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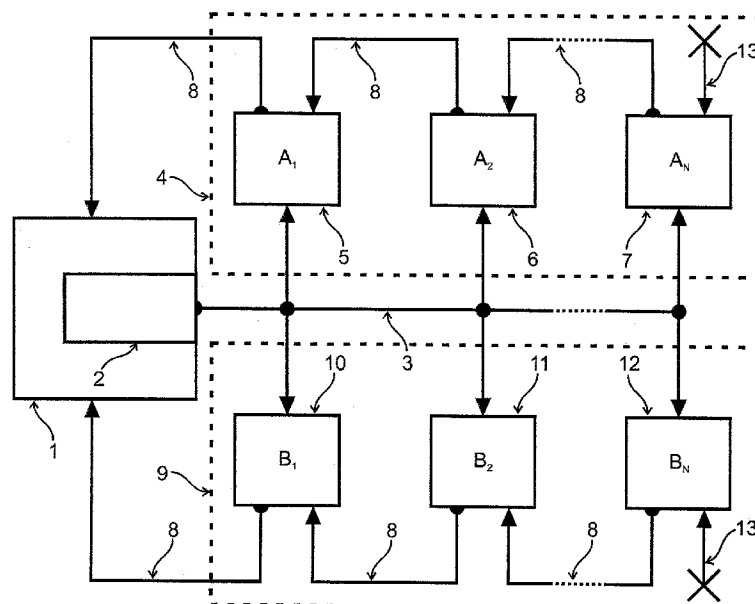


Fig. 1

(57) Abstract: The subject of the invention is a system for collecting medical data such as heart rate, breathing frequency, intracranial pressure, apnea and others, and method of use thereof. The present invention provides a unique way of collecting medical data, in particular in their acquisition from a plurality of measuring elements.

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MEDICAL DATA COLLECTION SYSTEM AND METHOD OF USE THEREOF

TECHNICAL FIELD

The present invention relates to the field of medical data processing. More precisely, the present invention provides a new method of a medical data collection. Especially
5 of medical data collection from a plurality of data acquisition elements.

BACKGROUND OF THE INVENTION

Remote monitoring has been used in health services for a long time. It is a very good tool for saving time and human resources. However, it is crucial to ensure that
10 remote monitoring is carried out efficiently and mainly without errors.

There is currently a significant amount of apparatuses which are used in healthcare. The examples of these apparatuses are vital signs sensors, sensors of patient presence on bed, sensors monitoring bed status and the like. It is apparently a challenging task to achieve reliable data from multiple sensors of these medical
15 apparatuses. Such apparatuses usually comprise several sensors which measure external mechanical or chemical states of their surroundings and by various electromechanical features provide measurement of the electrical physical quantities such as resistance, capacitance, amperage and so on. Measured data are sent as analog signal to a control unit. The analog signal has several disadvantages such as
20 have low resistance to electromagnetic interference and the signal can be damaged, therefore it is necessary to use wires that protect the signal from such external disturbances. Furthermore, it is the state of the art of these devices, that the signal needs to be modulated in the sensor and demodulated prior to entering the control unit. Microprocessors are the most commonly used control units in such apparatuses.

25 The usual way of collecting information from set of sensors in such apparatuses utilizes classical topology of electrical circuit such as Y, T or star topology. In some cases, the star-mesh topology can be also used. However, said topology brings the need of using separate connection for each apparatus. Usually the signal wire (or more generally signal path) and the data signal path have to be used. This connection is quite
30 expensive. It should be kept in mind that in typical healthcare application such as hospital beds, several apparatuses for measuring various states are provided. Firstly,

vital functions of patients are to be monitored, such vital functions are most commonly heartbeat and respiration, although other such as apnea, intracranial pressure or peristalsis can be measured. These vital functions of the patient are most commonly measured by sensors based on capacity sensors or piezoelectric sensors. Other multiple sensor apparatuses are used in hospital beds, stretchers or chairs. Apparatuses indicate for example weight status of the patient, state of the bed, state of its actuators and so on. There are various apparatuses in each room and most of them are remotely monitored from the nurses station. Therefore, in the case of star topology, every single apparatus has to be connected separately with the control unit of the measuring device, wherein the collected data are further sent to server or a readable monitor.

Prior art medical data collection systems do not provide safe collection of the measured data. Moreover, large number of hardware is needed for providing communication between sensors and control unit.

DESCRIPTION OF THE INVENTION

The above-mentioned disadvantages are partially overcome by the present invention of the medical data collection system. The system comprises a control unit and a plurality of measuring elements, wherein the measuring elements are connected in series via a data signal paths. A salient feature of the present invention is that the control unit further comprises a trigger and the trigger is connected to each measuring element via the trigger signal path. Preferably, the measuring element comprises piezoelectric and capacity sensor of vital functions. In a preferred embodiment, the measuring element includes the computing unit (23) of the measuring element.

The present invention also discloses a method of medical data collection in a data collection system. Said method introduces a set of logical operations which are necessary for data acquisition. First, the trigger initiates the data collection by transmitting the time-synchronizing impulse into each measuring element A_k . Second, the measuring element A_N transmits its data package to the measuring element A_{N-1} and measuring elements $A_2 - A_{N-1}$ simultaneously receive the data packages from the measuring element A_{k+1} and transmit their own data packages to the measuring element A_{k-1} . Simultaneously, the measuring element A_1 receives the data package from the measuring element A_2 and transmits its own data package to the control unit.

In the next step, measuring elements $A_2 - A_{N-2}$ simultaneously receive the data packages from the measuring element A_{k+2} and transmit previously received data packages to the measuring element A_{k-1} . At the end of this process, the measuring element A_1 receives the data package from the measuring element A_2 and transmit previously received data package to the control unit, cascade receiving and transmitting of data packages continues until the data package from the measuring element A_N is transmitted to the control unit by the measuring element A_1 .

Simplification of entire process lies in the fact that each measuring element A_k transmits its own data to the measuring element A_{k-1} and receives data from the measuring element A_{k+1} . The process repeats until the measuring element A_1 transmits N data packages to the control unit. It is preferably utilized that the sent data include information about the patient's vital functions.

DESCRIPTION OF DRAWINGS

Figure 1 is a schematic view of two chains of medical data collection system.

Figure 2 shows an example of the measuring element in a top view.

Figure 3 shows an example of the measuring element in a side view.

Figure 4 is a schematic view of the measuring element.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Figure 1 is a schematic view of the medical data collection system. The medical data collection system consists of a control unit 1, a first chain 4 and a second chain 9. The control unit 1 further consists of a trigger 2. The trigger 2 is a unit responsible for providing a time-synchronizing pulse. The trigger 2 can be provided as a single circuit or be a software part of the control unit 1. The time-synchronizing pulse is transmitted via trigger signal path 3, with the trigger being connected to each measuring element A_k , B_k in the first chain 4 and in the second chain 9. This arrangement allows to synchronize all measuring elements A_N , B_N to one given time. The number of measuring elements is not limited in any way, the measuring elements are in the following description specified by indices of $(1;2;\dots;N-1;N)$ series where N is the number of measuring elements connected in series, wherein the indices are

assigned to the measuring elements in the direction of connection from the closest to the most distant from the control unit 1. The index k is used for the current arbitrary measuring element belonging to the set of measuring elements $\langle 1; N \rangle$.

Measuring elements A_N , B_N are independent from each other. However, all measuring elements A_N in the first chain 4 are connected to series circuit (or more precisely to the daisy chain network/scheme). The measuring element A_N 7 is connected to the measuring element A_{N-1} via the data signal path 8 and the measuring element A_{N-1} is connected to the A_{N-2} via the data signal path 8. Such connection continues through each measuring element A_k . At the end, the measuring element A_2 6 is connected to the measuring element A_1 5 via the data signal path 8 and the measuring element 5 A_1 is connected to the control unit 1 via the data signal path 8. Thus, the control unit 1 and the plurality of measuring elements A_k form a serial connection. Such arrangement requires securing appropriate ending. An end element 13 is thus the representation of blanking of the measuring element A_N 7. The measuring element A_N 7 only measures and transmits the data, but receives none.

Every measuring element A_k , B_k provides data package. The idea of medical data collection system is to collect each data package from each measuring element A_k , B_k in control unit 1. When the trigger 2 transmits the time-synchronizing pulse through the trigger signal path 3 to each measuring element A_k , the data collection procedure is initiated and the control unit 1 is ready to collect the data packages from the measuring element A_1 5. Each measuring element A_k starts to both receive and transmit the data packages. Since the measuring element A_N 7 is at the beginning of the measuring element series, it does not receive any data package but immediately starts to transmit its own data package to the measuring element A_{N-1} . While the measuring element A_{N-1} is receiving the data package from the measuring element A_N 7 in the place $X+1$ of its data storage memory, it is simultaneously transmitting its own data package from the place X of its data storage memory to the measuring element A_{N-2} . Once the measuring element A_{N-1} finishes the transmission of its own data package to the measuring element A_{N-2} and receives the entire data package from the measuring element A_N 7, it starts transmitting the data package originally from the measuring element A_N 7 to the measuring element A_{N-2} . Each measuring element A_k performs the same procedure. Thus, this cascade procedure leads to collecting of all data packages in the control unit 1.

The measuring elements B_k in the second chain 9 form the same serial connection as described above. The data collection procedure is also initiated by the time-synchronizing impulse from the trigger 2 and the cascade procedure of data package collection is performed from the measuring element B_N 12 via all measuring elements B_k to the measuring element B_2 11 and the measuring element B_1 10 which finally transmits data packages to the control unit 1.

In another embodiment, each measuring element has X_N places in its data storage memory. The collection of data packages proceeds in the following process. The trigger 2 transmits a time-synchronizing pulse which initiates the collection of data packages. The measuring element A_N 7 transmits its data packages to the place $X-1$ of the data storage memory of the measuring element A_{N-1} . Once the measuring element A_{N-1} receives the entire data package from the measuring element A_N 7, it starts transmitting its own data package from the place X of its data storage memory and also the data package from the place $X-1$ of the data storage memory (i.e. the data package previously received from the measuring element A_N 7). The transmission could be either simultaneous or step-by-step. Said transmission continues towards the measuring element A_1 5 which has generally N places in the data storage memory. These N places are gradually filled by the incoming/receiving data package. In the final step, the data packages are transmitted from the measuring element A_1 5 to the control unit 1.

In the preferred embodiment, the data packages should have the same size. The same size of data packages ensures optimal time of data package transmission and receiving. However, this does not limit the present invention, since it is obvious to the person skilled in the art that the transmitting and receiving time could be optimized by utilizing additional software in each measuring element. In addition, the present embodiment is only illustrative and should not be considered the only solution of the technical problem. Person skilled in the art could implement the present invention in the range of application and thus use other embodiments such as connection of bed sensors, sensors of vital functions, bed exit sensors, brake sensors, bed tilt sensors or any other sensors relating to the medical data or condition collection sensors.

In addition, it is clear to the person skilled in the field of invention that the data collection system is not limited by two chains. It should be noted that the number of

chains is not limited. Furthermore, it is obvious that in some applications, the connection via both the trigger signal path 3 and the data signal path 8 could be wireless.

In yet another embodiment, the data package could be divided into smaller entities. In such case, the receiving and transmitting of one or more parts of the data package could be performed simultaneously. The measuring element A_k can receive part of the data package from the measuring element A_{k+1} and in the same time transmit the received part of the data package to the measuring element A_{k-1} before the whole data package of the measuring element A_{k+1} is stored in the A_k .

Using the system described above provides other positive effects, for example the data transmitted from each measuring element do not need additional overhead data. The overhead data can be for example packet header, packet footer, packet checksum, server bits and so on. The data package can in some embodiments comprise a checksum, parity bits or cyclic redundancy checks to detect errors that occur during transmission.

This method is preferably used on measuring elements for measuring patient's vital functions such as are heartbeat, respiration, apnea, peristalsis or twitches of the patient's head related to the intracranial pressure. This data can be considered data associated with patient's vital functions.

Such system can be used with the highest efficiency on multi-sensor measuring elements, e.g., the one described in detail below. The measuring element for monitoring patient's vital functions according to fig. 2, fig. 3 and fig. 4, comprising a piezoelectric transducer 21 (also known as a piezoelectric transducer), a comparator capacitor 22, a printed circuit 20 board 20, a plating 16 and a computing unit 23. The plating 16 may be, for example, of copper. The computing unit 23 of the measuring element is, according to a preferred embodiment, composed of a single processor but may also be composed of other computing parts communicating together by wire or wirelessly.

The piezoelectric transducer 21 utilized here for the purpose of measuring vital functions is a component for generating sound, namely an electro-acoustic transducer used in watches or as a siren. The piezoelectric transducer has suitable mechanical-deformative properties for measuring vital functions, which means that

springs and additional members transferring their deformations caused by movements associated with patient's vital functions to the measuring element are not necessary. Thereby low production costs, higher measuring accuracy, and simplicity of the entire measuring element 25 are achieved. A semiconductor component and a circuit utilized for measuring capacity in touchscreen displays (charge transfer technology/method) are utilized in measuring capacity with this component and another measuring (static) electrode 17. A specific exemplary embodiment is described below.

In the exemplary embodiment, the measuring element 25 is on the side of the piezoelectric transducer 8 covered by, for example, a plastic diaphragm which protects the measuring element 25 against water and dust and at the same time also removes the mechanical resonance oscillation of the measuring element 25. The measuring element 25 is on the side opposite of the piezoelectric transducer 21 covered by for example plastic foil which ensures the minimum height of the entire measuring element 25. The plastic film may be replaced by any flexible or movable cover which ensures the transfer of forces to the piezoelectric transducer 21 without its stiffness significantly affecting the resulting force being transmitted to the piezoelectric transducer 21. The measuring element 25 for monitoring patient's vital functions may be adapted for insertion into the pad. The pad can be stored, for example, between the mattress and the bed frame, in the mattress or between the mattress and the patient's body. The measuring element may also be adapted for a direct placement on the bed frame and for detachable locking, for example, with a riveting knob.

The piezoelectric transducer 21 consists of the piezoelectric element 14 made out of piezoceramics, the first electrode 28 and the second electrode 15. Piezoceramics are for example piezoceramic materials based on lead zirconate titanate $[\text{Pb}[\text{Zr}_x\text{Ti}_{1-x}]\text{O}_3$ with $0 \leq x \leq 1$] or sodium bismuth titanate $[\text{NaBi}(\text{TiO}_3)_2]$ or other piezoceramic material. By using such material, the required electromechanical properties are achieved, namely generation of charge in range of 130–930 pC/N. The piezoelectric element 14 is located between the first electrode 28 made, for example, out of silver, optionally from alloys with similar electrical properties, and the second electrode 15. The piezoelectric transducer 21 may have different shapes, such as a shape of circle, a triangle, square, or other shapes. A preferred shape is the circular shape, which ensures the most uniform decomposition of forces. The shape of the piezoelectric transducer 21 is usually a circular shape delimited in its height dimension

by two parallel planes. Preferably, form modification of the piezoelectric transducer 21 can be utilized, when its center is pressed in the direction of axis perpendicular to one of the delimiting planes and a board-like shape emerges, where the center is located in one plane and the borders of the piezoelectric transducer 21 lie in the parallel way.

5 The board-like shape is best illustrated by the shape of the second electrode 15 (or the entire piezoelectric transducer 21) in Figure 3. The second electrode 15 may be made of brass, aluminum, copper or another metallic material. The locations of the electrodes are interchangeable, it is essential that the piezoelectric element 21 is positioned in the middle between them. The second electrode 15 may have a circular or optionally
10 board-like shape. Alternatively, the second electrode may have the shape of ellipse, polygon, most frequently of rectangle, square, or another shape. Shape of the second electrode 15 is preferably derived from the shape of the piezoelectric transducer 21. The second electrode 15 is flat and its surface is in a rest position approximately parallel to the piezoelectric element 14. The second electrode 15 is located on the
15 plating 16 for electrical connection with the ground, which creates a firm connection with the printed circuit board 20. The second electrode 15 is connected at least in two places to cause the required deformation of the piezoelectric transducer 21. These two places may be located, for example, opposite of each other on the opposite sides of the length of the piezoelectric transducer 21. In an alternative embodiment, the
20 attachment can be provided so that that the first electrode 28 is located on the plating 16 and thereby the piezoelectric transducer 21 is connected with the printed circuit board 20. In a preferred embodiment, the second electrode 15 is connected in at least three places adjoining the printed circuit board 20 to provide greater stability and better course of deformation of the piezoelectric transducer 21. Preferably, these places are
25 in the piezoelectric transducer with circular shape positioned so that they create a triangle when connected. Alternatively, the piezoelectric transducer 21 may be connected to any fixed board in this way, but by connecting to the printed circuit board 20, the dimensions of the entire measuring element 25 are minimized. The measuring capacitor 26 consists of the second electrode 15 and the measuring electrode 17. The
30 measuring electrode 17 is connected with the printed circuit board 20 and forms electrode with higher electrical potential. The dielectric of the measuring capacitor 26 is formed by an air gap. On the opposite side of the printed circuit board 20 opposite of the measuring electrode 17 there is the shielding electrode 19 of the measuring capacitor 26. The shielding electrode 19 of the measuring capacitor 26 has the same

electrical potential as the measuring electrode 17 and together they can form a shielding capacitor 27 which provides resistance to external influences for example by the approximation of metal material. In some cases, two or more piezoelectric transducers 21 may be located on one circuit board 20.

5 The comparator capacitor 22 consists of the first comparator electrode 29, the first comparator electrode 29 can be made, for example, of brass, aluminum, copper. The first comparator electrode 29 is located on the plating 16 for electrical connection with the ground. The comparator capacitor 22 further consists of a second comparator electrode 18. The second comparator electrode 18 is located on the printed circuit
10 board 20 and forms an electrode with higher electrical potential. The dielectric of the comparator capacitor 22 is formed by an air gap. On the opposite side of the printed circuit board 20 opposite of the second comparator electrode 18 is located the shielding electrode 30 of the comparator capacitor 22. The shielding electrode 30 of the comparator capacitor 22 has the same electrical potential as the comparator electrode
15 18 and together they can form a shielding capacitor 27 which provides resistance to external influences for example by the approximation of metal material.

 The computing unit 23 of the measuring element combines piezoelectric voltage measurement and capacity measurement functions, for example, by means of charge transfer technology. The piezoelectric element 14 is connected to the computing unit
20 23 of the measuring element through a charge amplifier. Furthermore, the measuring capacitor 26, the comparator capacitor 22, the shielding capacitor 27 and the sampling capacitor 24 are connected to the computing unit 23 of the measuring element. The use of the measuring capacitor 26 and the comparator capacitor 22 causes resistance to changes in the measuring conditions such as temperature or humidity.

25 Furthermore, a method for monitoring patient's vital functions according to the above-mentioned exemplary embodiment is described. Heartbeat, breath and other vital functions of the patient, for example peristalsis, generate forces transmitted to the measuring element 25 for monitoring patient's vital functions. With respect to the construction of the measuring element 25, it is ensured that the vital functions of the
30 patient are measurable without the need for permanent connection of the measuring element 25 with the patient's body, for example by means of gluing or implanting. The measuring element 25 is capable of measuring patient's vital functions in contact with

the skin of the patient, but also in contact with patient's clothing, mediated through the mattress on which the patient is placed, or through the pad in which the measuring element 25 for monitoring vital functions may be located. The measuring capacitor 26 and the comparator capacitor 22 are used to measure slowly changing forces generated by, for example, breathing. During breathing, due to the applied forces, deflection of the central portion of the second electrode 15 (and therefore to the entire piezoelectric transducer 21) occurs, and thus also change in the air gap between the second electrode 15 and the measuring electrode 17. Due to the construction where the piezoelectric transducer 21 is attached to the board by one of the electrodes, a non-mediated deflection of the piezoelectric transducer 21 without the need for additional force transmitting components is enabled. The size of the air gap between the first comparator electrode 29 and the second comparator electrode 18 is independent of the action of the forces. The change in the capacity of the measuring capacitor 26 is dependent both on the varying air gap size and on the change of permittivity of the air gap. The change in the capacity of the comparator capacitor 22 is dependent only on change in permittivity of the air gap. The capacity of the measuring capacitor 26 and the capacity of the comparator capacitor 22 ratio will remove the dependence of the capacitance change on dielectric permittivity and thereby the independence of changing the measuring conditions.

Capacity changes are evaluated for example by charge transfer technology. The charge transfer technology operates on the principle of charging the capacitor and subsequent transfer of the accumulated charge into the sampling capacitor 24, wherein the number of accumulated charge transfers into the sampling capacitor is counted, until the voltage at the sampling capacitor 24 reaches the same value as the stable reference voltage. It is clear to a person skilled in the art that other methods of measuring capacity can be utilized, for example, the resonance method. In order to measure fast-changing forces caused for example by pulse, a direct piezoelectric effect of the piezoelectric material is used, where by deformation of the piezoelectric material due to external forces, a charge which is through the charge amplifier transferred to the computing unit 23 of the measuring element is generated where the voltage is evaluated. The output data are then transmitted via the data wire 8 to the control unit 1. The computing unit 23 of the measuring element can be provided as a

microprocessor, its location on the printed circuit board 20 ensures a protection of the signal because the distance of the transmitted non-digital signal is very small.

LIST OF REFERENCE SIGNS

- 1 ... main control unit
- 2 ... trigger
- 3 ... trigger signal path
- 5 4 ... first chain
- 5 ... measuring element A1
- 6 ... measuring element A2
- 7 ... measuring element AN
- 8 ... data signal path
- 10 9 ... second chain
- 10 ... measuring element B1
- 11 ... measuring element B2
- 12 ... measuring element BN
- 13 ... end element
- 15 14 ... piezoelectric element
- 15 ... second electrode
- 16 ... plating
- 17 ... measuring electrode
- 18 ... second comparator electrode
- 20 19 ... shielding electrode of the measuring capacitor
- 20 ... printed circuit board
- 21 ... piezoelectric transducer
- 22 ... comparator capacitor
- 23 ... computing unit of the measuring element

- 24 ... sampling capacitor
- 25 ... measuring element
- 26 ... measuring capacitor
- 27 ... shielding capacitor
- 5 28 ... first electrode
- 29 ... first comparator electrode
- 30 ... shielding electrode of the comparator capacitor

CLAIMS

1. Medical data collection system comprising a control unit (1) and a plurality of measuring elements, wherein the measuring elements are connected in series through the data signal path (8), **characterized in that** the control unit (1) further comprises a trigger (2) and this trigger (2) is connected to each measuring element via the trigger signal path (3).
2. Medical data collection system according to claim 1, **characterized in that** the measuring element comprises a piezoelectric or capacity sensor of vital functions.
3. Medical data collection system according to any one of the preceding claims, **characterized in that** the measuring element comprises a computing unit (23) of the measuring element.
4. A method of medical data collection in a data collection system comprising a plurality of measuring elements, wherein the measuring elements are connected in series through the data signal path (8), **characterized in that** the control unit (1) further comprises a trigger (2), wherein the trigger (2) is connected to each measuring element A_k through the trigger signal path (3), wherein the method comprises the following steps:
 - the trigger (2) initiates the data collection by transmitting a time-synchronizing impulse to each measuring element A_k
 - the measuring element A_N transmits its data package to the measuring element A_{N-1}
 - the measuring elements A_2 to A_{N-1} simultaneously receive the data packages from the measuring element A_{k+1} and transmit their own data packages to the measuring element A_{k-1}
 - the measuring element A_1 receives the data package from the measuring element A_2 and transmits its own data package to the control unit (1).
5. A method of medical data collection in a data collection system, **characterized in that** it further comprises the steps of:

- the measuring elements A_2 to A_{N-2} simultaneously receive the data packages from the measuring element A_{k+2} and transmits the previously received data packages to the measuring element A_{k-1} ,
 - 5 - the measuring element A_1 receives the data package from the measuring element A_2 and transmits the previously received data package to the control unit (1),
 - the cascade receiving and transmission of the data packages continues until the data package from the measuring element A_N is transmitted to the control unit (1) by the measuring element A_1 .
- 10 6. A method of medical data collection in a data collection system, **characterized in that** the transmitted data includes information about the patient's vital functions.

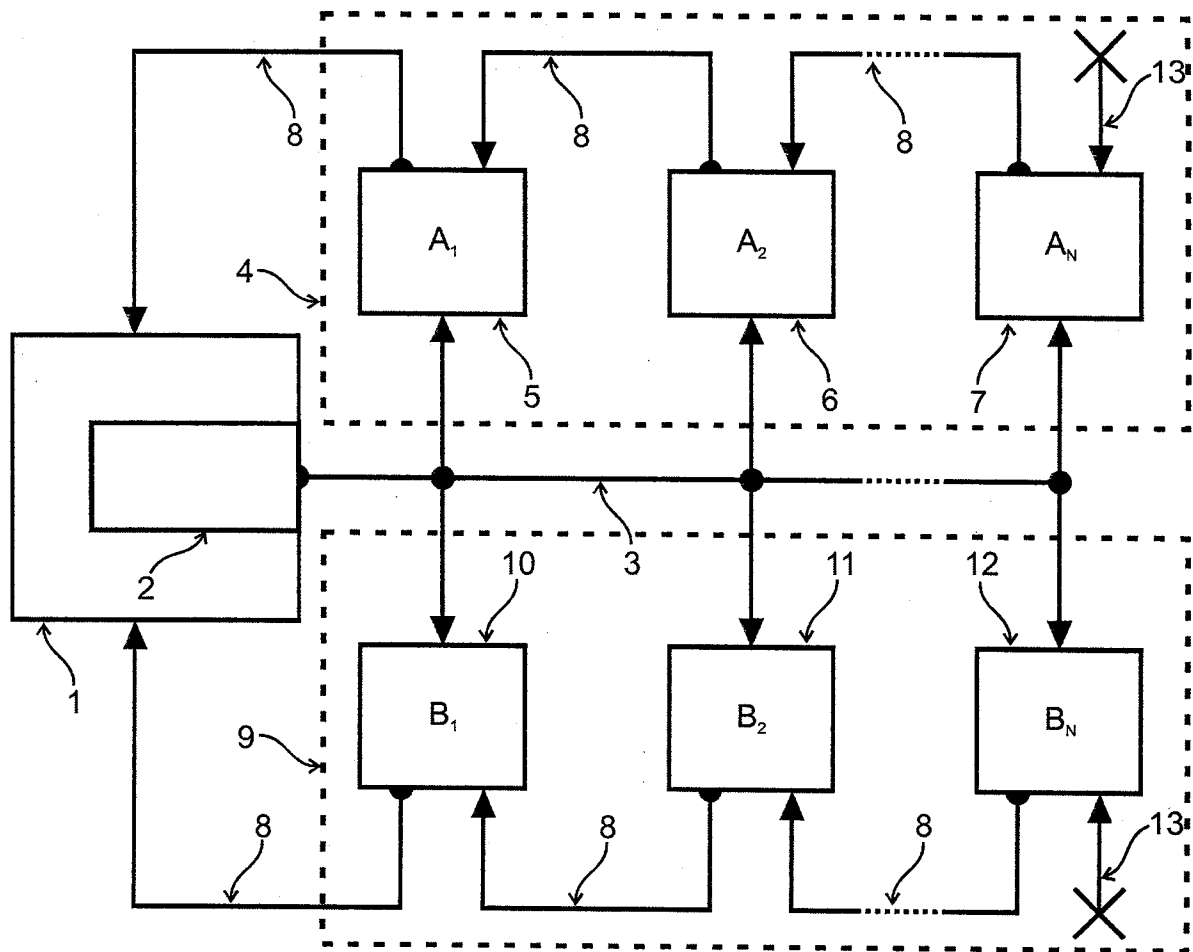


Fig. 1

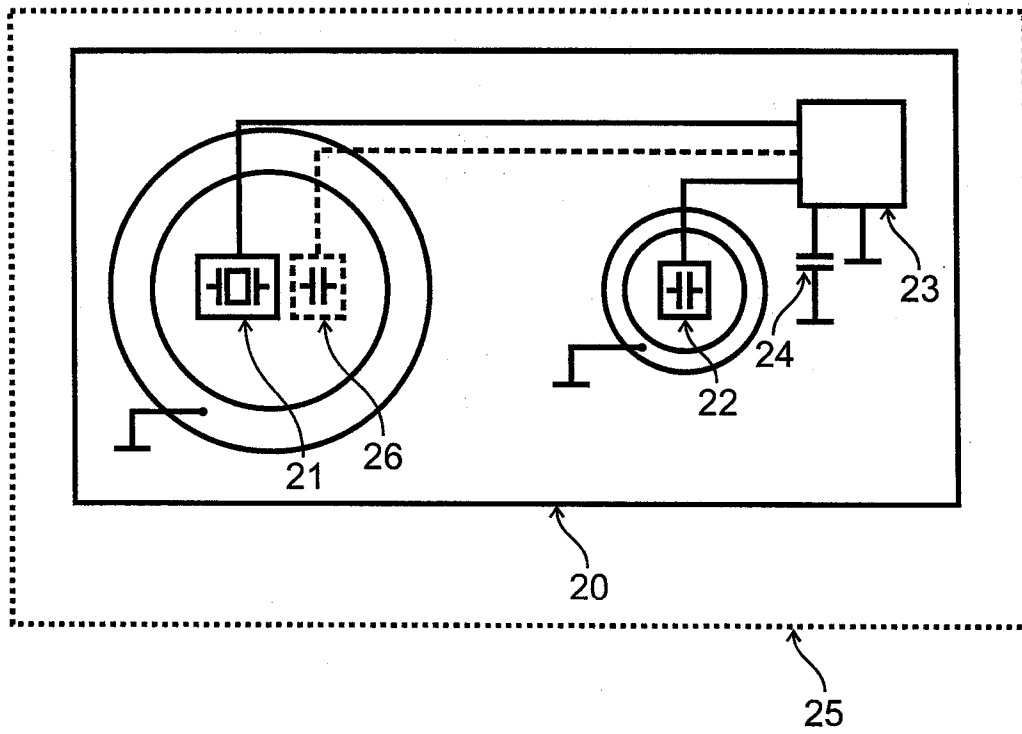


Fig. 2

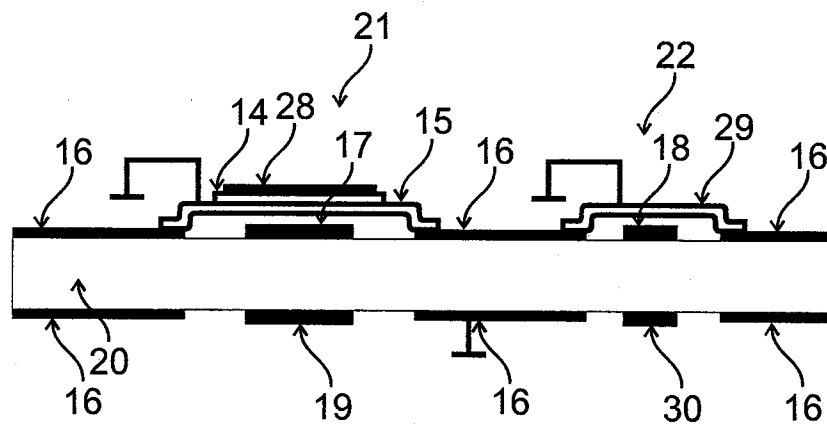


Fig. 3

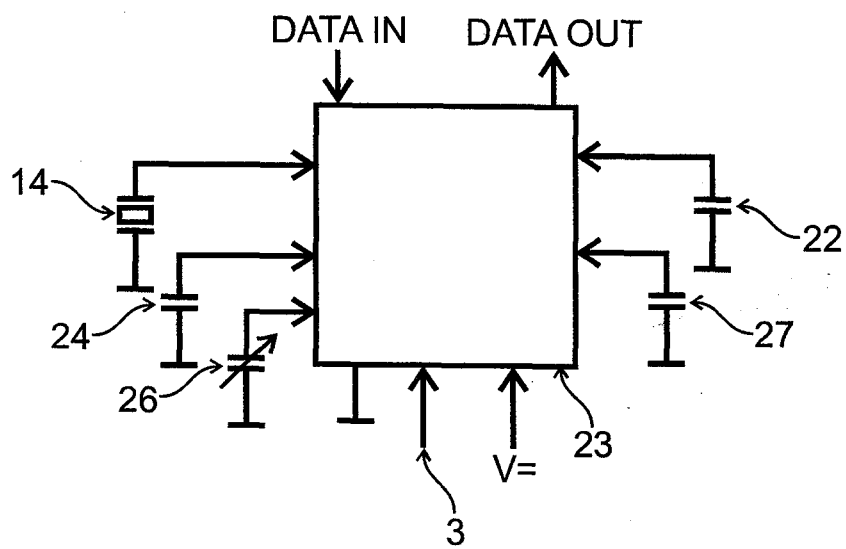


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/CZ2017/000042

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/00 A61B5/0205
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014/275891 A1 (MUEHLEMANN THOMAS [CH] ET AL) 18 September 2014 (2014-09-18) paragraphs [0136] - [0141]; figures 7,8 -----	1-6
X	US 2012/029304 A1 (MEDINA CASEY [US] ET AL) 2 February 2012 (2012-02-02) figure 4 paragraphs [0036], [0089] -----	1-6
X	WO 99/12607 A1 (MANN ALFRED E FOUND SCIENT RES [US]) 18 March 1999 (1999-03-18) abstract figures 1,2 page 12, line 25 - page 13, line 24 -----	1-6



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摘要(译)

本发明的主题是用于收集诸如心率，呼吸频率，颅内压，呼吸暂停等医疗数据的系统，以及其使用方法。本发明提供了一种收集医学数据的独特方式，特别是从多个测量元件中获取医学数据。