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# Surface Positioning Sensor For Contact Between Unrestrained Objects

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# SURFACE POSITIONING SENSOR FOR CONTACT BETWEEN UNRESTRAINED OBJECTS


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## Background of the Invention

During contact between two independent, unrestrained objects, how can it be determined where the surface of one object makes contact with the surface of the other object?

In the past, sensors have been mounted on specific devices to record athletic performance data about specific aspects of training. For example, combinations of force sensors have been used to detect data about where a target object is struck or how hard it was struck.

However, in many disciplines it is important to know not just that a collision occurred, how much force was involved, or where on an object the collision occurred. Often times this data alone is of limited use, since the object involved in the collision is not a simple shape and the user really needs to know where a specific point on one object collided with a specific point on the other object.

In boxing, this is particularly true, as proper punching requires accuracy of knuckle placement when contact is made with the target object. To detect the accuracy of knuckle placement in relation to the center of the target object, one must be able to observe where the desired part of the knuckle made contact within the outer surface of the target.

In short, knowing that a collision occurred or where it occurred on the target is of limited use alone. For information to be truly useful, it must include data about accuracy as determined in relation between two zones on different objects.

In short, aspects that existing sensors lack are:

1) For objects involved in a collision, existing sensors (whether using conductivity to detect data or not) lack the ability to discern the specific locations on each object involved in the collision, where the collision takes place.
2) Existing sensors use means other than electrical conductivity to detect data. [where as our invention relies on electrical conductivity as the means for detecting positioning data.]
3) Existing sensors lack the ability to discern between ambient movements and true collisions (i.e. did the force of a punch actually land, and if so, did it land on a valid region of the opponent?).
4) Existing sensors use a specific type of sensor on a specific device to collect only one type of collision data.

5) Existing sensor usage is inflexible and cumbersome to apply to circumstances other than that for which the sensor was specifically designed.
6) Usage of existing sensors encumbers the user by requiring the user to wear or interact with bulky devices that would not be necessary in the normal course of training.
7) Existing sensors do not integrate with the existing training techniques or methods of interaction in the field of use.
8) Existing sensors lack the ability to upload data into a persistent, location-agnostic, web system that provides comprehensive usage and visualization of the data.

## Description of the Invention

The positioning sensor device of this invention is a highly technical improvement over existing technologies because it provides the ability to identify the specific points on specific objects that make contact during a collision and it captures a wide range of other critical data (such as force and orientation) using one integrated device. Furthermore, the device can be applied in a way that integrates with existing training equipment and does not require users to alter the way they behave within the field of use. Also, data created by the device can be uploaded to the web and retrieved at a later date and location.

The device of this invention is a flexible, adaptable, accurate system for detecting surface positioning data during physical contact between multiple objects. For any pair of objects, the technology records where a fixed location on the surface of the first object (striker object or Striker) makes contact within the perimeter of a positioning sensor on the surface of the second object (target object or Target).

The positioning sensor of this invention comprises a set number of conductive zones on the surface of the Target, where there is connected a current source to some conductive zones and a positioning detection circuitry to the other zones. Then a single conductive zone is applied to the surface of the Striker, such that contact between the conductive zone on the Striker and any two differently connected conductive zones on the Target will cause current to flow and result in detecting the location of the collision on the surface of the Target.

The precision of the sensor technology is determined jointly by the size of the conductive zone on the Striker and the size and spacing of conductive zones on the Target. By reducing the size of the conductive zone on the Striker and reducing both the spacing and size of conductive zones on Target, the precision of the system can be greatly increased.

Also, multiple instances of this technology can be used at the same time in the same conceptual problem space. For instance, by varying the shape, size, or resistance (in Ohms) of the conductive zone on each Striker, it is possible to determine which striker object made contact with a given Target. It is also possible to apply multiple sensor arrays to the same target object or to include multiple target objects in the specific implementation of the technology for the given problem space.

Also, other types of sensors can be co-located with the sensor technology for the purpose of recording additional data, such as the force of the collision or orientation of the Target during collision. The positioning sensor technology supports the integration of accelerometers to detect force and orientation of objects.

One embodiment that has proved the feasibility and workability of the technology involves the specific application of this sensor technology to the sport of boxing, where the Target objects are focus mitts and the Striker objects are Boxing or MMA gloves. This embodiment does not define the only usage or application of the invention, as multiple embodiments exist for the specific field of boxing (to detect contact between fist, elbow, knee, shin, foot, head and any other force receiver such as head-gear, kick shield, Thai pad, human opponent, etc.), and furthermore, multiple embodiments exist for other fields in which this technology could be applied to enhance the knowledge and experience of users, such as other sports such as baseball (to detect bat-ball contact), American football (to detect hand-ball or foot-ball contact), soccer (to detect foot-ball or head-ball contact), hockey (to detect stick-puck or glove-puck contact), golf (to detect club-ball or club-tee contact), or any other sport or field of use where comprehensive contact detection data is valuable.

## Brief Descriptions of the Drawings

Fig. 1 is a frontal view of boxing gloves, focus mitts, and Thai pads currently in use.

Fig. 2 is a frontal view of the front face of the focus mitt cover and the positioning sensor of the first embodiment.

Fig. 3 is a side view of one column of concentric zones within the positioning sensor of the first embodiment. This figure shows the attachment of the U-shaped metal wires in sub-Figures 3a through 3d.

Fig. 4 is a side view of the same column of concentric zones within the positioning sensor as in the previous figure (Fig. 3). This figure shows the connection of the insulated wires.

Fig. 5 is an exploded view of the assemblage of the positioning sensor and focus mitt cover components of the first embodiment.

Fig. 6 is an overhead view of the assembled hardware used in the first embodiment of the invention.

Fig. 7 is an operational flowchart that conveys the process by which data is recorded during operation of the invention.

Fig. 8 is a frontal view of the front face of the Thai pad cover and the positioning sensor of an alternative embodiment of the invention. The bottom portion of the Figure depicts how to mount this Thai pad cover.

Fig. 9 is an overhead view of the assembled hardware used in a wireless alternative embodiment of the invention.

## Detailed Description of the Invention

Referring to the Figures, boxing gloves 100, focus mitts 101, and Thai pads 102 are shown in pairs for use on right and left hands. In Figures 6 and 9, the boxing gloves 100 will be affixed with a conductive aluminum sticker 110. In Figures 6, the focus mitts 101 will be fitted with covers 13 each containing a positioning sensor 10 and Data Detector 30. In Figures 9, the focus mitts 101 will be fitted with covers 13 each containing a flexible PCB positioning sensor 60 and wireless Data Detector 50. In Figure 8, the Thai pad will be fitted with its specific cover 91 and positioning sensor 90, where the Data Detector used in a fully assembled embodiment could be either a wired Data Detector 30 (Fig. 6) or wireless Data Detector 50 (Fig. 9).

Figure 2 illustrates the front face of the focus mitt cover 13 and the positioning sensor 10. The positioning sensor 10 is shown as comprising several conductive zones 11 and 12. In Figure 6, zones 11 will be connected to a current source and zones 12 will be connected to a contact detection circuit. The entire positioning sensor 10 is exposed on the surface of focus mitt cover 13.

Figure 3 illustrates the insertion of metal wires 14 through one column of concentric zones (11 or 12) within the positioning sensor 10, which resides on the surface of the focus mitt cover 13. Figure 3a shows a wire 14 aligned against the surface of its zone (in this specific case, a zone labeled 11). Figure 3b shows the wire 14 stapled through the surface of its zone 11, where its zone exists on the front surface of cover 13 and the ends of the wire 14 protrude from the backside of the cover 13. Figure 3c shows the beginning of the process of bending the protruding ends of wire 14 into a common point 14a. Figure 3d shows the wire 14 upon conclusion of the bending process, such that the two protruding ends meet at a common point 14a.

Figure 4 illustrates the connection between the common protruding points 14a of wires 14 previously shown in Figure 3d and the exposed ends 16a of the insulated wires 16. The protruding points 14a are soldered directly to ends 16a and a cylindrical piece of heat-shrink tubing 15 is inserted over the soldered joint to prevent wires from crossing. In Figure 6, the exposed ends 16b of insulated wire 16 will be connected to either a current source 31 (for zones labeled 11) or to specific input shift registers 32 (for zones labeled 12).

Figure 5 illustrates how the individual components within the focus mitt cover 13 are packaged together. After the soldering depicted in Figure 4 is accomplished, the insulated wires 16 are run through a thin layer of foam 20, then through grooves in a thick layer of foam 21, and then out to the exterior of the cover through slit 18. A final thin layer of foam 22 backs up the thick layer 21. Finally, the front surface 13 and front-side surface 17 of the focus mitt cover 13 are sewn to the rear surface 23 and rear-side surface 25, where surfaces 13 and 17 are preferably leather or faux-leather and surfaces 23 and 25 are preferably canvas. After sewing is complete, surfaces 19 and 24 will reside directly against each other inside the sewn together cover, such that they are no longer visible or accessible.

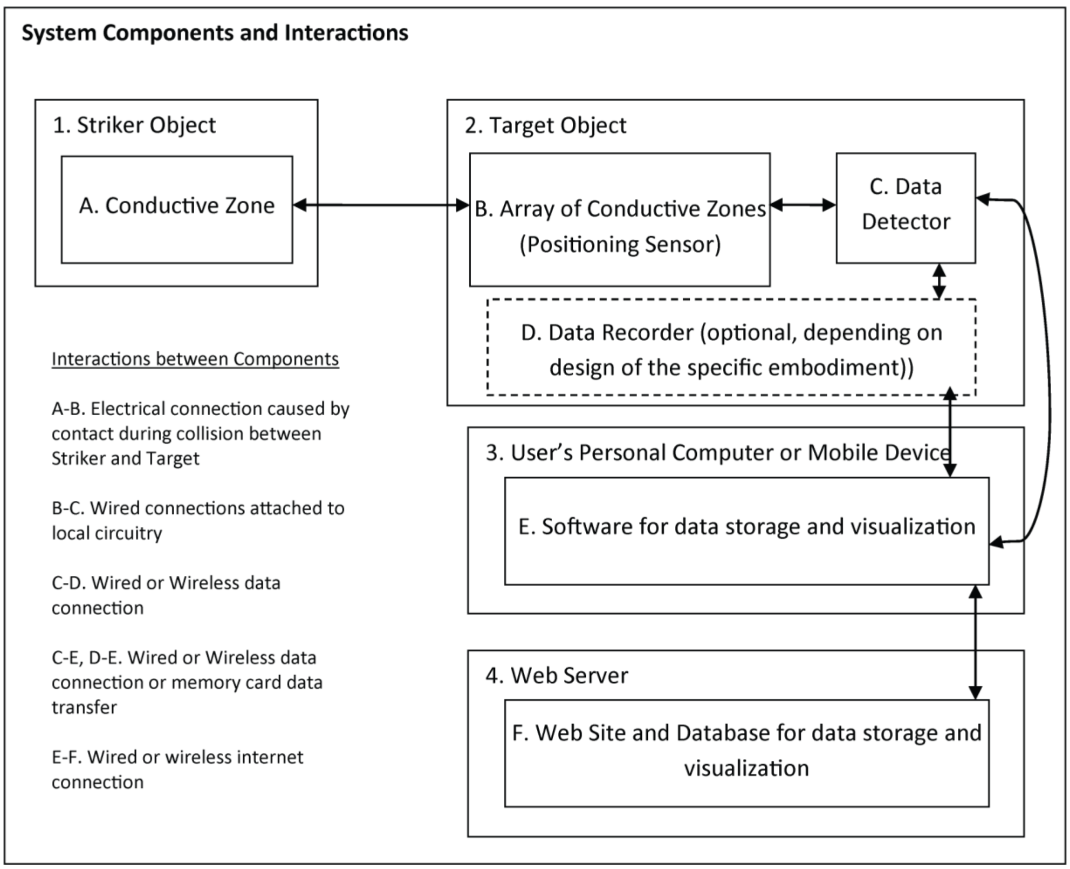
Figure 6 illustrates how the components are assembled into a functional embodiment of the invention. First, the focus mitt covers 13 are affixed to the focus mitts 101 using hook and loop fastener applied to the covers at locations 25 and applied to the mitts at locations 26. Then the Data Detectors 30 are attached to the rear of the focus mitts 101 using hook and loop fastener applied underneath the Data Detector 30 shown in the figure. Next, the wires 16 corresponding to zones labeled 11 are attached to the current source 31 and wires 16 corresponding to zones labeled 12 are attached to the input shift registers 32. Next the cables 37 are connected between the Data Detectors 30 and the Data Recorder 40. Finally, aluminum stickers 110 are attached to the boxing gloves 100. More detailed descriptions of the construction of individual components can be found later in this document under the detailed description of each particular component.

Figure 7 illustrates the flow of logic for the software that controls the Data Detector and Data Recorder circuits. This control-flow of logic is described in detail in the “Functional Operation” section of this document.

Figure 8 illustrates an alternative pattern of conductive zones used in the positioning sensor 90 and alternative cover design 91 so as to articulate how the invention can be adapted for alternate uses. The alternate positioning sensor 90 uses a slightly different design than the previous positioning sensor 10, such that more concentric rings are included, some rings have an increased or decreased number of segments within them, and from the center outward, the usage of zones 11 and 12 are swapped. Similar to the focus mitt cover 13, the front surface 91 would be constructed preferably using leather or faux-leather. Also, similar to focus mitt cover backing 23, the back surface 92 would be constructed preferably using canvas. Also, the shape of the cover 91 is generalized so that it can be easily applied to any flat, square, or cylindrical bag or pad. Figure 8 shows the mounting of this specific cover 91 to a Thai pad 102, where hook and loop fastener is applied at locations 93 and 103 to attach the cover 91.

Figure 9 illustrates an alternative embodiment of the invention from that depicted in Figure 6, where an alternate wireless Data Detector 50 is used to make operation more convenient. This wireless Data Detector 50 uses wireless Bluetooth communication to transmit data and relies on software running on a personal computer 70 or mobile device 80 to store the data, eliminating the need for a dedicated Data Recorder 40. The design of the wireless Data Detector 50 is similar to that of the wired Data Detector 30, except the new detector 50 requires a battery 51 and Bluetooth transceiver 52. The wireless Data Detector 50 is attached to the side surface 17 of the focus mitt cover 13 using hook and loop fastener under the Data Detector 50. Also, to increase convenience, this embodiment uses flexible PCB positioning sensors 60 that are applied to the front surface of the focus mitt covers 13 using adhesive on the back side of the flexible PCB positioning sensors 60. This implementation uses connectors 61 and adapters 62 to connect the flexible PCB positioning sensors 60 to the wireless Data Detector 50. This change eliminates the need to run wires 16 through the interior of the focus mitt cover, thus also eliminating the need for slit 18. More detailed descriptions of the construction of individual components can be found later in this document under the detailed description of each particular component.

Before explaining in detail the construction of each component mentioned above, it is necessary to articulate the breakdown of components required by an embodiment of the invention. The diagram below depicts the individual components (denoted by boxes labeled with letters A through F), the grouped objects (denoted by boxes labeled with numbers 1 through 4), and the connections between components (denoted by arrows between component boxes).




## A. Conductive Zone on Striker Object

During contact between the Striker and Target, the conductive zone on the Striker creates an electrical connection between two or more conductive zones on the Target object, allowing the circuitry to record the location where the Striker made contact with the Target. In the boxing-specific embodiment shown in Figures 6 and 9, this conductive zone is implemented by applying an aluminum sticker 110 (or any other conductive material, see “Alternative Components”) to the surface of the boxing glove 100 at the desired location where the knuckles should hit the center of the Target.

## B. Array of Conductive Zones (Positioning Sensor) on the Target Object

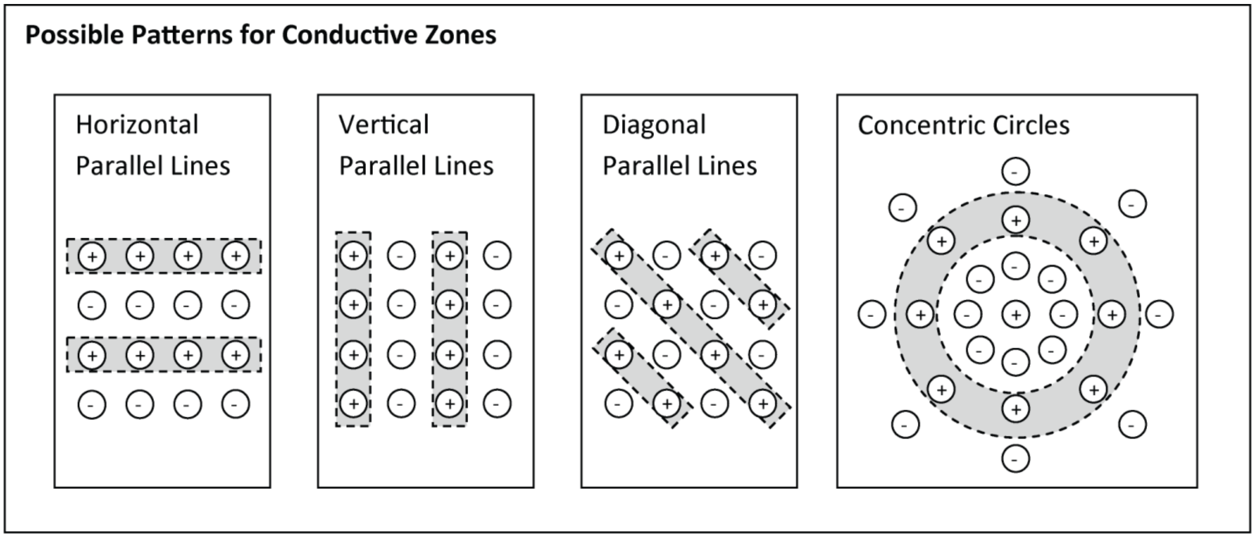
During contact between the Striker and Target, the array of conductive zones on the surface of the Target provides discrete points where positioning information is detected. During construction, these conductive zones are created either by applying conductive material (metal, conductive ink, conductive plastic) to the surface of the Target or by affixing printed circuit boards (regular PCB or flexible PCB) to the surface of the Target.

These conductive zones are then connected to detection circuitry (Data Detector) that processes the data resulting from the aforementioned contact. Specifically, each individual conductive zone is connected to either a common current source or a specific input within the Data Detector. These connections can be physically implemented using either the “Pull-Down” or “Pull-Up” model. The first embodiment of the technology for boxing uses the “Pull-Down” model, which will be the model used in subsequent circuit diagrams.

In the “Pull-Down” model, the zones connected to the common current source (Figure 2 Part 11) are connected to a positive voltage substantial enough for the detection circuitry to detect a voltage (for example +5 Volts) and the zones connected within the sensor circuitry (Figure 2 Part 12) are connected using a load resistor (for example 10,000 Ohms) to ground (0 Volts). When contact is made and two oppositely connected conductive zones are linked, the voltage detected by the detection circuitry changes from 0 Volts to +5 Volts.

In the “Pull-Up” model, the zones connected to the common current source (Figure 2 Part 11) are connected to ground (0 Volts), and the zones connected within the detection circuitry (Figure 2 Part 12) are connected using a load resistor (for example 10,000 Ohms) to a positive voltage substantial enough for the circuitry to detect a voltage (for example +5 Volts). When contact is made and two oppositely connected conductive zones are linked, the voltage detected by the detection circuitry changes from +5 Volts to 0 Volts.

As for the layout of the array of conductive zones, one can choose from a variety of patterns, depending on the requirements for the specific embodiment. Possible patterns include, but are not limited to parallel lines (horizontal, vertical, or diagonal) or concentric circles (see diagrams below).




In these patterns, the “+” zones correspond to the zones supplying current (Figure 2 Part 11) and the “-“ zones correspond to the zones receiving current (Figure 2 Part 12). Furthermore, since all zones supplying current are eventually connected to the same current source, one can use solid lines or rings of conductive material to replace contiguous “+” conductive zones in the pattern (denoted by dashed shapes filled with gray), thus reducing the number of wired connections required later in construction. Also, note that the number of conductive zones in each line or concentric circle need not be uniform, for instance, it may be desirable to add more conductive zones to the outer concentric rings.

The size of the conductive segment on the Striker determines the maximum possible size of the gap between any “+” zone and its closest “-“ zone. This is so because the conductive segment on the surface of the Striker must cause current to flow anytime it makes contact within the perimeter of the sensor. If this rule is violated in the pattern design, some instances of contact would not be detected. Due to this restriction, the perimeter of the sensor is defined as by the locations at which contact with the Striker fails to bridge two oppositely connected zones, and thus fails to cause current to flow.

Figure 2 depicts the pattern used in the boxing-specific embodiment. Construction begins by cutting a piece of fabric (preferably leather) into the appropriate shape 13, which matches the shape of a traditional boxing focus mitt 101. The positioning sensor 10 is constructed by first drawing the conductive zones 11 and 12 in conductive coating. Using the “Pull-Down” model, the conductive zones 11 supplying current will later be connected to +5 volts and the conductive zones 12 receiving current will later be connected to the current/voltage detection circuit.

Figure 3 depicts one method for connecting the conductive zones to the circuitry where a U-shaped non-insulated metal wire 14 is stapled through the fabric surface and then bent on the other side so both protruding ends rest touching each other 14a.

Figure 4 depicts how the portion of the non-insulated metal wire 14a connects to the exposed end 16a of the insulated wire 16 that connects to the Data Detector. After soldering 14a to 16a, the soldered joint is covered by heat shrink tube 15 to prevent wires from crossing.

Figure 5 depicts how the outer surface of the focus mitt cover 13 is connected to a side cover 17, where a slit 18 is cut for exposing wires 16. Furthermore, the backside of the side cover 19 is shown to clearly illustrate the ability to turn the side cover inside-out when attaching the cover to a focus mitt. The thin foam panel 20 resting directly behind the outer surface is shown with wires running straight through. The thick foam panel 21 resting behind panel 20 is shown with groves cut out so that the wires 16 can run sideways and then out slit 18. The second thin foam panel 22 is shown backing panel 21. Finally, the fabric backing 23 (preferably canvas) is shown such that the underside of this backing will rest directly against the front face of the focus mitt.

The inner surface of the side cover 24 is shown clearly, where this surface would sit directly behind surface 19. Finally, the backside 25 of the inner surface 24 is shown, where this backside would be covered with hook and loop fasteners so that it could be attached easily to the side surface of a boxing focus mitt. At this point, the second exposed end 16b of the insulated wires 16 corresponding to each zone protrude from slit 18 and can be connected to the Data Detector so that it can observe the state of each zone.

Two alternative implementations of the conductive zones exist that are not shown in the first embodiment. The first alternative uses PCB to replace the heat shrink tube 15, insulated wires 16, and foam panel 21. The second uses PCB to replace parts 14, 15, 16, 18, 20, and 21.

In the first alternative, a PCB (regular or flexible) would sit behind foam panel 20. Instead of soldering the protruding wires 14 to insulated wires 16, the protruding wires would directly attach to the PCB, and the PCB would connect to the Data Detector by means of an adapter. This would make construction simpler because it would eliminate the need for the complex set of canals carved in foam panel 21 that are currently necessary to run the insulated wires 16 out of the cover through the side slit 18.

In the second alternative (depicted in Figure 9), the design of the positioning sensor would be printed directly on a PCB 60 (regular or flexible), and this PCB would be affixed directly to the surface of the Target 13. This PCB would then connect to the Data Detector by means of a connector 61 and adapter 62. This implementation would use the same pattern depicted in Figure 2, but the PCB would eliminate the need to draw any conductive zones on surface 13, because the zones would already be exposed on the surface of the PCB. Furthermore, it would eliminate the need to run the wires depicted in Figures 4 & 5 through the interior of the focus mitt cover.

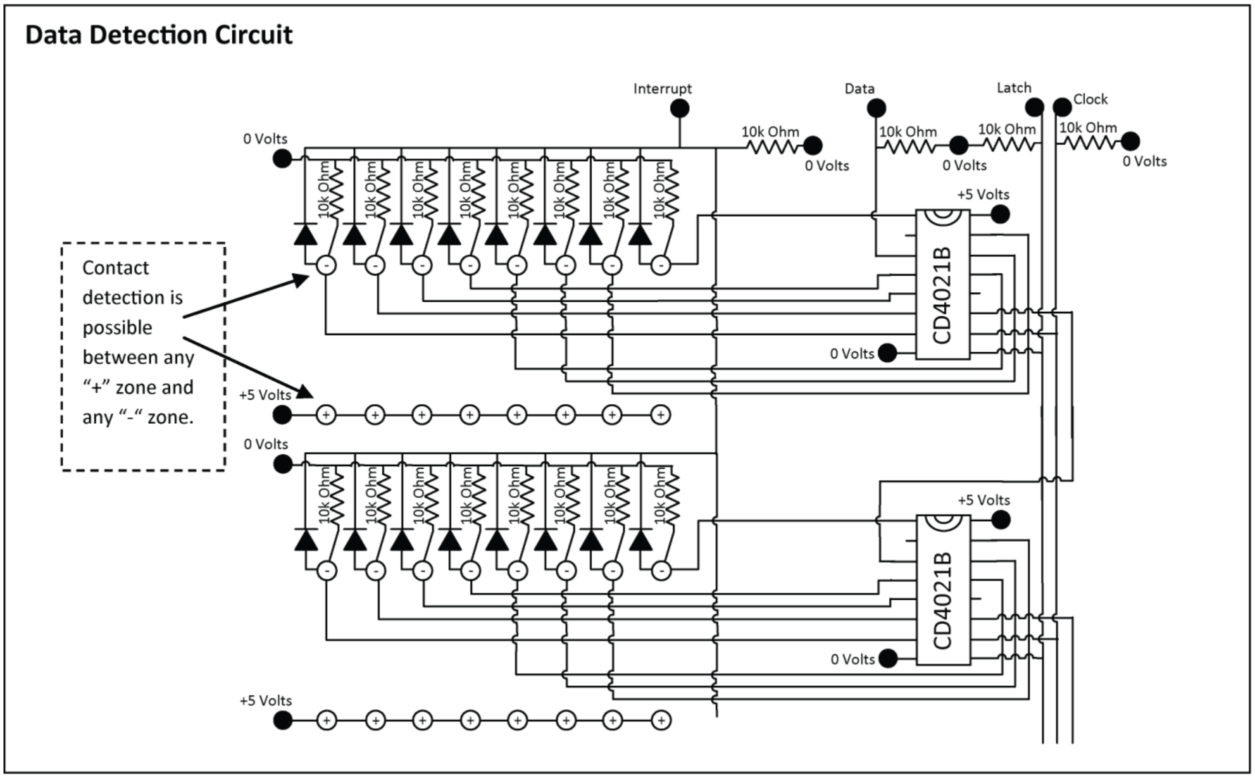
## C. Data Detector

As mentioned previously, the individual conductive zones on the surface of the Target must be connected to the data detection circuitry (Data Detector) in such a manner that contact between two or more oppositely connected zones is discretely detected.

Besides containing the circuitry necessary to detect data about the positioning of objects involved in the instance of contact, the Data Detector can also include other electronics that provide additional useful information. For example, the Data Detector supports integration of an accelerometer to determine force and X-Y-Z orientation for the instance of contact.

Furthermore, the means by which the Data Detector sends data to subsequent components in the complete system is quite flexible. While the first embodiment uses a VGA cable, it is also possible to include circuitry so that the Data Detector transmits data over an alternate data cable (such as a USB cable) or wirelessly.

The minimal circuit necessary to implement the Data Detector is specified as follows (using the "Pull-Down" model and the "Horizontal Parallel Lines" pattern):




As previously mentioned, the individual conductive zones ("+" zones and "-" zones) must be exposed on the surface of the Target and connected to the Data Detector. In this implementation of the circuitry for the pattern depicted in Figure 2, the conductive zones labeled 11 are connected to +5 Volts and the conductive zones labeled 12 are connected to CD4021B input shift registers, which are daisy-chained together so as to collect the data from a large number of individual conductive zones and transmit that data over one shared serial connection. In this implementation, a controller microchip located elsewhere in the circuit can access the data from these registers using this serial connection implemented using the "Latch", "Clock", and "Data" wire connections.

It is possible to implement the circuitry using chips other that the CD4021B input shift register (for example multiplexers or direct connections between the conductive zones and controller chip), but doing so may limit the flexibility of the overall embodiment to scale to the level of precision desired for contact detection.

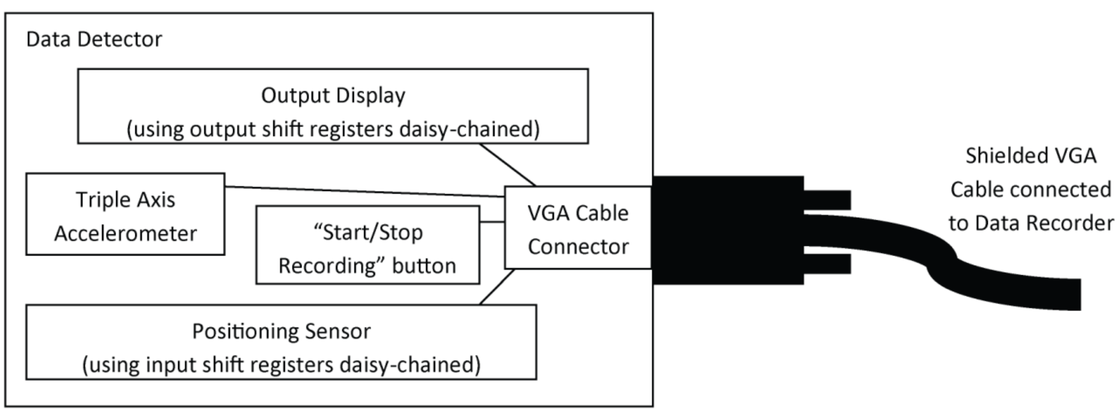
Furthermore, this circuit is implemented so that it provides an interrupt signal whenever contact occurs or ceases. This signal is useful in conserving power and preventing unnecessary processing, but it is not required for the circuit to provide data to the controller. However, if eliminated, the controller would need to continuously check for changes in contact detection, which is usually undesirable.

Figure 6 depicts the first embodiment, which contains two Targets mounted as covers over focus mitts, where each Target requires its own Data Detector 30. The exposed ends 16b of the wires 16 connected to the conductive zones 11 or 12 protrude from slit 18. The wires supplying current (connected to Figure 2 Part 11) attach to the current source 31. The wires used to detect current (connected to Figure 2 Part 12) attach to the CD4021B input shift registers 32 in a manner where the zones for each concentric ring connect to the same shift register in a clock-wise manner, where the top zone (12 o'clock) is connected first. Furthermore, an accelerometer 33 is used to measure force and X-Y-Z orientation, a LED 34 is used to show when the device is actively recording data, and a button 35 allows the user to start or stop recording. The data is transmitted to the Data Recorder 40 using shielded VGA cables 37, where one end 36 directly attaches to the Data Detector.

Finally, the cover containing the positioning sensor 10 is connected to the focus mitt 101 using hook and loop fasteners attached to the interior of the side covers 25 and the side of the focus mitt 26. Also, the Data Detector 30 is mounted on the back of the focus mitt 101 using hoop and loop fastener.

Figure 9 shows an alternative wireless Data Detector 50 that is functionally similar to the wired Data Detector 30, but uses a Bluetooth transceiver 52 to transmit data to a digital storage device. This wireless Data Detector 50 also requires a battery 51.

**Data Detector for First Embodiment**




Alternative methods of attaching the Data Detector exist where instead of being attached to the back of the focus mitt using hook and loop fastener, the Data Detector is connected directly to the focus mitt cover. One alternative embodiment is shown in Figure 9 where the wireless Data Detector 50 is directly attached to the side surface 17 of the focus mitt cover 13.

A second alternative is to connect the data detector to elastic bands sewn into the sides of the cover 13. Using these bands, the Data Detector 30 would reside in the same location as in Figure 6, but would not

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require hook and loop fastener, since the elastic bands would serve to compress the focus mitt 101 between the focus mitt cover and the Data Detector, thus holding the invention in place.

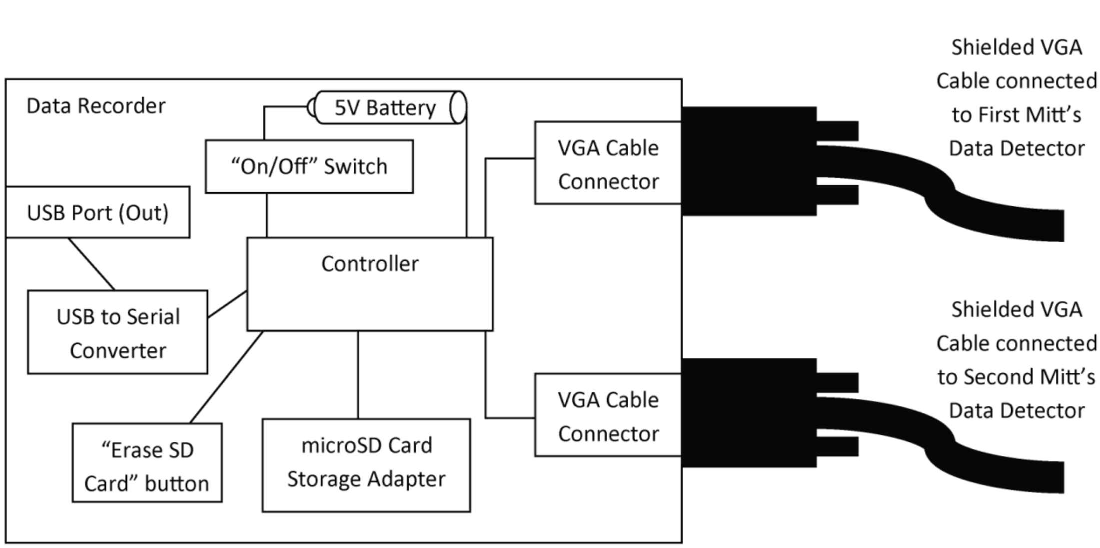
## D. Data Recorder

The Data Recorder is an optional component of the invention in the sense that if the Data Detector is designed to transmit data over a USB or wireless connection to a Personal Computer or Mobile Device running software to record the data, the need for a dedicated device to record data would be eliminated.

However, in the first embodiment includes a Data Recorder, which queries the Data Detectors for information and writes this information to a digital storage device (microSD card). The user is then expected to upload the data from the digital storage device to a computer for the purpose of permanent data storage and data visualization. This Data Detector implementation uses an ATMega328 microchip loaded with custom software as the Controller, which queries and writes data.

Figure 6 depicts how the Data Recorder 40 accepts the ends of the VGA cables 36 attached to the Data Detector 30 on each focus mitt 101 and records data from these Data Detectors 30 to a microSD card inserted into slot 43. The Data Recorder also includes a button 41 for erasing the data on the microSD card, a "On/Off" switch 42, and a belt clip 44 for attaching the device to the user's belt or waistband.

**Data Recorder for First Embodiment**




## E. Data Storage and Visualization Software

The invention includes a software component that can run on the user's Personal Computer or Mobile Device (SmartPhone or PDA). This application provides the capability to record data transmitted directly from the Data Detector or transferred from the Data Recorder, visualize this data, and compute performance analytics. Also, this software provides the capability to upload data into a remote web system using the device's internet connection.

## F. Website and Database

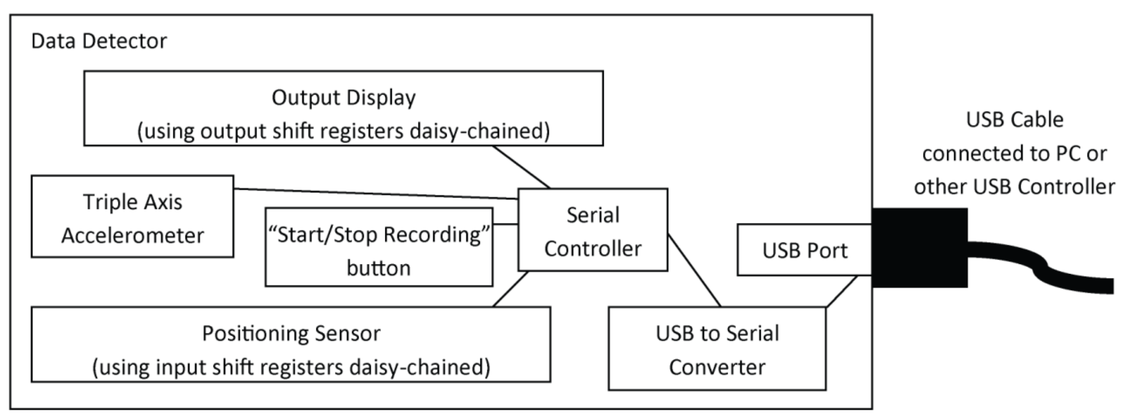
Similar to the aforementioned software component, the invention includes a website that allows access to the same functionality as the software component, plus the ability to share data with other users and to interact with other users online.

## G. Alternate Implementations of Data Detector

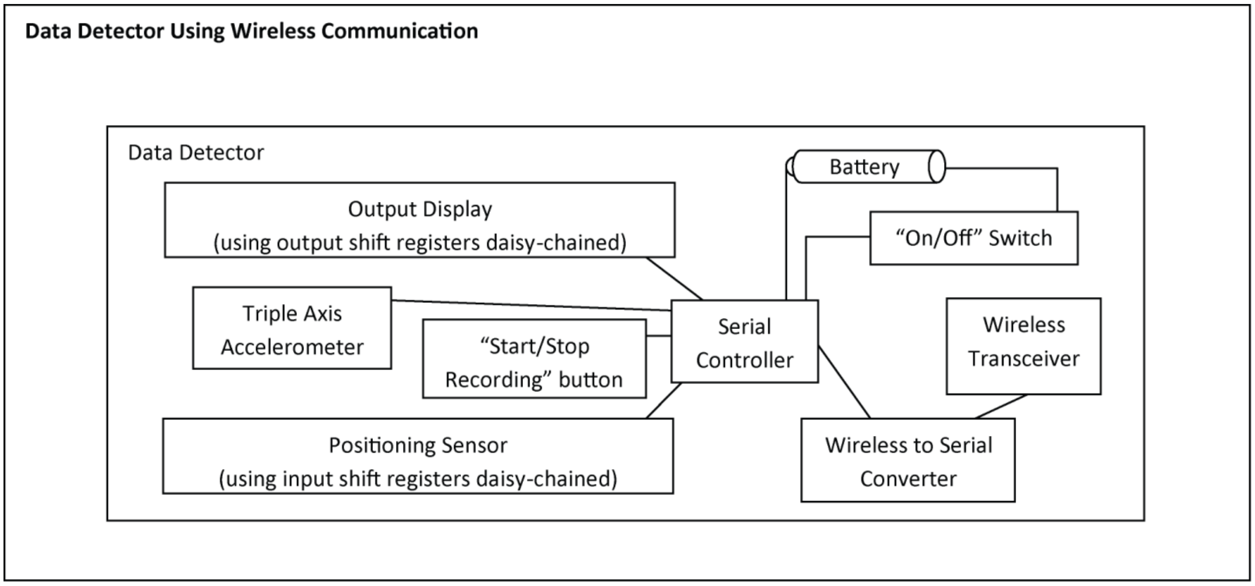
The previous drawings show the construction of the first embodiment of this technology for the purpose of detecting accuracy of knuckle placement for a punch contacting a boxing focus mitt. While the existing implementation has been proven to function correctly, other embodiments exist for the same purpose where the connectivity between the “Data Detectors” and the “Data Recorder” is less cumbersome.

One alternate implementation of the Data Detector uses a USB cable as the cable for transmitting information instead of a VGA cable or other custom data cable. This allows the Data Detector to be plugged into to any device that contains a USB host controller, such as a personal computer, mobile device, or gaming console, so that data can be recorded directly without the need for transferring a SD card from a Data Recorder.

**Data Detector Using USB Communication**




Another alternate implementation of the Data Detector uses wireless communications to transmit data to/from another device such as a Personal Computer or Mobile Device. The specific wireless technology used could be any variation of ZigBee, BlueTooth, Wireless USB, or any other technology for communicating wirelessly. One caveat of this design is that the wireless Data Detector 50 requires an on-board current source 51 (i.e. battery) to power the circuit and an on-board wireless transceiver 52.




Also, another alternative embodiment of this technology could contain a greater number of Data Detectors, not just one or two. For instance, it may be desirable to create a second embodiment which is identical to the first, except it has a third Data Detector for the purpose of recording data from an abdominal pad.

## Functional Operation

The operating description below is directly applicable to the first embodiment of the technology, the boxing focus mitt sensors. Operation of other embodiments would be quite similar, as the underlying sensor technology is designed to function in a generically applicable manner. Please note that this embodiment contains 1 switch ("On/Off") and 2 buttons ("Start/Stop Recording" and "Erase Data"); however, the description refers to the "Start Recording" and "Stop Recording" buttons, since the one "Start/Stop Recording" button behaves as a toggle. Also, please refer to Figure 7 for a graphical description of this explanation.

Operation of the first embodiment begins with the Data Recorder in the "Off" state 301, such that the device is not actively sensing or recording data. The user starts the device by switching it from "Off" to "On" 302. At this point, if the batteries are properly charged 303, the digital storage device is properly connected 304, and the storage device has free space remaining 305, the device will show as "Ready" 306 (i.e. properly configured, but not actively recording data yet). Otherwise, it will show as being in an "Error" state 307.

To start recording data, the user must first push the "Start Recording" button 308 so that the device enters the "Recording" state 309, where it listens for sensor input from either the Positioning Sensor or the Accelerometer. When the user wishes to stop recording data, the user must push the "Stop Recording" button 310, so that the device returns to the "Ready" state 306.

While in the “Recording” state 309, the athlete may punch the Positioning Sensor 311, and if contact occurs between the conductive zone on the boxing glove and two differently connected conductive zones on the Positioning Sensor 312, the Data Recorder notices the occurrence, queries the Data Detectors as to the state of the various sensors, and writes that data observation to the digital storage device 315.

Also, while in the “Recording” state 309, the holder may move the focus mitt (with the Positioning Sensor attached) 313, and if a preset movement threshold is exceeded 314, the Data Recorder notices the occurrence, queries the Data Detectors as to the state of the various sensors, and writes that data observation to the digital storage device 315.

After writing a data observation 315, the Data Recorder will check if more free space exists in the digital storage device, and if so, the Data Recorder will remain in the “Recording” state 309. However, if insufficient storage space is available, the device will enter the “Error” state 307.

Also, if the device is in either the “Ready” 306 or the “Error” 307 state, the user may push the “Erase Data” button 319, which will erase the contents of the digital storage 320, and then check whether the recorder is in a valid state (304 & 305), and if so, enter the “Ready” state 306. If the validity checks fail, the device will enter the “Error” state 307.

Regardless of whether the device is in the “Ready” 306, “Recording” 309, or “Error” 307 state, the user may switch the device off 316, thus ending the active operation of the device.

## Claims

1) A sensor technology for detecting surface positioning data during contact between two or more independent, unrestrained objects in which:
    a. A fixed size zone of conductive material is mounted on the surface of a first independent, unrestrained object;
    b. An array of zones of conductive material is mounted on the surface of a second independent, unrestrained object;
    c. Individual conductive zones within the array are alternately connected to either a current source or a current/voltage detection circuit;
    d. The detection circuit is connected through a controller microchip to a digital storage device and software embedded in the controller microchip records data from the detection circuit;
    e. The data collected during contact is uploaded to a computer application that runs on a Personal Computer (PC), Mobile Device, or Web Server that provides permanent storage and data visualization capability;

    whereby contact between the segment of conductive material on the first object and the array of segments of conductive material on the second object creates an electrical connection that allows electric current to flow through to the detection circuit, causing the controller microchip to record the surface positioning data about the contact that occurred.
2) A functional shape design for a mounting apparatus whereby the mounting apparatus mimics the shape of a focus mitt, providing the ability to mount a set of sensors without significantly affecting the form of the natural training device (focus mitt) or encumbering the holder of the training device.

## Alternative Components

For each component required in the first embodiment, listed are alternative components that could be used to achieve the same functional results.

CONDUCTIVE ZONES ON STRIKER OR TARGET
1) Silver conductive paint or ink
2) Other metal-based conductive paint or ink
3) Conductive plastics (such as graphite powder mixed with contact cement or liquid tape)
4) Embroidered wire
5) Embroidered conductive thread
6) Conductive fabric
7) Metallic stickers
8) Glued or soldered pieces of metal
9) PCB (flexible or regular) with exposed contacts

CONNECTIONS FROM CONDUCTIVE ZONES TO DATA DETECTOR

1) Individual insulated wires
2) Ribbon of wires
3) PCB (flexible or regular) connector

CHIPS FOR PROCESSING STATE OF CONDUCTIVE ZONES
1) Input shift registers
2) Multiplexers
3) Local Microcontroller
4) Serial Chip

FORCE DETECTION
1) Digital Serial Accelerometer
2) Analog Accelerometer
3) Pressure sensor
4) Capacitive force sensor
5) Piezo Sensor Matt

DEVICE CONTROLS
1) Buttons and LEDs
2) Buttons and LCD Screen
3) Touch Screen

ATTACHING DATA DETECTOR TO TARGET OBJECT
1) Hook and loop fastener
2) Elastic bands
3) Embedded within focus mitt cover

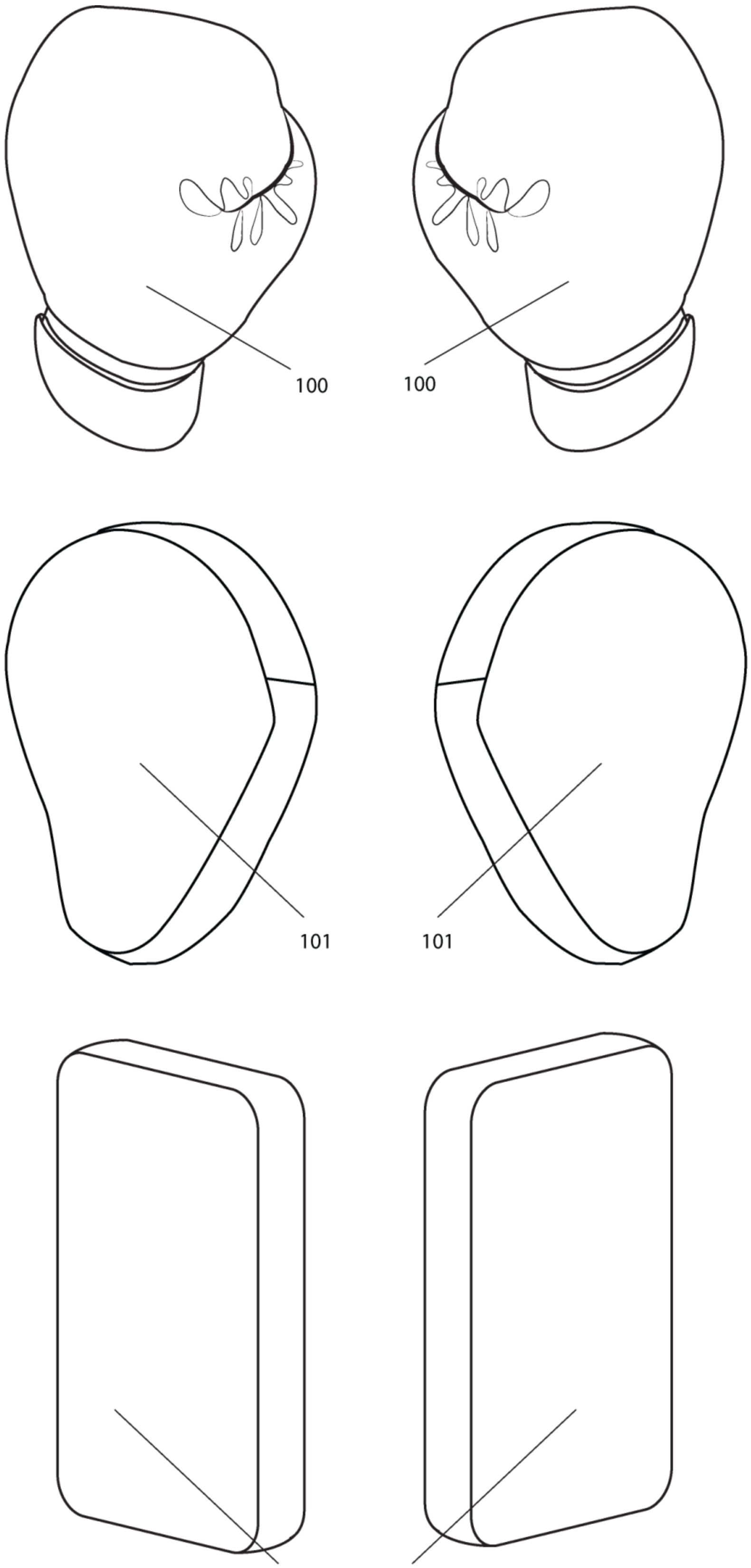
COMMUNICATIONS FROM DATA DETECTOR TO DATA RECORDER
1) Custom Data Cable
2) VGA Cable
3) USB Data Cable
4) Wireless USB
5) RF Transceiver
6) Bluetooth
7) Infared
8) WiFi

CONTROLLER WITHIN DATA RECORDER
1) Microcontroller (ATMega, PIC, ARM, etc.)
2) CPU

DIGITAL DATA STORAGE DEVICE WITHIN DATA RECORDER
1) SD card
2) miniSD card
3) microSD card
4) any other type of removable data card
5) USB memory stick
6) EEPROM memory chip

ALTERNATE OPTIONS FOR RECORDING DATA FROM DATA DETECTORS
1) Application for mobile device such as Smart Phone or PDA
2) Application for Personal Computer
3) Application for Tablet Computer
4) Application for Gaming Console

PROGRAMMING LANGUAGE
1) C++
2) .NET
3) Java
4) Objective C
5) Assembly
6) Other programming language




Prior Art
Fig. 1

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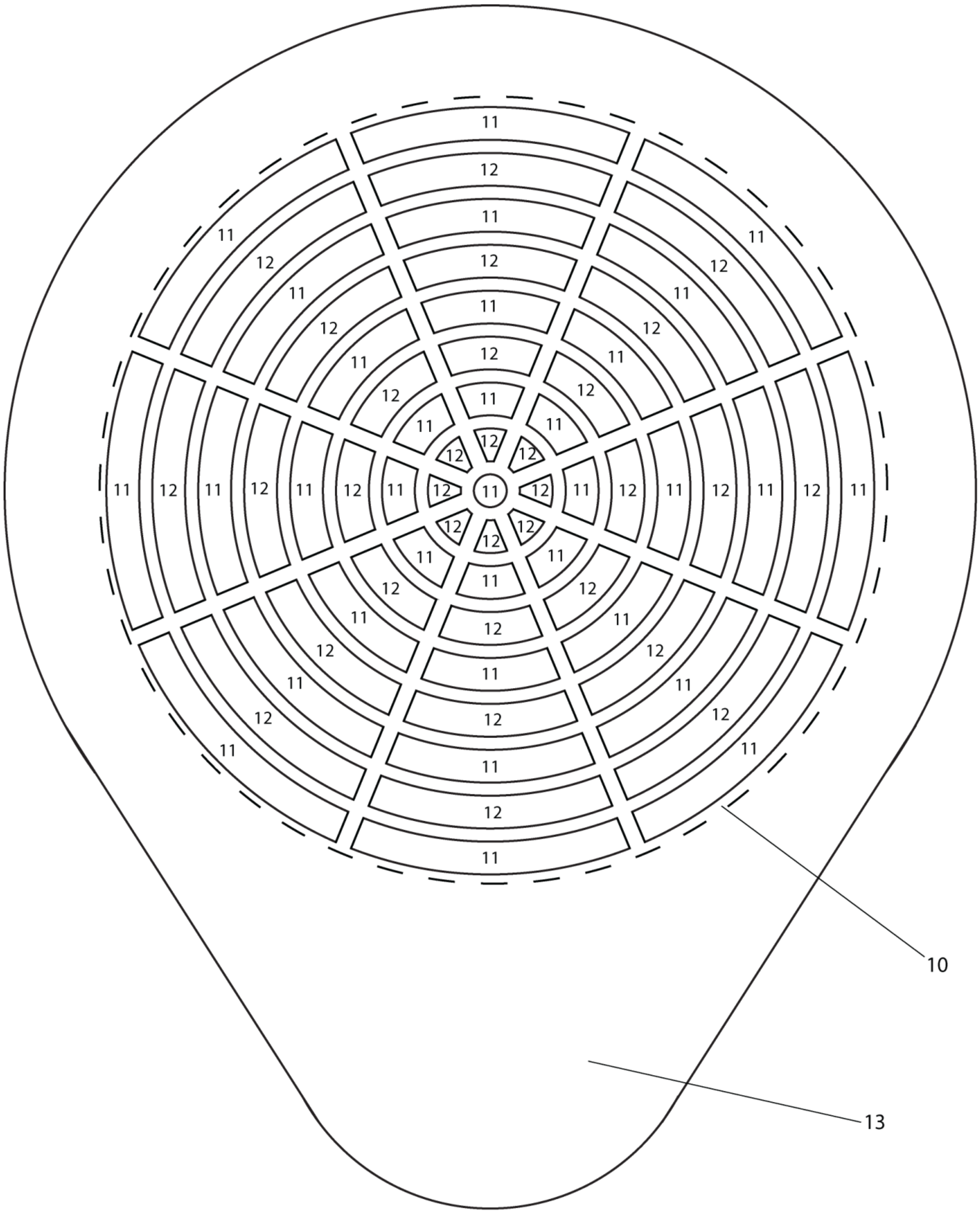


Fig. 2

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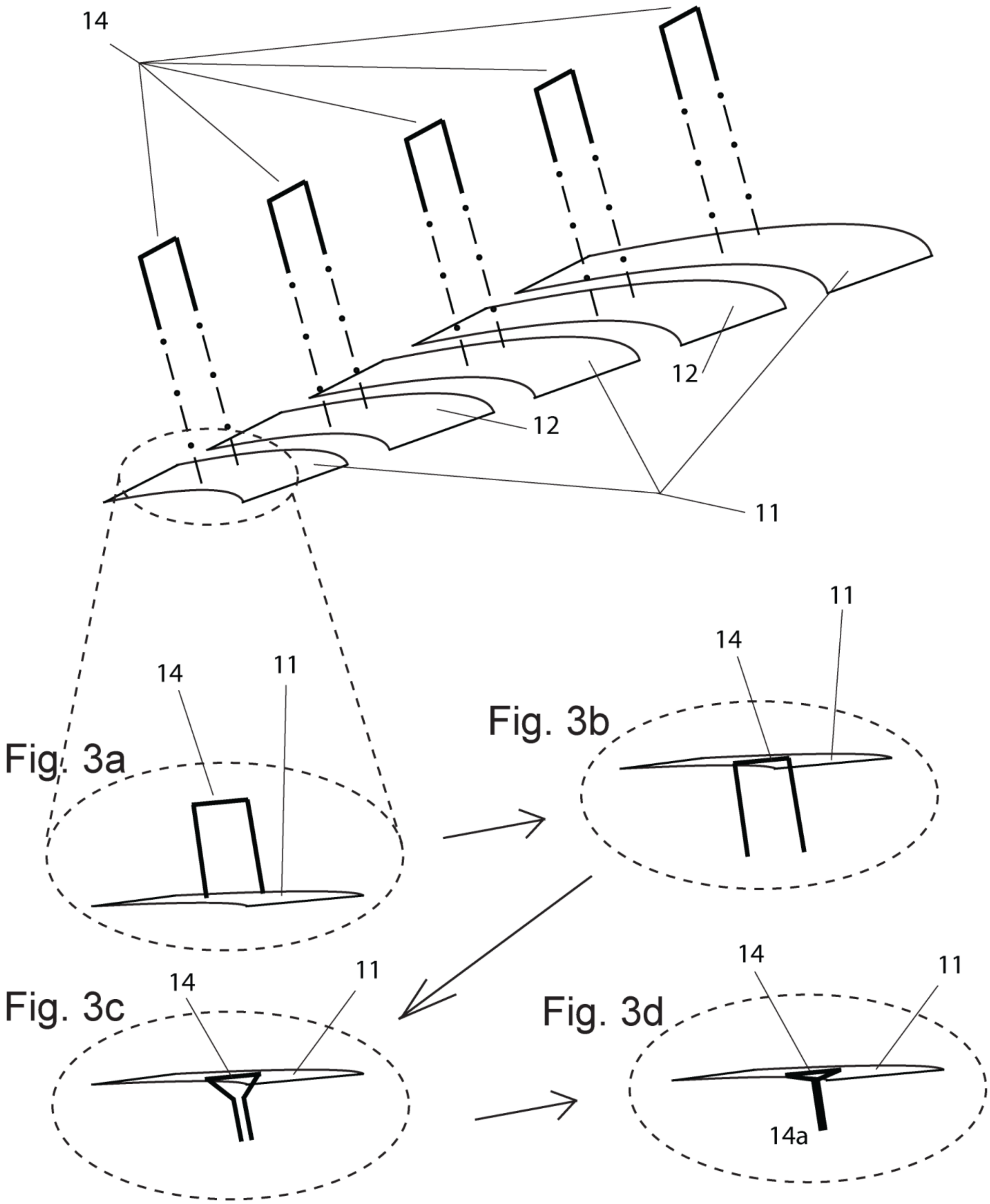


Fig. 3

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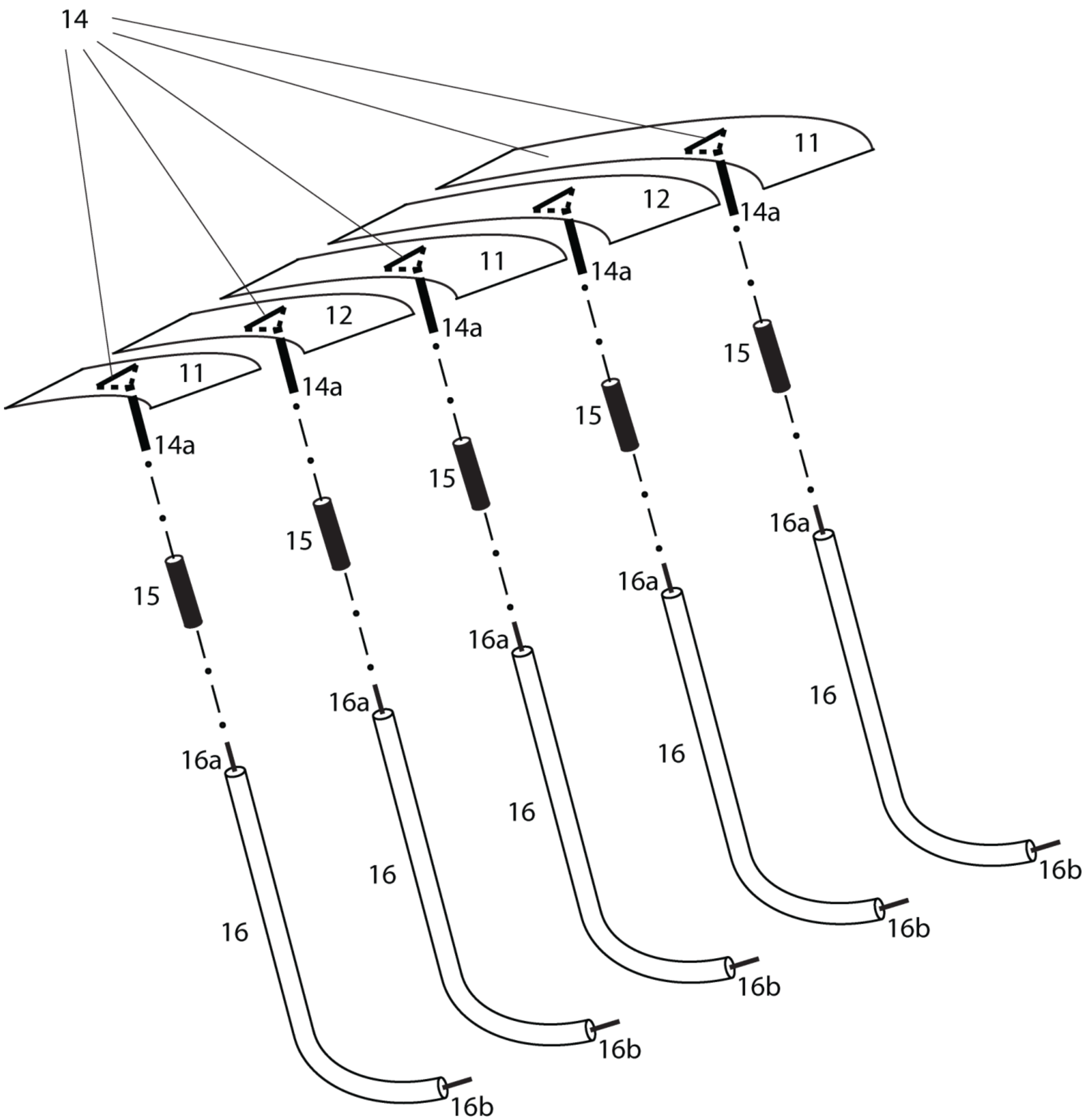
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Fig. 4

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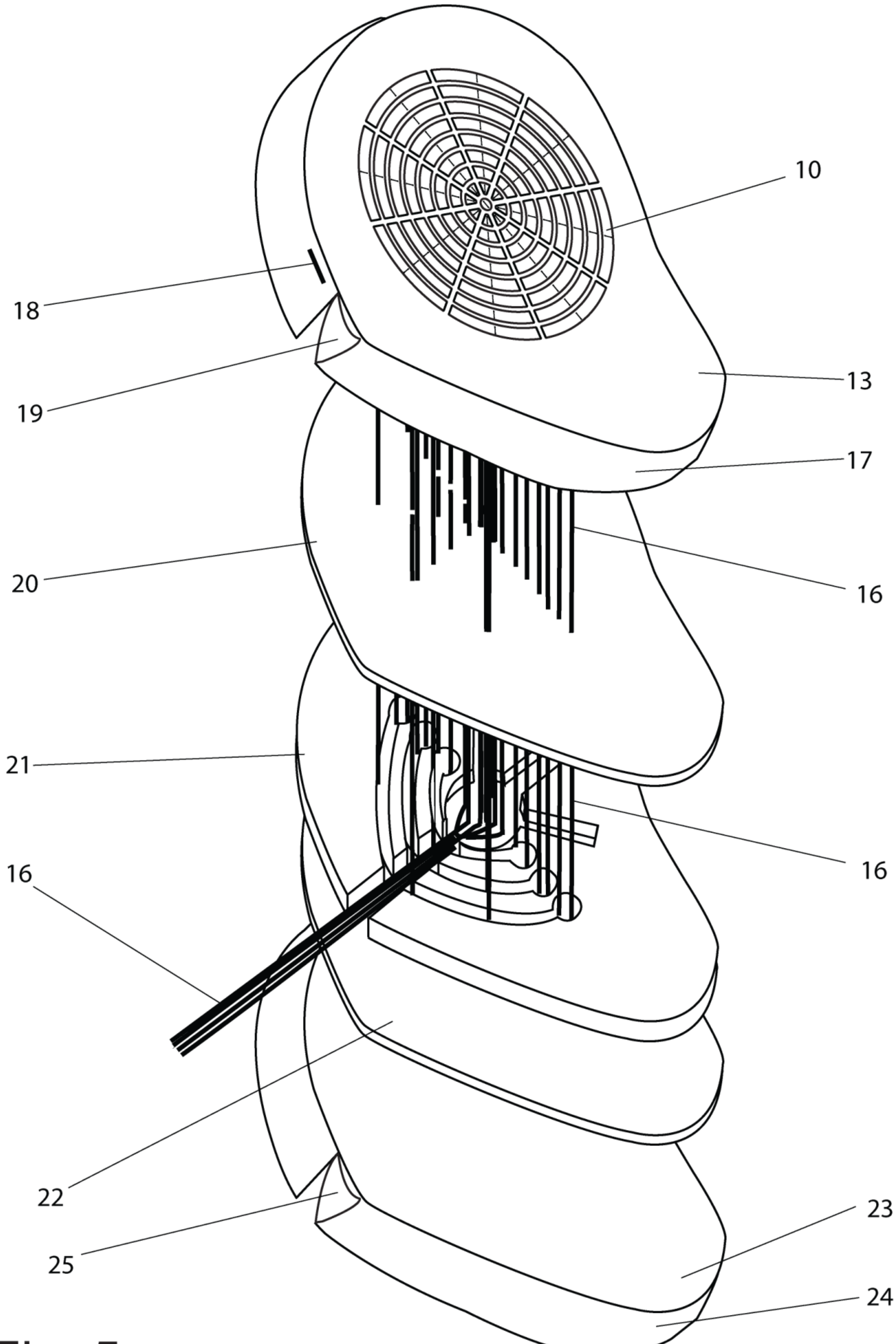


Fig. 5

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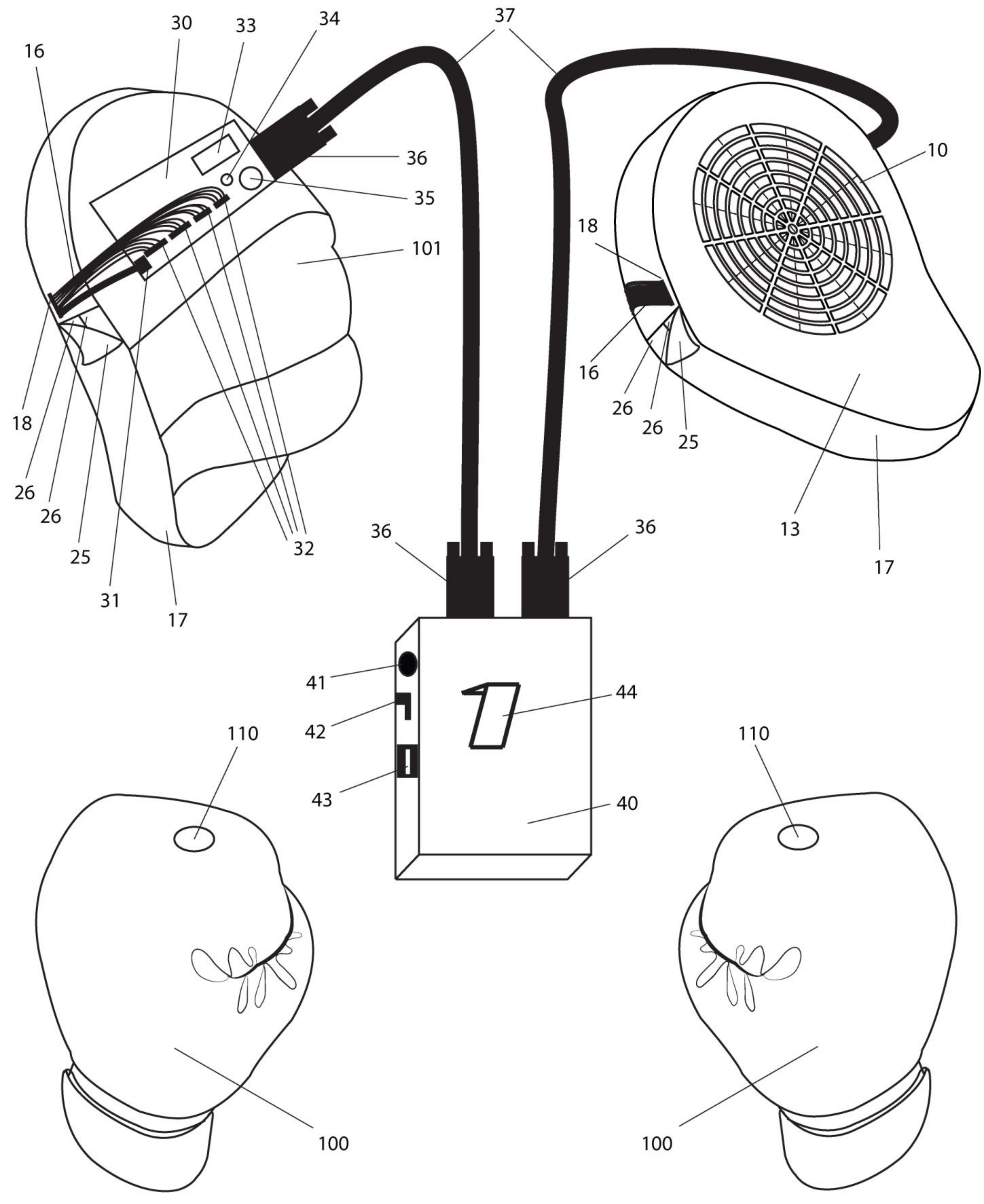
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Fig. 6

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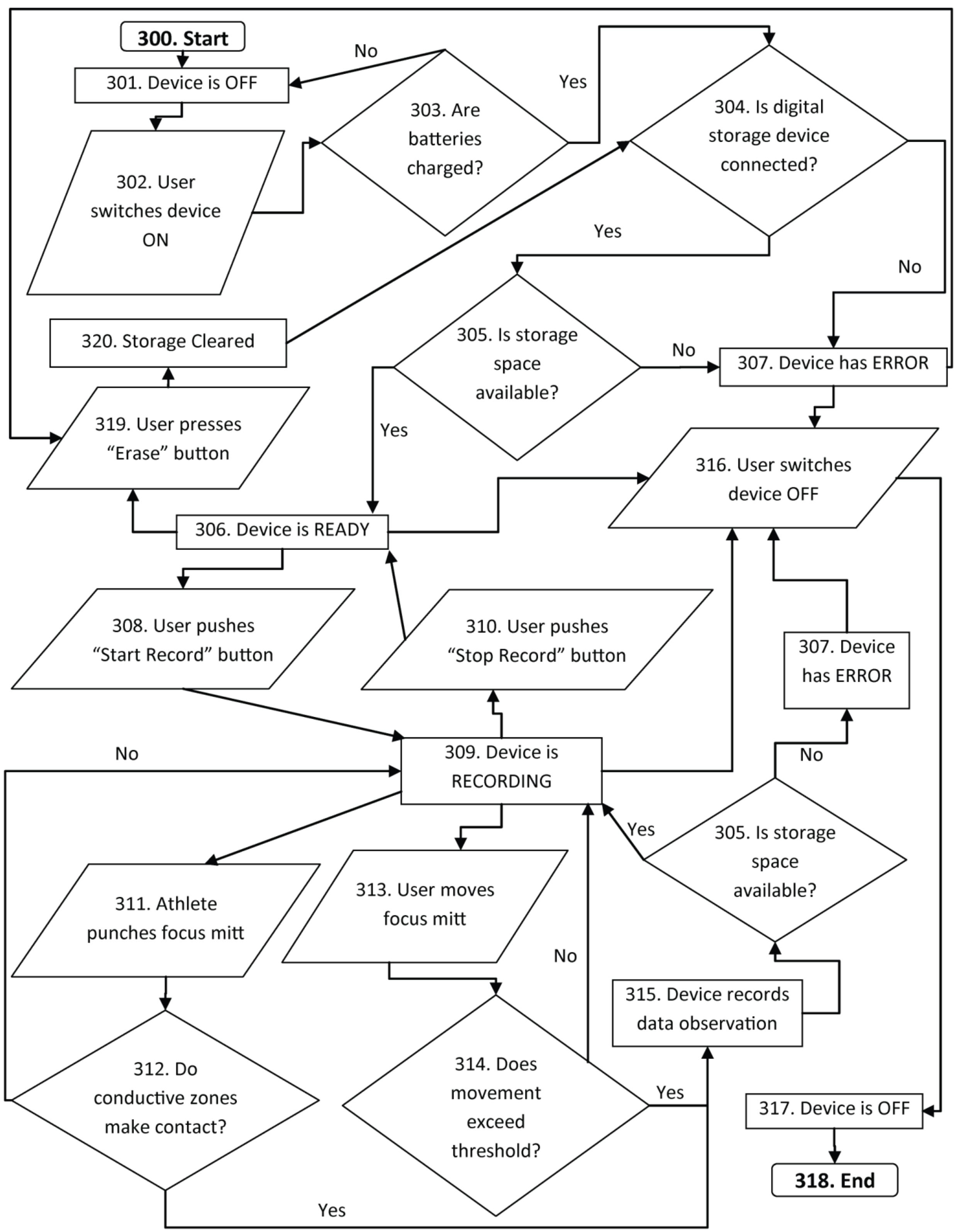
300. Start
301. Device is OFF
302. User switches device ON
303. Are batteries charged?
No
Yes
304. Is digital storage device connected?
Yes
No
305. Is storage space available?
No
Yes
307. Device has ERROR
320. Storage Cleared
319. User presses “Erase” button
306. Device is READY
316. User switches device OFF
308. User pushes “Start Record” button
310. User pushes “Stop Record” button
307. Device has ERROR
309. Device is RECORDING
No
305. Is storage space available?
Yes
No
311. Athlete punches focus mitt
313. User moves focus mitt
No
315. Device records data observation
312. Do conductive zones make contact?
314. Does movement exceed threshold?
Yes
317. Device is OFF
318. End
Yes

Fig. 7

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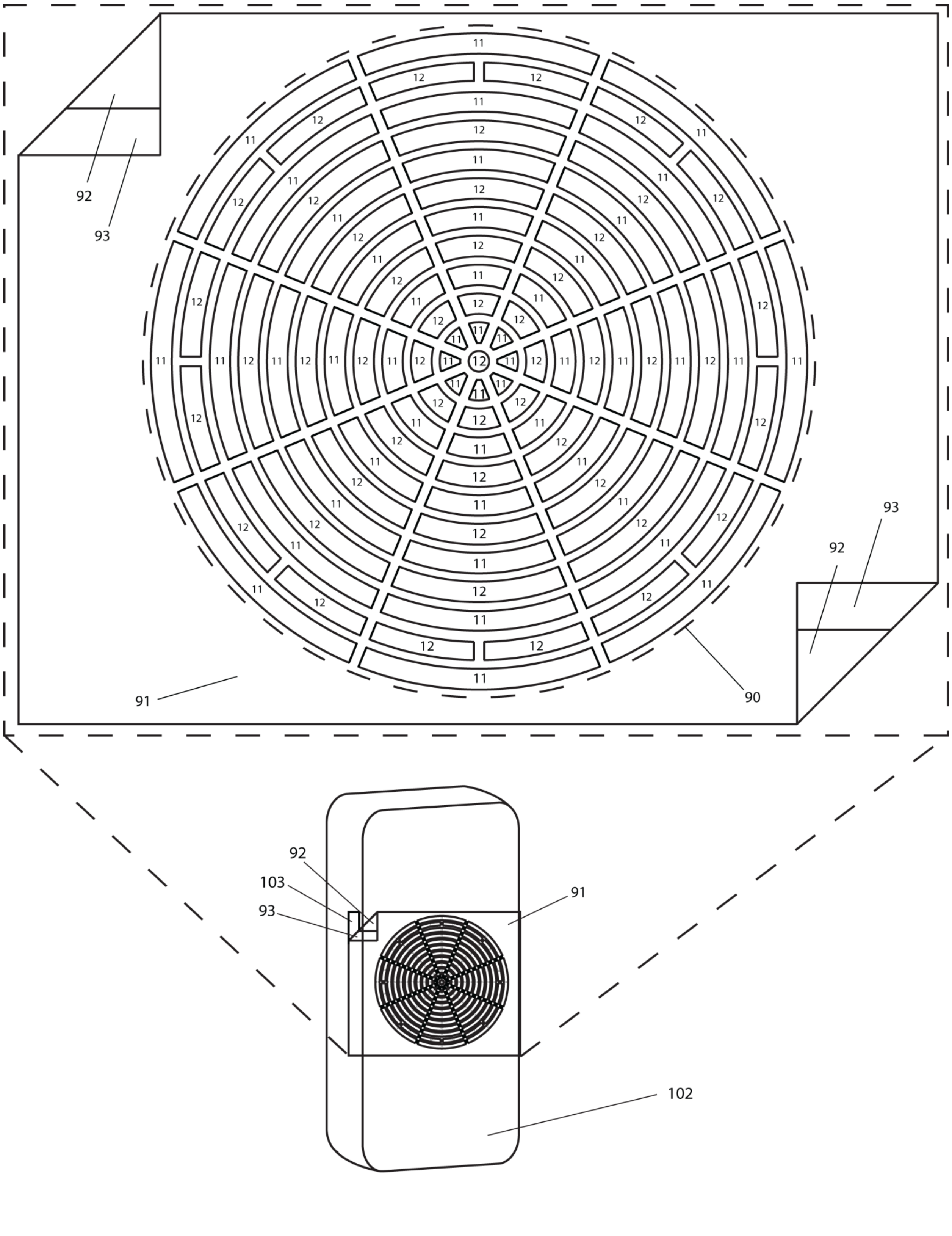
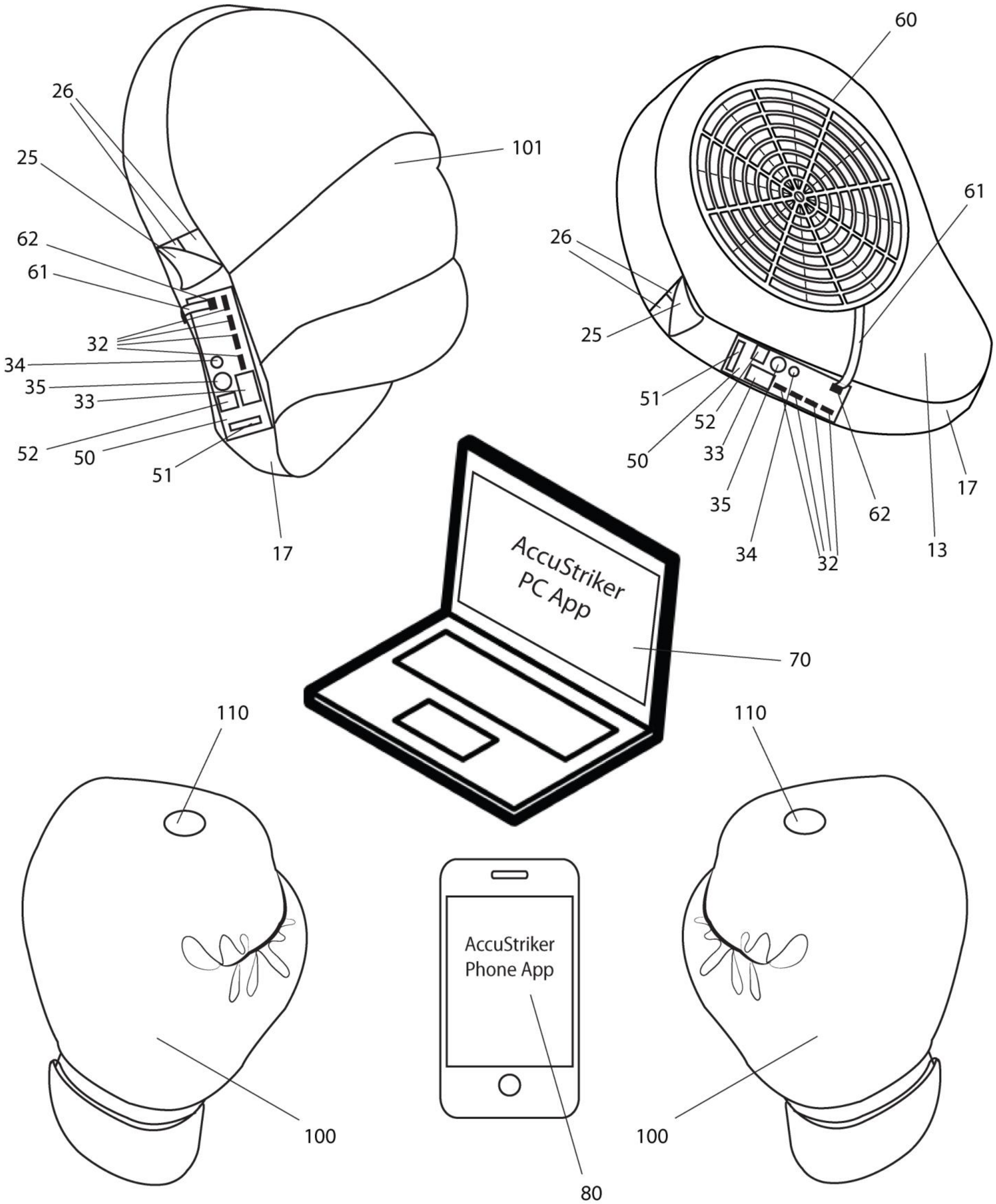



Fig. 8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13
AccuStriker
PC App
70
110
110
AccuStriker
Phone App
100
100
80

Fig. 9

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