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CA 2867205 C 2016/05/17

(11)(21) 2 867 205

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 2013/03/12
(87) Date publication PCT/PCT Publication Date: 2013/09/19
(45) Date de délivrance/Issue Date: 2016/05/17
(85) Entrée phase nationale/National Entry: 2014/09/12
(86) N° demande PCT/PCT Application No.: CA 2013/000221
(87) N° publication PCT/PCT Publication No.: 2013/134856
(30) Priorité/Priority: 2012/03/16 (US61/611,944)

(51) Cl.Int./Int.Cl. *H01R 13/52* (2006.01), *A41D 13/00* (2006.01), *H01R 11/16* (2006.01), *H01R 13/514* (2006.01), *H01R 13/703* (2006.01), *H02G 15/013* (2006.01)

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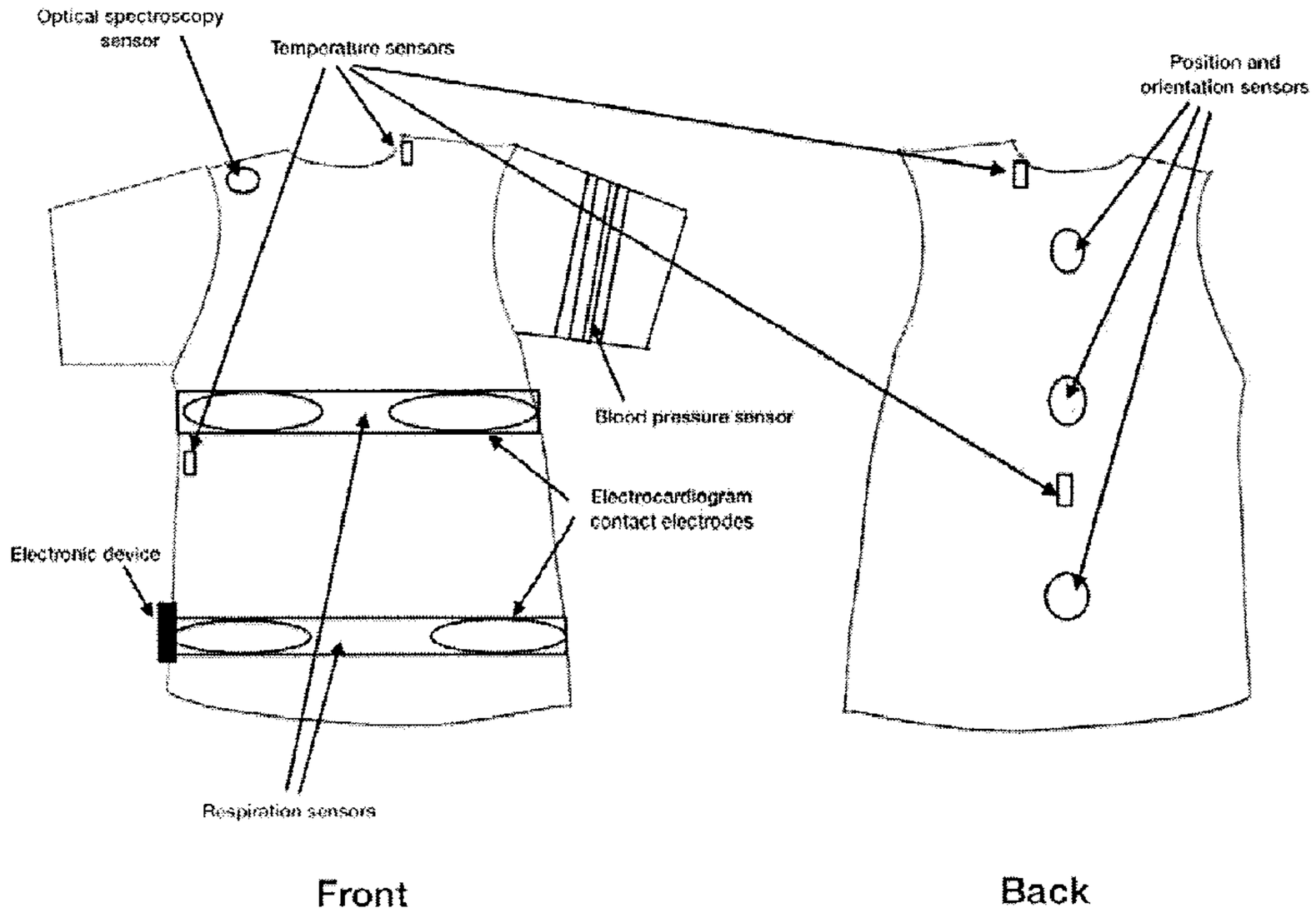
(54) Titre : VETEMENT INTELLIGENT LAVABLE ET SES COMPOSANTS
(54) Title: WASHABLE INTELLIGENT GARMENT AND COMPONENTS THEREOF



(57) Abrégé/Abstract:
The present relates to a washable interconnection patch, a connection assembly, and an intelligent washable garment equipped therewith. The patch receives and interconnects wires to a cable. The patch comprises two matching pieces interlocking together so as to define there between two opposite apertures. One of the apertures is adapted to receive and hold the wires, and the other aperture is adapted to receive and hold the cable. One of the two matching pieces defines on an interior face a channel to interconnect the wires to the cables. The connection assembly comprises a male connector and a female connector. The male connector defines a series of independent connection points along a length thereof. The female connector is adapted to receive the male connector, and defines along a length of an inner surface thereof a series of contact points. When the male connector is inserted within the female connector, the connection points and the contact points are aligned and in contact together.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 September 2013 (19.09.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/134856 A1

(51) **International Patent Classification**:
H01R 13/52 (2006.01) ***H01R 13/514*** (2006.01)
A41D 13/00 (2006.01) ***H01R 13/703*** (2006.01)
H01R 11/16 (2006.01) ***H02G 15/013*** (2006.01)

(21) **International Application Number**:
PCT/CA2013/000221

(22) **International Filing Date**:
12 March 2013 (12.03.2013)

(25) **Filing Language**: English

(26) **Publication Language**: English

(30) **Priority Data**:
61/611,944 16 March 2012 (16.03.2012) US

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(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

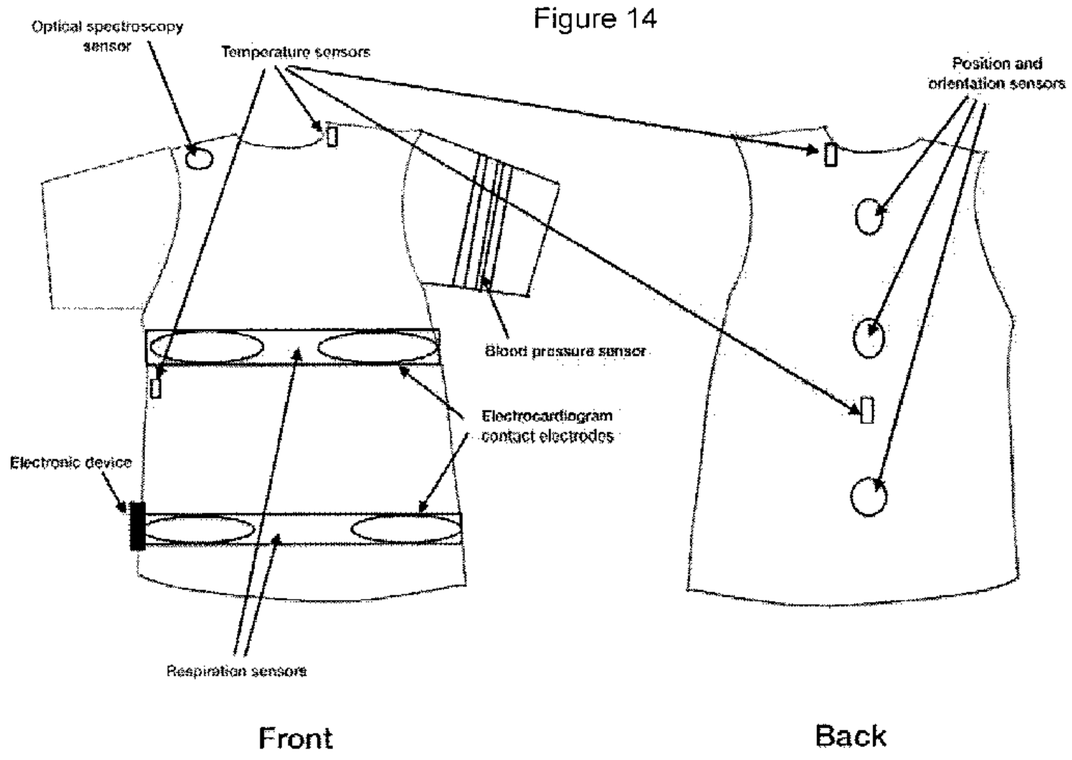
(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: WASHABLE INTELLIGENT GARMENT AND COMPONENTS THEREOF

Figure 14



(57) **Abstract**: The present relates to a washable interconnection patch, a connection assembly, and an intelligent washable garment equipped therewith. The patch receives and interconnects wires to a cable. The patch comprises two matching pieces interlocking together so as to define there between two opposite apertures. One of the apertures is adapted to receive and hold the wires, and the other aperture is adapted to receive and hold the cable. One of the two matching pieces defines on an interior face a channel to interconnect the wires to the cables. The connection assembly comprises a male connector and a female connector. The male connector defines a series of independent connection points along a length thereof. The female connector is adapted to receive the male connector, and defines along a length of an inner surface thereof a series of contact points. When the male connector is inserted within the female connector, the connection points and the contact points are aligned and in contact together.

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WASHABLE INTELLIGENT GARMENT AND COMPONENTS THEREOF

[0001] The present relates to a washable interconnection patch, a male-female connector assembly, and a washable intelligent garment equipped with such a washable interconnection patch and male-female connector assembly.

BACKGROUND

[0002] Physiological sensors have long been known and widely used for medical and health related applications. Various physiological sensors embedded in textile or garments, sometimes called portable or wearable sensors, have been described before in publications and patents (Portable Blood Pressure, Patent number: 4889132, Filing date: Sep 26, 1986 Issue date: Dec 26, 1989; Portable device for sensing cardiac function, Patent number: 4928690, Filing date: Apr 25, 1988, Issue date: May 29, 1990). The term "wearable sensors" is now commonly used to describe a variety of body-worn sensors to monitor activity, environmental data, body signals, biometrics, health related signals, and other types of data.

[0003] Electrocardiogram (ECG) electrodes made of conductive textile, conductive polymer, metal and other materials used in wearable sensors have been described in patents such as (Textile-based electrode, Patent number: 7970451, Filing date: Dec 31, 2008, Issue date: Jun 28, 2011).

[0004] Textile-based Respiratory Inductive Plethysmography sensors have been described in patents such as (Method and apparatus for monitoring respiration, Patent number: 4308872 Issue date: Jan 5, 1982).

[0005] Multi-parameter wearable connected personal monitoring systems (Zephyr Technology' BioHarness, Qinetiq's Traintrak, Weartech's GOW, Nuubo's nECG) are already available on the market.

[0006] However, the single or multi-parameter systems known in the industry use clip buttons made of conductive material for connecting the textile sensors to an electronic module. These clip buttons limit the number and types of interconnections available between the electronic module and the textile sensors.

[0007] Connectivity is a domain with many technological challenges to the manufacturer of e-textile solutions, intelligent garments, wearable sensors, and multi-parameter wearable connected personal monitoring systems. There is thus a need for improved connectivity solutions, and for garments equipped with such connectivity solutions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] In the appended drawings:

[0009] Figure 1 is a schematic representation of an interconnection patch that can be assembled in a garment, with a textile-covered cable and a washable male connector.

[0010] Figure 2a is a top view of a washable interconnection patch adapted for electrical and optical interconnections.

[0011] Figure 2b is a top view of the washable interconnection patch showing wire interconnections inside the patch before encapsulation.

[0012] Figure 3 is a cross-sectional side view of a male and female washable connector, showing spring-loaded electrical pins in contact with a printed circuit board of the male connector.

[0013] Figure 4 is a cross-sectional view of the male and female connector, showing a curve (called “ski” or “banana”) in the printed circuit board of the male

connector, allowing the spring-loaded electrical pins to be put in compression without applying a side force on the pin of the female connector while inserting.

[0014] Figure 5 is a cross-sectional view of the female connector, without the spring-loaded electrical pins.

[0015] Figure 6 is a view of the male connector assembled with a cable segment, inserted in the female connector.

[0016] Figure 7 is a side view of the male connector, further showing the spring-loaded electrical pins of the female connector in contact with the printed circuit board conductive pads of the male connector.

[0018] Figure 8a is a bottom view of the PCB of the male connector showing circular electrical contacts.

[0019] Figure 8b is a top view of the PCB of the male connector showing rectangular contacts for soldering and printed wires.

[0020] Figure 9 is a cross-sectional view of the female connector made with standard spring-loaded contacts embedded in a plastic component and aligned with an aperture shaped like a cylinder to host the male connector.

[0021] Figure 10 is a bottom view of the plastic component of the female connector showing the shape and apertures ready to host a row of spring-loaded contacts.

[0022] Figure 11 is a view of the male connector and a cable segment

inserted in the side of the female connector of a small electronic device.

[0023] Figure 12 is Hexoskin garment with a male connector. The garment illustrated has conductive textile electrodes and textile-based respiratory inductive plethysmography sensors connected to the interconnection patch with flexible and elastic wires.

[0024] Figure 13 shows garments that use the present patch and connection system to connect textiles sensors for heart and breathing monitoring to an electronic device with an accelerometer and a Bluetooth wireless connection. The electronic device also contains analog and digital filters and amplifiers, a microprocessor device, solid-state memory storage, sensor circuits, power management circuits, buttons, and other circuits.

[0025] Figure 14 shows a garment with electrical and optical sensors that use the present system to connect textiles, electrical, thermal, and optical sensors for cardiac monitoring, breathing monitoring, blood pressure monitoring, skin temperature and core temperature monitoring to an electronic device with position sensors and a wireless data connection.

[0026] Figure 15 shows a device that includes a female connector, connected to a cable with a right-angle male connector. The device has a button that can be used to record an event, initiate wireless pairing using a protocol like Bluetooth, or reset the device. In this example, the device has 3 light emitting diodes used to communicate with users.

[0027] Figure 16 shows a diagram of sensor front-end electronic module that can have the electronic device to process the analog physiological data, digitize the analog value using an analog to digital converter, and processing the physiological data using a CPU.

[0028] Figure 17 shows a diagram of how the device can be used to record the physiological signals from the body sensors and transmit it first to any connected computing device that can be used to interpret the signals or an Internet gateway, and then to a distant computing and storage system.

[0029] Figure 18 shows a diagram of functional components used in the electronic device.

[0030] Figure 19 shows a diagram of a physiological data processing flow, in this case the data coming from the electrocardiogram sensor.

DETAILED DESCRIPTION

[0031] The foregoing and other features of the present garment and components thereof will become more apparent upon reading of the following non-restrictive description of examples of implementation thereof, given by way of illustration only with reference to the accompanying drawings.

[0032] Connectivity is a domain with many technological challenges for designers and manufacturers of e-textile solutions, intelligent garments, wearable sensors, and multi-parameter wearable connected personal monitoring systems.

[0033] In an aspect, the present specification describes a washable electronic male-female connector. The male connector is designed to be attached to a washable and/or wearable sensor system (as exemplary shown in Figure 1) and comprises a cable, which may be covered with textile, and an interconnection patch where many electric and/or optical wires can be connected to the cable as exemplary shown in Figure 2a and 2b. The male connector may further comprise strain relief components.

[0034] The male connector and its components can be made of various

materials. In one example, the patch and strain relief components may be made of any of the following material: silicone, rubber, or another flexible material over-molded over the cable. The cable may be made of many color-coded electrical wires, bundled together using a textile fabric knitted around the wires. The male connector and strain relief components may be made using over-molded resin. In one example electrical interconnections between wires coming from the garment and the wires in the cable are made using a small open crimp or a crimp tube (as exemplary shown in Figure 2b, and the interconnection is sealed using silicone, rubber, or any other sealing material compatible with the over-molded patch.

[0035] The interconnection patch can be made using a manufacturing process that does not require heating, for example crimps and/or glue and/or silicone with low curing temperature, which has among its advantages the benefit of reducing the risk to deteriorate or destroy heat sensitive textiles that can be used in a garment.

In a particular embodiment, the male connector is designed with a small curve at one of its longitudinal extremity to be adapted to deflect spring-loaded contacts of the female connector during insertion in the female connector, until full insertion of the male connector as seen on Figure 4. In one example, the male connector is made of a printed circuit board having a resilient 'ski tip' shaped end, electronic contacts with the female connector being made when engaged with conductors printed at the bottom of the ski-shaped circuit board (Figure 8a). The wires are soldered on the top of the circuit board (Figure 8b) before it is over-molded to become the male connector and the strain relief for the wires and cable connected to the washable interconnection patch. The strain relief (Figure 11) can also be made at a right angle (Figure 15) to make the cable follow the side of the device and reduce the space needed for the cable and device in a pocket on the garment. For example, the circuit board and cable may be overmolded in one piece to create the male connector. The strain relief is then the part of the connector attaching the cable to the plastic shell of the male connector to avoid putting tension on the soldered connection between the wires and the circuit board.

[0037] In a further embodiment, the electrical contacts on the male connector are plated with gold or another conductive material not affected by oxydation or degradation caused by air, light, water, soap, enzymes or other chemical or biological products.

[0038] The female connector may comprise spring-loaded contacts that are lined up along an aperture shaped like a cylinder (see Figures 4 and 9). The aperture is asymmetric to facilitate the alignment of the contacts with the contacts of the male connector (see Figure 3). The female connector can be made as one piece including the spring-loaded contacts, or two pieces including for example one row of spring-loaded connectors and an injection molded plastic piece defining an asymmetric aperture (see Figure 10).

[0039] Electric and/or optic connection between the male and female connectors is completed upon complete engagement of the male connector within the female connector, which permits the contacts of the male connector to be aligned with the spring-loaded contacts of the female connector (see Figure 7).

[0040] The device starts recording the physiological signals automatically from the sensors upon complete connection of the male connector within the female connector, and stops recording when the male connector is removed from the female connector. This feature simplifies the use of the recording device and reduces power consumption from the battery when the device is not connected.

[0041] An example of use of the present male-female connector and the present interconnection patch are wearable physiological monitoring garments as shown in Figures 12 and 13.

[0042] Reference is now made to Figure 14, which depicts another exemplary use of the present system, where an upper-body garment is equipped with physiological sensors to measure body activity and state with a recording,

processing and transmitting wearable device that connects to physiological sensors. The garment is embedded with electrodes for electrocardiogram (ECG) or electromyogram (EMG) recordings, thermal sensors for skin temperature monitoring, multidimensional acceleration and position sensors for position and movement monitoring, microphone for heart and lung auscultation, inductance plethysmography sensors to measure changes in volume of the upper body, optical sensors for body spectrophotometry, and a blood pressure sensor on the left arm of the garment. This wearable physiological sensor system provides enhanced users' mobility compared to previous systems, allows simultaneous recording of all the aforementioned signals, allows simultaneous encoding and wireless transmission of all the aforementioned signals, allows automatic processing, analysis, and modeling of all the aforementioned signals, is less vulnerable to position and motion artifacts hence capable of producing high quality signals during sleep, running, exercising and other normal activities. The sensor system, including the present male-female connector, and the interconnection patch, is thus washable in a regular domestic washing machine. Any electronic device may be connected to the garment using the present male-female connector. The electronic device may thus be located in a pocket designed for carrying. The electronic device can communicate with mobile phones and computer devices using a wireless or wired communication protocol. When used with low height profile embedded sensors, the present system makes it possible to wear the garment during sleep, physical activity, and in other contexts.

[0043] In one example, the electronic device is further equipped with a button that can be used to record an event, initiate wireless pairing using a protocol like Bluetooth, or reset the device. In this example shown in Figure 15, the device has 3 light emitting diodes used to communicate with users, for example to confirm to a wearer of the garment that the garment is connected, the electronic device is connected using a wireless link, a state of a battery of the electronic device, any malfunction or any other information the electronic device must communicate to the user. The electronic device may contain several analog and digital circuits to record and process the physiological signals as shown on Figure 16. The electronic device

can further implement all the normal functions of a computing device as shown on Figure 18. The device can be connected to other computing and networking devices using a wired or wireless protocol as shown on Figure 17, and can use another computing or networking device to communicate with a remote server, a distance storage system, or a distance computing system, which can provide automatic physiological data analysis services and help with the interpretation of physiological signals. For example, such an automatic physiological data analysis can be constructed using a stack of simple processing units to achieve a high-level understanding of the original physiological signal, such as detailed cardiac activity shown on Figure 19, symptoms, and pathologies.

[0044] The present interconnection patch, male-female connector and washable intelligent garment have been described in the foregoing description by way of illustrative embodiments thereof. The scope of the claims should not be limited by the embodiments set forth in the examples, but should be given the broadest interpretation consistent with the description as a whole.

What is claimed is:

1. A washable interconnection patch for receiving and interconnecting wires to a cable, the patch comprising:

two matching pieces interlocking together so as to define therebetween two opposite apertures, one of the apertures being adapted to receive and hold the wires and the other aperture being adapted to receive and hold the cable, one of the two matching pieces defining on an interior face a channel to interconnect the wires to the cables.

2. The patch of claim 1, wherein one of the two matching pieces further comprises a fastening member for fastening the interlocked matching pieces to a fabric.

3. The patch of claim 1, wherein the two matching pieces are further adapted to be filled with a sealant.

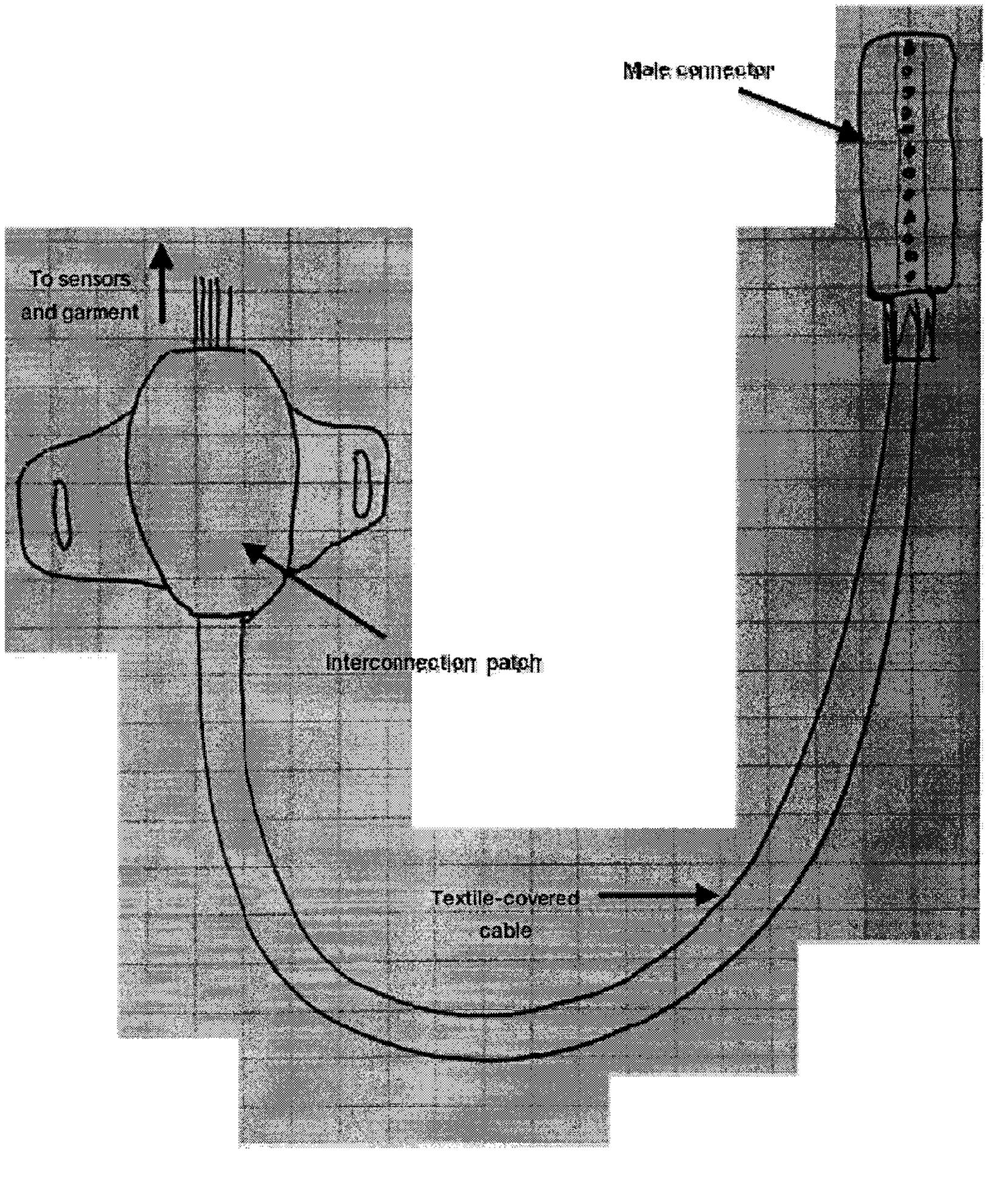

To sensors
and garment
Male connector
Interconnection patch
Textile-covered
cable

Figure 1

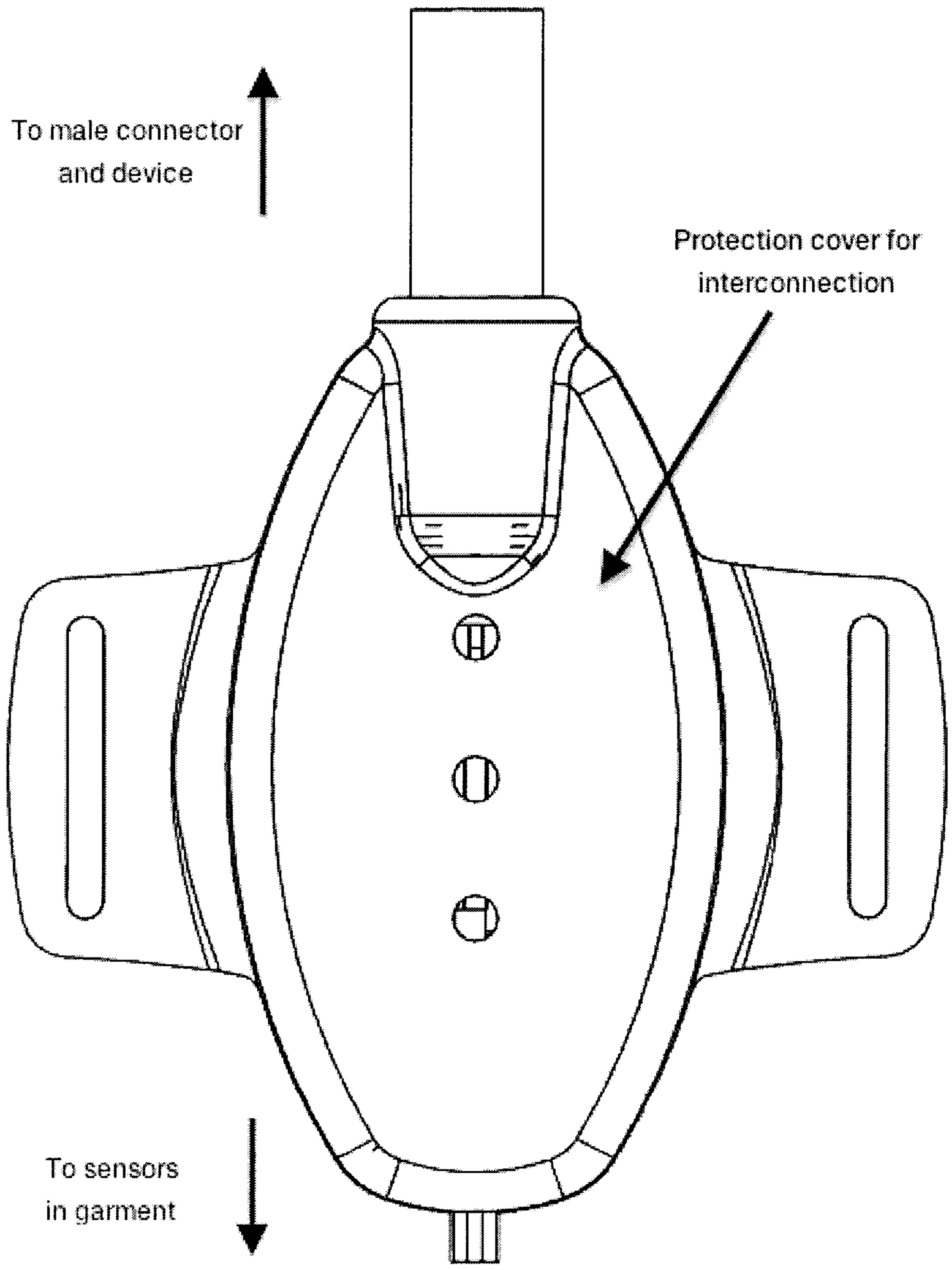

To male connector
and device
Protection cover for
interconnection
To sensors
in garment

Figure 2a

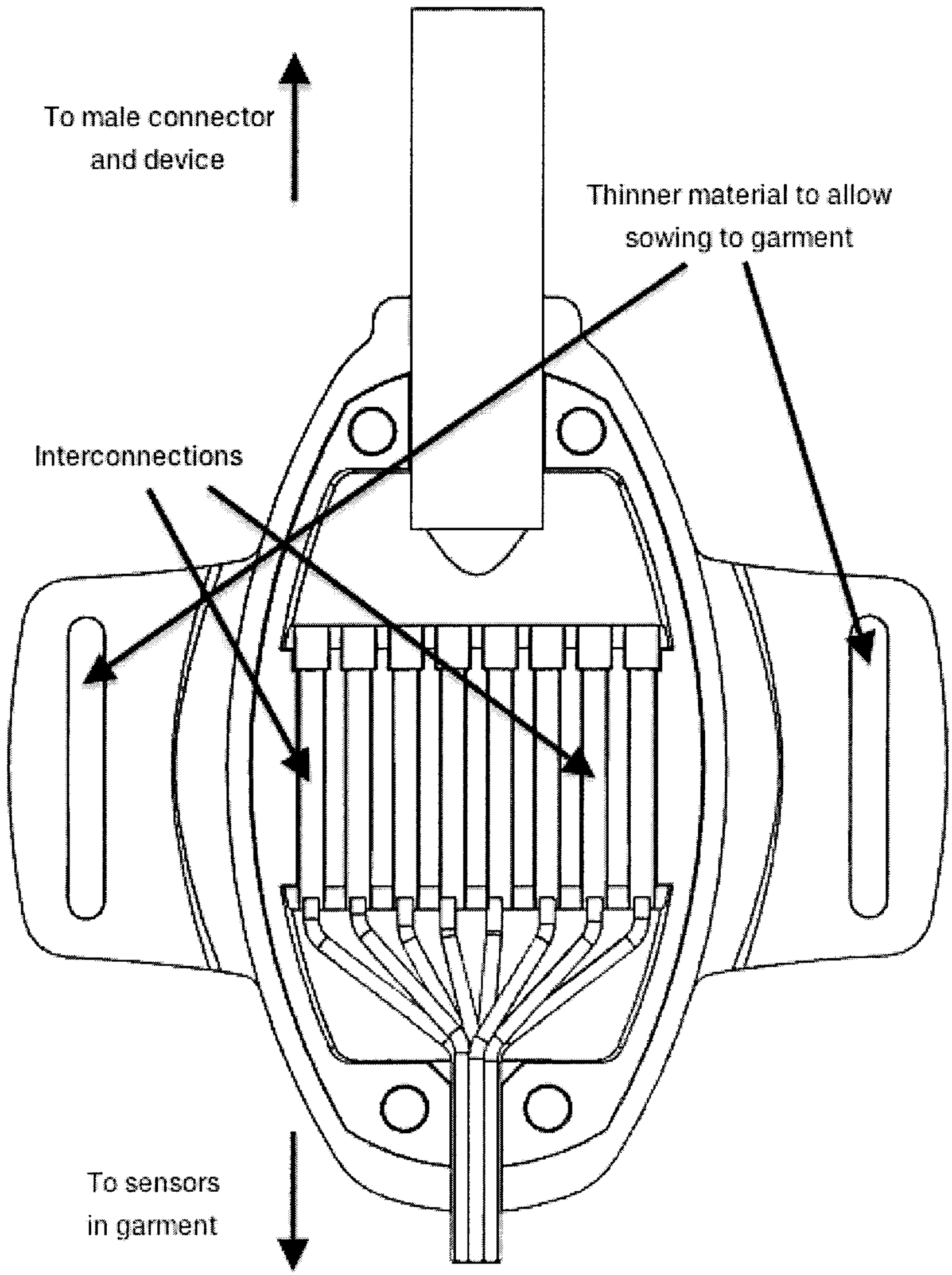

To male connector
and device
Thinner material to allow
sowing to garment
Interconnections
To sensors
in garment

Figure 2b

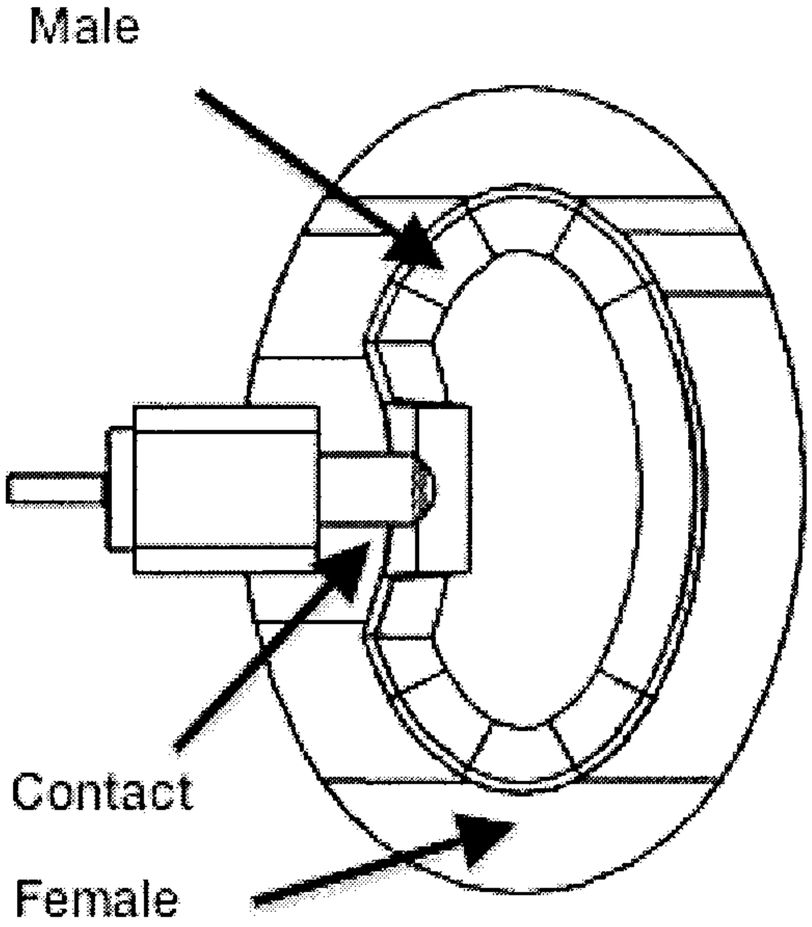


Figure 3

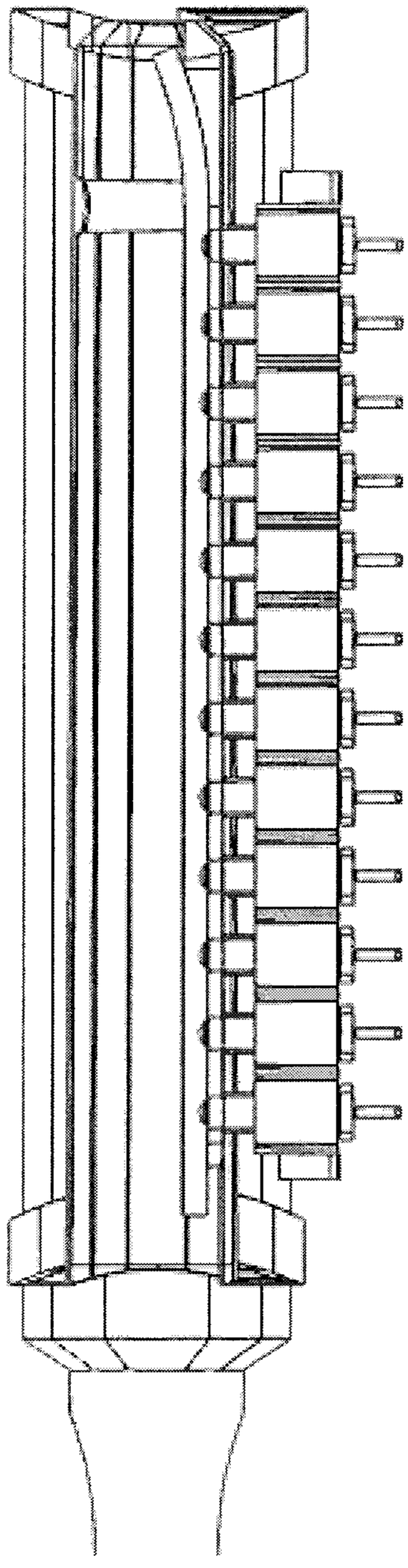


Figure 4

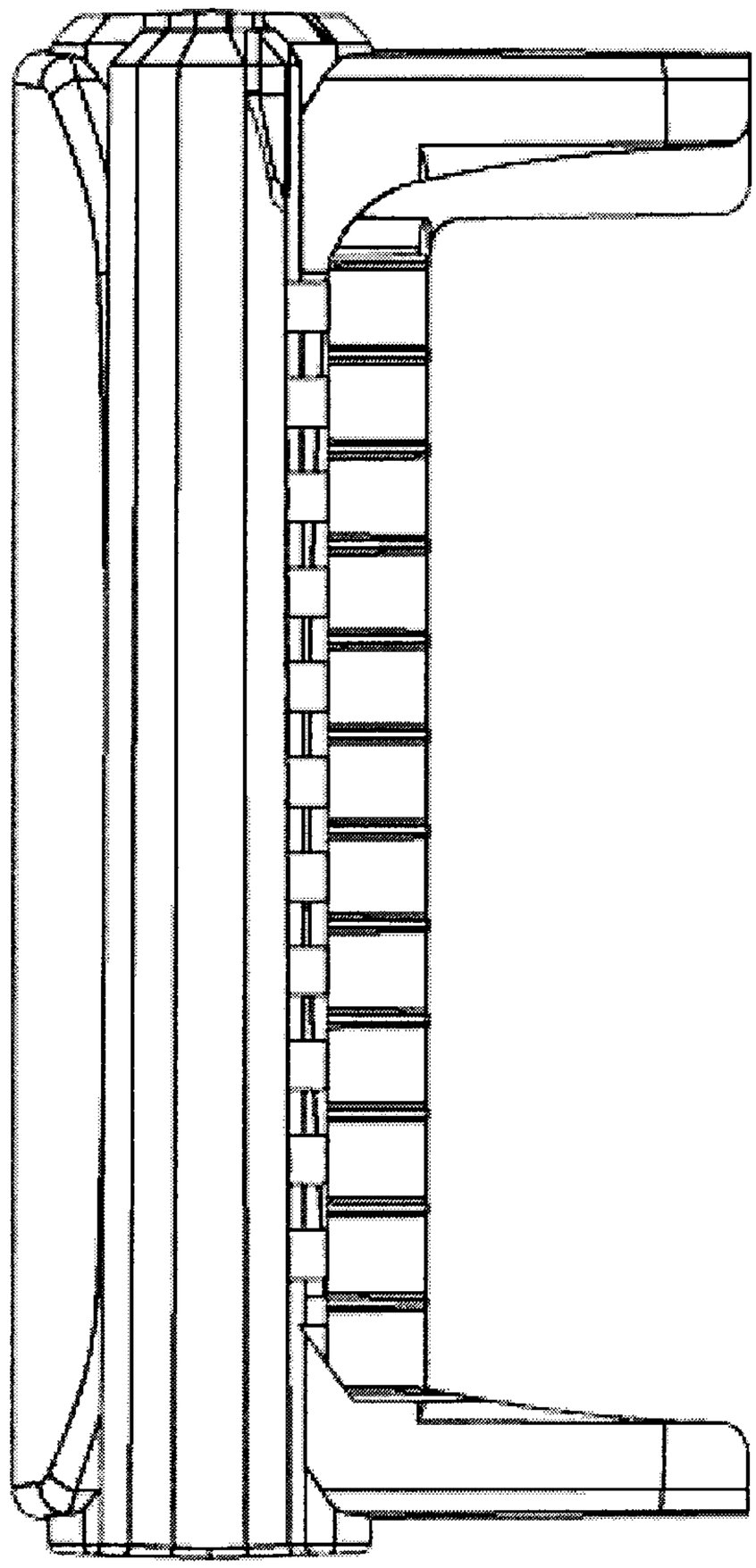


Figure 5

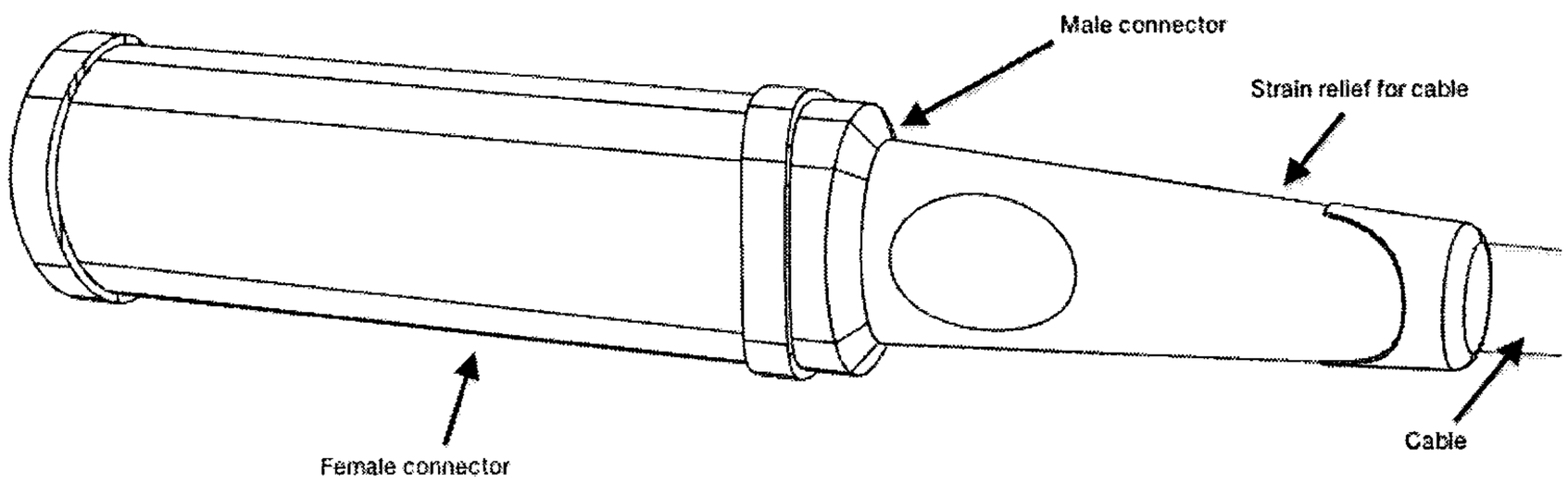

Male connector
Strain relief for cable
Female connector
Cable

Figure 6

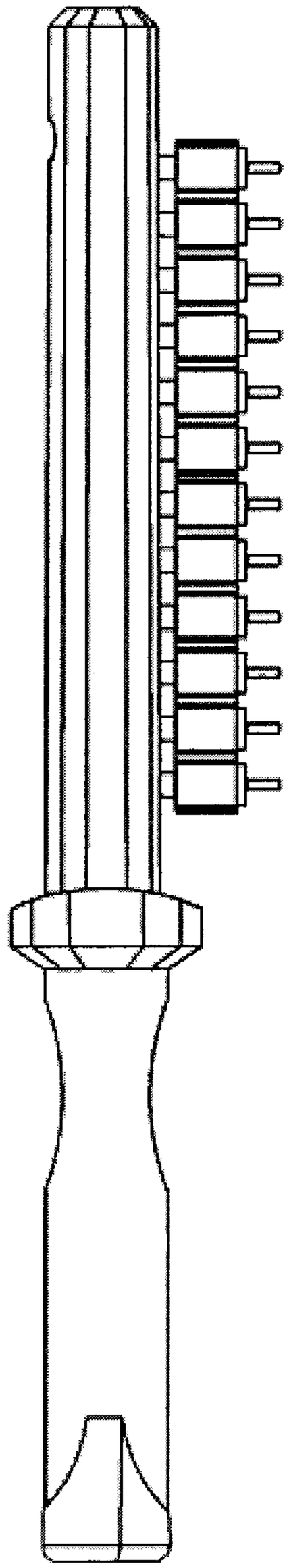


Figure 7

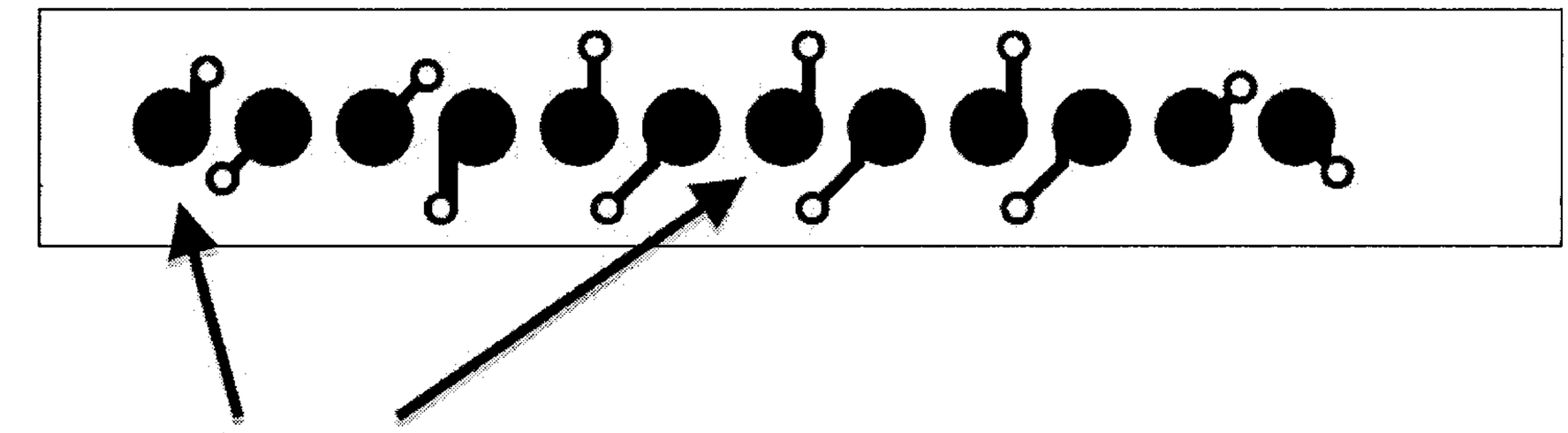


Figure 8 A

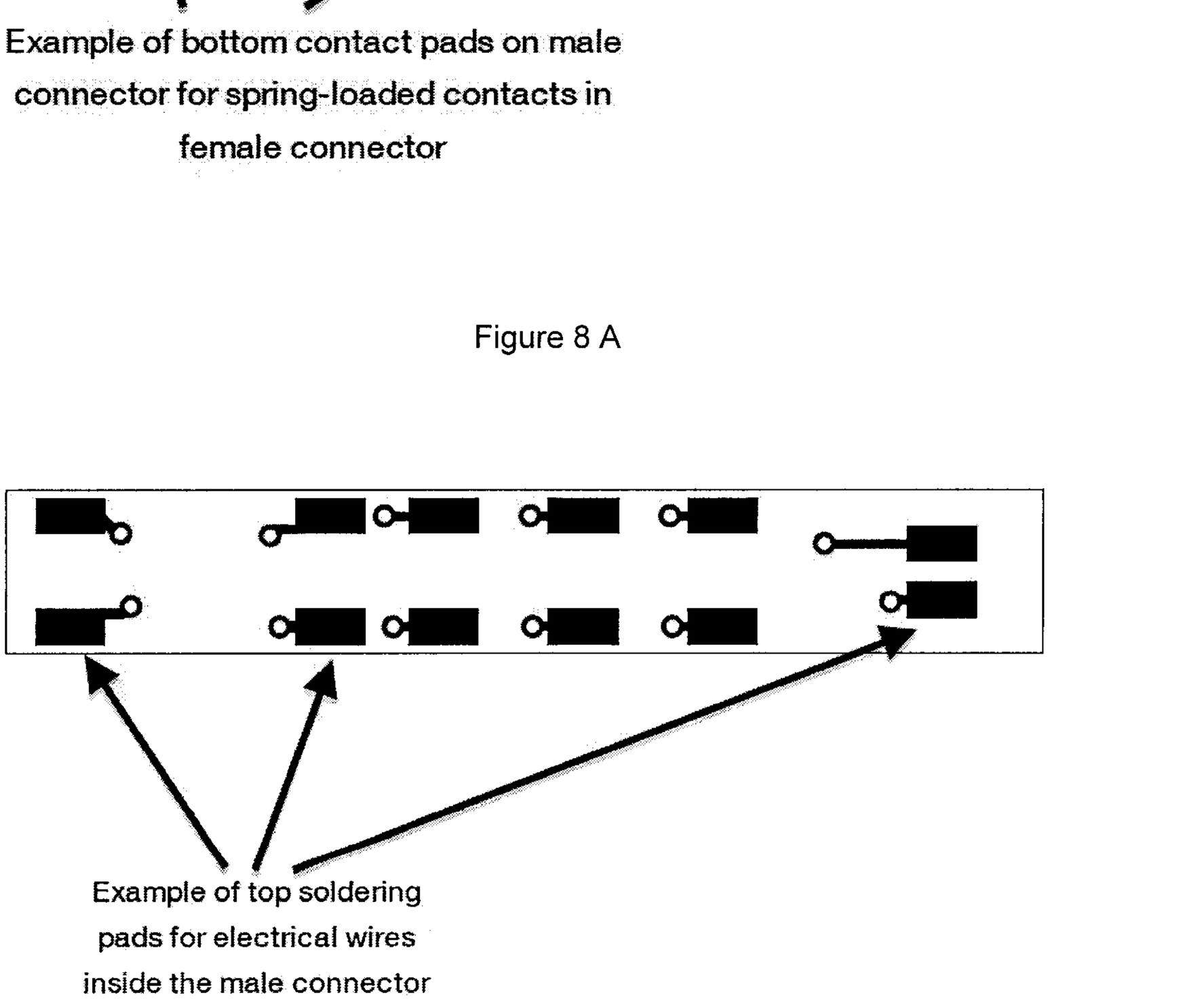


Figure 8 B

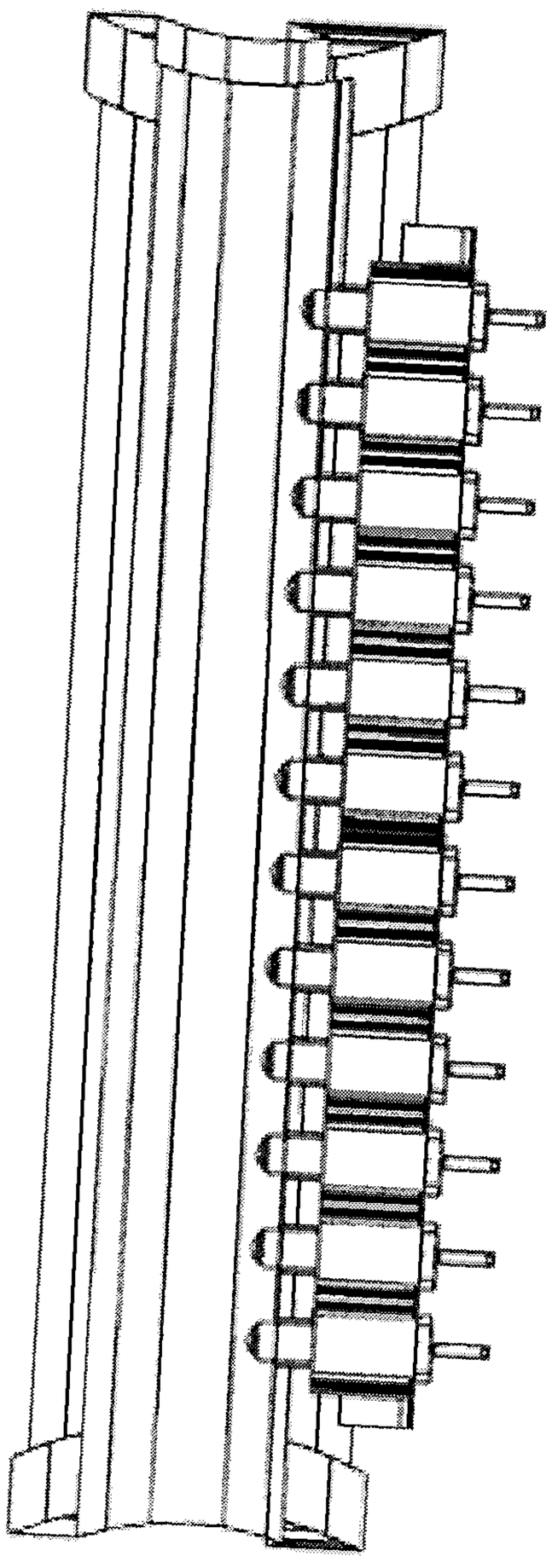


Figure 9

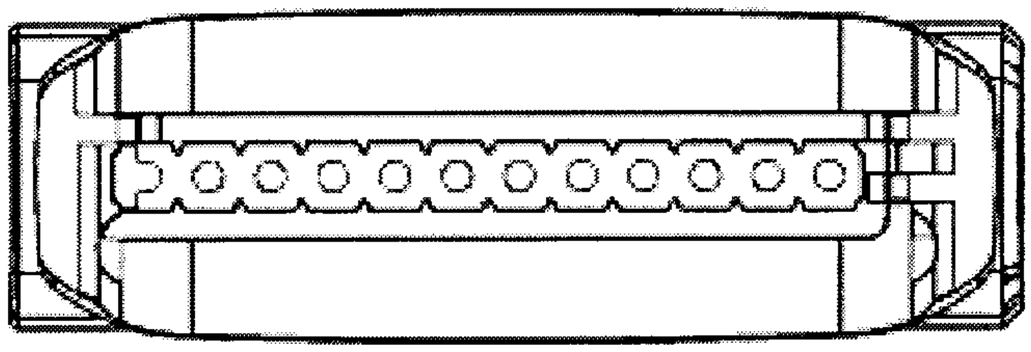


Figure 10

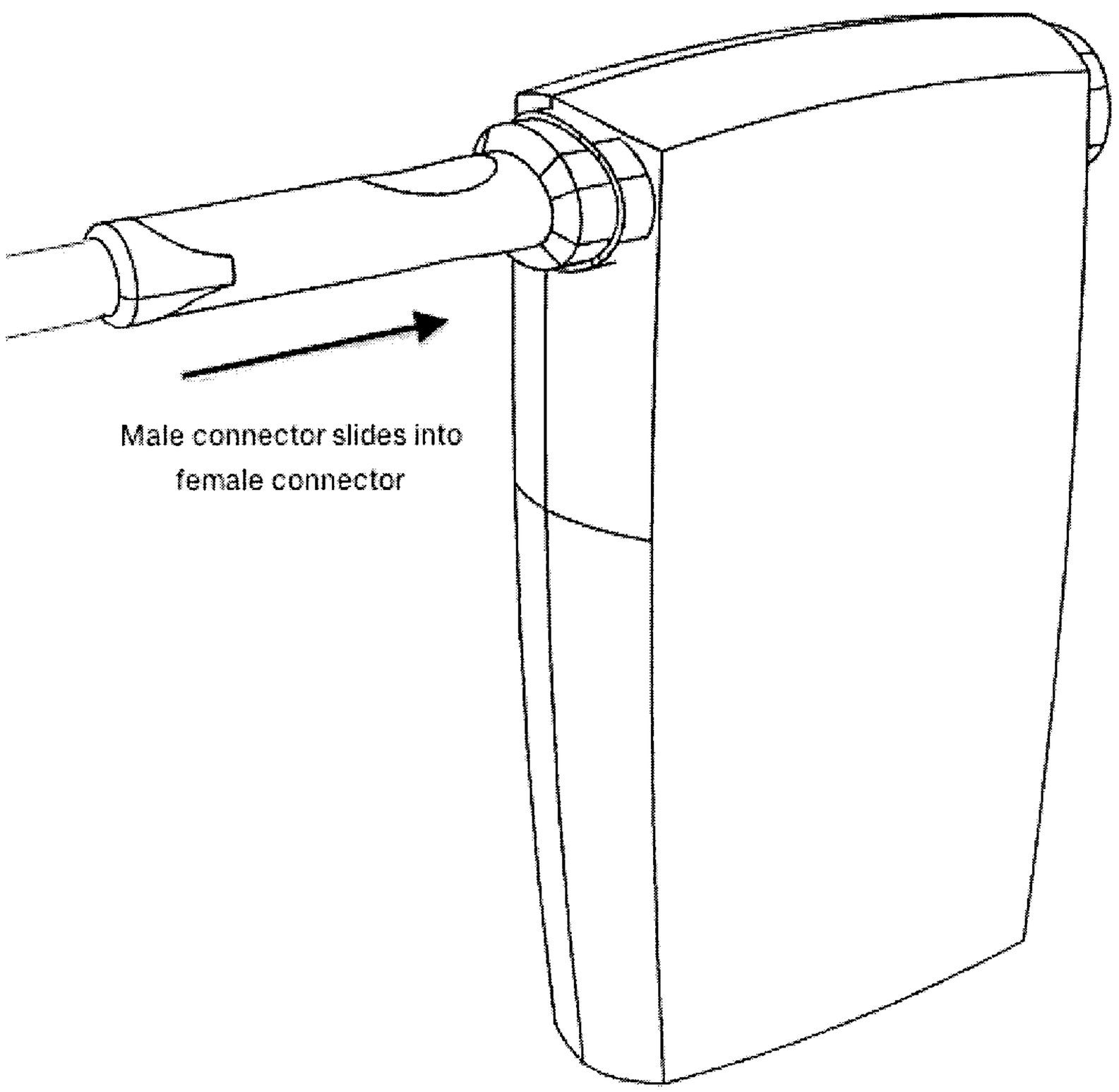


Figure 11

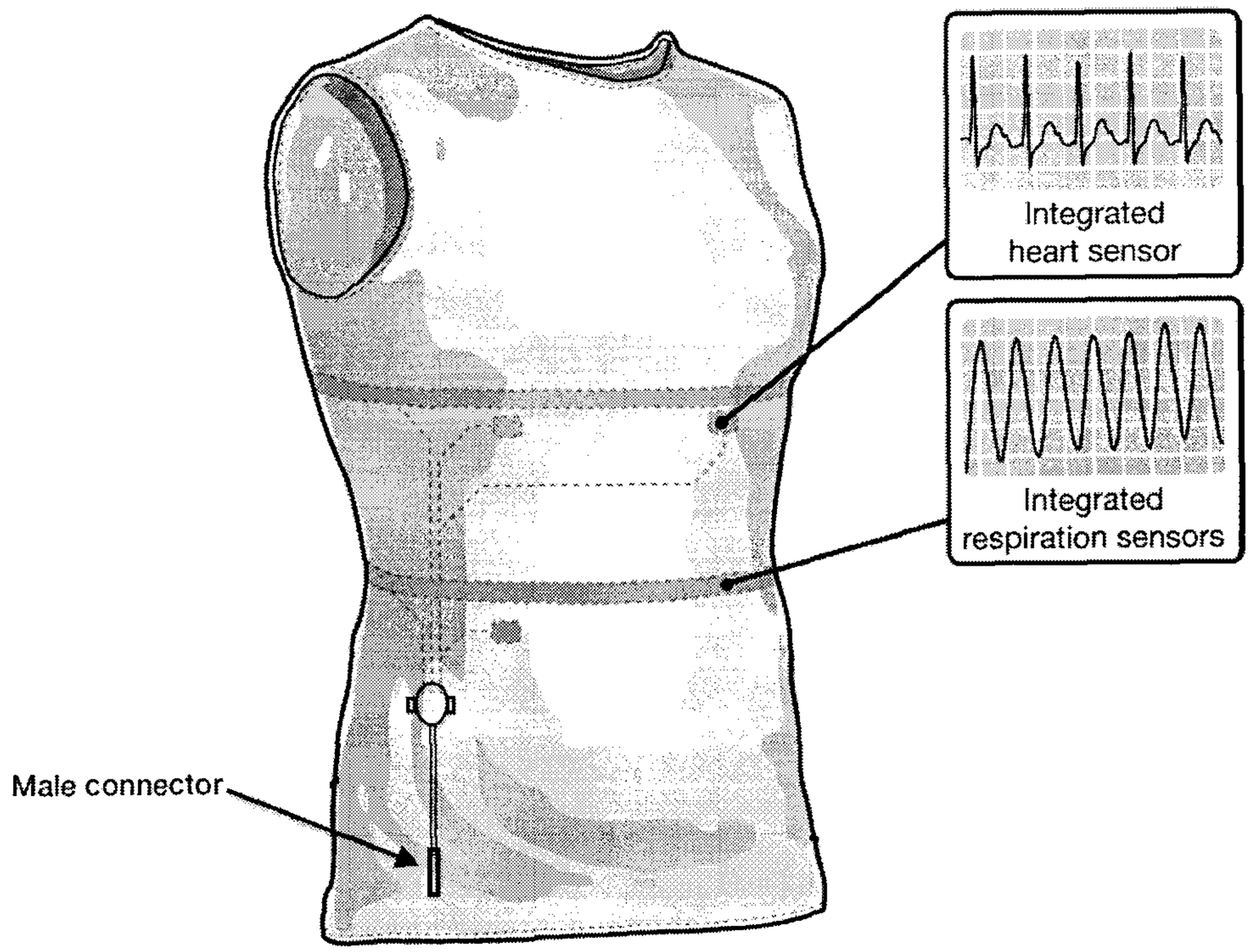


Figure 12

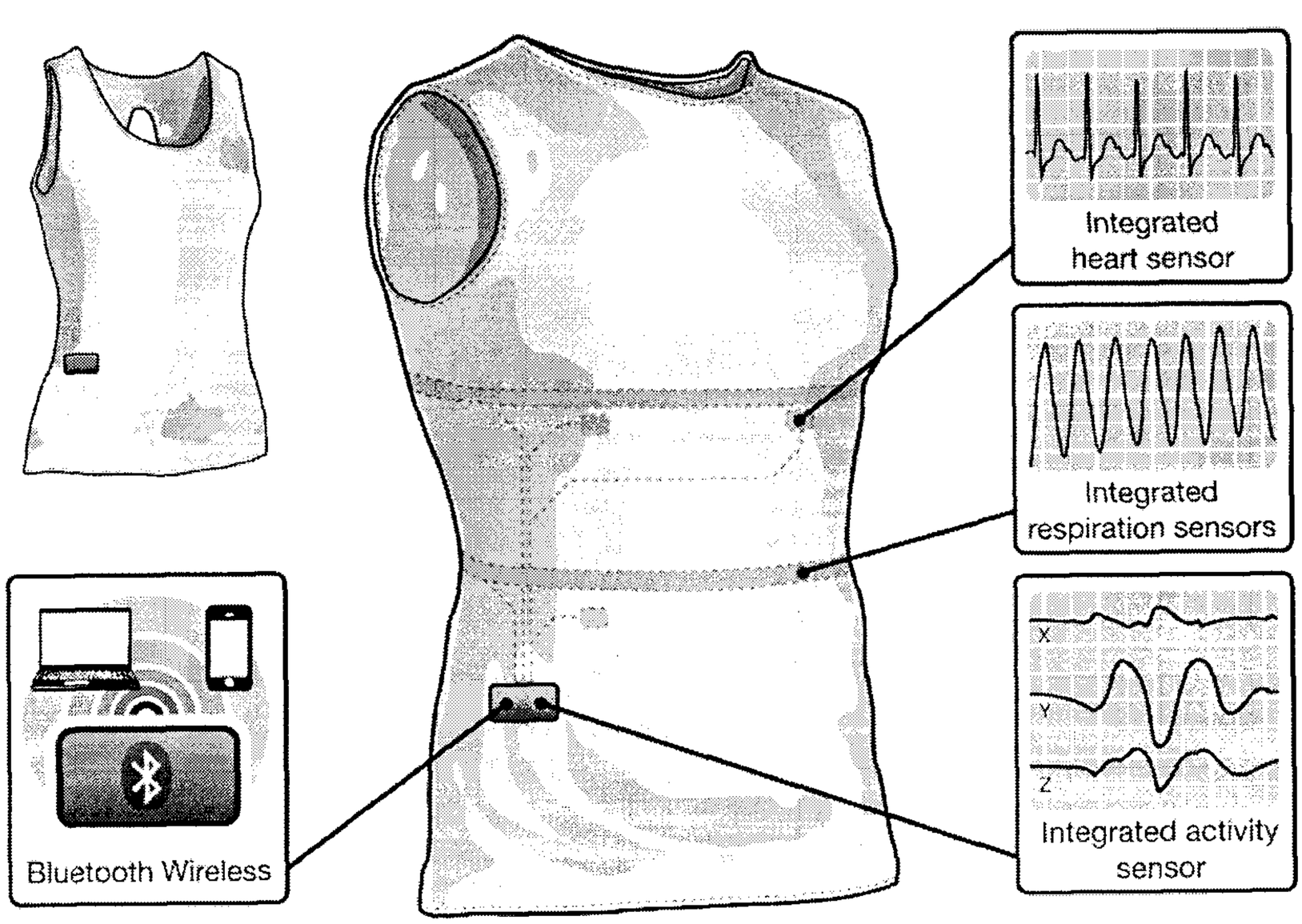


Figure 13

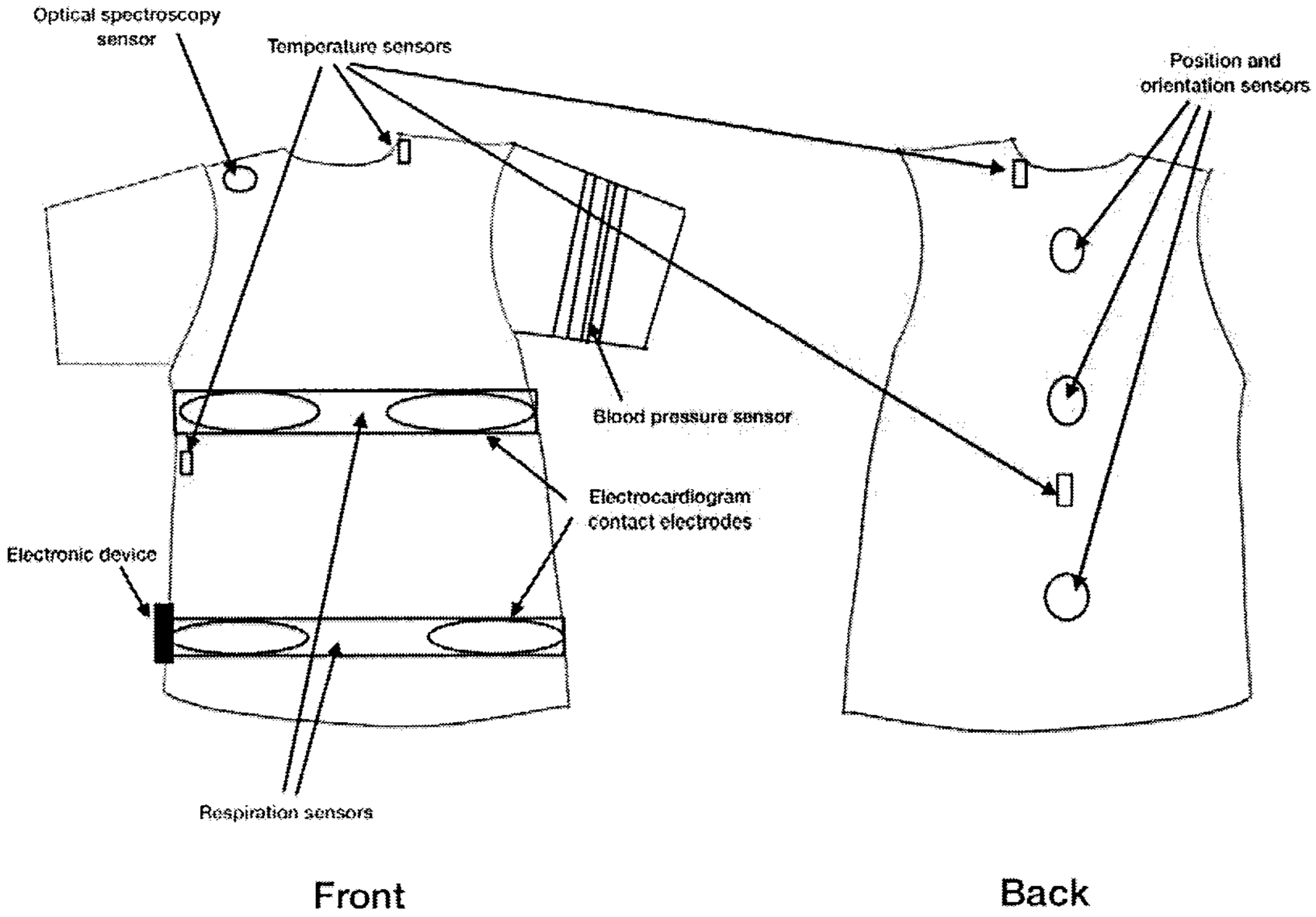

Optical spectroscopy sensor
Temperature sensors
Position and orientation sensors
Blood pressure sensor
Electrocardiogram contact electrodes
Electronic device
Respiration sensors
Front
Back

Figure 14

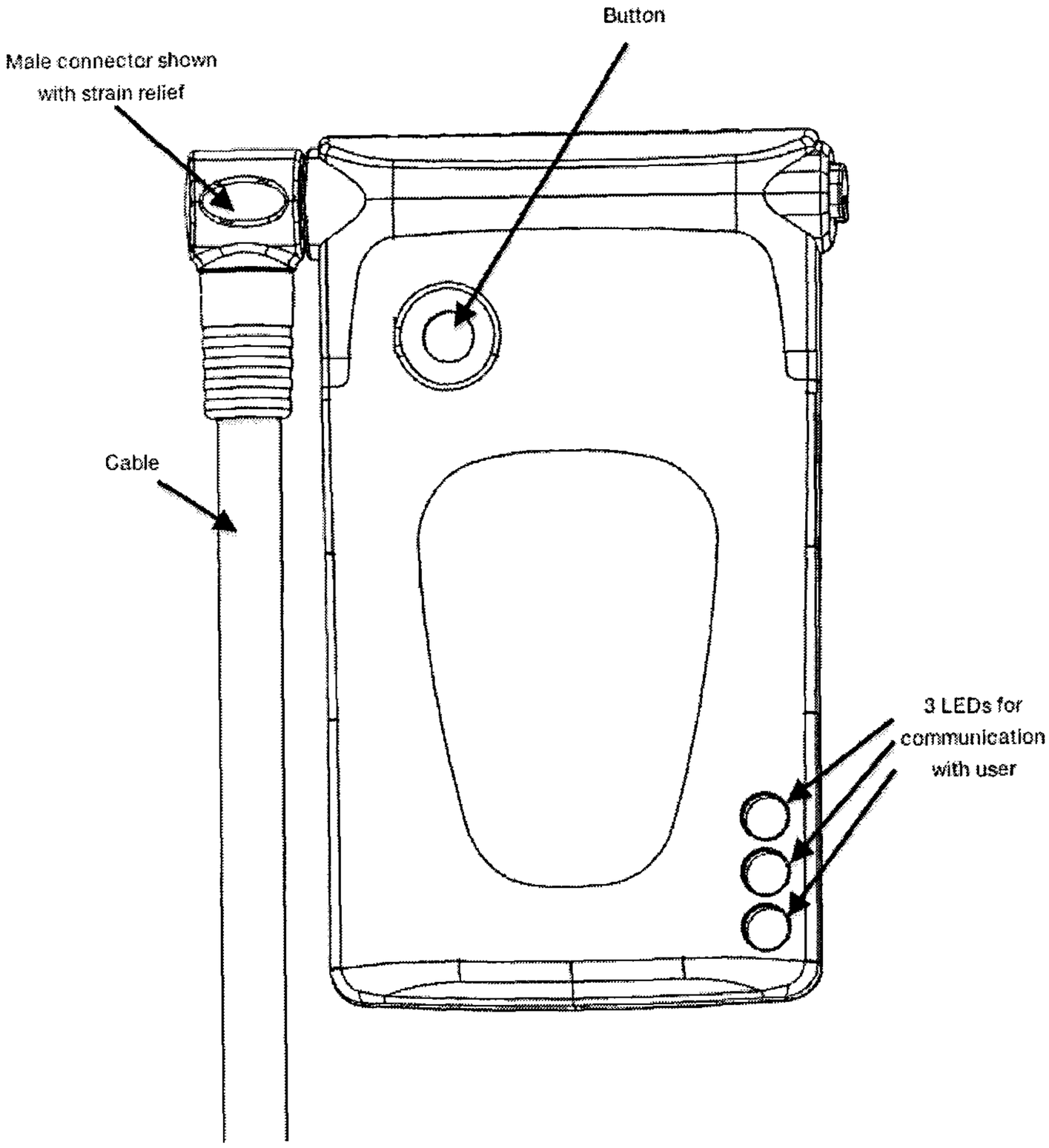

Male connector shown
with strain relief
Button
Cable
3 LEDs for
communication
with user

Figure 15

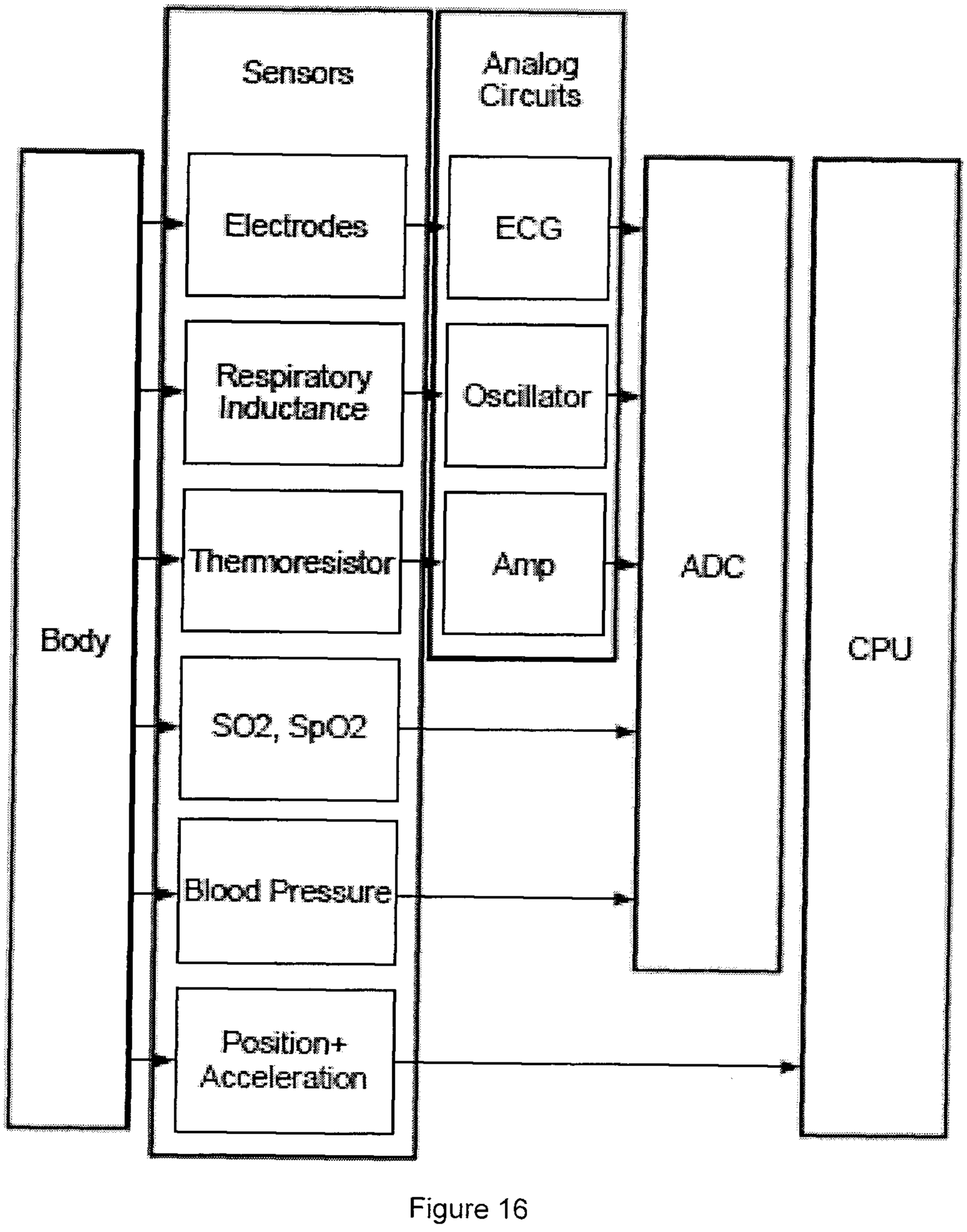

Sensor Stack
Sensors
Analog Circuits
Body
Electrodes
ECG
Respiratory Inductance
Oscillator
Thermoresistor
Amp
ADC
CPU
SO2, SpO2
Blood Pressure
Position+ Acceleration

Figure 16

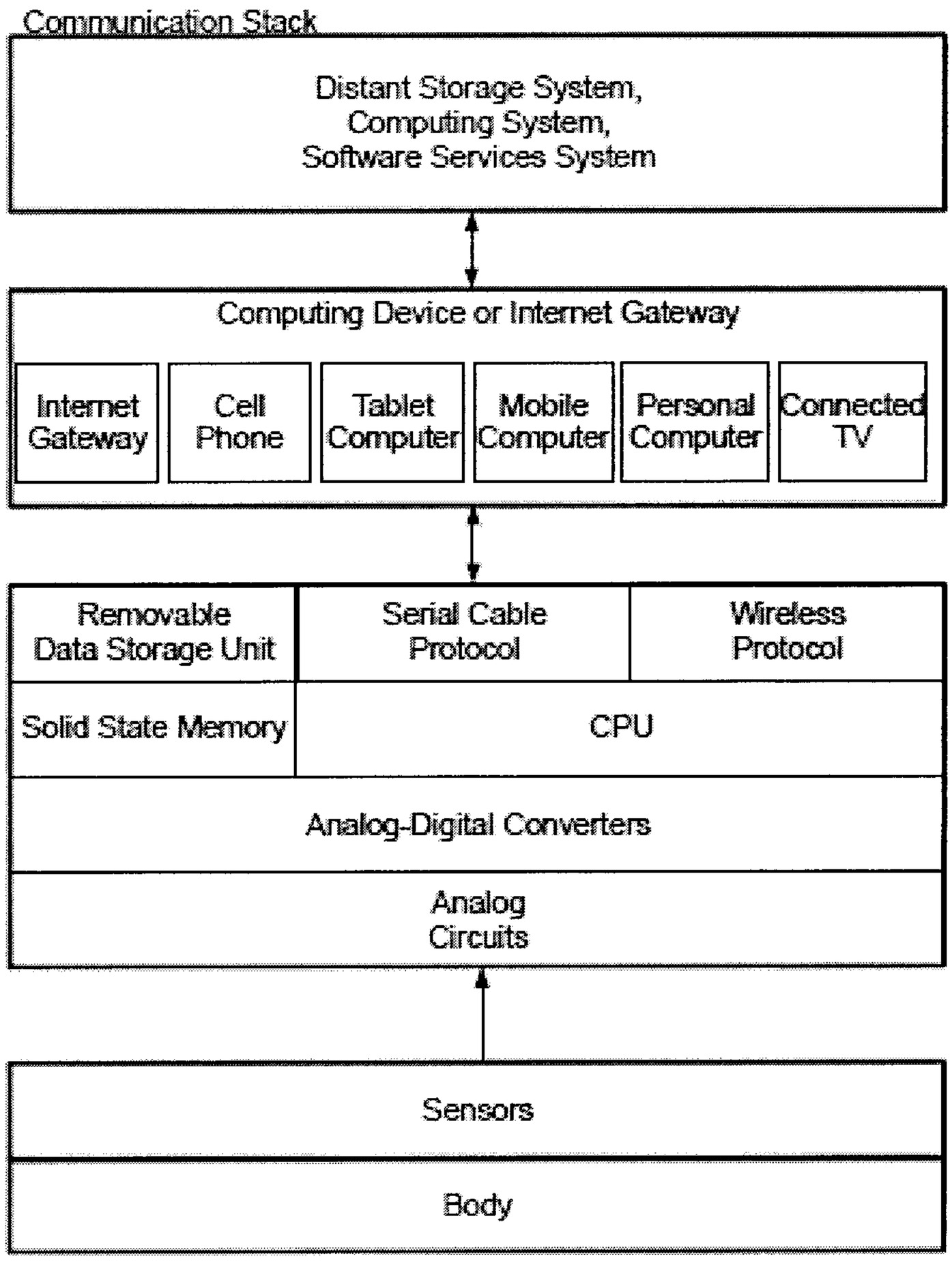

Communication Stack
Distant Storage System,
Computing System,
Software Services System
Computing Device or Internet Gateway
Internet Gateway
Cell Phone
Tablet Computer
Mobile Computer
Personal Computer
Connected TV
Removable Data Storage Unit
Serial Cable Protocol
Wireless Protocol
Solid State Memory
CPU
Analog-Digital Converters
Analog Circuits
Sensors
Body

Figure 17

Removable Data Storage Unit	Wireless Components, Antenna	Power Management
Solid State Memory	Serial Protocol Components, Connector	Rechargeable Battery
CPU / Analog-Digital Converters		
Electrocardiogram	Respiratory Inductance Plethysmograph	Thermistors Amplification	Position/ Acceleration Sensors
Connector to garment sensors		

Figure 18

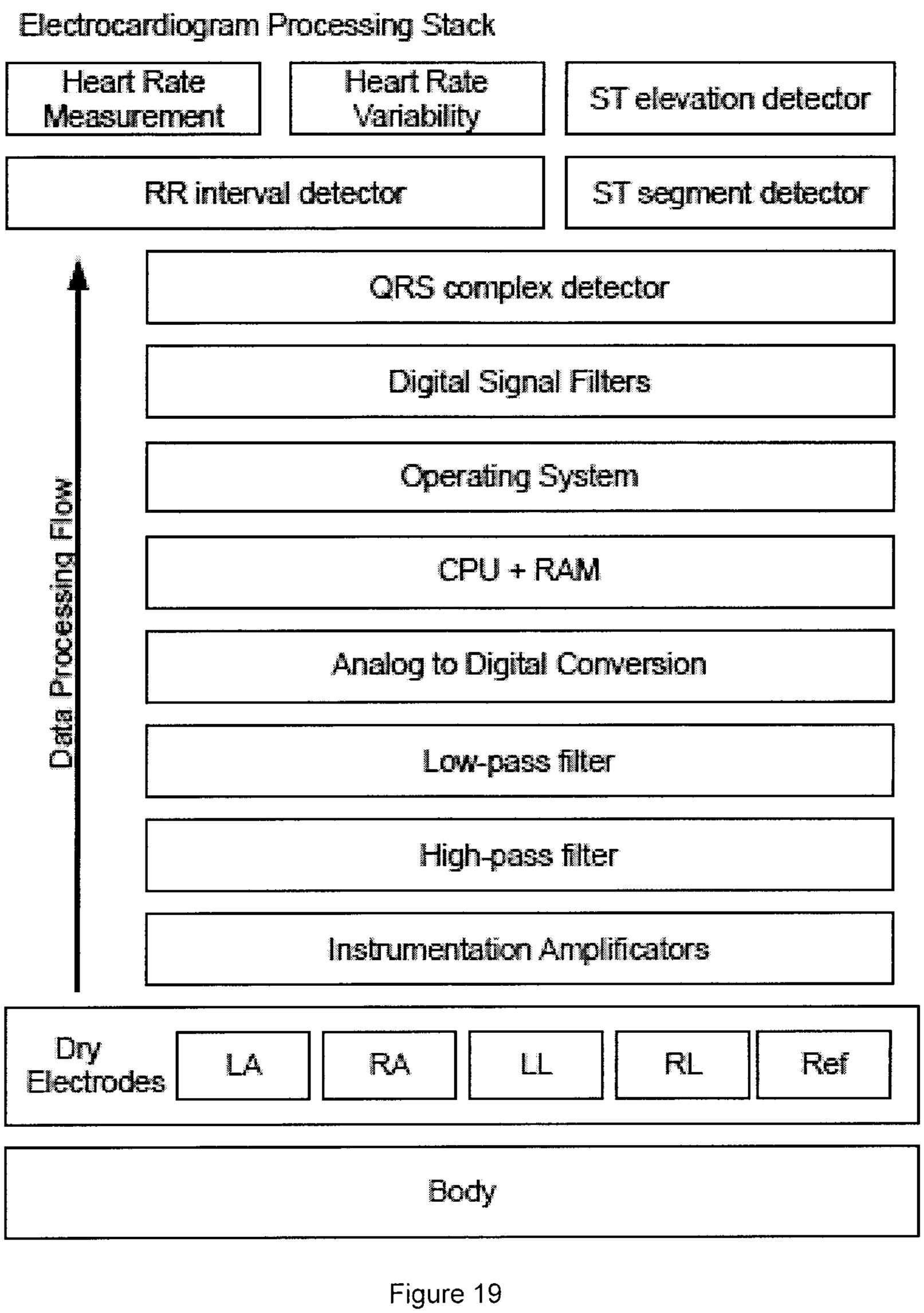
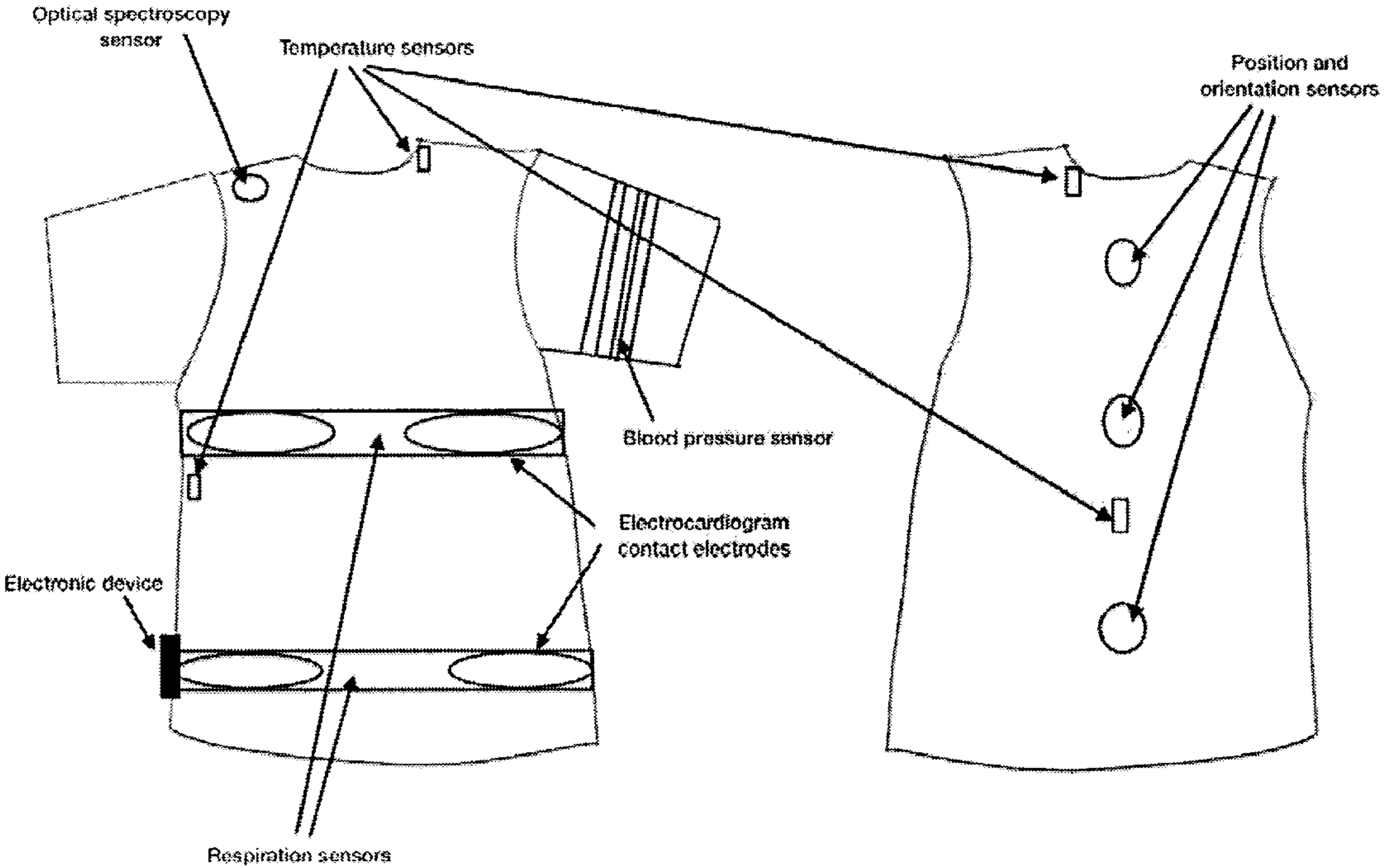

Electrocardiogram Processing Stack
Heart Rate Measurement
Heart Rate Variability
ST elevation detector
RR interval detector
ST segment detector
Data Processing Flow
QRS complex detector
Digital Signal Filters
Operating System
CPU + RAM
Analog to Digital Conversion
Low-pass filter
High-pass filter
Instrumentation Amplificators
Dry Electrodes
LA
RA
LL
RL
Ref
Body

Figure 19


Optical spectroscopy sensor
Temperature sensors
Position and orientation sensors
Blood pressure sensor
Electrocardiogram contact electrodes
Electronic device
Respiration sensors
Front
Back