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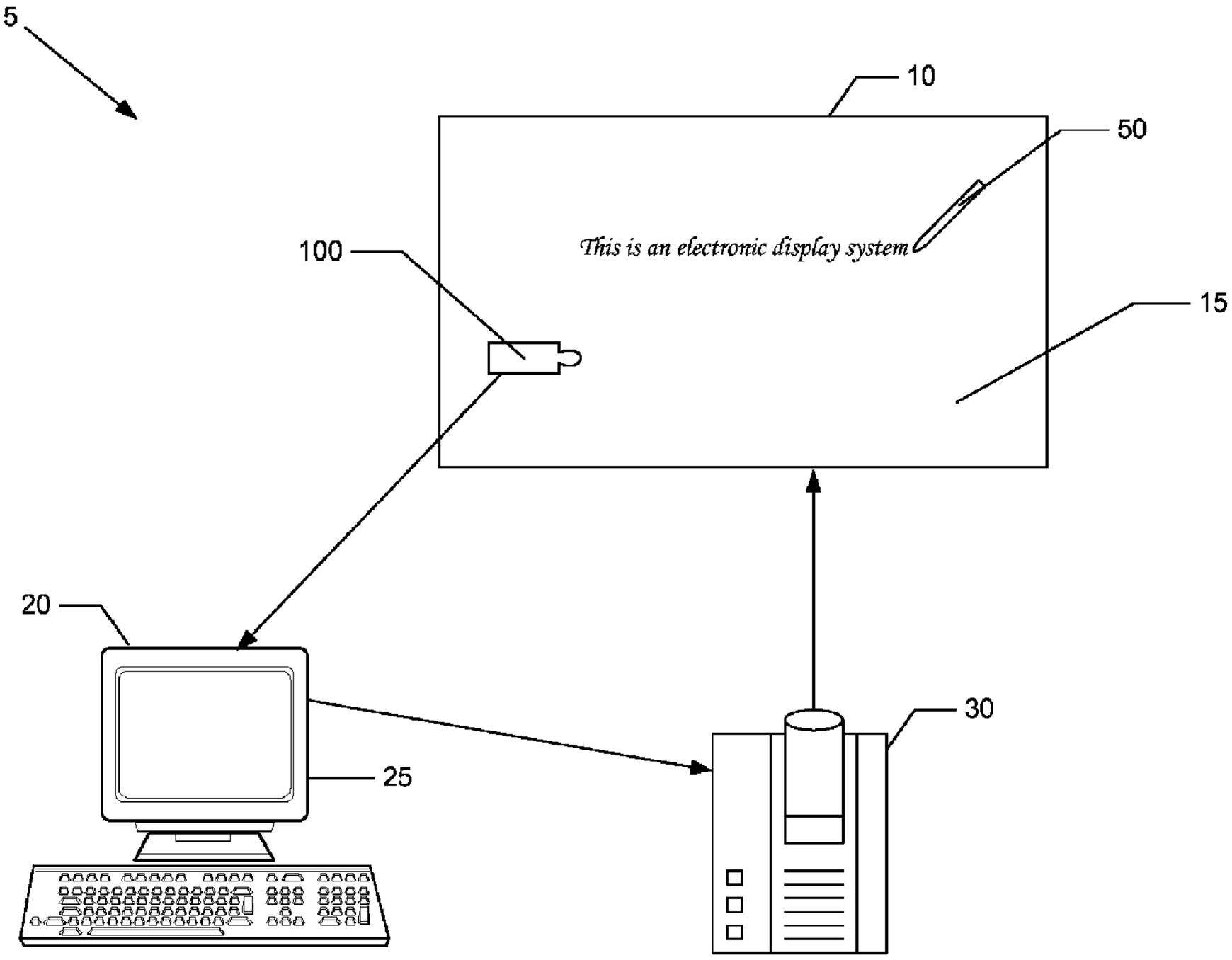

Fig. 1

(57) Abrégé/Abstract:
Eraser assemblies for electronic display systems are disclosed herein. An electronic display system can comprise a display surface with a coding pattern, and an eraser assembly can interact with the display surface. The eraser assembly can comprise a body

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(57) Abrégé(suite)/Abstract(continued):
assembly carrying an eraser pad and a sensing device, such as a camera. When the eraser pad is in use, the camera can capture one or more images of the coding pattern on the display surface. Based on captured images of the coding pattern, the electronic display system can identify a swath on the display surface to be erased.

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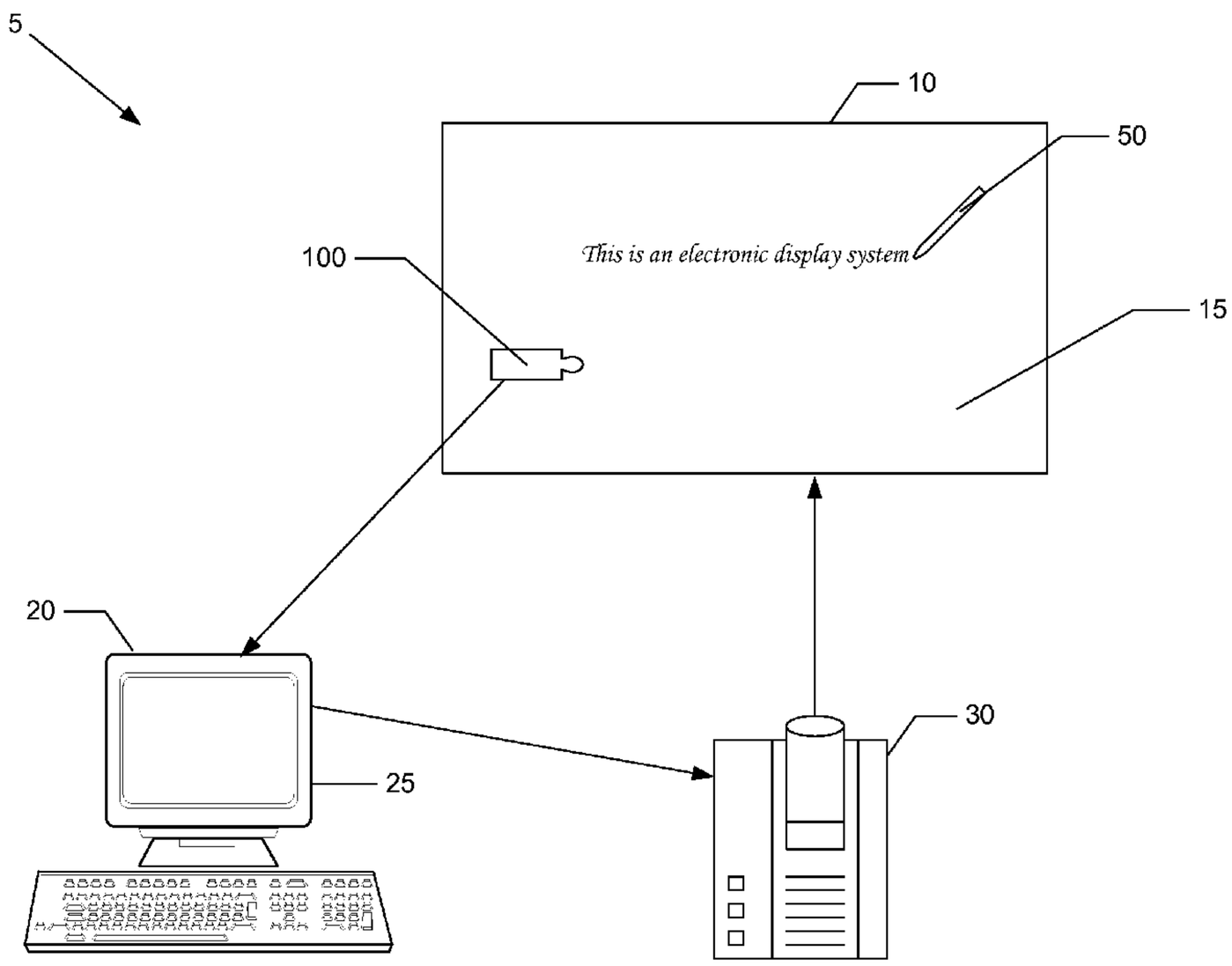

Fig. 1

(57) Abstract: Eraser assemblies for electronic display systems are disclosed herein. An electronic display system can comprise a display surface with a coding pattern, and an eraser assembly can interact with the display surface. The eraser assembly can comprise a body assembly carrying an eraser pad and a sensing device, such as a camera. When the eraser pad is in use, the camera can capture one or more images of the coding pattern on the display surface. Based on captured images of the coding pattern, the electronic display system can identify a swath on the display surface to be erased.

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ERASER ASSEMBLIES

BACKGROUND

Various aspects of the present invention relate to eraser assemblies and, moreover, to eraser assemblies for electronic display systems.

It is known to digitize handwriting on a surface, such as a piece of paper, by determining how a pen is moved. A position-coding pattern for coding coordinates of points can be provided on the surface. The pen can be provided with a sensor for recording the position-coding pattern locally at the tip of the pen as the pen is moved across the surface. A processing unit, which can be placed in the pen or at a distance therefrom, can decode the recorded position-coding pattern by analyzing the portion of the pattern viewed by the sensing device. As a result, movement of the pen across the surface can be determined as a series of coordinates.

For example, there exists a method of determining coordinates from a dot pattern on a piece of paper. Each set of six-by-six dots accurately defines a single coordinate. A pen containing a sensing device can view the dots and, thereby, calculate the coordinate at which the pen is positioned. For example, International Patent Publication No. WO 01/26032 and U.S. Patent No. 7,249,716 describe such dot patterns.

Conventional electronic whiteboard systems do not currently implement dot patterns.

Conventional electronic whiteboard systems do, however, provide erasers for erasing digital markings of a pen or stylus. But currently, electronic erasers for such systems come with a number of disadvantages.

Rectangular erasers are provided for conventional non-electronic whiteboards. Rectangular erasers are beneficial because they allow a user to erase either a large swath or a smaller portion with a single stroke, depending on how the eraser is oriented in the plane of the whiteboard surface.

On the other hand, electronic whiteboard systems generally implement circular erasers. Rectangular erasers, while beneficial, would require the electronic whiteboard system to determine the orientation as well as the placement of the eraser, as the area of erasure depends on both these variables. In contrast, orientation of a circular eraser is irrelevant because a circle covers the same space regardless of orientation. The user of an electronic whiteboard system with a circular eraser, however, may not be able to vary the size of the area erased in a single stroke.

With standard whiteboard erasers, the user can tip the eraser against the whiteboard surface, so that an angle greater than zero exists between the surface and the eraser pad. Tipping can result in erasure of an even smaller swath than can be otherwise erased. With most electronic whiteboards, however, tipping the eraser causes undesirable effects. For example, the whiteboard system may not recognize that erasure is desired, or may incorrectly determine the position, orientation, or both, of the eraser.

SUMMARY

There is a need in the art for an improved eraser for an electronic display system, such as an electronic whiteboard system. Preferably, such an improved eraser can be implemented in conjunction with a position-coding pattern, such as a dot pattern.

Briefly described, various embodiments of the present invention include eraser assemblies and electronic display systems having eraser assemblies. An eraser assembly indicates an area of a display surface for erasure. The eraser assembly comprises a body assembly, one or more eraser pads, and a sensing system.

The body assembly can comprise one or more eraser portions, such as a first eraser portion and a second eraser portion. The eraser portions are couplable to each other.

A first eraser pad is attached to the first eraser portion, and a second eraser pad is attached to the second eraser portion. The eraser pads are attached to the body assembly such that the eraser pads create an obtuse angle with respect to each other.

The body assembly can further comprise, or carry, one or more guards for preventing the user from tipping or angling the eraser pads against the display surface.

The sensing system is in communication with the body assembly, and is adapted to sense indicia of the eraser assembly's posture with respect to the display surface. For example and not limitation, the sensing system can include a sensing device for viewing a position-coding pattern on the display surface. A single sensing device can be used with multiple eraser pads, including both the first and second eraser pads.

These and other objects, features, and advantages of the present invention will become more apparent upon reading the following specification in conjunction with the accompanying drawing figures.

BRIEF DESCRIPTION OF THE FIGURES

Fig. 1 illustrates an electronic display system, according to an exemplary embodiment of the present invention.

Fig. 2A illustrates a side, partial cross-sectional view of an eraser assembly, according to an exemplary embodiment of the present invention.

Fig. 2B illustrates an underside view of the eraser assembly, according to an exemplary embodiment of the present invention.

Fig. 2C illustrates a front view of the eraser assembly, according to an exemplary embodiment of the present invention.

Fig. 3 illustrates a side view of the eraser assembly having a single eraser pad, according to an exemplary embodiment of the present invention.

Fig. 4A illustrates predetermined threshold tipping angles of the eraser assembly, according to an exemplary embodiment of the present invention.

Figs. 4B-4C illustrate side views of the eraser assembly tipped at angles exceeding the threshold tipping angles, according to an exemplary embodiment of the present invention.

Fig. 5 illustrates a side view of the eraser pad having a guard, according to an exemplary embodiment of the present invention.

Figs. 6A-6C illustrate various images of a pattern, as captured by a sensing device of the eraser assembly, according to an exemplary embodiment of the present invention.

Fig. 7A illustrates a cross-sectional side view of the eraser assembly, according to an exemplary embodiment of the present invention.

Fig. 7B illustrates an underside view of the eraser assembly, according to an exemplary embodiment of the present invention.

Fig. 8A illustrates a retrofit implementation of the eraser assembly, according to an exemplary embodiment of the present invention.

Fig. 8B illustrates the retrofit implementation of the eraser assembly coupled to a conventional eraser, according to an exemplary embodiment of the present invention.

Fig. 9 illustrates a flow chart of a manufacturing process of the eraser assembly, according to a preferred embodiment of the present invention.

Fig. 10 illustrates a method of using the eraser assembly in the display system.

DETAILED DESCRIPTION

To facilitate an understanding of the principles and features of the invention, various illustrative embodiments are explained below. In particular, the invention is described in the context of being an eraser assembly for an electronic display system. Embodiments of the invention, however, are not limited to use in electronic display systems. Rather, embodiments of the invention can be used for erasure in many electronic writing or drawing systems.

The components described hereinafter as making up various elements of the invention are intended to be illustrative and not restrictive. Many suitable components that would perform the same or similar functions as the components described herein are intended to be embraced within the scope of the invention. Such other components not described herein can include, but are not limited to, for example, components that are developed after development of the invention.

Various embodiments of the present invention comprise eraser assemblies and electronic display systems having eraser assemblies. Referring now to the figures, wherein like reference numerals represent like parts throughout the views, embodiments of eraser assemblies and electronic display systems will be described in detail.

Fig. **1** illustrates an electronic display system **5**, for example, an electronic whiteboard system, implementing the eraser assembly **100**. The electronic display system **5** includes an electronic display device **10**, such as an electronic display board, having a display surface **15**. The electronic display system **5** can further include a processing device **20** and a projector **30**.

The display board **10** is operatively connected to the processing device **20**. The processing device **20** can be an integrated component of the display board **10**, or the processing device **20** can be an external component. Suitable processing devices include a computing device **25**, such as a personal computer.

The projecting device **30**, such as a conventional projector, can project images from the processing device **20** onto the display surface **15**. For example and not limitation, the projector **30** can project a graphical user interface or markings created through use of a digital writing device, such as a pen or stylus **50**. The projecting device **30** can be in communication with the processing device **20**. Such communication can be, for example, by means of a wired or wireless connection, Bluetooth, or by many other means through which two devices can communicate. The projecting device **30**, however, can be excluded from the display system **5** if the display device **10** is internally capable of displaying markings and other objects on its surface **15**.

The stylus **50** can transmit a signal to the processing device **20** that digital markings are to be projected onto the display surface **15** as indicated by the stylus **50**. Such signal can be transmitted to the processing device **20** over a wired or wireless, such as 802.11b or Bluetooth, connection. Additionally, the stylus **50** can be adapted to physically mark the display surface **15**, for example, with dry-erase ink or some other removable marking material. The display surface **15** can be adapted to receive such physical markings. These markings, both digital and physical, of the stylus **50** can be adapted by the display system **5** for printing, storage, sharing, sending, or many other purposes.

The eraser assembly **100** can cause objects, such as markings, to be erased or blanked from the display surface **15**. When objects are blanked, such objects are no longer visible on the display surface **15**, but may or may not remain in memory of the processing device **20**.

The eraser assembly **100** can be activated by many means, such as by an actuator, such as a switch or button, or by bringing the eraser assembly **100** in proximity to the display surface **15**. While activated, placement or movement of the eraser assembly **100** on, or in proximity to, the display surface **15** can indicate to the processing device **20** that objects are to be removed from the display surface **15**. Additionally, if the display surface **15** is adapted to receive removable markings, such as from the stylus **50**, the eraser assembly **100** can be analogously adapted to physically erase such markings.

Figs. 2A-2C illustrate, respectively, side, underside, and front views of the eraser assembly **100**. The eraser assembly **100** can comprise a body assembly **110**, one or more eraser pads **120**, one or more pad guards **170**, and a sensing system **130**.

Body Assembly

The body assembly **110** acts as a support and backbone for the eraser assembly **100**. The body assembly **110** can be composed of many materials, including, but not limited to plastic, metal, or wood. At least a portion of the body assembly **110** can be comprised of a rigid material, such that a user can grip the body assembly **110** to guide the eraser along the display surface **15**. Additionally, the body assembly **110** can be composed of multiple parts, or can be a single unsegmented component. As shown, the body assembly **110** can comprise one or more eraser portions **160**, such as a body portion **140** and a head portion **150**.

The body portion **140**, or body, and the head portion **150**, or head, each perform as eraser portions **160**. Each eraser portion **160** provided in the body assembly **110** can provide a means

to erase. Further, each distinct eraser portion **160** can indicate to the display system **5** a distinct set of parameters for erasure. For example, and not limitation, the head **150** indicates a smaller area of erasure than does the body **140**. In addition to the head **150** and body **140**, additional eraser portions **160** can be provided in the eraser assembly **100**.

The body **140** can comprise a hand-hold **141** and a power-source compartment **144**.

The hand-hold **141** enables secure and comfortable handling of the eraser assembly **100** during erasing. As shown in **Fig. 2A**, the body **140** can define a holding cavity **142**, further defining the hand-hold **141** that the user can wrap a hand through. The holding cavity **142**, however, is not required. For example, the hand-hold **141** can comprise a grip **143** additionally or alternatively to the holding cavity **142**. If the hand-hold **141** is not provided, it is preferable, though not required, that the body **140** have an ergonomic shape for comfortable handling by the user.

The body **140** further defines a second cavity for use as a power-source compartment **144**, and can further comprise a cover **145**. The power-source compartment **144** houses a power source, such as one or more batteries, used to power elements of the eraser assembly **100**. When secured to the remainder of the body **140**, the cover **145** can enclose the power source in the power-source compartment **144**. Further, when secured, the cover **145** can form a generally flush surface with the remainder of the body **140**. Additionally or alternatively, the eraser assembly **100** can be wired to a power source for powering the eraser assembly **100**.

The head **150** can protrude from one end of the body **140**, as shown. It is not required, however, that there be a distinct separation between the eraser portions **160**, as with the head **150** protruding from the body **140**. For example and not limitation, the body assembly **110** can comprise any polyhedron, with each face of the polyhedron representing a distinct eraser portion **160**.

Eraser Pads

As stated above, the eraser assembly **100** can additionally comprise one or more eraser pads **120**. Each eraser pad **120** is analogous to a foam, pad, or cloth material that contacts the display surface **15** in a conventional non-electronic eraser. As the display surface **15** can be adapted to receive physical marking, such as from a dry-erase marker, the eraser pads **120** can be adapted to erase such physical markings. Accordingly, the eraser pads **120** can be composed of materials similar to those used with a conventional whiteboard. In other words, one or more

eraser pads **120** can be composed of foam, pad, cloth, or many other materials capable of removing physical markings. Further, one or more eraser pads **120** can be treated with water or chemicals, such as a cleaning solution, for removing physical markings.

Alternatively, if the display system **5** is not adapted to receive physical marking on the display surface **15**, then no physical erasure of such markings is required. In that case, the eraser pads **120** need not be composed of a conventional material, but can comprise many materials, such as wood or plastic. To emulate the feel and maintain a similar weight of a conventional eraser, however, the eraser pads **120** are preferably composed of conventional materials.

While many eraser pads **120** can be provided in the eraser assembly **100**, preferably one eraser pad **120** is provided for each eraser portion **160**. Each eraser pad **120** can be in communication with a corresponding eraser portion **160**, and is preferably physically attached to such eraser portion **160** by means of one or more adhesives, screws, nails, and the like.

Exemplarily, an eraser pad **120** is in use when it contacts, or is in sufficient proximity to, the display surface **15**. The user can use an eraser pad **120** by moving its corresponding eraser portion **160** in sufficient proximity to the display surface **15**. When an eraser pad **120** is in use, erasing can occur with that eraser pad **120**. The size and shape of an area erased can correspond to the general size and shape of the eraser pad **120** in use.

Two eraser pads **120** can be provided, a body eraser pad **124** and a head eraser pad **128**. The body eraser pad **124** can be attached to a body pad surface **146** of the body **140**. Likewise, the head eraser pad **128** can be attached to a head pad surface **152** of the head **150**.

The eraser pads **120** can be many shapes and sizes. Preferably, provided eraser pads **120** differ in size, shape, or both. As shown, the head eraser pad **128** can be smaller than the body eraser pad **124**. As such, the user can vary the area of erasure by switching between the body and head eraser pads **124** and **128**.

Alternatively, a single eraser pad **120** can be provided, and can be directly attached to more than one eraser portion **160**. **Fig. 3** illustrates this configuration. Preferably, the angle of the eraser pad **120** varies from one eraser portion **160** to an adjacent eraser portion **160**. In other words, the single eraser pad **120** can be bent between eraser portions **160**. As such, adjacent eraser portions **160** could not be used simultaneously for erasing because only one would be sufficiently proximate the display surface **15** at any instant.

Referring now back to **Figs. 2A-2C**, the head eraser pad **128** can be set at many angles with respect to the body eraser pad **124**. For example, when the body eraser pad **124** faces the display surface **15**, that is, when the body eraser pad **124** is generally parallel to the display surface **15**, the angle **α** between the display surface **15** and the head eraser pad **128** is an acute angle. Preferably, **α** is in the range of approximately 10 degrees to approximately 80 degrees. For example, in one embodiment, **α** can be approximately 25 degrees. To switch between use of the two eraser pads **124** and **128**, the user can rotate the eraser assembly by approximately **α** toward the desired eraser pad **124** or **128**.

Pad Guards

A pad guard **170** can, but need not, be provided as part of each eraser portion **160**. All or none of the eraser portions **160** can have pad guards **170**. Alternatively, one or more eraser portions **160** can comprise pad guards **170**, while one or more other eraser portions **160** do not.

Eraser tipping can cause negative effects on the display system **5**. Pad guards **170** are adapted to reduce or prevent eraser tipping. To this end, a pad guard **170** can obstruct, block, or shield an eraser pad **120** from the display surface **15** when the eraser assembly **100** is undesirably tipped. This obstruction occurs when the eraser assembly **100** is tipped to such a degree that the eraser pad **120** is positioned at least a predetermined angle away from the display surface **15**. Erasure cannot occur with a particular eraser pad **120** when a pad guard **170** prevents the eraser pad **120** from reaching the display surface **15**.

As shown in **Figs. 2A-2B**, the body **140** can comprise or carry a body pad guard **148**. The body pad guard **148** can prevent the body eraser pad **124** from contacting the display surface **15** when the body eraser pad **124** is tipped to greater than a predetermined threshold tipping angle **β** with respect to the display surface **15**. **Fig. 4A** shows the threshold tipping angle **β** applicable to the body eraser pad **124**. **Fig. 4B** illustrates the eraser assembly **100** when tipping of the body eraser pad **124** past angle **β** occurs. As shown, the eraser assembly **100** and the body eraser pad **124** are tipped at angle **γ** with respect to the display surface **15**, where **γ** is greater than **β**. As shown in **Fig. 4B**, the eraser pad **124** of the body **140** will not contact, or come sufficiently proximate to, the display surface **15**. Thus, the display system **5** can recognize that markings on the display surface **15** should not be erased or deleted. Accordingly, there can be a reduced risk of miscalculating a swath of the display surface **15** to be erased.

Referring back to **Figs. 2A-2B**, the body pad surface **146** can have a greater perimeter than does the body eraser pad **124**. As such, an outer edge **147** of the body pad surface **146** extends outside the perimeter of the body eraser pad **124**. The body pad guard **148** comprises this outer edge **147**.

Likewise, the head **150** can comprise or carry a head pad guard **154**. The head pad guard **154** can prevent the head eraser pad **128** from contacting the display surface **15** when the head eraser pad **128** is tipped to greater than a predetermined threshold tipping angle **θ** with respect to the display surface **15**. **Fig. 4A** shows the threshold tipping angle **θ** applicable to the head eraser pad **128**. **Fig. 4C** illustrates the eraser assembly **100** when tipping of the head eraser pad **128** past angle **θ** occurs. As shown, the eraser assembly **100** and the head eraser pad **128** are tipped at angle **φ** with respect to the display surface **15**, where **φ** is greater than **θ**. As shown in **Fig. 4C**, the eraser pad **128** of the head **150** will not contact, or come sufficiently proximate to, the display surface **15**. Thus, the display system **5** can recognize that markings on the display surface **15** should not be erased or deleted. Accordingly, there can be a reduced risk of miscalculating a swath of the display surface **15** to be erased.

Referring again to **Figs. 2A-2B**, the head pad surface **152** can have a greater perimeter than does the head eraser pad **128**. As such, an outer edge **155** of the head pad surface **152** extends outside the perimeter of the head eraser pad **128**. The head pad guard **154** comprises this outer edge **155**.

Alternatively, a pad guard **170**, such as the body or head pad guard **148** or **154**, can comprise a lip, cover, or many other physical barriers to prevent undesirable tipping of the eraser assembly **100**. For example, **Fig. 5** illustrates a ridge implementation of the body pad guard **148** and the head pad guard **154**. A shown in **Fig. 5**, the body and head pad guards **148** and **154** can comprise ridges **175** for obstructing undesirable tipping of the eraser assembly **100**.

As illustrated in **Fig. 4A**, the tipping angles **β** and **θ** can be determined by the distance the applicable pad guard **170** extends past the perimeter of the eraser pad **120** and by the distance the eraser pad **120** extends below the pad guard **170**. An eraser pad **120** can have many thicknesses, and a pad guard **170** can have many widths. As a result, the tipping angles **β** and **θ** can vary between eraser portions **160** and, further, can vary around the perimeter of an eraser pad **120**. In one embodiment, one or more of the resulting tipping angles **β** and **θ** are minimized, so that tipping is minimized.

Sensing System

Referring back to **Figs. 2A-2C**, the sensing system **130** can be coupled to, and in communication with, the body assembly **110**. The sensing system **130** can have many implementations adapted to sense indicia of the posture of the eraser assembly **100** with respect to the display surface **15**. For example, the sensing system **130** can sense data indicative of the distance of the eraser assembly **100** from the display surface **15**, as well as the position, orientation, tipping, or a combination thereof, of the eraser assembly **100** with respect to the display surface **15**.

The eraser assembly **100** has six degrees of potential movement. In the two-dimensional coordinate system of the display surface **15**, the eraser assembly **100** can move in the horizontal and vertical directions. The eraser assembly **100** can also move normal to the display surface **15**, and can rotate about the horizontal, vertical, and normal axes. These rotations are commonly referred to, respectively, as the roll, yaw, and tilt of the eraser assembly **100**. The sensing system **130** can sense all, or many combinations of, these six degrees of movement.

The term "tipping" as used herein, refers to angling of the eraser assembly **100** away from normal to the display surface **15**, and, therefore, includes rotations about the horizontal and vertical axes, *i.e.*, the roll and the yaw of the eraser assembly **100**. On the other hand, "orientation," as used herein, refers to rotation parallel to the plane of the display surface **15** and, therefore, about the normal axis, *i.e.*, the tilt of the eraser assembly **100**.

As shown, the sensing system **130** can include a first sensing device **132**, a second sensing device **134**, and a third sensing device **136**. Each sensing device **132**, **134**, and **136** can be adapted to sense indicia of the posture of the eraser assembly **100**. Further, each sensing device **132**, **134**, and **136** can individually detect data for determining the posture of the eraser assembly **100** or, alternatively, can detect such data in conjunction with other components, such as another sensing device.

To facilitate analysis of data sensed by the sensing system **130**, the eraser assembly **100** can further comprise either or both of an internal processing unit **180** and a communication device **185**. The internal processing unit **180** can process data detected by the sensing system **130**. Such processing can result in determination of, for example: distance of the eraser assembly **100** from the display surface **15**; position of the eraser assembly **100** in the coordinate

system of the display surface **15**; roll, tilt, and yaw of the eraser assembly **100** with respect to the display surface **15**, and, accordingly, tipping and orientation of the eraser assembly **100**.

The communication device **185** can transfer data to the processing device **20**, and can accept data from the processing device **20**. For example, if processing of sensed data is conducted by the processing device **20** instead of in the internal processing unit **180**, the communication device **185** can transfer sensed data to the processing device **20** for such processing.

The first sensing device **132** can be a display sensing device adapted to sense the posture of the eraser assembly **100** based on properties of the display surface **15**. The display sensing device **132** can be, or comprise, a capture device, such as a camera. The display sensing device **132** can detect portions of a pattern **200** (see **Figs. 6A-6C**) on the display surface **15**, such as a dot pattern, a dot matrix position-coding pattern, or other coding image. Detection by the display sensing device **132** can comprise viewing, or capturing an image of, a portion of the pattern **200**.

The display sensing device **132** can be in communication with the body assembly **110** of the eraser assembly **100**, and can have many positions and orientations with respect to the body assembly **110**. For example, the display sensing device **132** can be positioned on, or housed in, the head **150**, as depicted in **Figs. 2A-2C**. Additionally or alternatively, the display sensing device **132** can be in communication with the head **150** or the body **140**, or can positioned on, or housed in, the body **140** or other eraser portions **160** or portion of the body assembly **110**.

As a result of the position of the display sensing device **132** between the body and head eraser pads **124** and **128**, as shown, the display sensing device **132** can detect the display surface **15** regardless of which eraser pad **124** or **128** is in use. The display sensing device **132** can be directed normal to the head **150**, such that the display sensing device **132** views the position-coding pattern generally straight-on when the head eraser pad **128** is in use, and generally at angle α when the body eraser pad **124** is in use.

As mentioned previously, the angle α is preferably less than 90 degrees. If α is 90 degrees or greater, then the display sensing device **132** would be unable to detect the display surface **15** during use of the body eraser pad **128**, as the display sensing device **132** on the head **150** would then be directed away from the pattern **200** on the display surface **15**. As a result, if α is 90 degrees or greater, a second display sensing device **138** (see **Figs. 7A-7B**), such as a second camera, can be provided and oriented normal to the body eraser pad **124**. From a complexity and

economic standpoint, however, it may be desirable to provide a single display sensing device **132** in the eraser assembly **100**.

The second and third sensing devices **134** and **136** can be contact sensors, such as a body contact sensor **134** and a head contact sensor **136**. The body contact sensor **134** and the head contact sensor **136** can sense, respectively, when the body **140** and the head **150** come into contact with a surface, such as the display surface **15**. The body contact sensor **134** can be in communication with the body eraser pad **124**. The body contact sensor **134** can comprise, for example and not limitation, a switch that closes a circuit when the body eraser pad **124** contacts a surface with predetermined pressure. Similarly, the head contact sensor **136** can be in communication with the head eraser pad **128**, and can comprise, for example, a switch that closes a circuit when the head eraser pad **128** contacts a surface. Accordingly, when the body or head eraser pad **124** or **128** contacts the display surface **15**, the display system **5** can determine that erasure is indicated.

Various detection systems can be provided in the eraser assembly **100** for detecting the posture of the eraser assembly **100**. For example, a tipping detection system **190** can be provided in the eraser assembly **100** to detect the angle and direction at which the eraser assembly **100** is tipped with respect to the display surface **15**. An orientation detection system **192** can be implemented to detect rotation of the eraser assembly **100** in the coordinate system of the display surface **15**. Additionally, a distance detection system **194** can be provided to detect the distance of the eraser assembly **100** from the display surface **15**.

These detection systems **190**, **192**, and **194** can be incorporated into the sensing system **130**. For example, the position, tipping, orientation, and distance of the eraser assembly **100** with respect to the display surface **15** can be determined, respectively, by the position, skew, rotation, and size of the appearance of the pattern **200** on the display surface **15**, as viewed from the display sensing device **132**. The internal processing unit **180**, the processing device **20**, or both can be configured to decode the pattern **200** to determine the posture of the eraser assembly **100**.

Figs. 6A-6C illustrate various views of an exemplary dot pattern **200** on the display surface **15**. The dot pattern **200** serves as a position-coding pattern in the display system **5**.

As previously discussed, determining an area of erasure can require calculating a number of variables, including the position of the eraser assembly **100** in the coordinate system of the

display surface **15**, tipping of the eraser assembly **100**, and, in the case of a non-circular eraser pad **120**, the orientation of the eraser assembly **100** in the coordinate system of the display surface **15**. All of these variables can be determined by the view of the pattern **200** from the display sensing device **132**.

Fig. 6A illustrates an image of the pattern **200**, which is considered a dot pattern, as viewed at an angle normal to the display surface **15**. For example, this is how the dot pattern **200** would appear from the display sensing device **132** when the head eraser pad **128** is in use, and when the display sensing device **132** is positioned on the head **150** and oriented, or rotated, normal to the head eraser pad **128**. In the image, the dot pattern **200** appears in an upright orientation and not angled away from the display sensing device **132**. When the display sensing device **132** captures such an image, the display system **5** can determine that the head eraser pad **128** is parallel to the display surface **15** and is in use.

As the eraser assembly **100** moves away from the display surface **15**, the distance between the dots in the captured image decreases. Analogously, as the eraser assembly **100** moves toward the display surface **15**, the distance between the dots appears to increase. As such, in addition to sensing the tipping and orientation of the eraser assembly **100**, the display sensing device **132** can sense the distance of the eraser assembly **100** from the display surface **15**.

Fig. 6B illustrates a rotated image of the dot pattern **200**. A rotated dot pattern **200** indicates that the eraser assembly is rotated in the coordinate system of the display surface **15**, about a normal axis of the display surface **15**. For example, when a captured image depicts the dot pattern rotated at an angle of 30 degrees clockwise, it can be determined that the eraser assembly **100** is oriented at an angle of 30 degrees counter-clockwise. As with the image of **Fig. 6A**, this image was taken with the display sensing device **132** oriented normal to the display surface **15**, so even though the eraser assembly **100** is rotated, the head eraser pad **128** is still in use.

Fig. 6C illustrates an image of the dot pattern **200** as viewed when the body eraser pad **124** is in use. The flattened image depicting dots angled away from the display sensing device **132** indicates that the display sensing device **132** is not oriented normal to the display surface **15**. Further, the rotation of the dot pattern **200** indicates that the eraser assembly **100** is rotated as well. The image can be analyzed to determine the tipping angle and direction as well as the orientation angle. For example, it may be determined that the eraser assembly **100** is tipped

downward 45 degrees, and then rotated 25 degrees. These variables determine an area to be erased. If it is determined that the tipping is approximately **α** degrees (see **Fig. 2A**) and approximately directly toward the body **140**, then the body eraser pad **124** is parallel to the display surface **15** and, possibly, in use.

If, however, the calculated tipping angle and direction fall outside the ranges of the body and head eraser pads **124** and **128**, it can be determined that the eraser assembly **100** is tipped away from the display surface **15**, such that neither eraser pad **124** or **128** is facing and nearly parallel to the display surface **15**. This could result from the user's attempt to eraser with a corner of an eraser pad **120**. The tipping angle and direction can be used to determine whether and to what degree the eraser pad **120** in use is angled with respect to the display surface **15** and, therefore, what area is erased. In some embodiments, tipping can be disallowed and, therefore, indicated to the user as an error through a vibrator, buzzer, flashing light, or other sound or signal emitted from the display system **5**. Additionally, or alternatively, the eraser assembly 100 can be temporarily deactivated during tipping, such that no erasure occurs while the eraser assembly 100 is undesirably tipped.

Accordingly, by analyzing images captured by the display sensing device **132**, the display system **5** can determine whether erasure should occur and, if so, which eraser pad **120** is in use and at what distance and orientation. The display system **5** can then respond accordingly.

Fig. 7A illustrates a side cross-sectional view of another embodiment of the eraser assembly **100**, and **Fig. 7B** illustrates an underside view of the eraser assembly **100**.

Eraser pads **120**, including body and head eraser pads **124** and **128**, can be of many thicknesses. As shown in **Figs. 7A-7B**, an eraser pad **120**, such as the body or head eraser pad **124** or **128**, can be embedded in its corresponding eraser portion **160**.

The body **140** can comprise a cutout **149** for receiving the body eraser pad **124**. The body pad surface **146**, to which the body eraser pad **124** is secured, can be a side of the cutout **149**. Accordingly, the body eraser pad **124** can be disposed inside the body **140**. The body pad guard **148** can comprise an outer edge of the body **140** surrounding the body eraser pad **124**. If provided, the second display sensing device **138** can be embedded, or disposed, in the body eraser pad **124**, as shown.

Likewise, the head **150** can comprise a cutout **156** for receiving the head eraser pad **128**. The head pad surface **152**, to which the head eraser pad **128** is secured, can be a side of the

cutout **156**. Accordingly, the head eraser pad **128** can be disposed inside the head **150**. The head pad guard **154** can comprise an outer edge of the head **150** surrounding the head eraser pad **128**. The display sensing device **132** can be embedded, or disposed, in the head eraser pad **128**, as shown.

Additionally, a bridge **115** can be provided in the body assembly **110** for coupling and connecting the body **140** and the head **150**.

The eraser assembly **100** can be adapted to utilize a conventional eraser in lieu of an eraser pad **120** and, thereby, retrofit the conventional eraser **300**. **Fig. 8A-8B** illustrate a retrofit implementation of the eraser assembly **100**. **Fig. 8A** illustrates the eraser assembly **100** and a separate conventional eraser **300**, while **Fig. 8B** illustrates the eraser assembly **100** secured to the conventional eraser **300**.

As shown in **Figs. 8A-8B**, the body eraser pad **124** need not be provided in the eraser assembly **100**. A securing element **195** can be provided in the eraser assembly **100** to secure the conventional eraser **300** to the body pad surface **146** of the eraser assembly **100**. In one embodiment, the securing element **195** is positioned on the body assembly **110**, specifically on the body pad surface **146**. The securing element **195** can include one or more of adhesives, Velcro, screws, nails, pins, magnets, and the like, and can secure the eraser assembly **100** to the conventional eraser **300**. Accordingly, the conventional eraser **300** is adapted to interact with the display system **5** and to be used on the display surface **15**.

The size of the body **140** can be adapted to fit at least a standard-size conventional eraser **300**. To facilitate adaptation of conventional erasers **300** of various heights, the body pad guard **148** can be adjustable to accommodate shorter conventional erasers **300**. For example and not limitation, the body pad guard **148** can be composed of a contracting material, such as a foam, such that when the body pad guard **148** is pressed against the display surface **15**, the body pad guard **148** contracts, thereby allowing the conventional eraser **300** to contact the display surface **15**. While a foam pad guard **170** would reduce tipping to some degree, the foam material could cause the pad guard **170** to be less effect than a pad guard **170** composed of a rigid material.

Fig. 9 illustrates a flow diagram of a manufacturing process **400** of the eraser assembly. Each box in **Fig. 9** represents a sub-process of the overall manufacturing process. One skilled in the art would appreciate that the sub-processes illustrated in **Fig. 9** need not be undertaken in the order illustrated, and one or more of the sub-processes can be segments of other sub-processes.

Further, not all of the sub-processes illustrated need be undertaken for every embodiment of the manufacturing process, and additional sub-processes can be provided.

In an exemplary embodiment, the manufacturing process **400** comprises providing the body assembly **110** at **410**. The body assembly **110** can comprise one or more eraser portions **160**.

At **420**, a first eraser pad **120** is secured to the body assembly **110**. The first eraser pad **120** can be secured to one or more eraser portions **160**. Additionally, other eraser pads **120** can be provided and secured to eraser portions **160** of the body assembly **110**. Preferably, each eraser pad **120** is secured to a single eraser portion **160**.

At **430**, a sensing system **130** can be coupled to the body assembly **110**. The sensing system **130** can comprise a display sensing device **132**, such as a camera, which can be housed in an eraser portion **160** of the body assembly **110**.

Additionally, one or more pad guards **170** can be provided around one or more eraser pads **120**. And a second display sensing device **138**, such as a second camera, can be provided in a second eraser portion **160**.

Fig. 10 illustrates a method of using the eraser assembly **100** in the display system **5**. At a moment in time, the display surface **15** can display an image communicated from the processing device **20**. If a projector **30** is provided, such image can be communicated from the processing device **20** to the projector **30**, and then projected by the projector **30** onto the display surface **15**. The image can include digital markings produced by the stylus **50**, and the display surface **15** can further comprise physical markings produced by the stylus **50**. Images and markings on the display surface **15** can be saved to electronic media, emailed, posted on the web, or archived in many ways, and can also be recalled for further editing.

In an exemplary embodiment, a user **90** can initiate erasure by bringing a portion of the eraser assembly **100** in sufficient proximity to the display surface **15**, or by placing a portion of the eraser assembly **100** in contact with the display surface **15**. To erase a swath of the display surface **15**, the user **90** can move the eraser assembly **100** along the display surface **15**. This movement can result in physical removal of physical markings on the display surface **15** and, through the electronic display system **5**, removal of digital markings as well.

As the eraser assembly **100** travels along the display surface **15**, the sensing system **130** periodically senses indicia of the changing posture of the eraser assembly **100** with respect to the

display surface **15**. These indicia are then processed by the display system **5**. In one embodiment, the internal processing unit **180** of the eraser assembly **100** processes this data. In another embodiment, the data is transferred to the processing device **20** by the communication device **185** of the eraser assembly **100**, and the data is then processed by the processing device **20**. Processing of such data can result in determining the position, orientation, tipping, or a combination thereof, of the eraser assembly **100** and, thereby, can result in determining areas to be erased. If processing occurs in the internal processing unit **180** of the eraser assembly **100**, the results are transferred to the processing device **20** by the communication device **185**.

Based on determination of the relevant variables, the processing device **20** produces a revised image to be displayed onto the display surface **15**. The revised image can exclude a set of markings previously displayed in the erased swath. The display surface **15** is then refreshed, which can involve the processing device **20** communicating the revised image to the optional projector **30**. Accordingly, digital markings indicated by the eraser assembly **100** can be erased through the electronic display system **5**. In one embodiment, this occurs in real time.

From the foregoing, it can be seen that the invention provides a number of different eraser assemblies **100**.

For example, the eraser assembly **100** can comprise an eraser portion **160** with attached eraser pad **120**, and a sensing system **130** for sensing indicia of the posture of the eraser assembly **100**.

The eraser assembly **100** can comprise an eraser portion **160** with attached eraser pad **120**, and a pad guard **170** for reducing tipping of the eraser assembly **100**.

The eraser assembly **100** can comprise an eraser portion **160** with attached eraser pad **120**, a sensing system **130**, and a pad guard **170**.

The eraser assembly **100** can comprise an eraser portion **160** with a tipping detection system **190** to detect tipping of the eraser assembly **100** with respect to the display surface **15**.

The eraser assembly **100** can comprise a first eraser portion **160**, such as the body **140**, and a second eraser portion **160**, such as the head **150**. Each eraser portion **160** can have an attached eraser pad **120**, or a single eraser pad **120** can be attached to both eraser portions **160**. Further, at least one of the eraser portions **160**, such as the head **150**, can be in communication with a sensing system **130**.

The eraser assembly **100** can comprise a first eraser portion **160**, such as the body **140**, a second eraser portion **160**, such as the head **150**, as well as one or more eraser pads **120**. Further, at least one of the eraser portions **160**, such as the body **140**, can include a pad guard **170**.

The eraser assembly **100** need not be limited to the specific embodiments disclosed herein. That is, the eraser assembly **100** can include many combinations of these features, and can implement additional features as well.

The concepts described herein need not be limited to these illustrative embodiments. It would be appreciated by those skilled in the art that the eraser assembly **100** can be embodied in other specific forms without departing from the spirit or essential characteristics thereof.

The presently disclosed embodiments are, therefore, considered in all respects to be illustrative and not restrictive. The scope of the eraser assembly **100** is indicated by the appended claims, rather than the foregoing description, and all changes that come within the meaning and range of equivalents are intended to be embraced therein.

CLAIMS

What is claimed is:

1. An eraser assembly for erasing a display surface, the display surface comprising a coding pattern thereon, the eraser assembly comprising:

a body assembly;

a first eraser pad in communication with the body assembly; and

a first sensing device carried by the body assembly, the first sensing device adapted to sense a position of the eraser assembly on or in proximity to the display surface when the first eraser pad is in use.

2. The eraser assembly of Claim 1, the first sensing device comprising a camera for viewing the display surface.

3. The eraser assembly of either of Claims 1 or 2, further comprising an internal processing unit configured to determine a posture of the eraser assembly with respect to the display surface.

4. The eraser assembly of Claim 3, the internal processing unit further configured to decode the coding pattern on the display surface.

5. The eraser assembly of Claim 3, the internal processing unit configured to determine a position of the eraser assembly in a coordinate system of the display surface based on a portion of the coding pattern detected by the sensing device.

6. The eraser assembly of Claim 3, the internal processing unit configured to determine a distance of the eraser assembly from the display surface based on a portion of the coding pattern detected by the sensing device.

7. The eraser assembly of Claim 3, the internal processing unit configured to determine an orientation of the eraser assembly in the plane of the display surface based on a portion of the coding pattern detected by the sensing device.

8. The eraser assembly of Claim 3, the internal processing unit configured to determine a tipping angle of the eraser assembly with respect to the display surface based on a portion of the coding pattern detected by the sensing device.

9. The eraser assembly of any of the preceding claims, further comprising a second eraser pad in communication with the body assembly.

10. The eraser assembly of Claim 9, the first sensing device further configured to sense a position of the eraser assembly on or in proximity to the display surface when the second eraser pad is in use.

11. The eraser assembly of Claim 9, the second sensing device configured to sense a position of the eraser assembly in proximity to or in contact with the display surface when the second eraser pad is in use.

12. The eraser assembly of any of the preceding claims, further comprising a first guard adapted to shield the first eraser pad from contacting the display surface when the first eraser pad is tipped past a predetermined angle with respect to the display surface.

13. The eraser assembly of any of the preceding claims, wherein the body assembly is adapted to receive and secure a conventional eraser.

14. The eraser assembly of any of the preceding claims, further comprising a tipping detection system for detecting rotations of the eraser assembly about the horizontal and vertical axes of the display surface.

15. The eraser assembly of any of the preceding claims, further comprising an orientation detection system for detecting a rotation of the eraser assembly in a coordinate system of the display surface.

16. The eraser assembly of any of the preceding claims, further comprising a distance detection system for detecting a distance between the eraser assembly and the display surface.

17. An eraser assembly for erasing a display surface, the eraser assembly comprising:

a first eraser portion; and

a first eraser pad attached to the first eraser portion; and

a second eraser portion coupled to the first eraser portion;

a second eraser pad attached to the second eraser portion, the second eraser pad set at an acute angle with respect to the display surface when the first eraser pad is parallel to and facing the display surface.

18. The eraser assembly of Claim 17, further comprising a first sensing device for detecting a portion of a coding pattern on the display surface.

19. The eraser assembly of Claim 18, the first sensing device being a camera for capturing one or more images of the coding pattern on the display surface.

20. The eraser assembly of Claim 18, further comprising an internal processing unit for determining which eraser pad is in use with the display surface.

21. The eraser assembly of Claim 18, further comprising an internal processing unit for decoding the coding pattern on the display surface.

22. The eraser assembly of any of Claims 17-21, further comprising a first guard adapted to shield the first eraser pad from the display surface when the first eraser pad is tipped at greater than a predetermined angle with respect to the display surface.

23. The eraser assembly of Claim 22, the first guard comprising an outer edge of the first eraser portion, which outer edge extends past the perimeter of the first eraser pad.

24. The eraser assembly of either of Claims 22 or 23, further comprising a second guard adapted to shield the second eraser pad from the display surface when the second eraser pad is tipped at greater than a predetermined angle with respect to the display surface.

25. The eraser assembly of Claim 24, the second guard comprising an outer edge of the second eraser portion, which outer edge extends past the perimeter of the second eraser pad.

26. The eraser assembly of any of the preceding claims, further comprising a first contact switch in communication with the first eraser pad, the first contact switch for detecting when the first eraser pad contacts a surface.

27. The eraser assembly of Claim 26, further comprising a second contact switch in communication with the second eraser pad, the second contact switch for detecting when the second eraser pad contacts a surface.

28. A system comprising:

a display surface comprising a coding pattern; and

an eraser assembly interactable with the display surface and comprising:

a body assembly;

a first eraser pad in communication with the body assembly; and

a first sensing device carried by the body assembly, the first sensing device adapted to sense a position of the eraser assembly in proximity to or in contact with the display surface when the first eraser pad is in use.

29. The system of Claim 28, the display surface being a whiteboard surface.

30. The system of either of Claims 28 or 29, the coding pattern of the display surface being a dot pattern.

31. The system of any of Claims 28-30, the coding pattern of the display surface configured to encode two-dimensional coordinates on the display surface.

32. The system of any of Claims 28-31, further comprising a projector for projecting one or more images onto the display surface.

33. The system of any of Claims 28-32, further comprising a processing device in communication with the eraser assembly.

34. The system of Claim 33, the processing device configured to render one or more images for display on the display surface.

35. The system of either of Claims 33 or 34, the processing device configured to decode the coding pattern on the display surface.

36. The system of any of Claims 33-35, the processing device configured to process data obtained by the first sensing device.

37. The system of Claim 36, the processing device configured to determine a posture of the eraser assembly relative to the display surface based on the data obtained by the first sensing device.

38. The system of any of Claims 28-37, the eraser assembly further comprising an internal processing unit for processing data obtained by the first sensing device.

39. The system of any of Claims 28-38, the first sensing device of the eraser assembly comprising a camera for viewing the display surface.

40. The system of Claim 39, the camera of the eraser assembly adapted to view the coding pattern on the display surface.

41. The system of Claim 40, the eraser assembly adapted to determine a position of the eraser assembly in a coordinate system of the display surface based on one or more images of the coding pattern captured by the camera.

42. The system of Claim 40, the eraser assembly adapted to detect a rotation of the eraser assembly about the horizontal and vertical axes of the display surface based on one or more images of the pattern captured by the camera.

43. The system of Claim 40, the eraser assembly adapted to detect a rotation of the eraser assembly in a coordinate system of the display surface based on one or more images of the pattern captured by the camera.

44. The system of Claim 40, the eraser assembly adapted to detect a distance between the eraser assembly and the display surface based on one or more images of the pattern captured by the camera.

45. The system of any of Claims 28-44, further comprising a first guard adapted to shield the first eraser pad from the display surface when the first eraser pad is tipped past a predetermined angle with respect to the display surface.

46. The system of any of Claims 28-45, the eraser assembly further comprising a second eraser pad in communication with the body assembly.

47. The system of Claim 46, the first sensing device of the eraser assembly further adapted to sense a position of the eraser assembly on or in proximity to the display surface when the second eraser pad is in use.

48. The system of Claim 46, further comprising a second sensing device carried by the body assembly, the second sensing device adapted to sense a position of the eraser assembly on or in proximity to the display surface when the second eraser pad is in use.

49. A system comprising:

a display surface;

an eraser assembly for erasing the display surface, the eraser assembly comprising:

a first eraser portion; and

a first eraser pad attached to the first eraser portion; and

a second eraser portion coupled to the first eraser portion;

a second eraser pad attached to the second eraser portion, the second eraser pad set at an acute angle with respect to the display surface when the first eraser pad is parallel to and facing the display surface.

50. The system of Claim 49, the display surface comprising a coding image.

51. The system of either of Claims 49 or 50, the coding image being a dot pattern.

52. The system of any of Claims 49-51, the eraser assembly further comprising a first sensing device.

53. The system of Claim 52, the first sensing device of the eraser assembly being an image-capture device.

54. The system of either of Claims 52 or 53, the first sensing device of the eraser assembly adapted to sense a position of the eraser assembly in a coordinate system of the display surface when the first eraser pad is in use.

55. The system of any of Claims 52-54, the first sensing device of the eraser assembly adapted to sense a position of the eraser assembly with respect to the display surface when the second eraser pad is in use.

56. The system of any of Claims 52-54, the eraser assembly further comprising a second sensing device adapted to sense a position of the eraser assembly with respect to the display surface when the second eraser pad is in use.

57. The system of any of Claims 49-56, further comprising a first guard adapted to shield the first eraser pad from the display surface when the first eraser pad is tipped at greater than a predetermined angle with respect to the display surface.

58. The system of Claim 57, the first guard comprising an outer edge of the first eraser portion, which outer edge extends past the perimeter of the first eraser pad.

59. The system of either of Claims 57-58, further comprising a second guard adapted to shield the second eraser pad from the display surface when the second eraser pad is tipped at greater than a predetermined angle with respect to the display surface.

60. The system of any of Claims 49-59, the eraser assembly further comprising a tipping detection system for detecting rotations of the eraser assembly about the horizontal and vertical axes of the display surface.

61. The system of any of Claims 49-60, the eraser assembly further comprising an orientation detection system for detecting a rotation of the eraser assembly in a coordinate system of the display surface.

62. The system of any of Claims 49-61, the eraser assembly further comprising a distance detection system for detecting a distance between the eraser assembly and the display surface.

63. A system comprising:

a display surface comprising a fixed coding pattern and an alterable display image; and

an eraser assembly for indicating erasure of markings in the display image of the display surface, the eraser assembly comprising:

a first eraser portion corresponding to a first set of erasure parameters;

a second eraser portion corresponding to a second set of erasure parameters;

a sensing system for detecting a portion the coding pattern on the display surface; and

and internal processing unit configured to determine which of the first and second eraser portions is currently active based on the detected portion of the coding pattern.

64. The system of Claim 63, the display surface being a whiteboard surface.

65. The system of either of Claims 63 or 64, further comprising a processing device for updating the display image.

66. The system of Claim 65, the eraser assembly further comprising a communication device for transmitting to the processing device a set of erasure parameters corresponding to the active eraser portion.

67. The system of Claim 66, the processing device configured to update the display image according to the transmitted set of erasure parameters.

68. The system of any of Claims 63-67, further comprising a stylus for marking on the display surface.

69. The system of Claim 68, the eraser assembly being adapted to erase markings produced by the stylus.

70. The system of any of Claims 63-69, the sensing system of the eraser assembly comprising a first camera.

71. The system of Claim 70, the first camera of the eraser assembly configured to capture one or more images of the coding pattern of the display surface when the first eraser portion is active.

72. The system of either of Claims 70 or 71, the first camera of the eraser assembly configured to capture one or more images of the coding pattern of the display surface when the second eraser portion is active.

73. The system of any of Claims 70-72, the sensing system further comprising a second camera configured to capture one or more images of the coding pattern of the display surface when the second eraser portion is active.

74. The system of any of Claims 63-73, the sensing system configured to detect six degrees of movement of the eraser assembly relative to the display surface.

75. The system of any of Claims 63-74, the sensing system of the eraser assembly being configured to detect a position of the eraser assembly in a coordinate system of the display surface.

76. The system of any of Claims 63-75, the sensing system of the eraser assembly being configured to detect a distance of the eraser assembly from the display surface.

77. The system of any of Claims 63-76, the sensing system of the eraser assembly being configured to detect an orientation of the eraser assembly in a coordinate system of the display surface.

78. The system of any of Claims 63-77, the sensing system of the eraser assembly being configured to detect a tipping angle of the eraser assembly with respect to the display surface.

79. The system of Claim 78, wherein the eraser assembly is deactivated when the tipping angle of the eraser assembly is outside of a predetermined set of tipping parameters.

80. The system of any of Claims 63-79, the first eraser portion of the eraser assembly being non-circular.

81. The system of any of Claims 63-80, the second eraser portion of the eraser assembly being non-circular.

82. The system of any of Claims 63-81, the first eraser portion of the eraser assembly having a different size than the second eraser portion.

83. The system of any of Claims 63-82, the first eraser portion of the eraser assembly having a different shape than the second eraser portion.

84. The system of any of Claims 63-83, the first eraser portion comprising a first pad guard configured to obstruct tipping of the eraser assembly with respect to the display surface.

85. The system of Claim 84, the second eraser portion comprising a second pad guard configured to obstruct tipping of the eraser assembly with respect to the display surface.

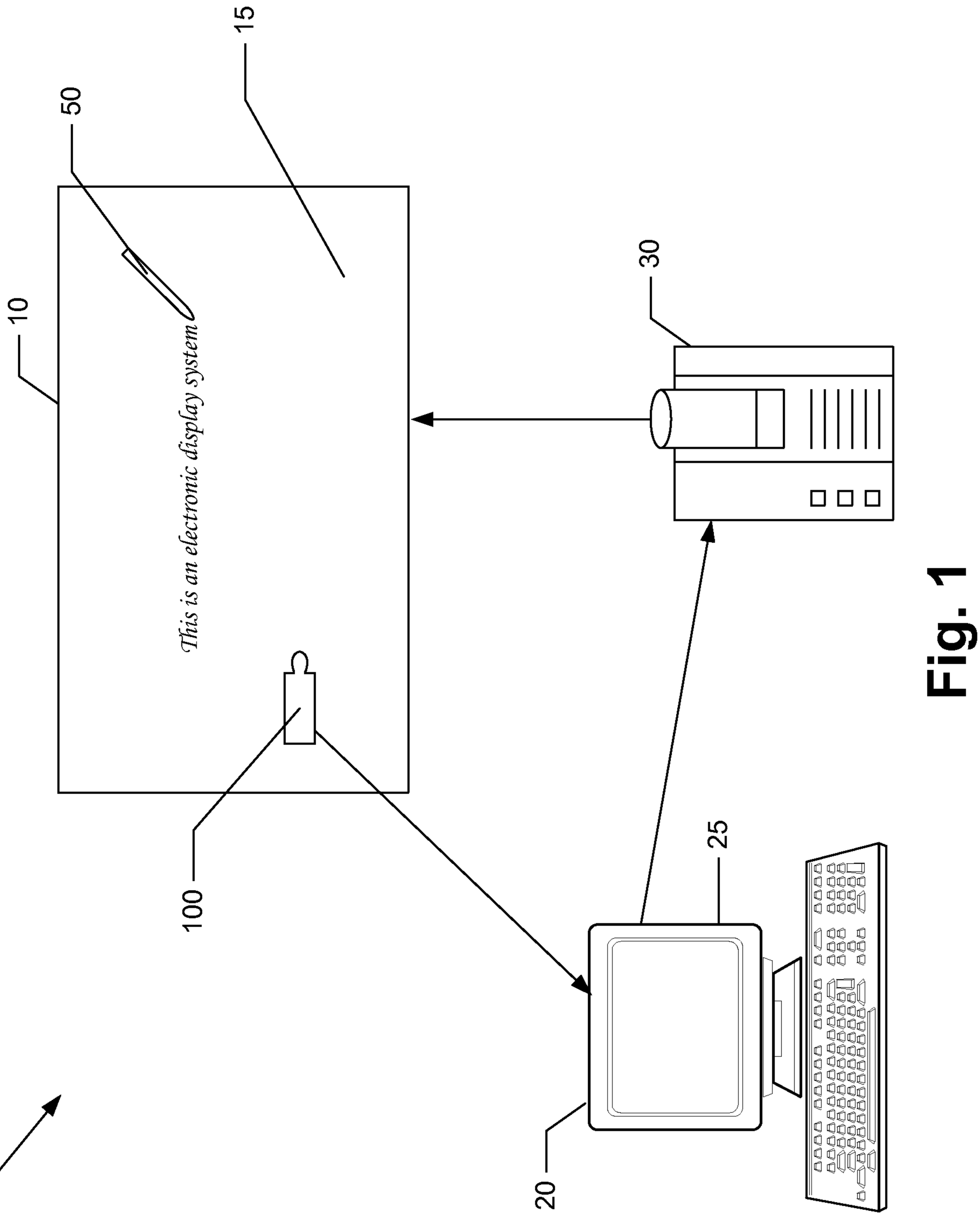


Fig. 1

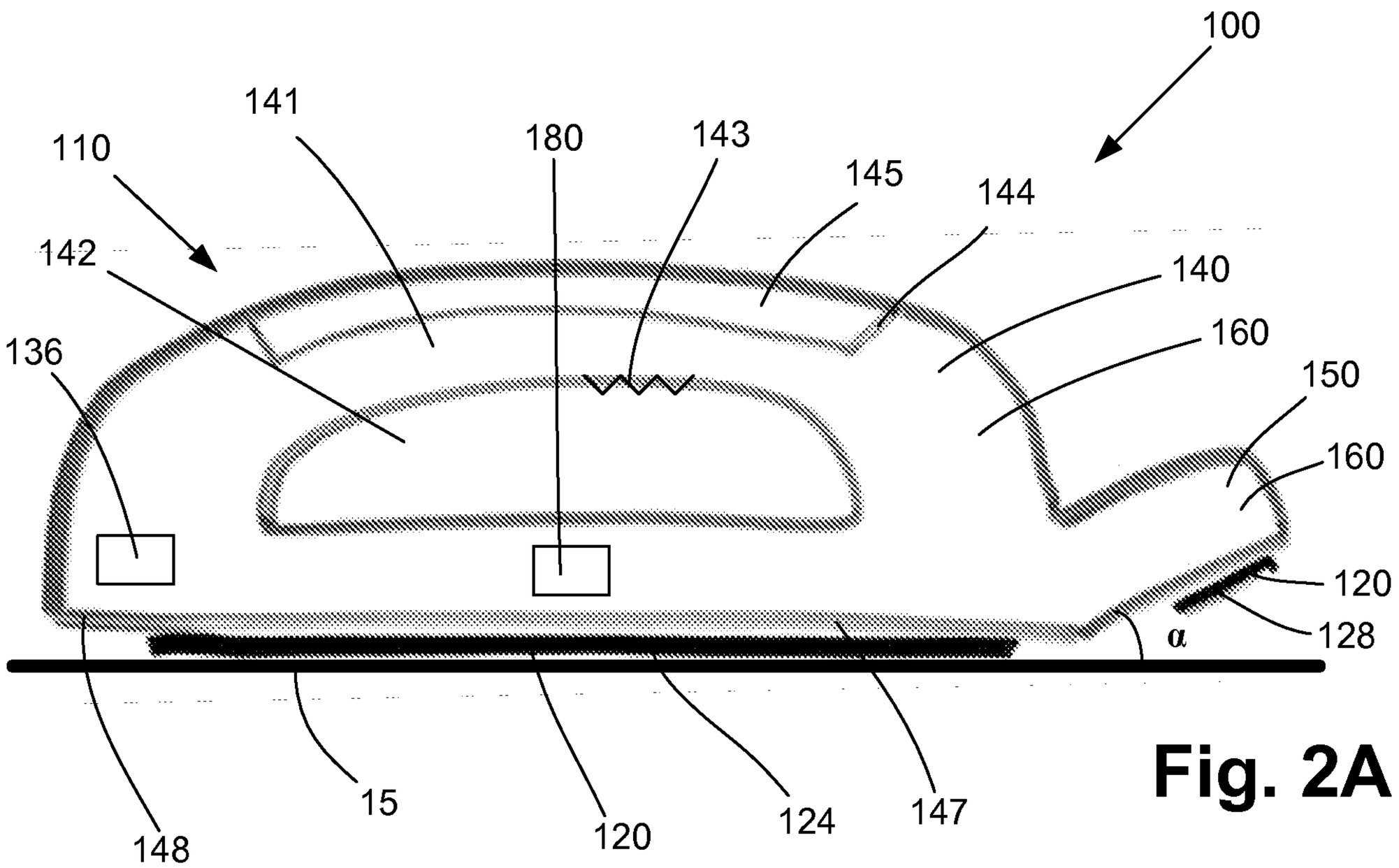

100
141
110
180
143
145
144
142
140
160
136
150
160
120
128
α
148
15
120
124
147

Fig. 2A

100
110
146
120
124
147
160
120
130
128
160
136
170
150
152
154
132
190
192
194
134
170
148
140

Fig. 2B

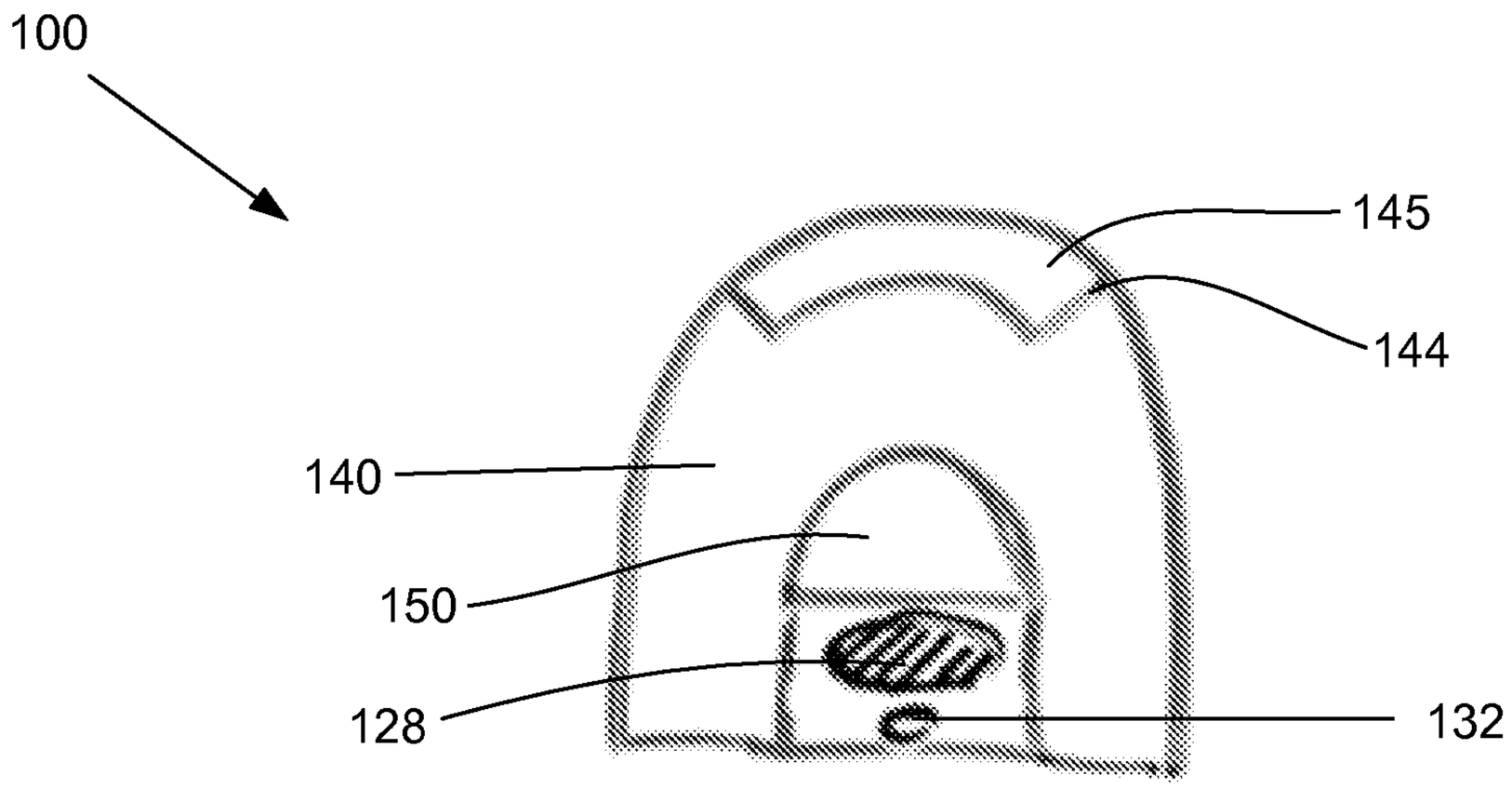


Fig. 2C

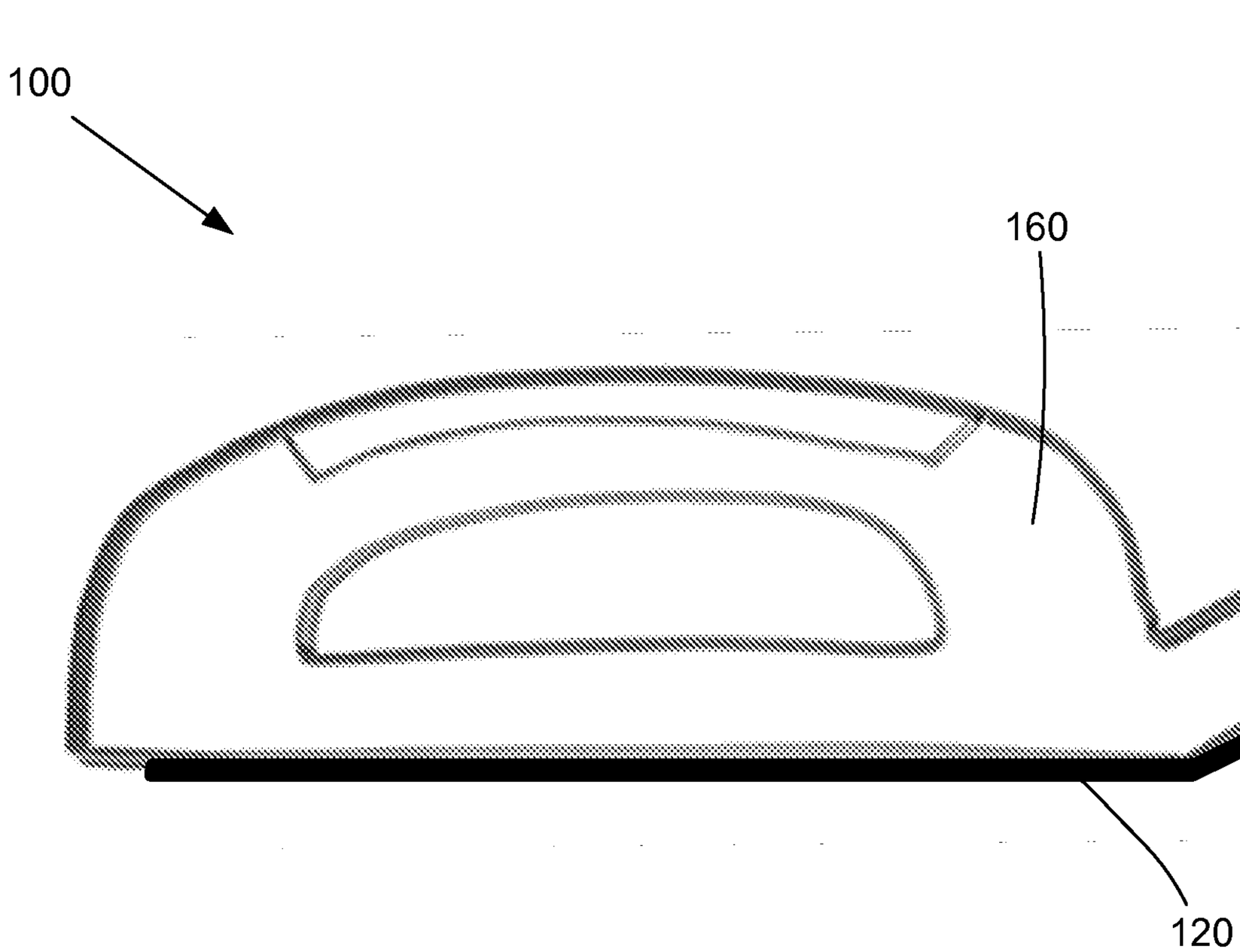


Fig. 3

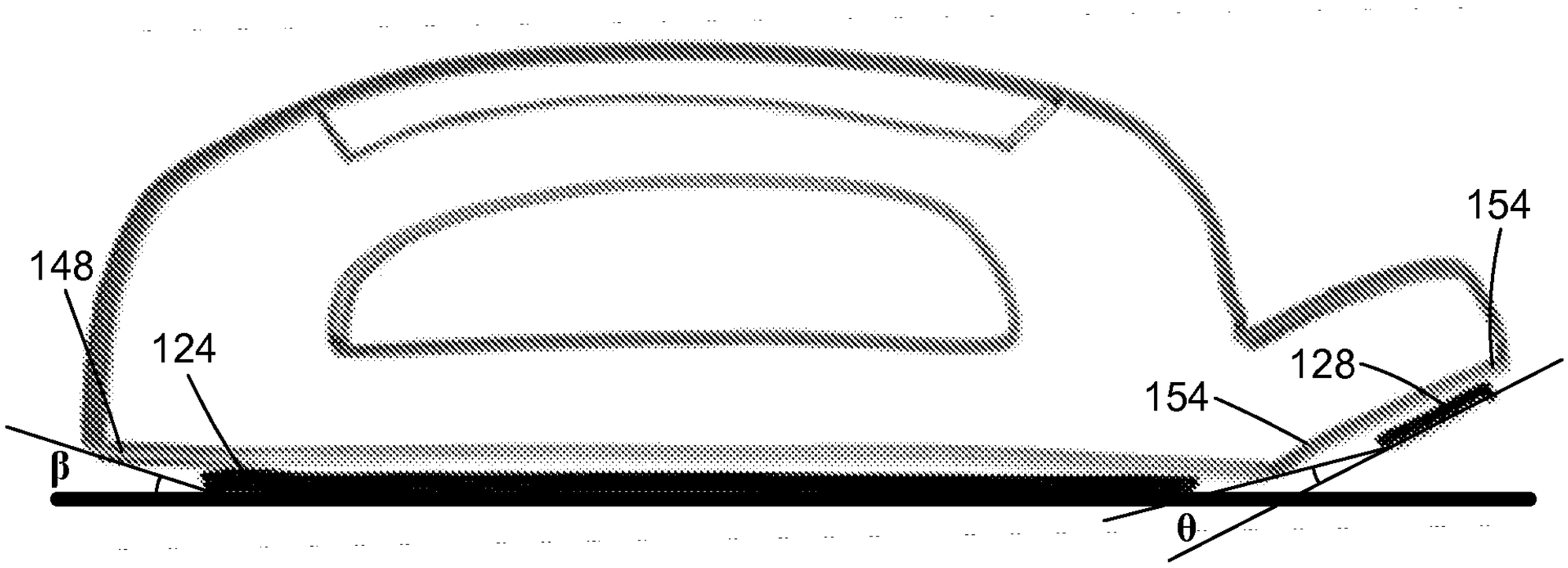


Fig. 4A

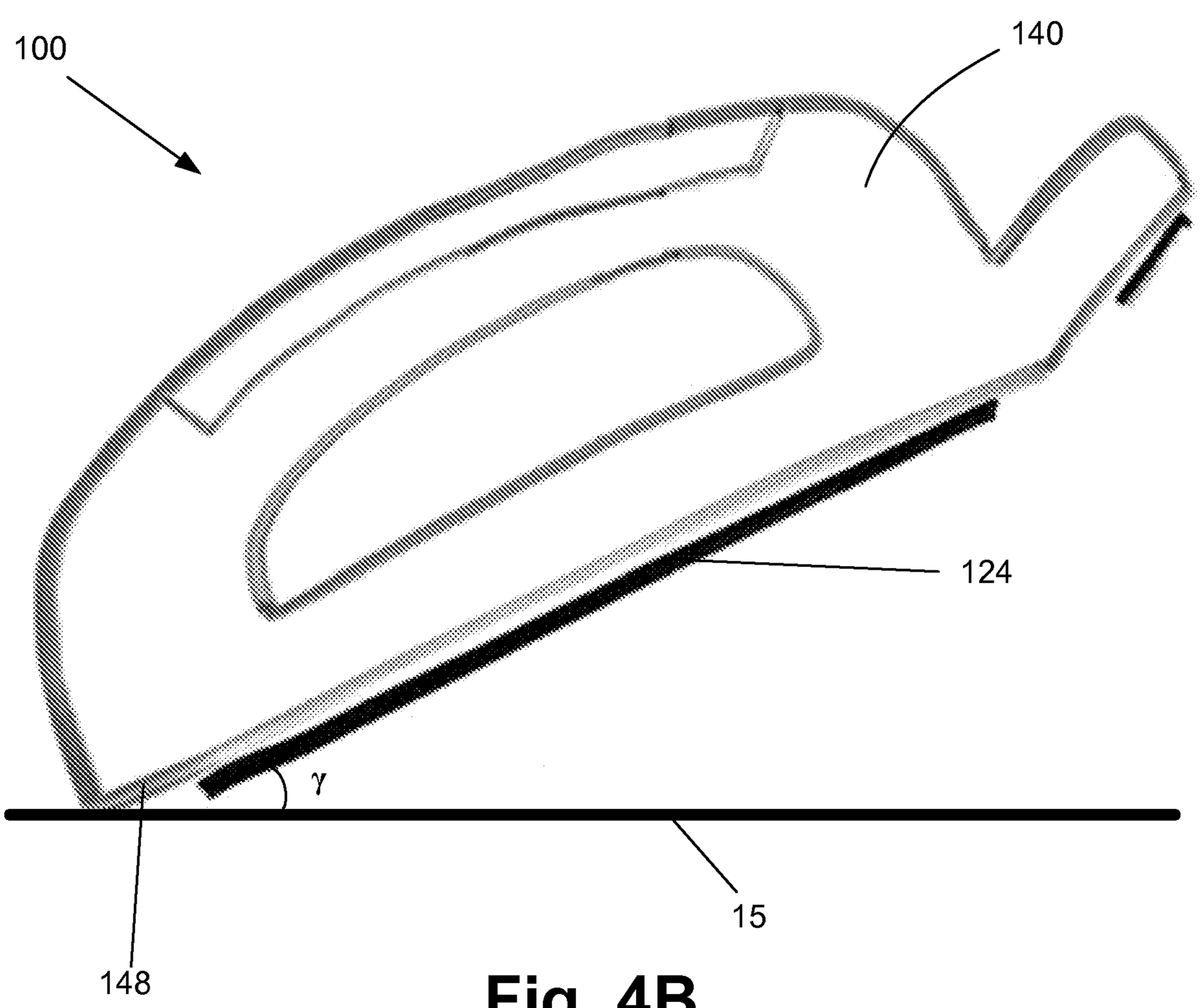


Fig. 4B

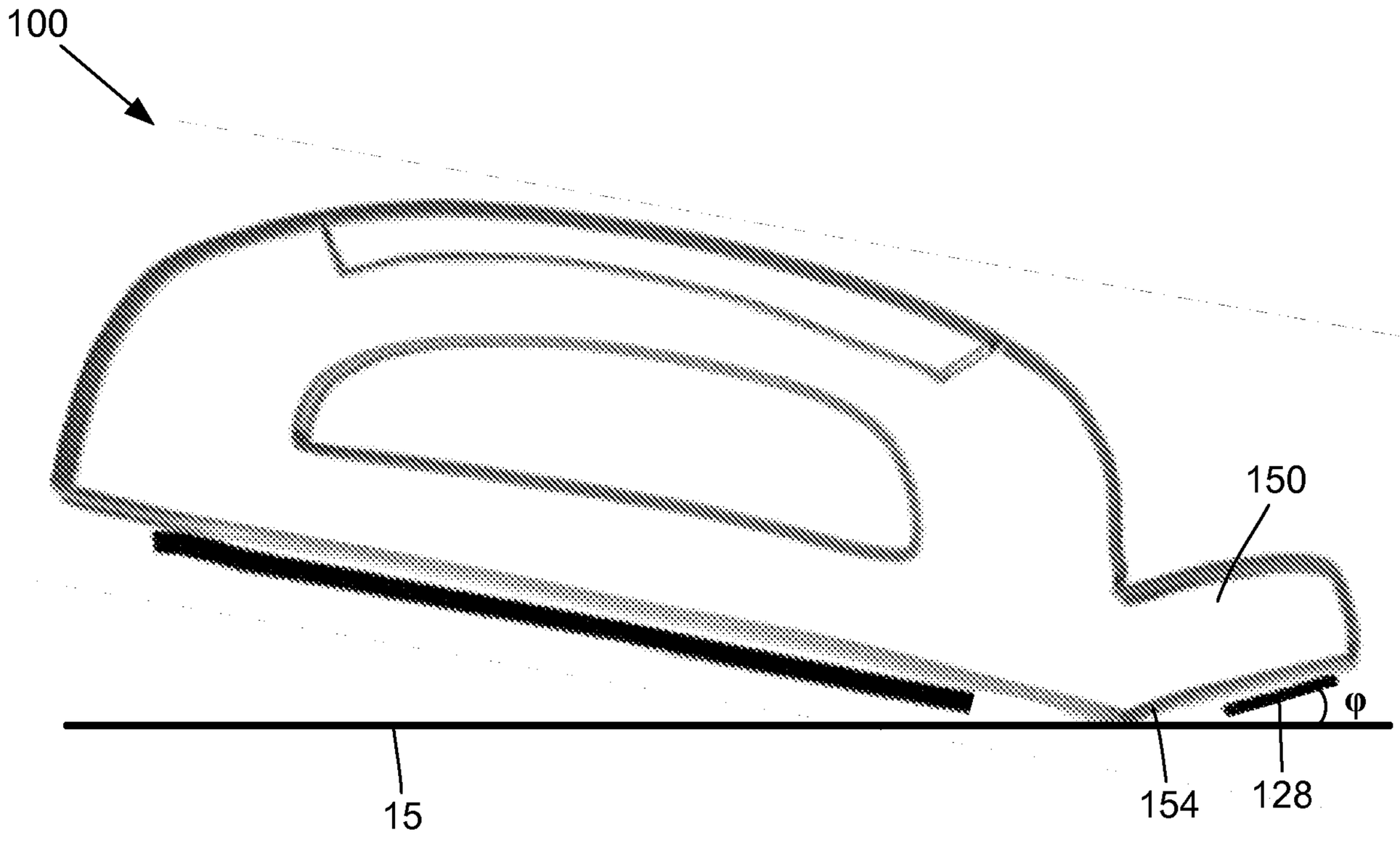

100
150
φ
15
154
128

Fig. 4C

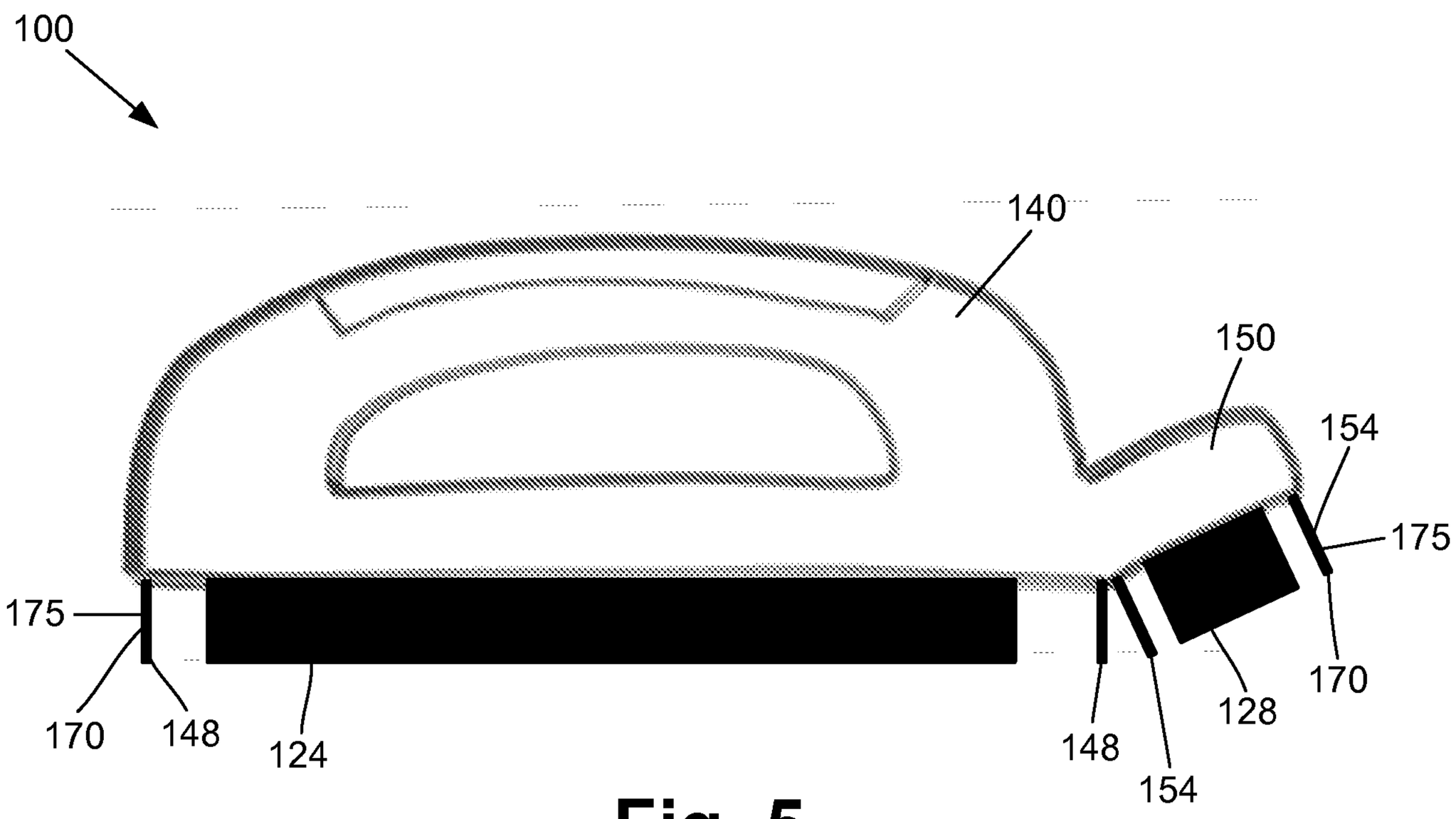

100
140
150
154
175
175
170
148
124
148
154
128
170

Fig. 5

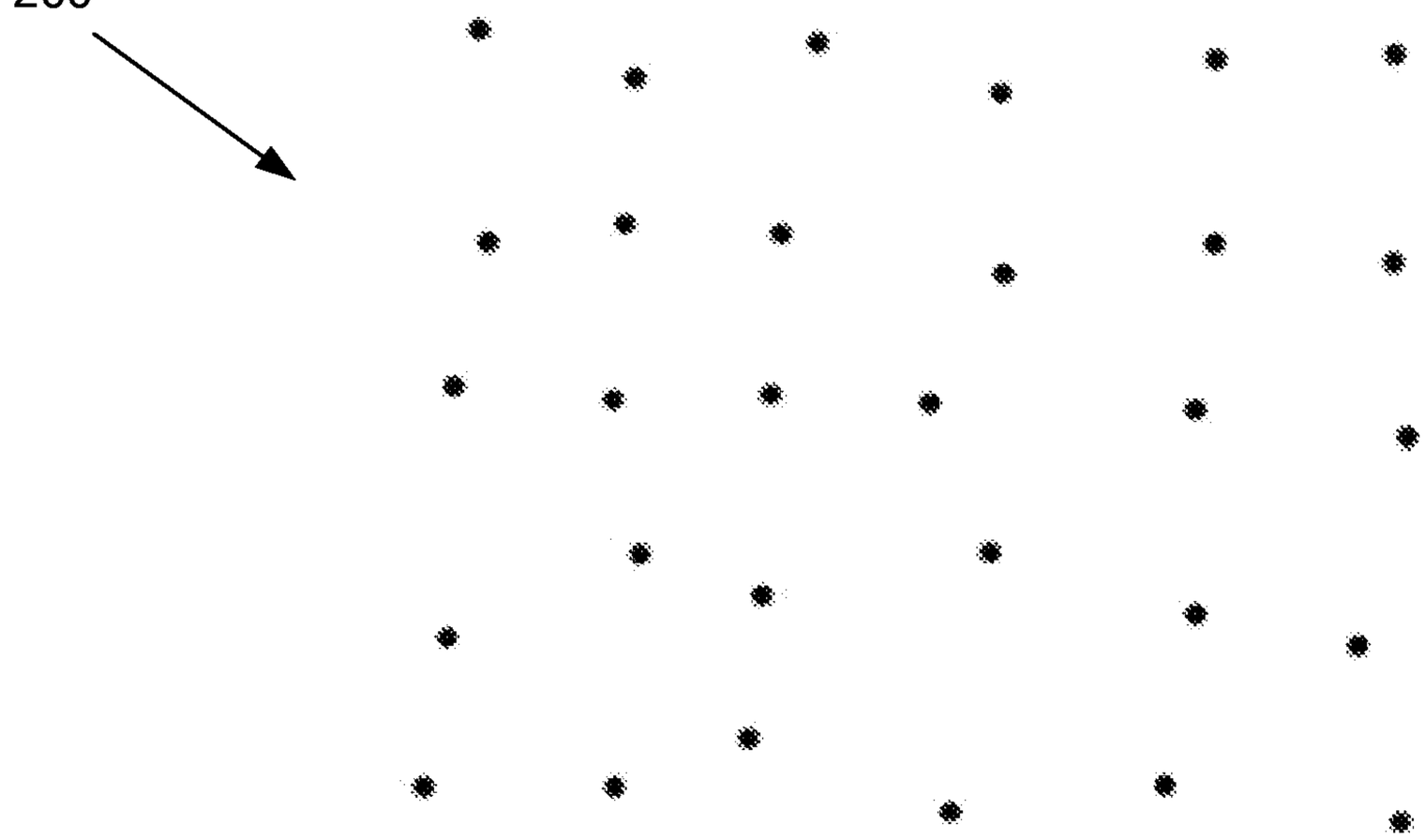


Fig. 6A

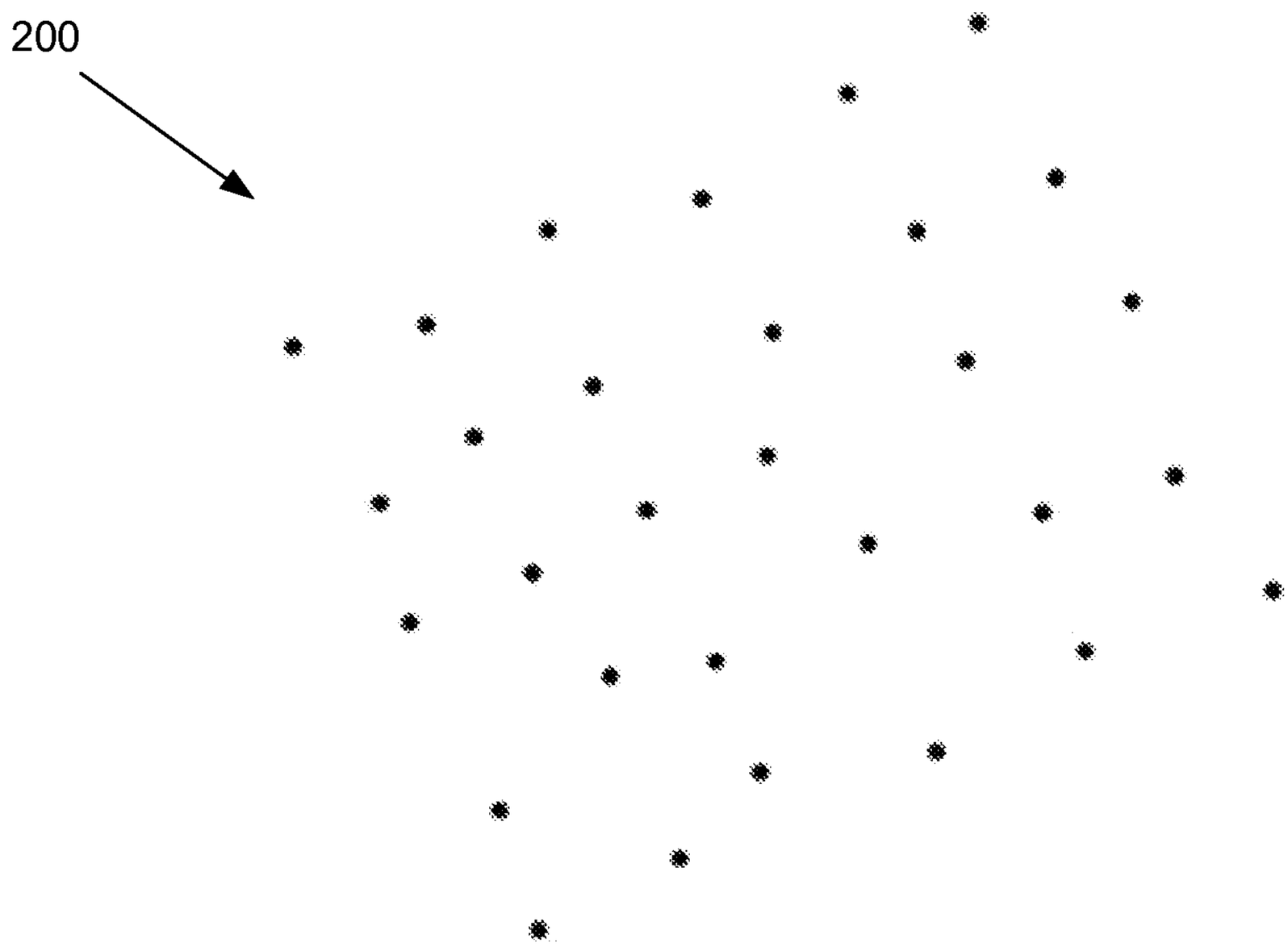


Fig. 6B

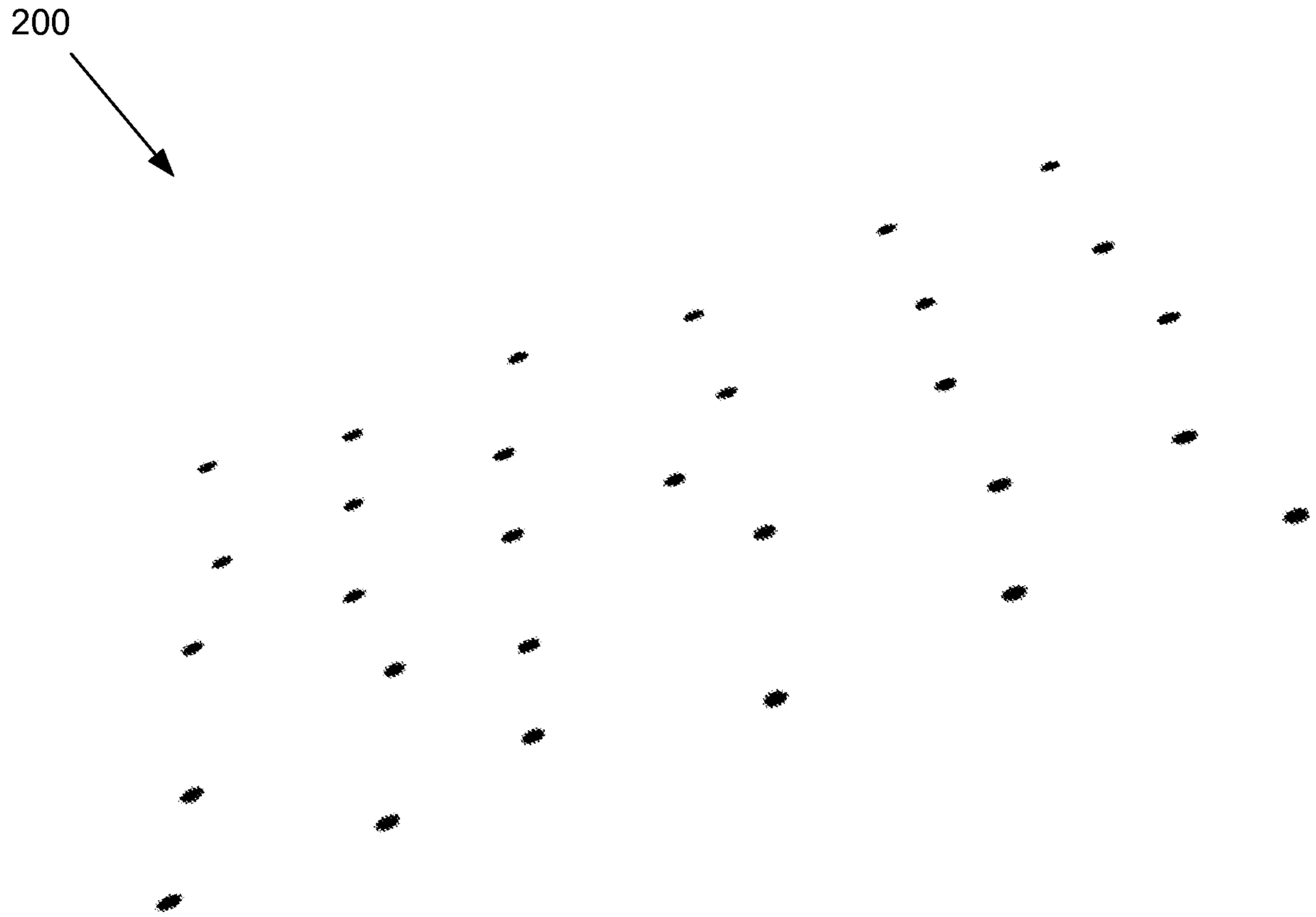
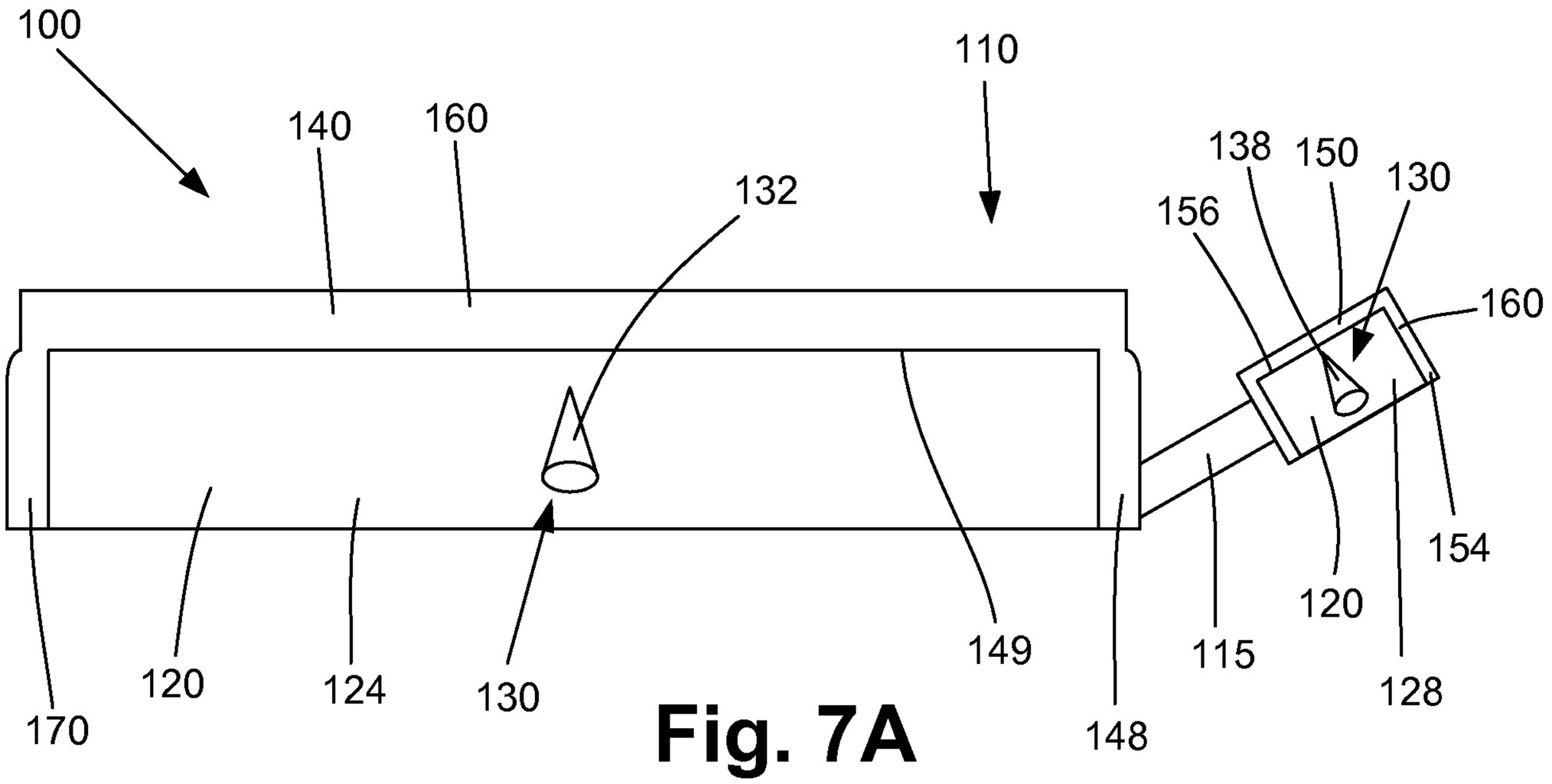


Fig. 6C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124
130

Fig. 7A

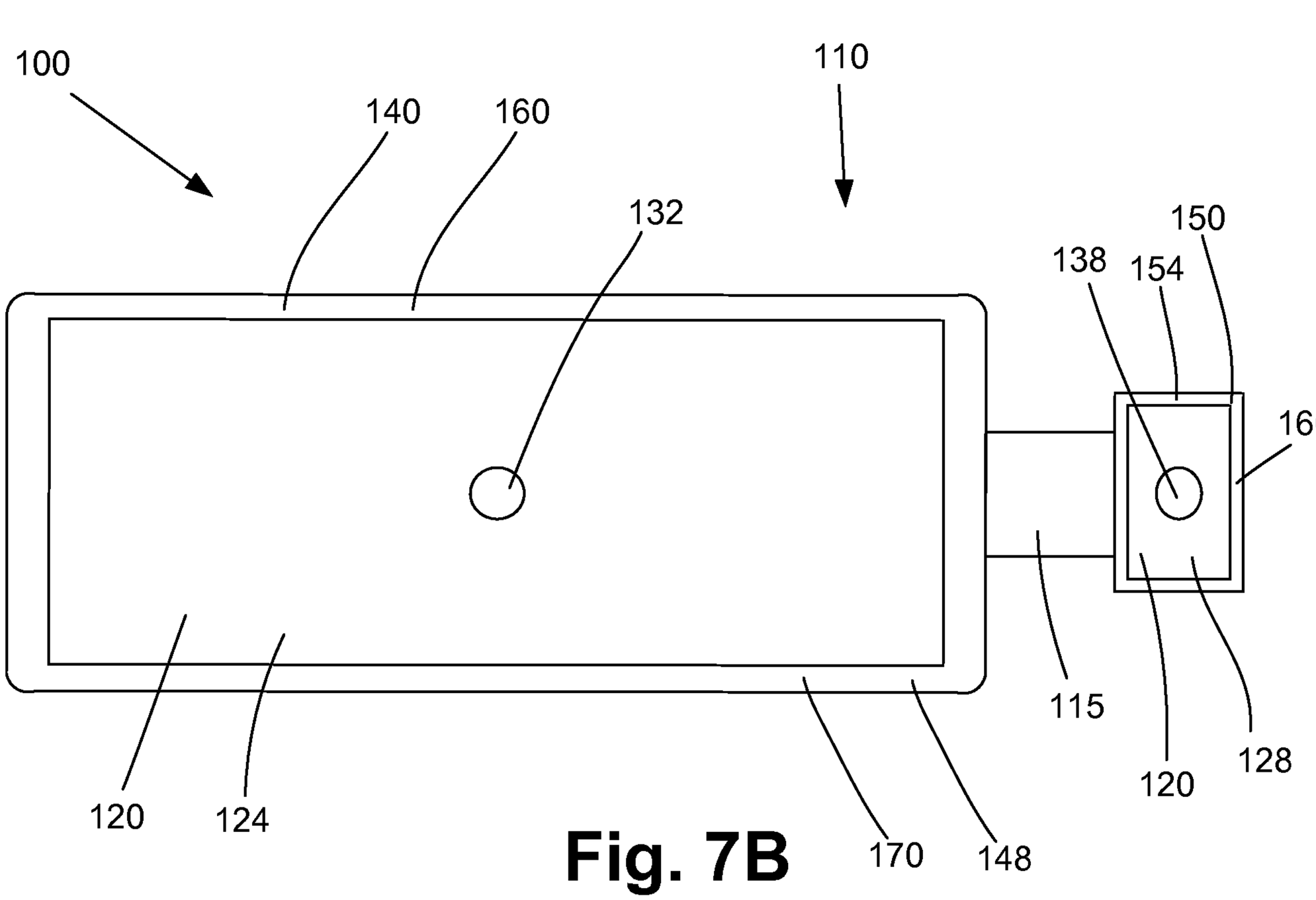
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Fig. 7B

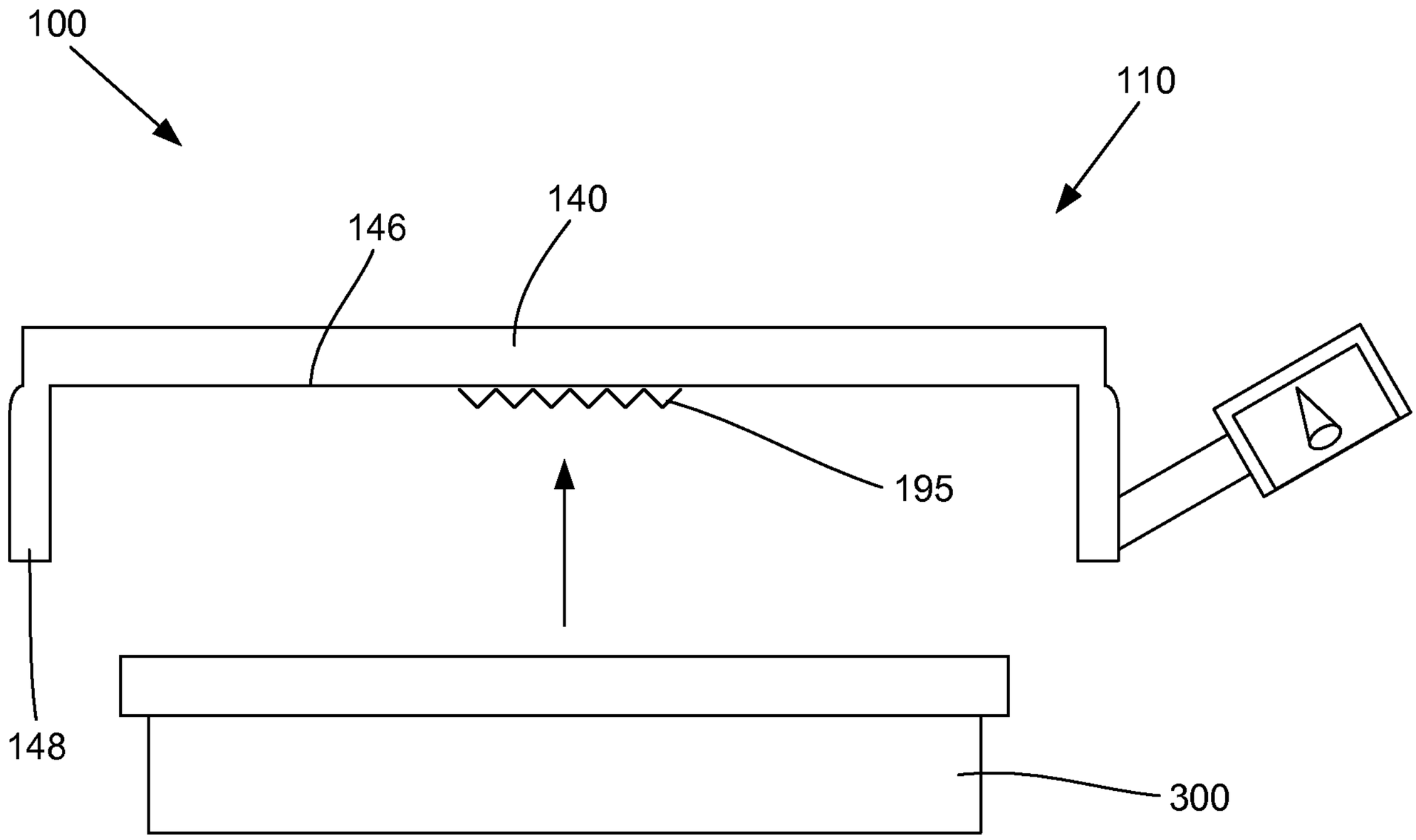

Fig. 8A

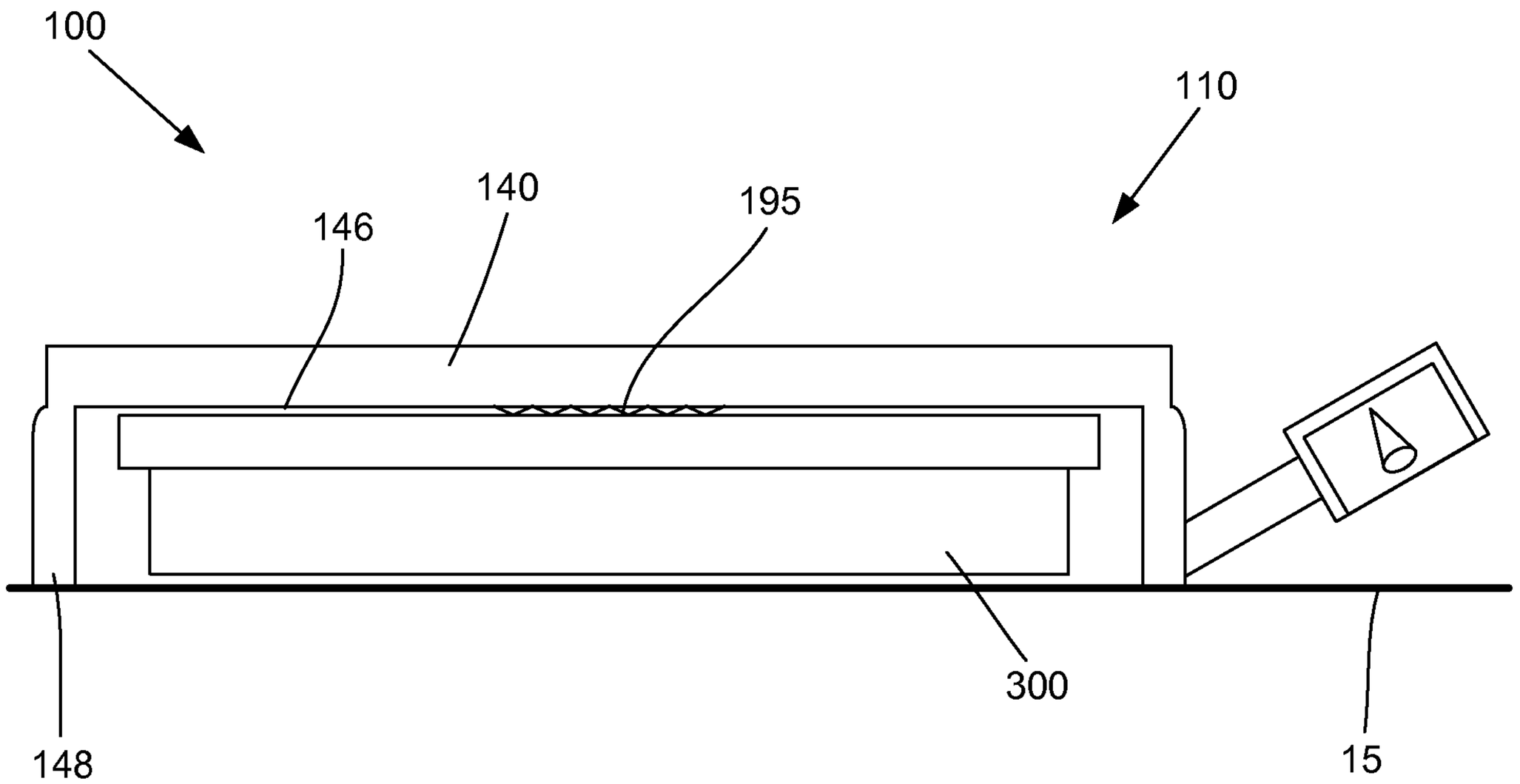

Fig. 8B

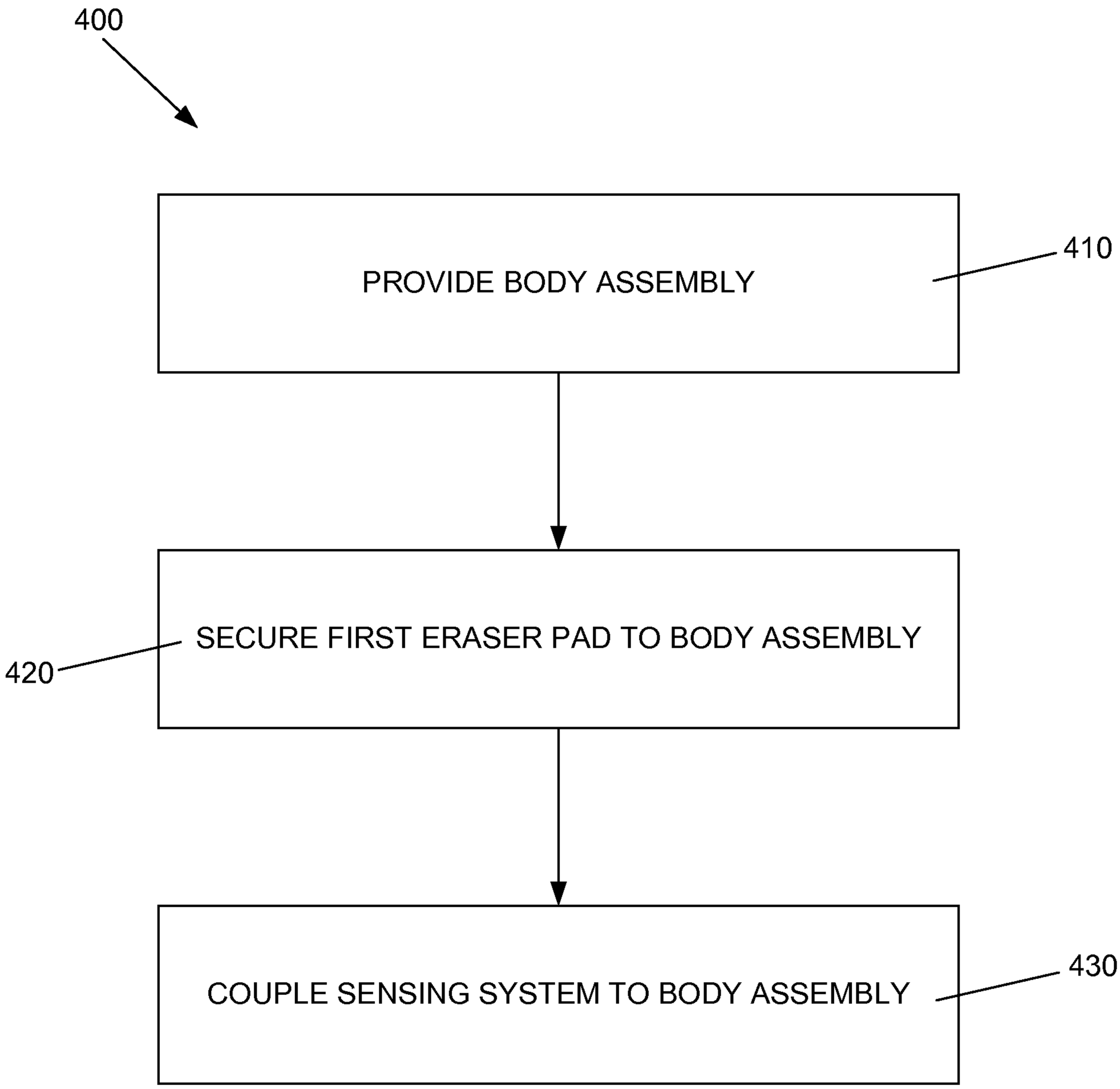
400
PROVIDE BODY ASSEMBLY
410
SECURE FIRST ERASER PAD TO BODY ASSEMBLY
420
COUPLE SENSING SYSTEM TO BODY ASSEMBLY
430

Fig. 9

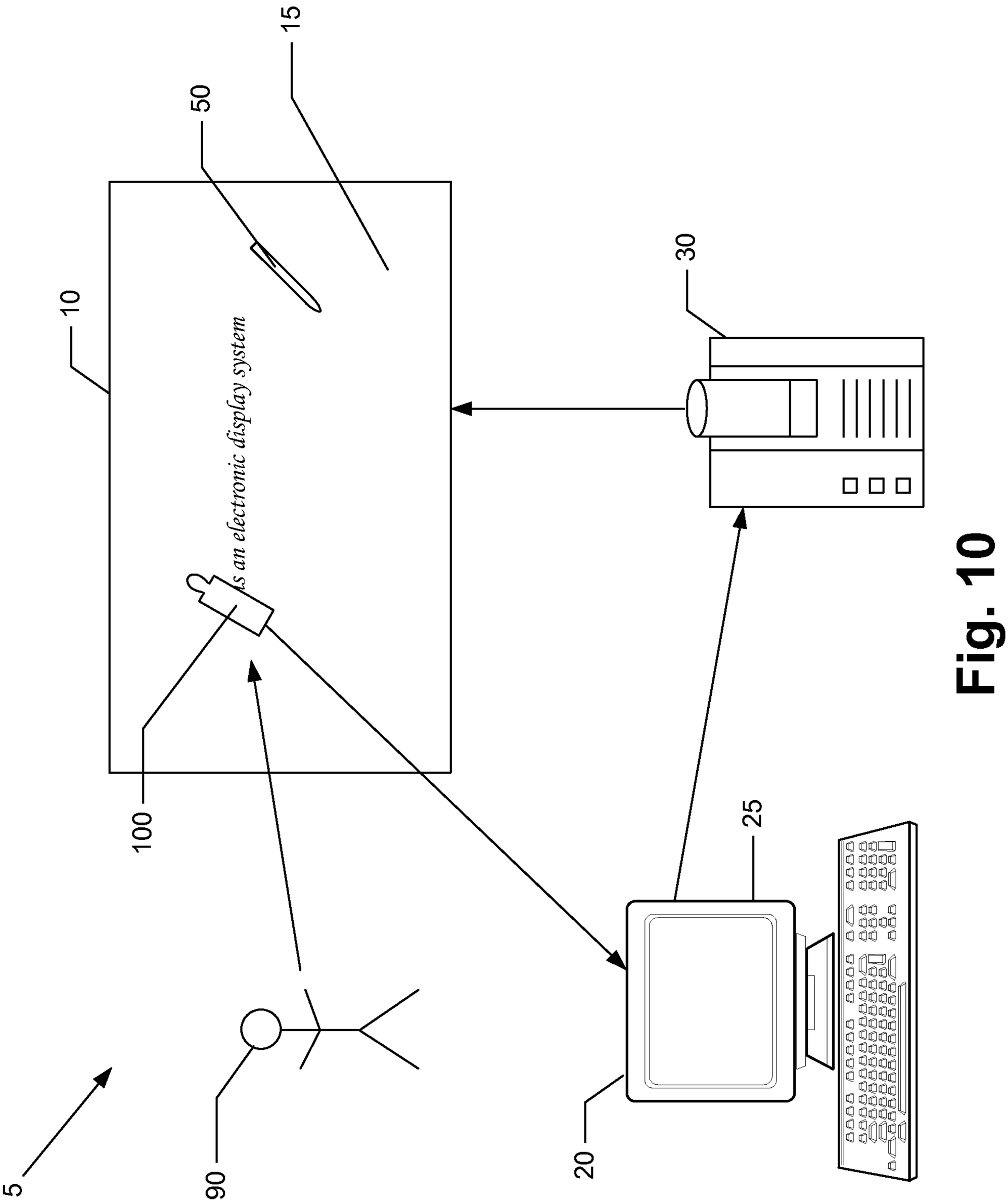

Fig. 10

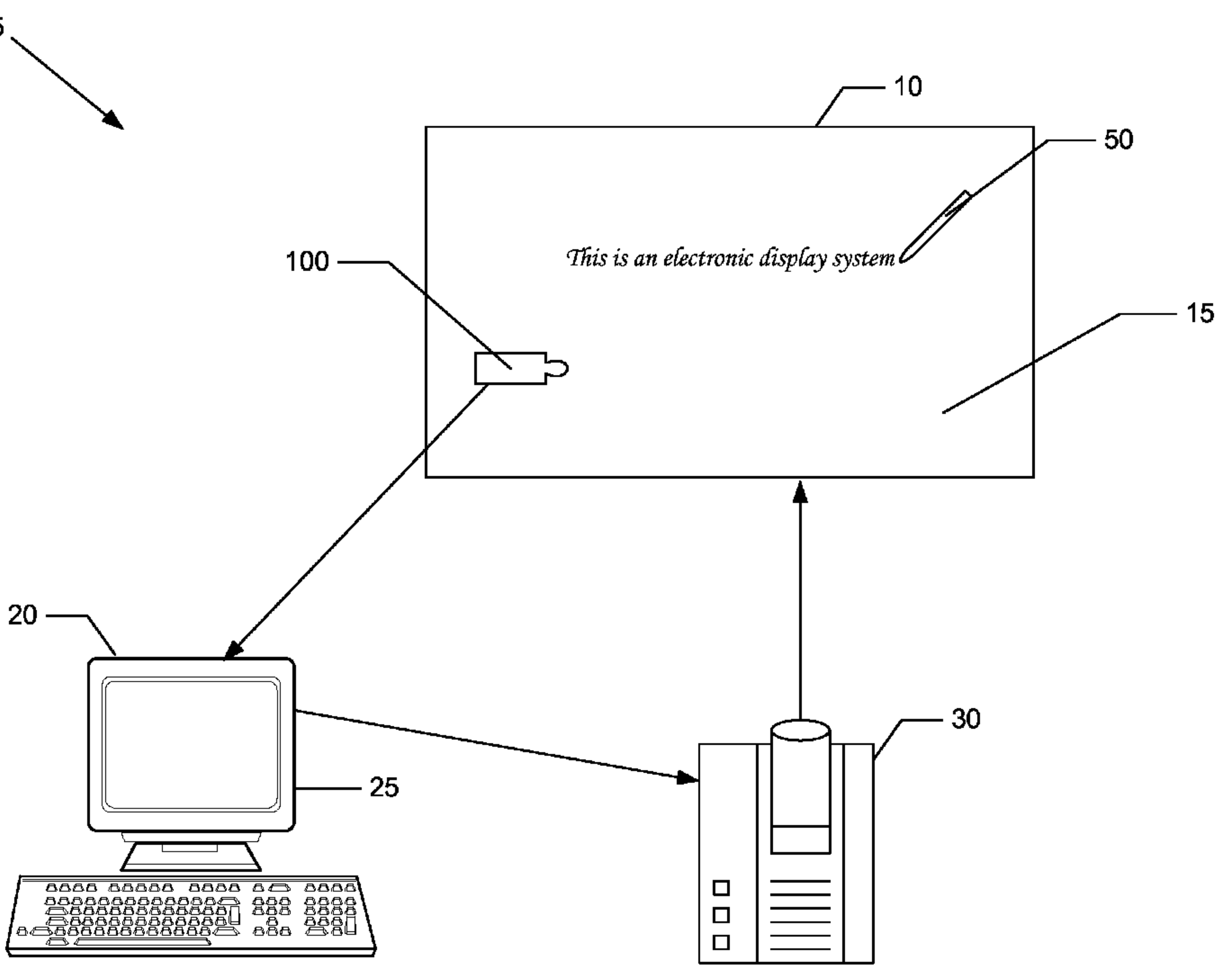

Fig. 1