and ground elements 22b can take a wide variety of forms and shapes such as, but not limited to, planar or non-planar shapes (e.g. square, circular, rectangular, ellipse, etc.) and/or multiple traces (e.g. patterns or arrangements of lines of selected widths and spacing) configured into a selected pattern (e.g. fractal, dipole, loop, slot, etc.).

It is recognised that one or more slots and/or grooves in the exterior surface (facing the environment 14) of the antenna signal element 22a can be used to assist in tuning of the antenna 10 to desired frequency bands and/or for desired polarization diversities. It is also recognised that these slots and/or grooves can also be used to account for non-equal side dimensions of signal element 22a (e.g. rectangular rather than square), thus making the rectangular-shaped signal element 22a appear to the antenna 10 as being square-shaped and thus compatible with circular polarized diversity tuning for antenna 10. It is recognised that the length and/or width of the antenna signal element 22a on the substrate 24 can influence the gain, resonant frequency/frequency band, and/or the impedance of antenna 10.

Antenna signal element 22a can be formed on substrate 24 as conductive pathways, patches, tracks, and/or trace patterns, and can, for example, be etched from copper sheets or coatings laminated onto a non-conductive carrier to form substrate 24.

Ground element 22b can be a metal layer bonded to the side of substrate 24 opposite the side on which signal element 22a is located and ground element 22b is electrically connected to ground 26 by any suitable means. It is recognised that the dimensional size and/or shape of the ground element 22a can influence the gain, resonant frequency/frequency band, and/or the impedance of the PCB antenna 10. Ground element 22b can be formed on substrate 24 as conductive pathways, patches, tracks, and/or trace patterns, for example etched from copper sheets laminated onto a non-conductive substrate (e.g. carrier body 24).

Ground 26 can be an electrical structure associated with the current source/sink in device 20 (e.g. an electrical ground of device 20 that is coupled to antenna 10 via the transmission line 18). An antenna grounding structure 22b can be referred to as a structure for establishing a reference potential level for operating the active antenna element 22a. The antenna grounding structure 22b can be any structure closely associated with (or acting as) the ground 26 which is connected to the terminal 23 of the signal receiver or source opposing the active antenna terminal 23.

A ground plane element 22b, and/or other objects with electromagnetic properties and in proximity to signal element 22a, forms a relationship with signal element 22a. Ground plane element 22b, and/or any other relatively nearby objects with electromagnetic properties, permit antenna 10 to function by acting as a reflector or director for antenna 10. This sometimes serves as the near-field reflection point for an antenna 10, or as a reference ground in a circuit.

Ground element 22b can also be a specially designed shape or pattern, such as the radial elements of a quarter-wave ground plane antenna. Artificial (or substitute) grounds (e.g., ground elements 22b) provide the grounding structure for the antenna 10 and can include a conductive structure used in place of the Earth and which grounding structure is distinct from the Earth. For example, a ground element 22b in the antenna 10 can be a layer of copper or other conductive material that appears to the electromagnetic energy 12 as an infinite ground potential. The use of the ground element 22b can help reduce noise and help provide that circuitry within device 20 compare different signals' voltages to the same potential. The ground element 22b can also serve to make the design of the antenna 10 more straightforward, providing a common signal and electrical ground without having to run multiple traces, such that any component (of the antenna 10 and/or device 20) requiring electrical grounding is routed directly to the ground element 22b.

Ground element 22b can be located on carrier 24 as one or more metallic traces or areas adjacent to and on the same side of the carrier 24 as signal element 22a or adjacent to (e.g. non overlapping) signal element 22a but on the opposite side of the substrate 24 as the signal element 22a.

As will be apparent to those of skill in the art, depending upon the performance characteristics desired for antenna 10, ground element 22b can be arranged in a variety of manners, such as being split into two adjacent planes and then connected by another trace. The connecting trace can have sufficiently low impedance to keep the connected portions of the ground element 22b very close to the same potential, while keeping the ground currents of one portion from significantly impacting the other.

As shown in Figures 1 and 3, the feed line 18 in a radio transmission, reception or transceiver system is the physical electrical connection that carries the RF signal currents 16 to and/or from antenna 10. The feed line 18 carries the electrical currents 16 for transmission and/or as received with antenna 10. There are different types of feed lines 18 in use in modern RF systems, such as, but not limited to: coaxial; twin-lead; and, at frequencies above about 1 GHz, waveguides.

Referring again to Figure 2, the substrate 24 can be a printed circuit board (PCB), which is used to mechanically support conductive pathways, patches, tracks, and/or traces, affixed to a non-conductive layer, or layers, of substrate 24. In the case of the antenna 10, these traces, pathways, patches, etc. can be signal elements 22a and/or the ground elements 22b. As noted above, signal elements 22a and/or ground elements 22b of antenna 10 can be made of thin copper foil, or other conductive materials, which are affixed to the non-conductive layer(s) of substrate 24. Typically, substrate 24 is composed of an insulating and dielectric layer typically laminated together with the conductive layers with an epoxy resin or the like. There are a number of different dielectric materials that can be chosen to provide different properties for substrate 24 depending on the requirements for antenna 10. Some of these dielectric materials are, for example, polytetrafluoroethylene (Teflon), FR-1, FR-2 (Phenolic cotton paper), FR-3 (Cotton paper and epoxy), FR-4 (Woven glass and epoxy), FR-5 (Woven glass and epoxy), FR-6 (Matte glass and polyester), G-10 (Woven glass and epoxy), CEM-1 (Cotton paper and epoxy), CEM-2 (Cotton paper and epoxy), CEM-3 (Woven glass and epoxy), CEM-4 (Woven glass and epoxy), CEM-5 (Woven glass and polyester). Other suitable materials for substrate 24 will be apparent to those of skill in the art and the list of materials given above represent only examples and are not intended as limiting the present invention to such configurations.

Substrate 24 can be formed in any desired shape (e.g. in a rectangular, circular or irregular form) on which signal element(s) 22a and ground element(s) 22b can be positioned. Substrate 24 will also typically include one or more mounting regions 36 (e.g. protrusions, etc.) to facilitate mounting of the antenna 10 within device 20. It is contemplated that mounting regions 36 will be dimensionally configured and located to match corresponding mounting locations in the housing 100 of device 20. Mounting regions 36 of substrate 24 can be provided as a series of holes in a layout which matches a layout for threaded fasteners provided in housing 100 of device 20.

Referring again to Figure 3, mounting regions 36 are illustrated as both a protrusion on the substrate 24 itself, as well as holes (shown as black circles) in the substrate 24 through which threaded fasteners, stakes, rivets or other mounting elements may be received. In the illustrated embodiment, it is noted that the predefined removal portion 32 is located away from the mounting regions 36, in order to provide for consistent mounting of the antenna 10 in device 20, even after removal of a predefined removal portion 32 for tuning purposes. In this manner, antennas 10 which are tuned differently (different removal portions 32 being present or not) can still be installed in housing 100.

Referring again to Figure 2, the predefined removal portions 32 of substrate 24 can be used to remove one or more corresponding removal element portions 33 of the signal element 22a and/or the ground element 22b that overlie the predefined removal portions 32. These removal element portions 33 are differentiated from the remainder element portion(s) 35 which are positioned outside of the predefined removal portions 32 of substrate 24. Thus, in effect, remainder portions 35 are those signal elements 22a and ground elements 22b that contribute to the generation/reception of electromagnetic energy 12 during operation of the antenna 10.

As will be apparent, any predefined removal portions 32 which are not removed are considered to be remainder element portions 35. For example, it is recognised that removal of a predefined removal portion 32 and the associated removal element portion 33 from substrate 24 can result in changing the antenna 10 from a first resonance frequency (or frequency band) to a second resonance frequency (or frequency band). In other words, the first resonance frequency of the antenna 10 is obtained using both the element portion 33 (on a predefined removal portion 32) and the remainder element

portion 35 (outside of the predefined removal portion 32). If it is desired to tune the antenna to a second resonance frequency, then the element portion 33 on the predefined removal portion 32 is removed from substrate 24 and the remaining element portion 35 outside of the predefined removal portion 32 provides for operation of the antenna 10 at the second resonance frequency.

This use of the predefined removal portion 32 can be used, for example, to provide an antenna 10 that can be selectively tuned to operate at either one resonance frequency or at least a second resonance frequency, depending upon the presence or removal of one or more predefined removal portions 32 (and their associated removal element portions 33).

In an embodiment, substrate 24 can be configured for a particular resonance frequency (or frequency band) and at least one removal portion 32 (and the associated removal element portion 33) can be used to fine tune the antenna 10 for operation in a particular device 20. In such a case, the removal of one or more predefined removal portions 32 (and their associated removal element portions 33) can be performed to shift the resonant frequency and/or input impedance of antenna 10 incrementally towards a desired value. For example, if the resonance frequency of the antenna 10 is slightly too low, one or more predefined removal portions 32 (and their associated removal element portions 33) can be removed successively so as to make the antenna element 22a appropriately shorter, raising the resonant frequency of antenna 10.

In another embodiment, antenna element 22a can be made intentionally longer than likely necessary with the resulting resonance frequency/frequency band likely being below that desired for use in a particular device 20. Removal of one or more of the predefined removal portions 32 (and their associated removal element portions 33) can then be performed to tune/shift the intentionally too low resonance frequency/frequency band towards the desired resonance frequency/frequency band, by shortening of the antenna element 22a (i.e. the remaining element 35) through removal of one or more of the predefined removal portions 32 (and their associated removal element portions 33).

In yet another embodiment, even if the antenna 10 resonates at the appropriate frequency/band, the antenna 10 may not be well matched to the correct impedance pertaining to the particular device 20 configuration.

Dependent on the antenna 10 type, there can be one or more possibilities to obtain appropriate impedance at the correct frequency through removal of the one or more of the predefined removal portions 32 (and their associated removal element portions 33). Determining which, and/or how many, removal portions 32 should be removed can depend upon a variety of factors including, but not limited to: size (e.g. length, shape, and/or width) of the ground element 22b; distance from antenna element 22a to the ground plane/element 22b; dimensions (e.g. length, shape and/or width) of the antenna elements 22b, and/or feed point 23 location. Thus by varying these factors through removal of the one or more of the predefined removal portions 32 (and their associated removal element portions 33), the installer can improve the impedance match of the antenna 10 with the configuration of the respective device 20.

In a further embodiment, the removal of the one or more of the predefined removal portions 32 (and their associated removal element portions 33) can be used to both change the resonance frequency (or frequency band) and to fine tune the resonance frequency (or frequency band) and/or the impedance for optimized operation in a particular device 20 configuration.

Referring again to Figures 2 and 3, substrate 24 is shown as having a number of predefined removal portions 32. Each of removal portions 32 is defined by a weakness pattern 34 introduced into substrate 24, in order to predispose substrate 24 to break along the weakness pattern 34 when force is applied (e.g. by an installer of the antenna 10 in a selected device 20) to the selected removal portion 32. Upon breakage of substrate 24 along the weakness pattern 34, the respective removal portion 32 can be separated from the remaining substrate 24, including any removal element portion 33 positioned on the removal portion 32 of substrate 24.

Examples of the weakness patterns 34 formed in substrate 24 can be mechanical deformations in the material of substrate 24 such as, but not limited to: scoring of one or more lines (straight or otherwise, including segmented/broken line scoring); a cut groove (or series of groove segments); punched out sections arranged adjacent one another; and/or a series of small holes or perforations created in series (e.g. perforation line(s)).

It is noted in Figure 3 that a periphery 37 of the predefined removal portions 32 can be defined solely by the formed weakness pattern 34 or as a combination of the formed weakness pattern 34 and a free edge 38 of the carrier body 24.

As is now apparent, signal element(s) 22a and/or ground element(s) 22b can be provided in different configurations as a trace on the surface of substrate 24, for example signal element(s) 22a can use trace shapes such as, but not limited to: a dipole; bent dipole; folded dipole; meander dipole pattern; tilted whip; F-antenna; spiral; loop (e.g. half-wave, full-wave, series loaded short loop); patch; and/or slot. Similarly, ground element(s) 22b can use a wide variety of trace shapes as may be desired to obtain a desired functionality for antenna 10.

Figures 5a, 5b and 5c show an example of the possible tuning of antenna 10, when configured as an F-antenna. Specifically, antenna 10 is tuned, as needed or desired, through removal of some predefined removal portions 32 (shown as solid black portions 32 in Figures 5b and 5c) and their associated removal element portions 33. Accordingly, the removal of one or more removal portions 32 from substrate 24, through breaking along the weakness pattern 34 (see Figure 2) provides for removal of the selected removal element portions 33 positioned on the removed removal portions 32. In effect, the difference between the signal element 22a of Figure 5a and Figure 5b is that removal portions 32a of whip and removal portion 32b of leg of signal element 22a have been removed, effectively shortening the whip and leg of signal element 22a. Further, the area of the ground element 22b has also decreased by removal of removal portion 32c. If these removals do not result in the desired performance of antenna 10, additional removal portions 32 can be removed, as indicated in Figure 5c, wherein removal portion 32d has been removed from the whip portion of signal element 22a to provide for further tuning of the antenna 10. As will be apparent, other removal portions, such as removal portion 32e of ground element 22b, can be removed - either alternatively or in additionally - to achieve the desired tuning and performance from antenna 10.

Figures 6a and 6b show an example of tuning of antenna 10 wherein signal element 22a includes a half wave slot 40. Tuning is achieved through removal of predefined removal portions 32 (and their associated removal element portions 33) to lengthen slot

40 as desired. Accordingly, removal portions 32 are removed by breaking along the weakness pattern 34 provided. In effect, the difference between antenna 10 of Figure 6a and tuned antenna 10 of Figure 6b is that end portions of slot 40 have been removed so as to lengthen the slot 40. Figure 6c shows an alternative configuration of antenna 10 of Figure 6a wherein weakness pattern 34 extends to an edge 42 of substrate 24, such that the predefined removal portion 32 is not wholly contained within the interior of substrate 24.

Figures 7a and 7b show an example of tuning of antenna 10 when signal element 22a is patch signal element. A patch signal element 22a (also known as a Rectangular Microstrip Antenna) typically consists of a metal patch (signal element 22a) suspended over a ground plane (ground element 22b). A simple embodiment of a patch antenna 10 uses a signal element 22a which is one half-wavelength-long with the dielectric loading located over a larger ground element 22b which it is separated from separated by a constant thickness dielectric material, in the illustrated example substrate 24. In the illustrated embodiment, substrate 24 is composed of a number of layers (in the illustrated example, three) that are partially bonded together using known lamination or bonding materials 28. Materials 28 are configured so as to provide for removal of the removal portions 32 without affecting positioning of the mounting regions 36 (i.e. the removal portions 32 are not bonded to an inner layer 24a of substrate 24 by materials 28). Accordingly, removal of removal portions 32 can be accomplished, as before, through breaking along the weakness pattern 34 as needed.

As shown, the difference between antenna 10 in Figure 7a and antenna 10 in Figure 7b is that the area of signal element 22a has been decreased by removing removal portions 32f. Further, the area of the ground element 22b has also been decreased by removing removal portions 32g. While in the illustrates example both removal portions 32f and both removal portions 32g have been removed, only one of removal portions 32f or one of removal portions 32g can be removed, if desired. Further, it is recognised that the respective sizes of signal element 22a and ground element 22b can be reduced, independently of one another, if desired, by removing either, or both of, removal portions 32f and/or 32g.

Figures 8a and 8b show an example of adjusting (i.e. decreasing) the width of signal element 22a of antenna 10. In this case, removal portions 32 run along the width of signal element 22a such that removing a removal portion 32 removes material from the width of signal element 22a as indicated in the solid black portions of Figure 8b).

It is recognised in the above examples that the removal portions 32 can be used to remove a portion of signal element 22a and/or a portion of the ground element 22b positioned on the carrier 24. It is also recognised in the above examples for weakness patterns 34, the positioning of the removal portions 32 in the carrier 24 can be done so as to not affect the structural integrity and/or positioning of the mounting regions 36 or other parts of antenna 10. This positioning of the removal portions 32 away from the mounting regions 36 provides for consistent mounting of the antenna 10 in the corresponding device 20, with or without the presence of the removal portions 32 in the carrier 24.

The above relates to tuning antenna 10 based on removing, as needed, one or more removal portions 32 of substrate 24. Removal portions 32 can be internal to substrate 24 (i.e. - permitting a continuous outer perimeter to substrate 24 even after removal of one or more removal portions 32) or removal portions 32 can be otherwise positioned to allow consistent mounting regions 36 for antenna 10 within housing 100, after the removal portion(s) 32 has/have been removed.

It is contemplated that antenna 10 will be manufactured with signal element(s) 22a and ground element(s) 22b having an area equal to a maximum area that might be expected under any expected conditions to be required to obtain desired tuning for antenna 10. As antenna 10 is utilized in circumstances requiring tuning, by removal of the area of signal element(s) 22a or ground element(s) 22b, appropriate ones of removal portions 32 can be removed, as needed to obtain the desired tuning.

It is also contemplated that the process of tuning antenna 10 can be performed in a variety of manners, as will occur to those of skill in the art. For example, if device 20 is manufactured with a consistent configuration, the performance and characteristics of antenna 10 can be tested in one such device 20 and appropriately tuned. Antennas 10 for each other device 20, assuming the configuration of the devices 20 has not changed, can have antenna 10 pre-tuned in the same way (by removing the same

removal portion(s) 32, if any) as the tested device 20 and this tuning can be performed before installation of antenna 10 into device 20.

Alternatively, and especially if device 20 is subject to a wide variety of possible configurations (such as changes to housing 100, the inclusion or omission of components in device 20, the desire to have device 20 operate in a different radio band, etc.), antenna 10 can be empirically tuned, as needed, by a process of testing performance and characteristics of antenna 10 within a device 20 and, if necessary, removing one or more removal portions 32. This process can be repeated, as necessary, by testing the performance and characteristics of antenna 10 after one or more removal portions 32 have been removed and determining if the desired performance has been achieved or removing additional removal portions 32 as desired.

The present invention provides a tuneable antenna whose signal element(s) and/or ground element(s) can have their respective areas altered by removing predefined removal portions of the substrate 24 on which the antenna is formed. In this manner, a single antenna can be designed for use in multiple devices, or for use in devices which are subject to multiple configurations and/or for use in devices which operate at different radio frequencies. Preferably, the antenna provides a consistent set of mounting points such that the antenna can be mounted in a variety of devices in the same manner, independently of its tuned state.

What is claimed is:

1. An antenna configured for at least one of transmission or reception of electromagnetic waves with respect to a surrounding environment, the antenna having an antenna element positioned in metal trace on a carrier body, antenna element being isolated from an electrical ground of the antenna, the antenna comprising:

at least one predefined removal portion positioned in the carrier body for containing a removal fraction of the antenna element, such that the carrier body located outside of the predefined removal portion is configured to contain the remainder fraction of the antenna element; and

a weakness pattern in the carrier body about at least part of the periphery of the at least one predefined removal portion, the weakness pattern configured for predisposing the carrier body to break along the weakness pattern upon application of force, such that the at least one predefined removal portion and corresponding removal fraction would be separated from the antenna upon application;

wherein the separation of the predefined removal portion and corresponding removal fraction is modifying at least one tuning parameter of the antenna having the remainder fraction as the tuned antenna element.

2. The antenna of claim 1 further comprising a plurality of the predefined removal portions such that each of the plurality of the predefined removal portions contains a corresponding removal fraction of the antenna element.

3. The antenna of claim 2, wherein at least one of the corresponding removal fractions becomes part of the remainder fraction of the tuned antenna element

when the weakness pattern of the respective predefined removal portion remains unbroken.

4. The antenna of claim 2 further comprising one or more mounting regions formed on the carrier body for facilitating coupling of the carrier body with a housing or internal element of at least one of a mobile computing device, a mobile communication device, a cellular telephone device or a fixed communication device.

5. The antenna of claim 4 further comprising the plurality of the predefined removal portions located away from the one or more mounting regions, such that consistent coupling of the carrier body with the housing or internal element is provided where one or more of the plurality of the predefined removal portions are separated from the carrier body.

6. The antenna of claim 2, wherein the carrier body is composed of a resin impregnated dielectric material.

7. The antenna of claim 2, wherein the metal trace provides for an antenna type selected from the group consisting of: dipole; loop; and slot.

8. The antenna of claim 2, wherein the metal trace provides for a patch type antenna.

9. The antenna of claim 8 further comprising a ground element positioned in metal trace on the carrier body on an opposite side to that of the antenna element.

10. The antenna of claim 9 further comprising the carrier body composed of a plurality of layers coupled together to facilitate removal of the at least one predefined removal portion separate from the part of the carrier body having the ground element positioned thereon.
11. The antenna of claim 2, wherein the tuning parameter is selected from the group consisting of: resonant frequency of the antenna; impedance of the antenna; and feed point location.
12. The antenna of claim 11, wherein the removal of the at least one predefined removal portion changes a shape of the antenna element.
13. The antenna of claim 12, wherein the shape is selected from the group consisting of electrical length of the antenna element and electrical width of the antenna element.
14. The antenna of claim 11 further comprising a ground element positioned in metal trace on the carrier body and at least one of the plurality of the predefined removal portions is a ground removal fraction of the ground element, such that the carrier body located outside of the ground removal fraction contains the ground remainder fraction of the ground element.
15. The antenna of claim 14, wherein the removal of the at least one predefined removal portion changes a shape of the ground element.
16. The antenna of claim 15, wherein the shape is selected from the group consisting of electrical length of the ground element and electrical width of the ground element.

17. The antenna of claim 1, wherein the at least one predefined removal portion is configured to change operation of the antenna element from a first resonance frequency band to a second resonance frequency band, such that the center frequency of the second resonance frequency band is outside of the first resonance frequency band.

18. The antenna of claim 1, wherein the at least one predefined removal portion is configured to change operation of the antenna element from a first resonance frequency band to a second resonance frequency band, such that the center frequency of the second resonance frequency band is inside of the first resonance frequency band.

19. The antenna of claim 1, wherein the weakness pattern is selected from the group consisting of: one or more scoring lines; one or more sequential perforations; and one or more slots cut through the thickness of the carrier body.

20. A method for manufacturing an antenna configured for at least one of transmission or reception of electromagnetic waves with respect to a surrounding environment, the antenna having an antenna element positioned in metal trace on a carrier body, antenna element being isolated from an electrical ground of the antenna, the method comprising the steps of:

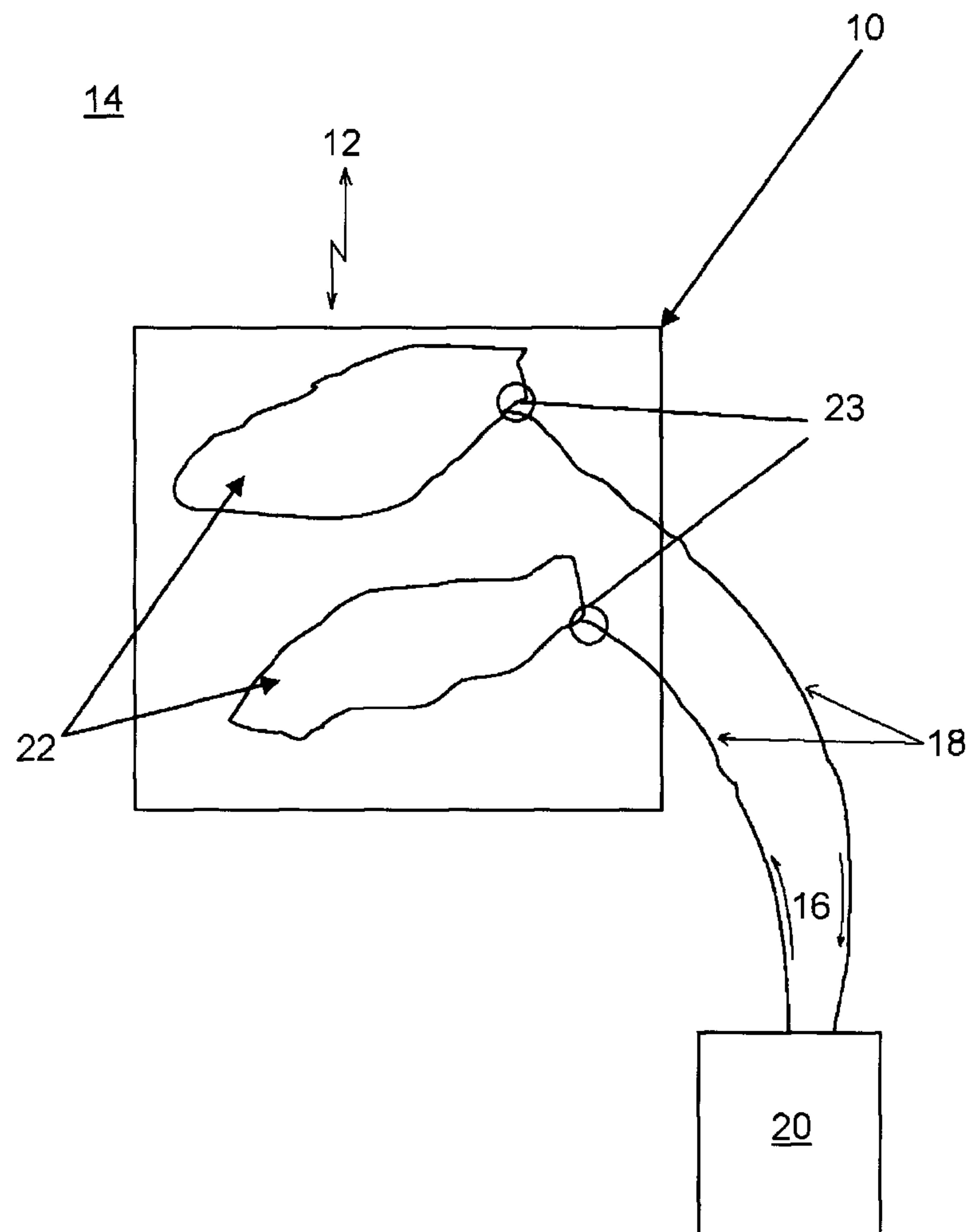
providing a carrier body;

forming a weakness pattern in the carrier body about at least part of the periphery of at least one predefined removal portion, the weakness pattern configured for predisposing the carrier body to break along the weakness pattern upon application of force, the at least one predefined removal portion positioned in the carrier body for containing a removal fraction of the antenna

element, such that the carrier body located outside of the predefined removal portion is configured for containing the remainder fraction of the antenna element; and

applying the metal trace of the antenna element on the carrier body to form the removal fraction and the remainder fraction;

wherein application of the force and subsequent separation of the predefined removal portion and corresponding removal fraction from the carrier body is modifying at least one tuning parameter of the antenna having the remainder fraction as the tuned antenna element.

1/13Fig. 1

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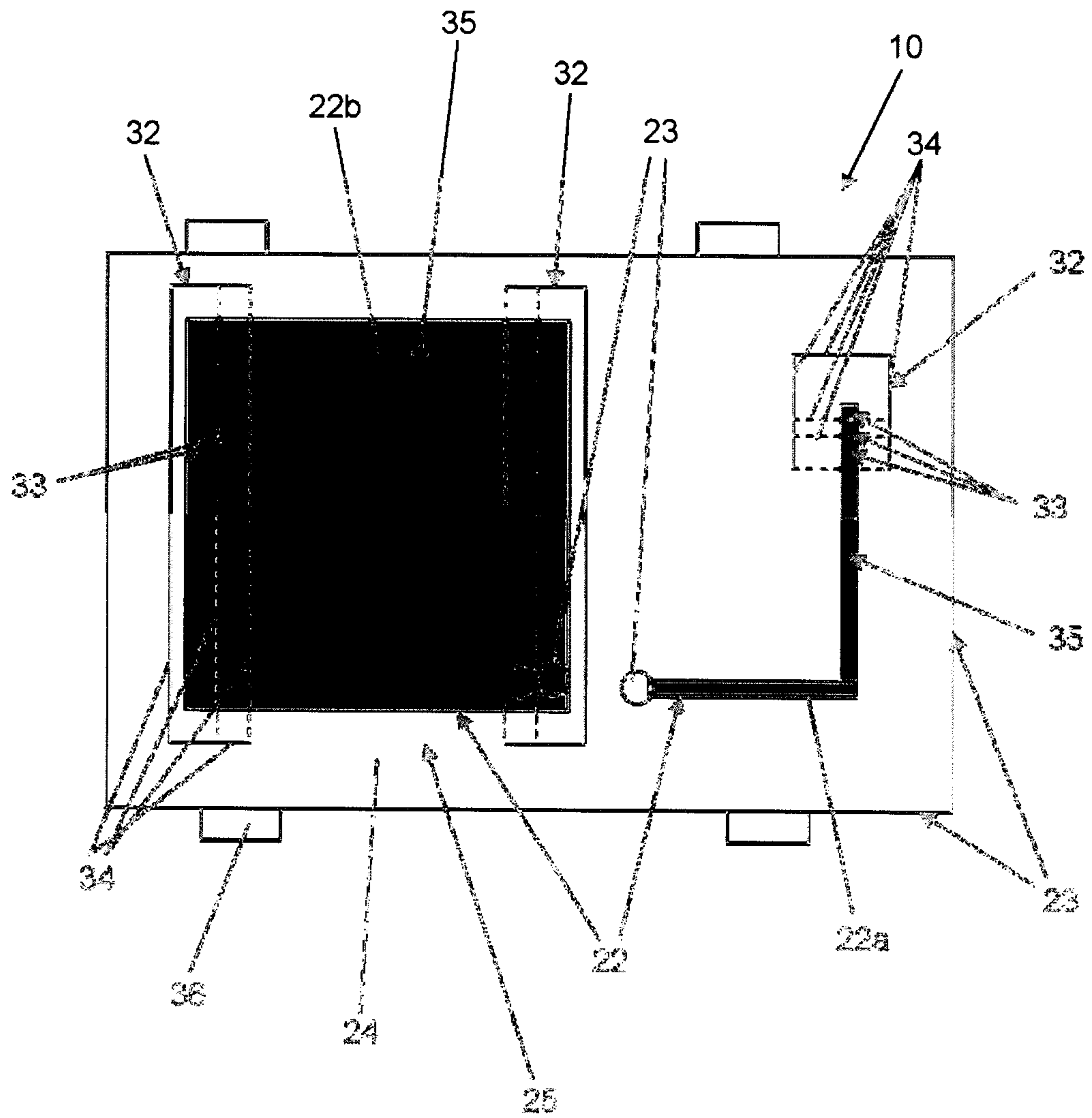
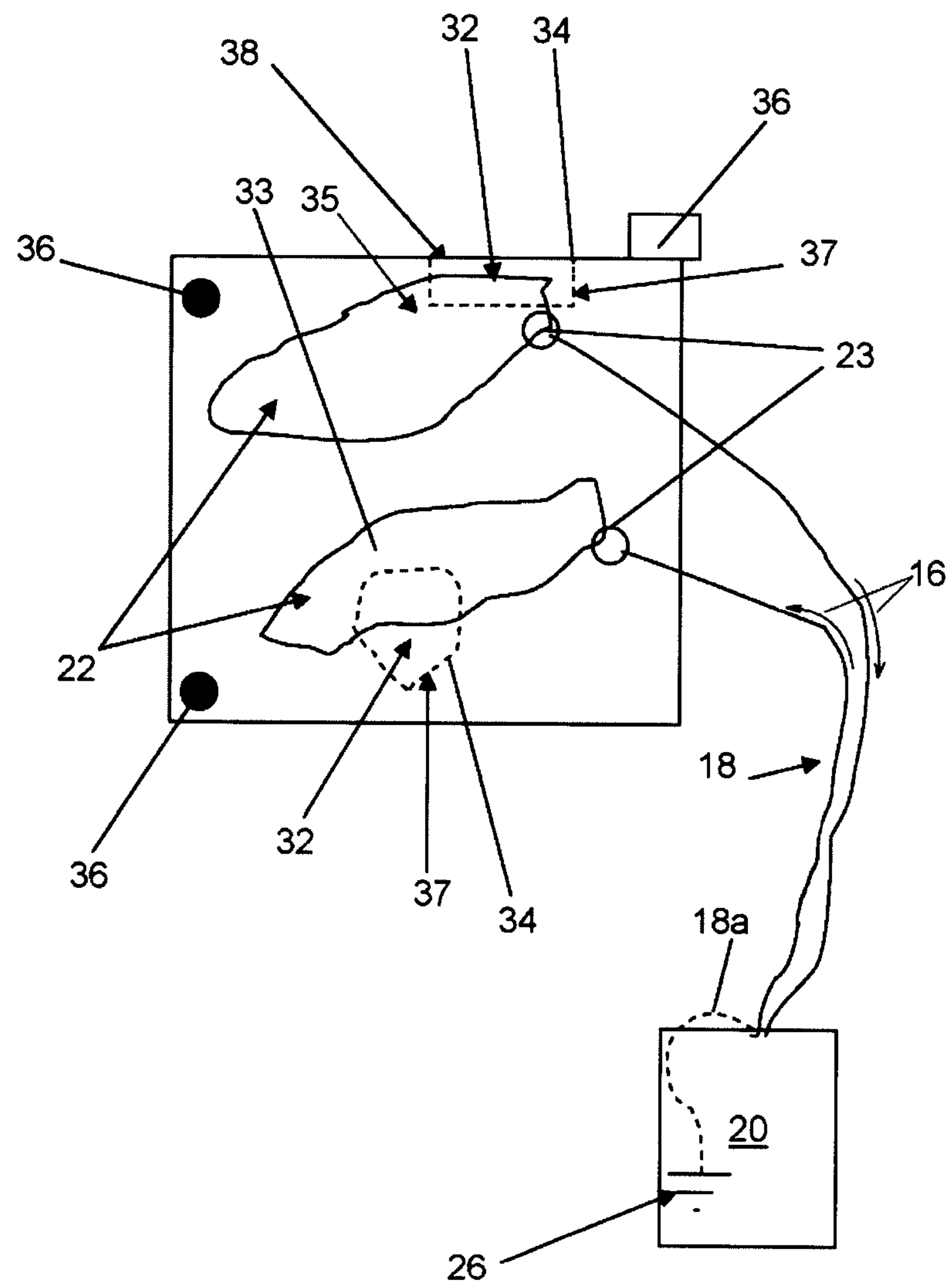
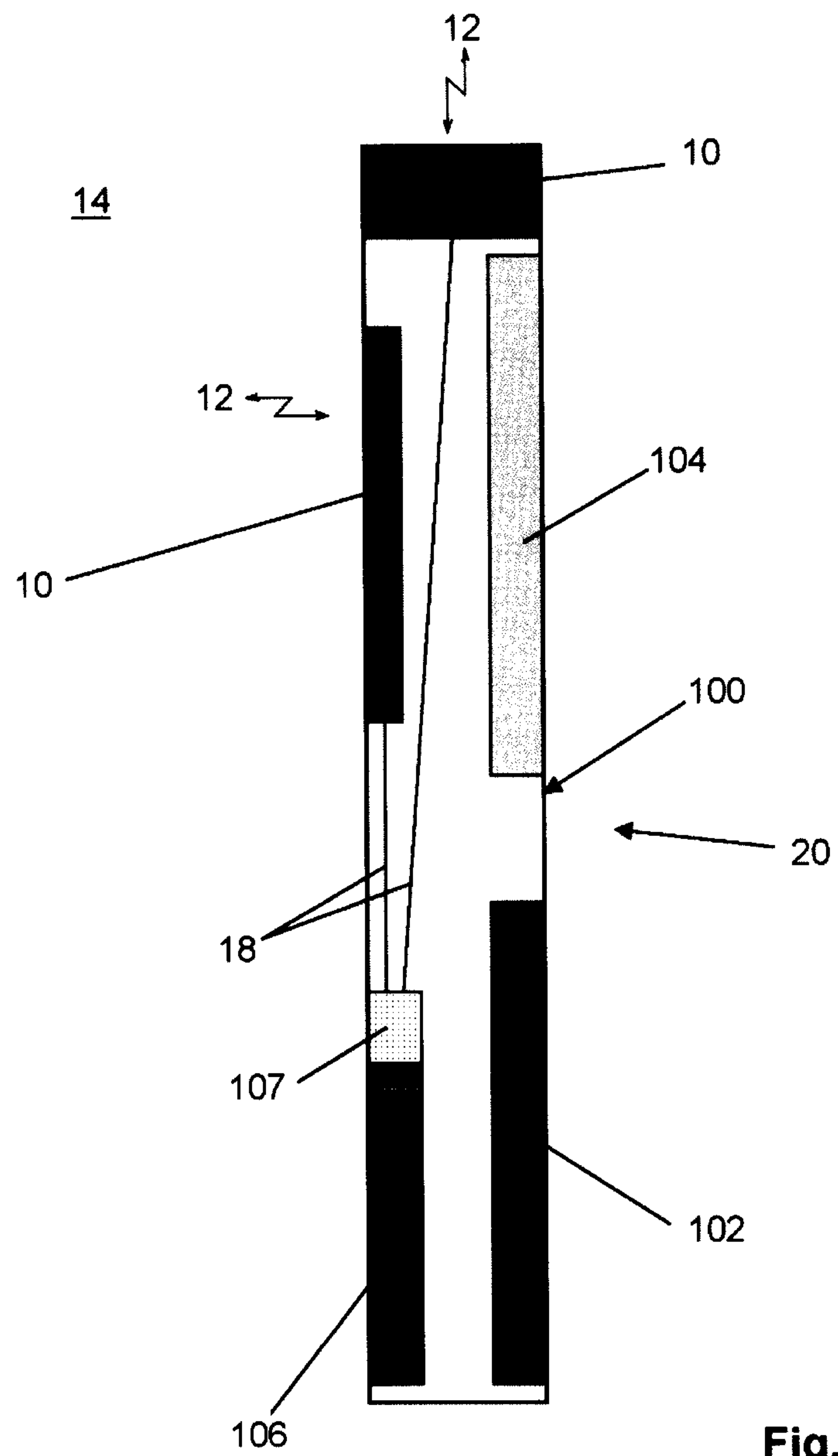
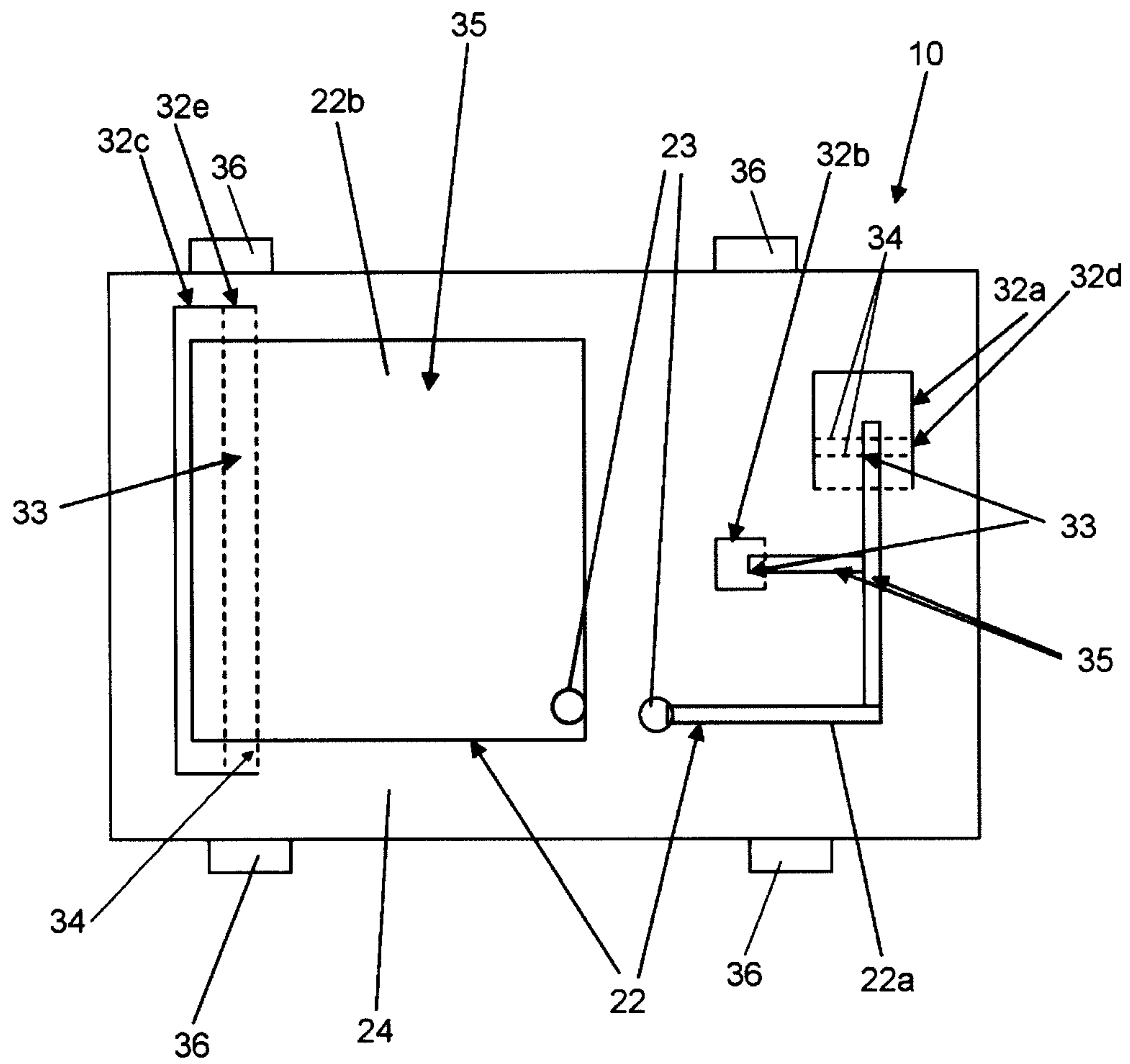
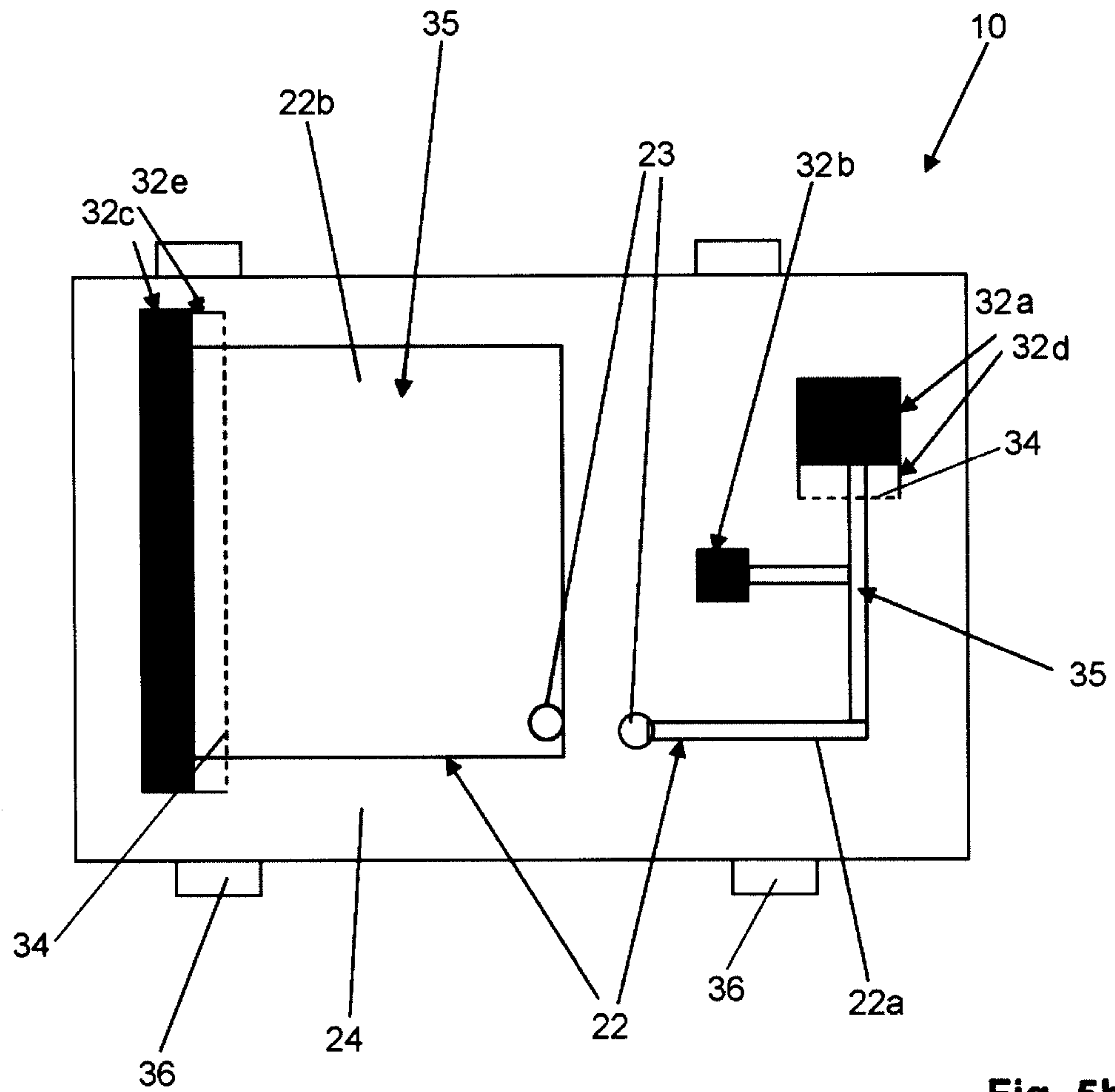


Fig. 2

3/13**Fig. 3**

4/13**Fig. 4**

5/13**Fig. 5a**

6/13**Fig. 5b**

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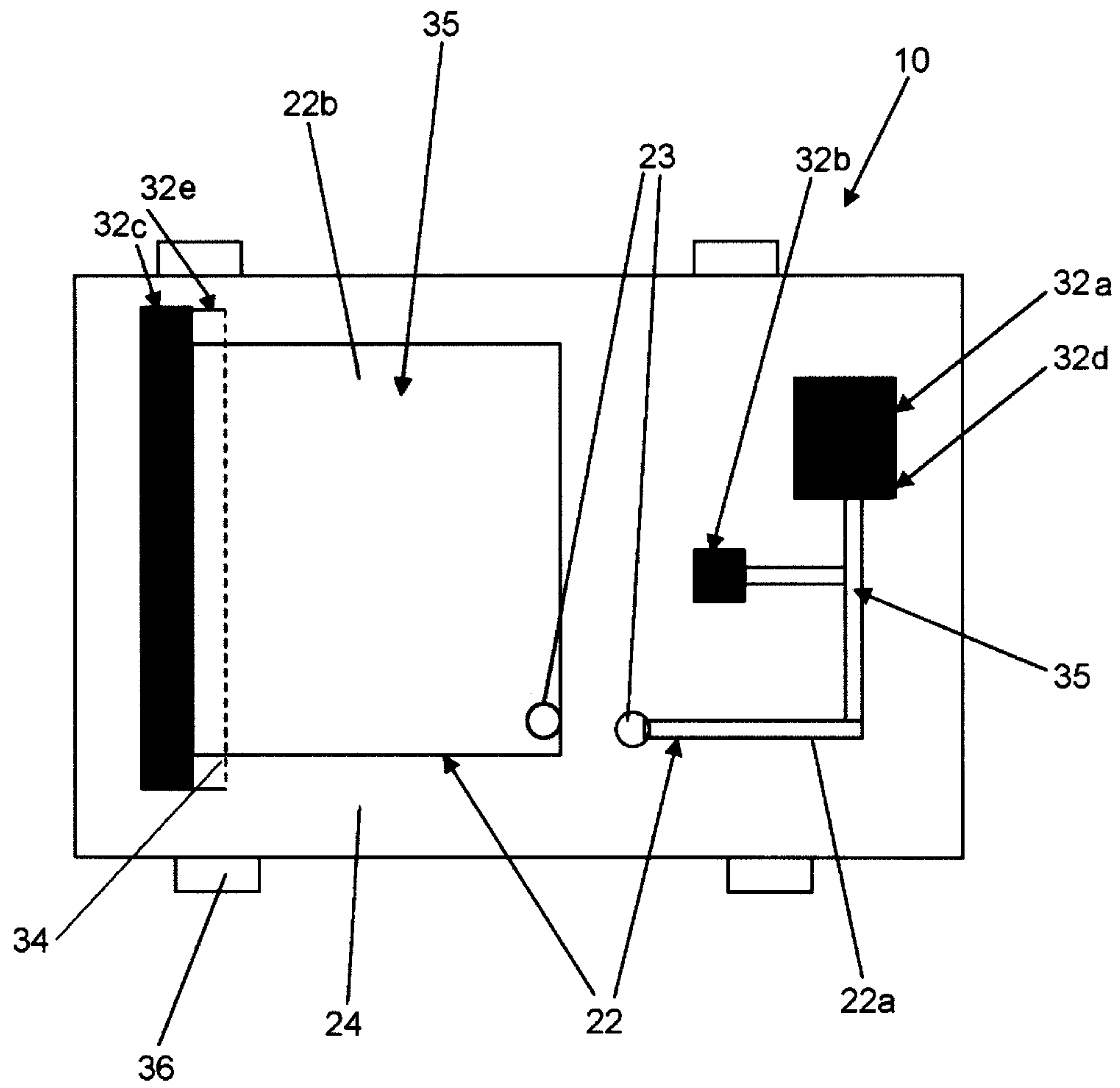
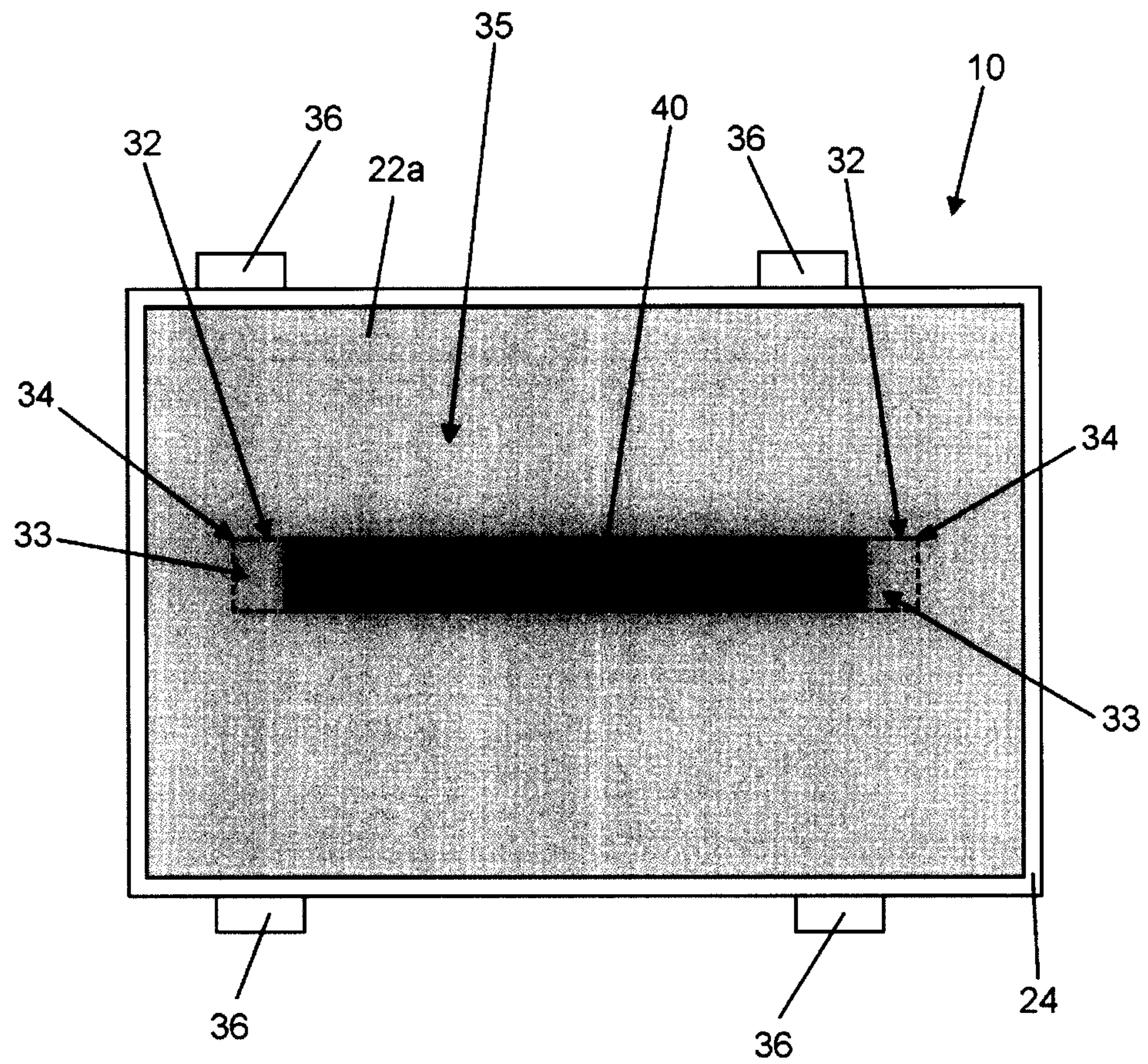
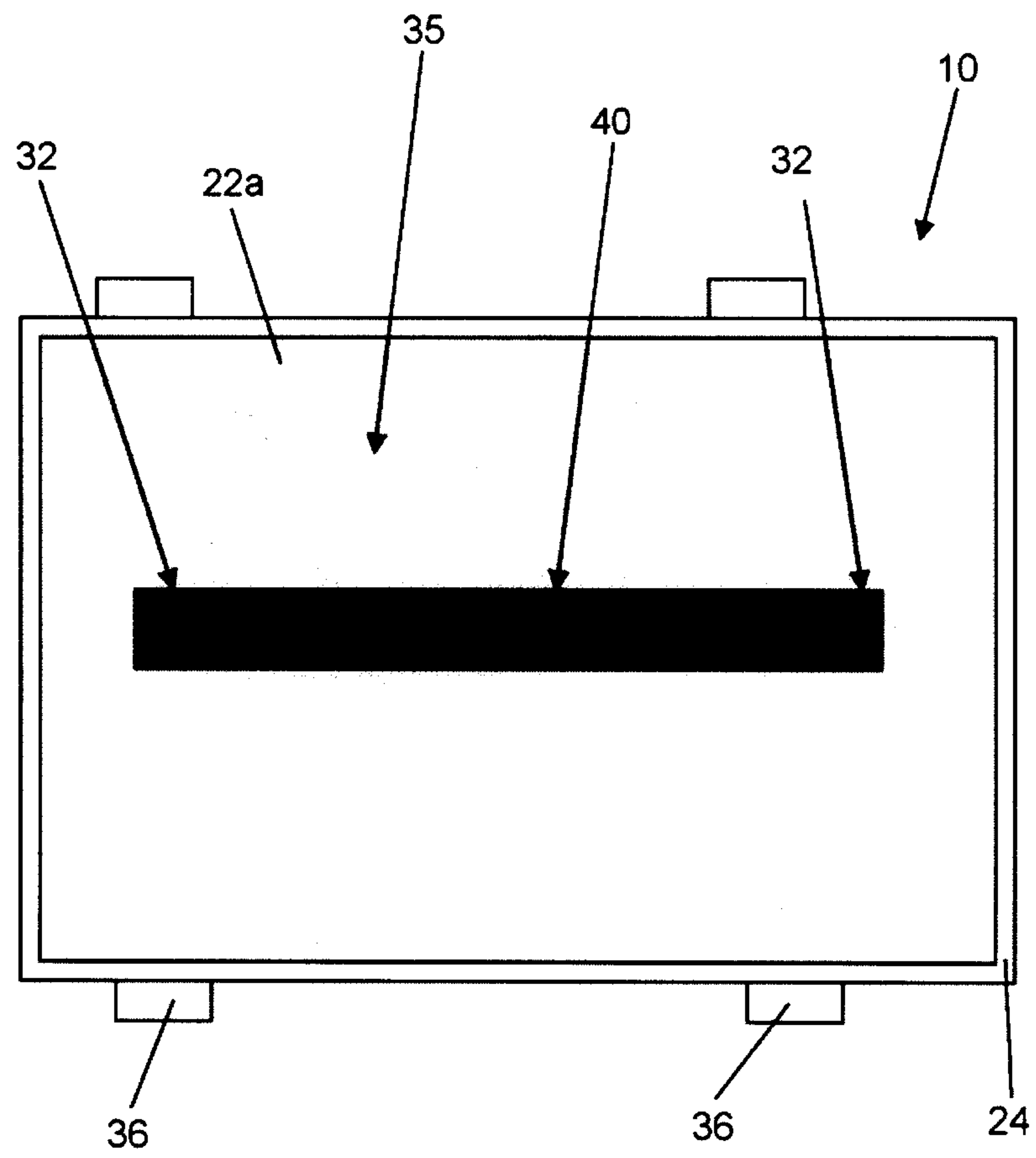
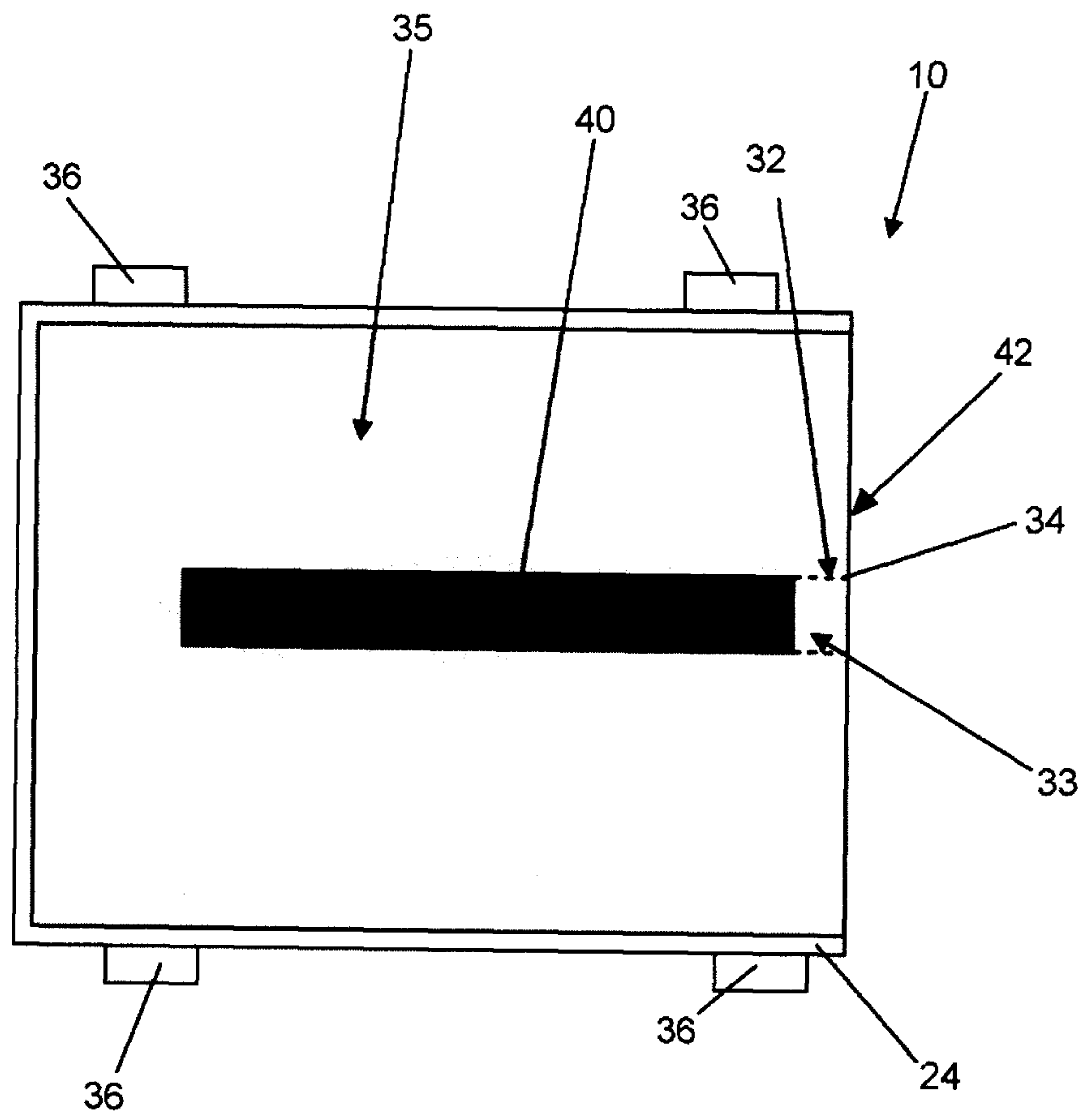
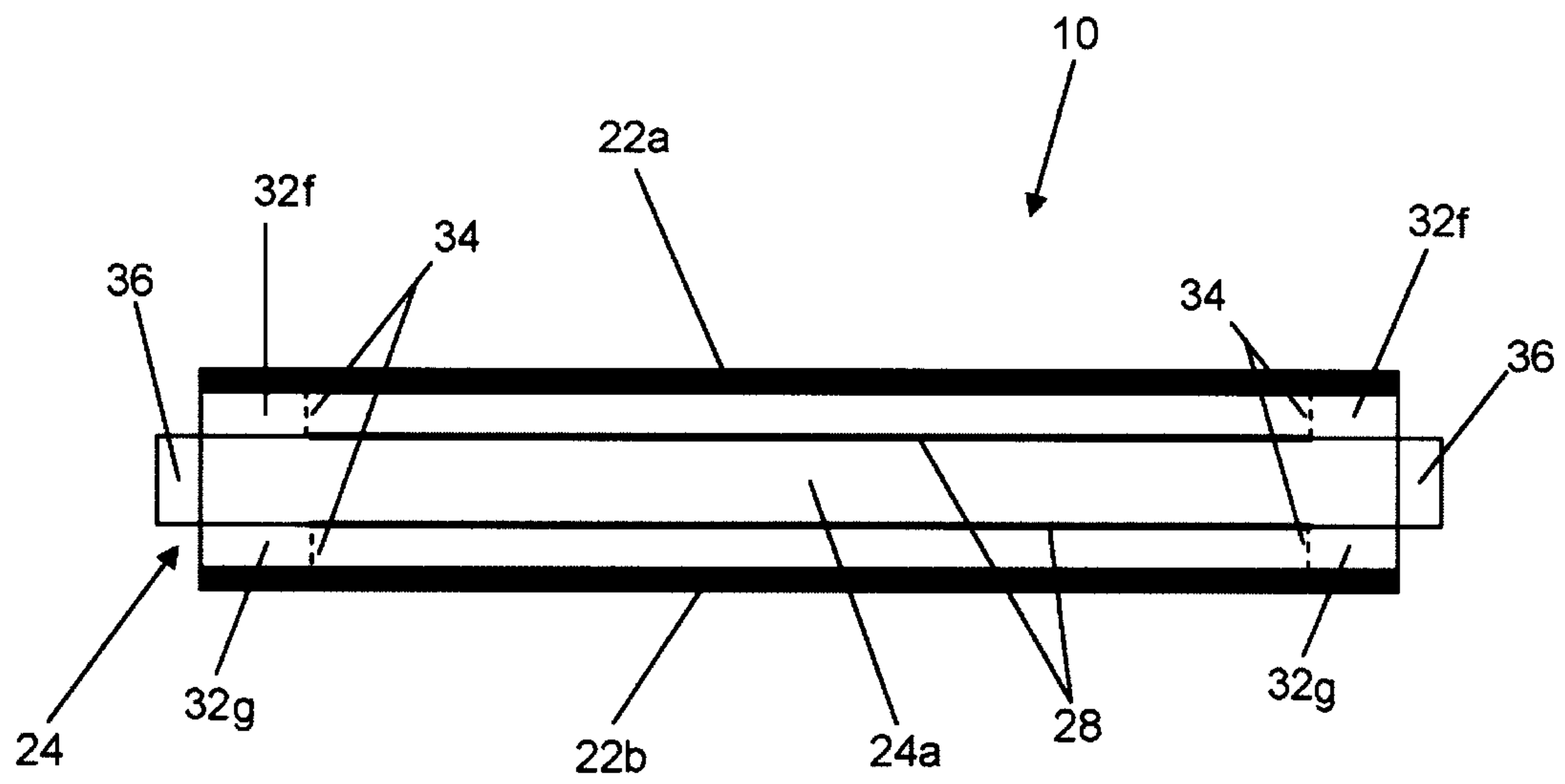
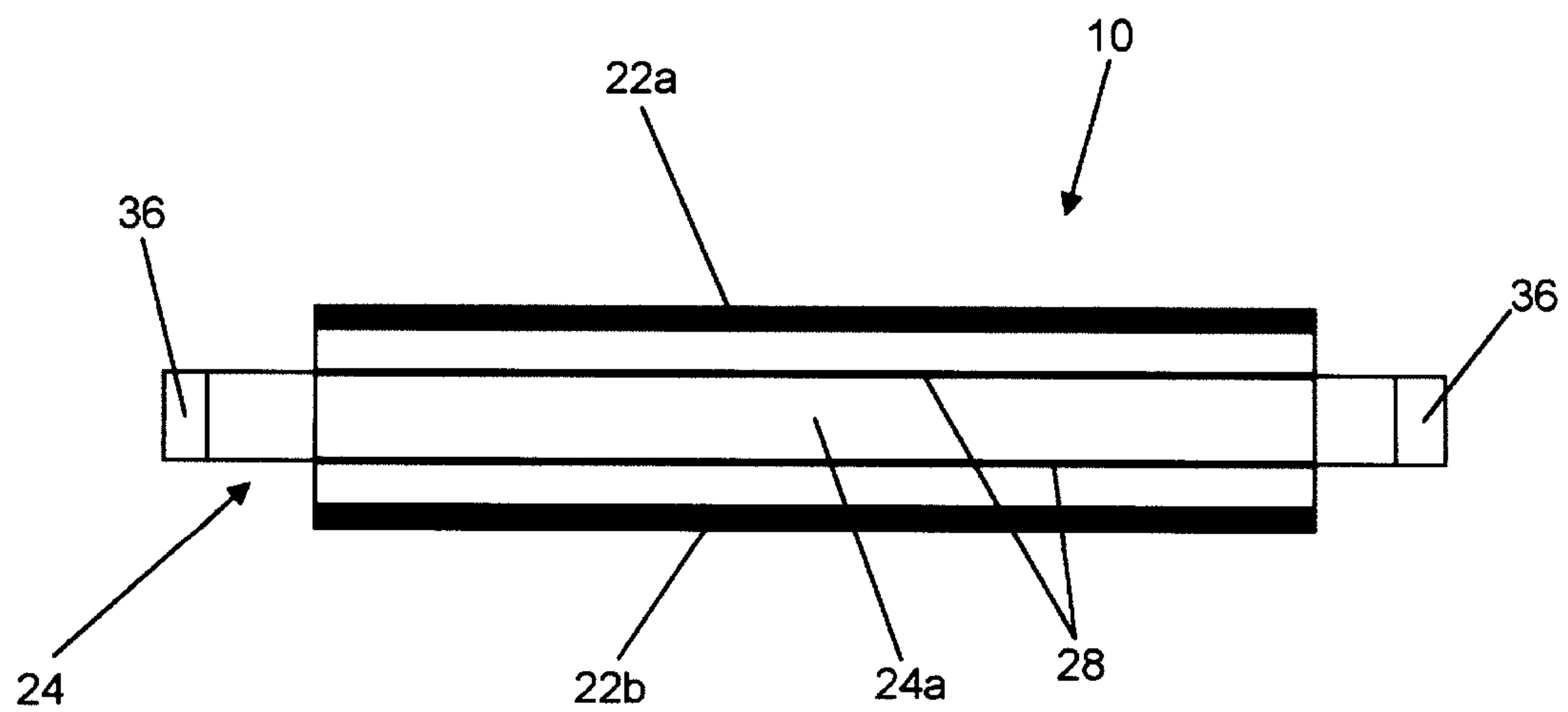


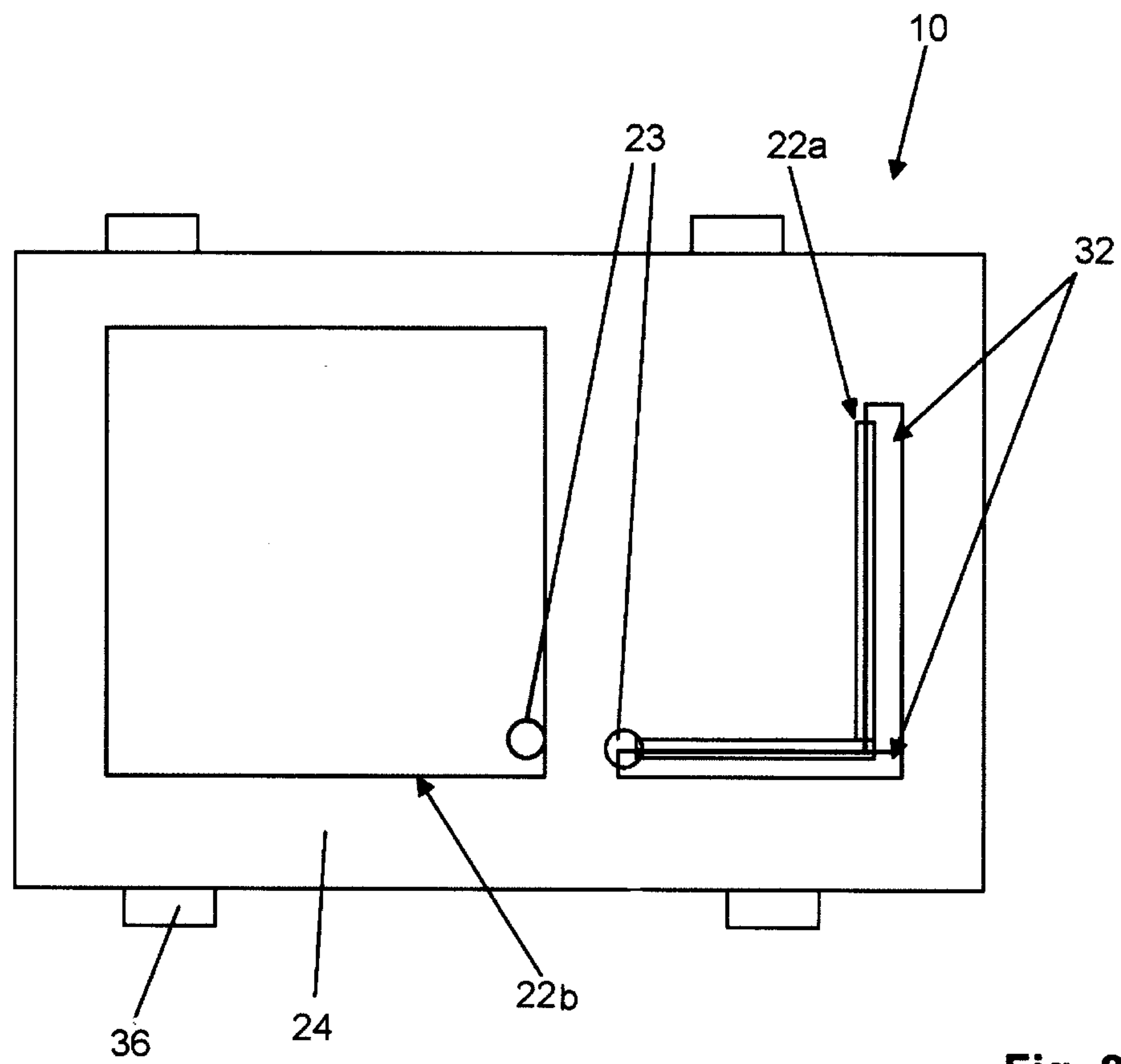
Fig. 5c

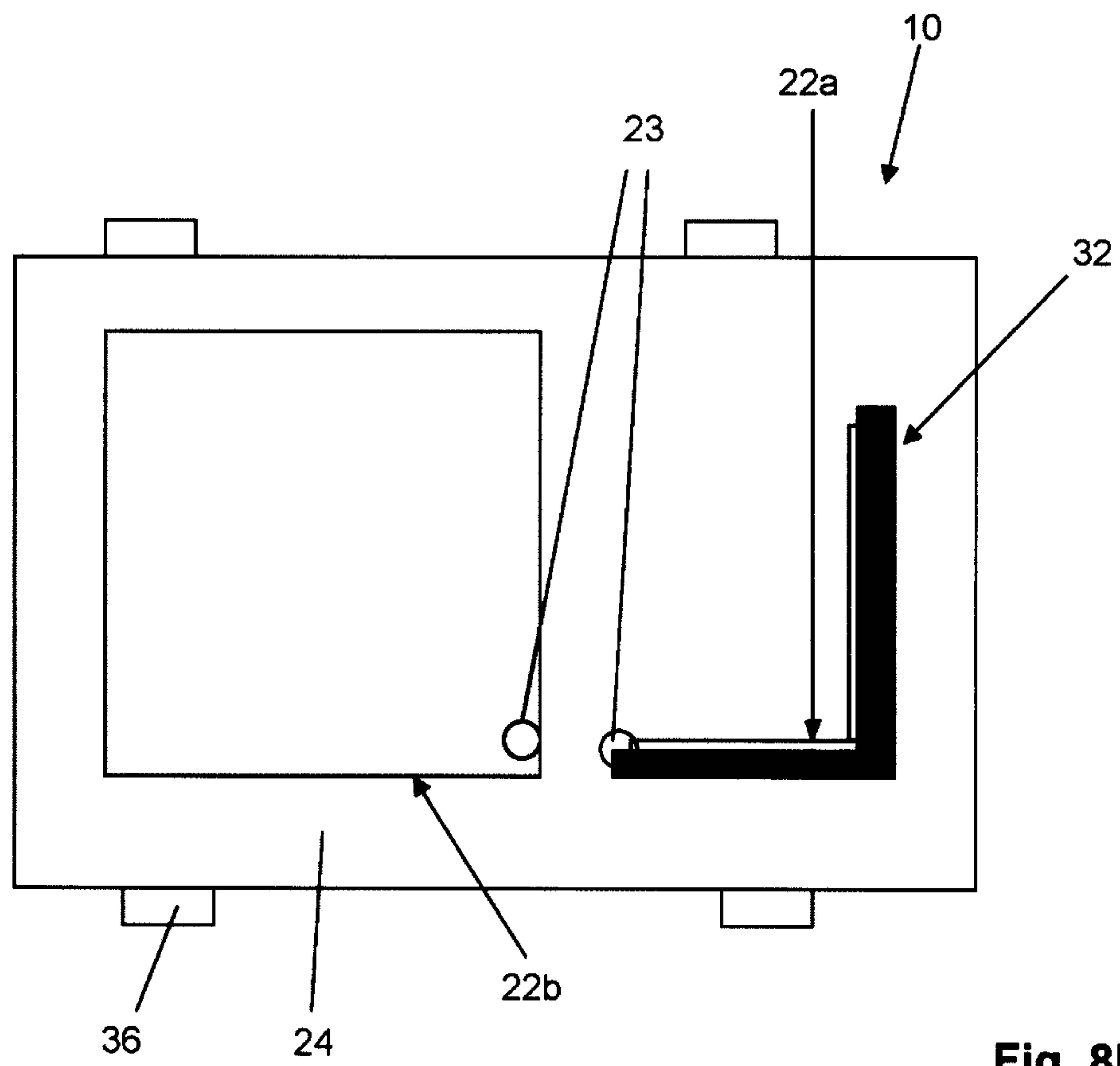
8/13**Fig. 6a**

9/13**Fig. 6b**

10/13**Fig. 6c**

11/13**Fig. 7a****Fig. 7b**

12/13**Fig. 8a**

13/13**Fig. 8b**

