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(54) Title: A SYSTEM WITH A CARDIOLOGICAL SENSOR FOR LUNG FLUID DETECTION

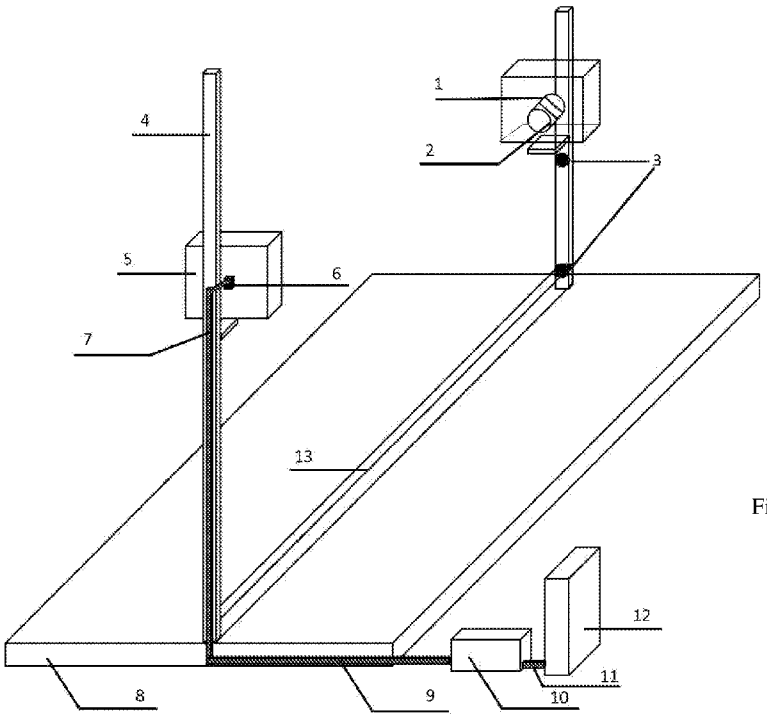

Fig. 1

(57) Abstract: The invention relates to a system of the cardiological sensor for lung fluid detection, which is a non-invasive cardiological sensor intended for the study of left ventricular heart failure by measuring the amount of transudate in the lungs. The system of the cardiological sensor for lung fluid detection, characterised in that it consists of a base (8) to which a movable tripod is attached, consisting of two vertical profiles with a rail (4) connected to the horizontal profile with a rail (13) by means of angle brackets (3), and a set of helical antennas (14) oriented parallel to the plane of the base (8) supported by horizontal crossbars (7), fixed using the angle brackets (3) with screws to vertical profiles with the rail (4), and each of the helical antennas (14) consist of: rectangular shielding made of copper sheet without walls on the side of patient thorax, an inner cylinder-shaped carcass core (2) with a copper wire (1) wound on it, fixed so that its geometric centre coincides with a geometric centre of a ground and a shield, and microwave coaxial cables (9)

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[Continued on next page]

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connecting both helical antennas (14) through a N-type coaxial connector (6) with a vector network analyser (10) through a cable (11) leading to a data analysis computer (12).

A SYSTEM WITH A CARDIOLOGICAL SENSOR FOR LUNG FLUID DETECTION

The subject of the invention is a system of the cardiological sensor for lung fluid detection, which is a non-invasive cardiological sensor intended for the study of left ventricular heart failure by measuring the amount of transudate in the lungs. The clinical condition of patients with left ventricular heart failure is characterised by an increased amount of fluid in the lungs, which translates into a change in a physical quantity known as dielectric loss. The direct consequence of this fact is a decrease in the transmission of electromagnetic waves that can penetrate the patient's rib cage.

The US application US4488559A discloses a microwave radiometer for passive, non-invasive measurement of fluid content in animal bodies. The radiometer system includes a waveguide antenna that responds to frequencies in the microwave range emitted from the patient's body and is compact in size and light in weight so that it can be easily attached to the patient while resulting in minimal discomfort and loss of mobility. A heating system is attached to the antenna to maintain the temperature of the antenna at a level close to the patient's skin temperature. The associated control circuit processes the signals received from the antenna at one or more frequencies and produces an output signal that correlates with the amount of fluid in the area of the body being examined.

US application US20050107719A1 describes a method for estimating the stroke volume of the heart by taking electrical data from the chest in the first phase of the cardiac cycle, estimating the volume of the heart from a first set of electrical data, then taking a second set of electrical data from the chest in the second phase of the heart cycle, estimating the second heart volume values from the second set of electrical data and using the difference between the first and second heart volume values to estimate cardiac stroke volume.

The US patent US9727986B2 describes a method of creating a 3D visualization of a patient's lung model using an X-ray examination to create a three-dimensional visualization of a patient's lungs based on the images of the patient's lungs taken in computed tomography technology and analysed by CPU.

The application description WO2007105996 describes an invention relating to an implantable medical device and a method for assessing a degree of pulmonary oedema of a patient using an implantable medical device. The method comprises the steps of detecting at least two specific body positions of the patient; then initiating at least one impedance sensing session to sense trans-thoracic impedance signals when the patient is in one position of the at least two specific positions; obtaining impedance values from the impedance signals; determining a relation

between respective impedance values at the at least two positions; storing the relation; and using the relation as a metric of pulmonary oedema to assess the degree of pulmonary oedema.

The application US20200297309A1 discloses systems using radio waves to measure the amount of fluid in tissues or the position and cycle of the heart, in combination with electrodes known from ECG. The described solution uses the measurement of the dielectric constant change. The measurement is also performed using real-time analysers, not sweep analysers.

In the patent description EP3664694A4 one can find a physiological patient monitoring system. It uses a radio signal and a device that measures the amount of fluid in the tissues based on reflection spectroscopy. The device comprises a shielded housing placed over the patch, the patch being configured to be removably attached to or near the patient's skin, the housing containing at least one memory. An antenna located on the housing transmits radio frequency RF waves towards the target portion of the patient's internal tissue and receives the reflected RF waves from the internal tissue. RF circuitry in communication with at least one memory performs an RF-based measurement of the fluid level in the patient's lungs over a period of time.

The publication entitled *"UWB pulse propagation into human tissues"* (M. Cavagnaro et al. *Physics in Medicine & Biology)* describes a method for monitoring a person's respiratory status using a radar device located at a distance from the examined person.

The system of the cardiological sensor for lung fluid detection according to the invention consists of a wooden base to which a movable tripod made of two vertical aluminum profiles with a rail is attached, connected to a horizontal aluminum profile with a rail by means of angle bars.

It is equipped with two helical antennas consisting of a cubic shielding (ground and screen) without a wall facing the patient's chest.

The helical antennas are oriented parallel to the plane of the base on the horizontal crossbars supporting them, fastened with screws to the vertical profiles with the rail using angle brackets. Each of the antennas has an inner cylinder-shaped carcass core with a copper wire wound on it, fixed so that its geometric centre coincides with the geometric centre of the ground and the shield. The system is also equipped with microwave coaxial cables connecting both helical antennas through an N-type

coaxial connector with a vector network analyser connected to the data analysis computer.

The cylindrical carcass core is preferably made of HIPS material.

The screen and the ground are preferably made of copper sheet.

The vertical and the horizontal profiles with the rail are preferably made of aluminium.

The base is preferably made of wood.

The main advantage of the system of the cardiological sensor for lung fluid detection, according to the invention, is the application of a non-invasive system for the study of left ventricular heart failure by using helical antennas shielded from the sides with a significantly reduced height compared to standard helical antennas operating in the axial mode for gigahertz frequencies. The use of low-energy microwave radiation for measurements allows for obtaining results regarding the amount of transudate without the need to use an invasive measurement methods.

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An additional advantage of the invention is the adaptation of the dimensions of the antennas to the geometry of the patient while maintaining high directivity and impedance matching for the 50 ohm system.

The design of the system allows for a quick and simple measurements, which in extreme cases can even be performed by the patients themselves as well as provides the opportunity to obtain an immediate result of the examination.

The subject of the invention has been shown in an embodiment and in a drawing, in which Fig. 1 shows an isometric projection of the system, Fig. 2 shows a cross-section through the system, and Fig. 3 shows a schematic view of a helical antenna.

The system of the cardiological sensor for lung fluid detection includes wooden base 8, to which a movable tripod is attached. The tripod consists of two vertical aluminium profiles with the rail 4 and the aluminium horizontal profile with the rail 13. The helical antennas 14 are attached to the horizontal aluminium crossbars 7 which are attached to aluminium vertical profiles with the rail 4. The angle brackets 3 are fastened to profiles 4 with screws allowing for stiffening or loosening of the clamp. This allows the angle bars 3 to move freely (in the vertical axis) together with the elements attached to them - horizontal aluminum crossbars 7 on which the helical antennas 14 are placed, so that the transmitting antenna touches the front part of the patient's chest and the receiving antenna touches the patient's back.

Each of the helical antennas 14 has the cylinder-shaped inner carcass core 2 (made of HIPS plastic) on which the copper wire 1 is wounded on. The carcass core 2 is fixed so that its geometric center coincides with the geometric center of the cubic shielding made of copper sheet without one wall facing the patient's chest.

The principle of operation of the system consists in performing a measurement, which is carried out by passing a short broadband signal through the patient's rib cage, and then analysing the attenuation of the signal power by the vector network analyser 10 and then transferring the data to computer 12 through the cables 11.

Claims

1. The system of the cardiological sensor for lung fluid detection, characterised in that it consists of a base (8) to which a movable tripod is attached, consisting of two vertical profiles with a rail (4) connected to the horizontal profile with a rail (13) by means of angle brackets (3), and a set of helical antennas (14) oriented parallel to the plane of the base (8) supported by horizontal crossbars (7), fixed using the angle brackets (3) with screws to vertical profiles with the rail (4), and each of the helical antennas (14) consist of: rectangular shielding made of copper sheet without walls on the side of patient thorax, an inner cylinder-shaped carcass core (2) with a copper wire (1) wound on it, fixed so that its geometric centre coincides with a geometric centre of a ground and a shield, and microwave coaxial cables (9) connecting both helical antennas (14) through a N-type coaxial connector (6) with a vector network analyser (10) through a cable (11) leading to a data analysis computer (12).

2. The system according to claim 1, characterised in that the cylindrical carcass core (2) is made of HIPS material.

3. The system according to claim 1, characterised in that the shield and the ground are made of copper sheet.

4. The system according to claim 1, characterised in that the vertical profiles with the rail (4) and the horizontal profile with the rail (13) and the horizontal crossbars (7) are made of aluminium.

5. The system according to claim 1, characterised in that the base (8) is made of wood.

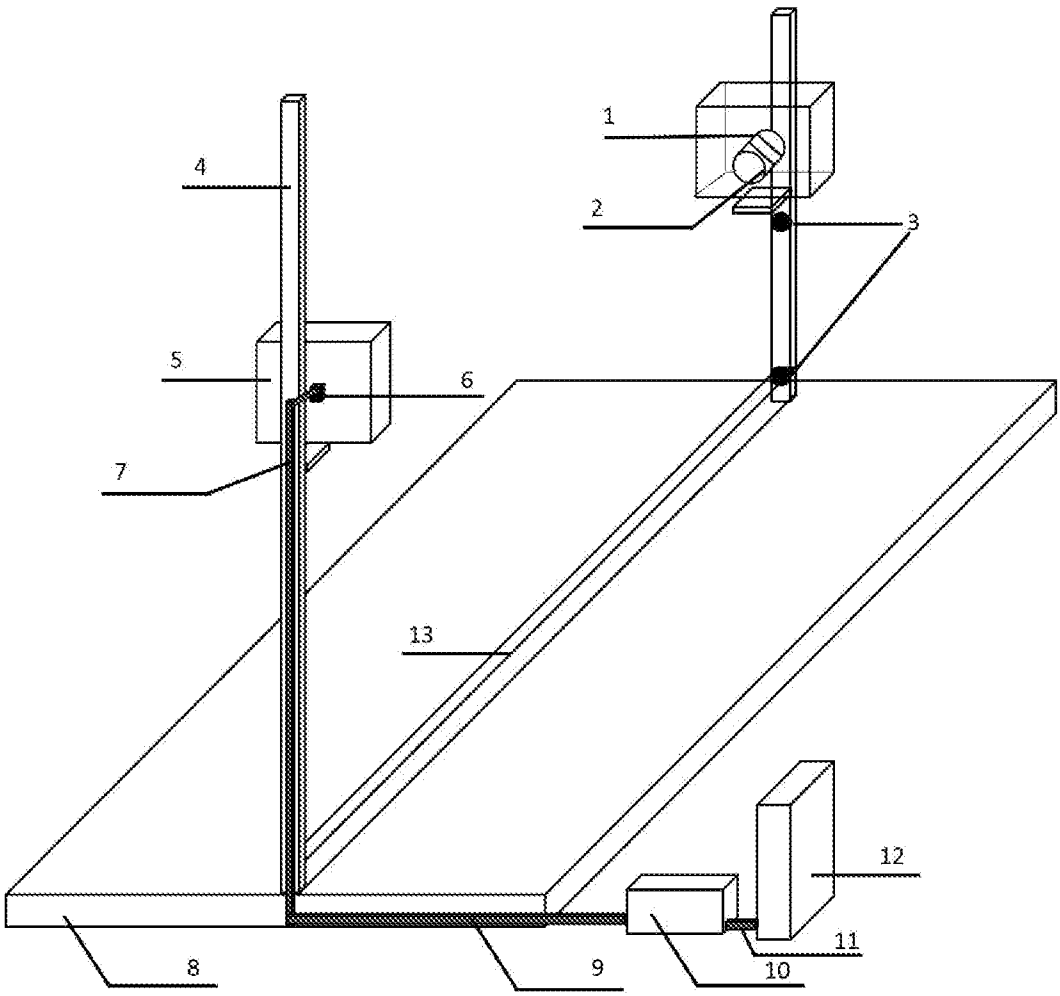

Fig. 1

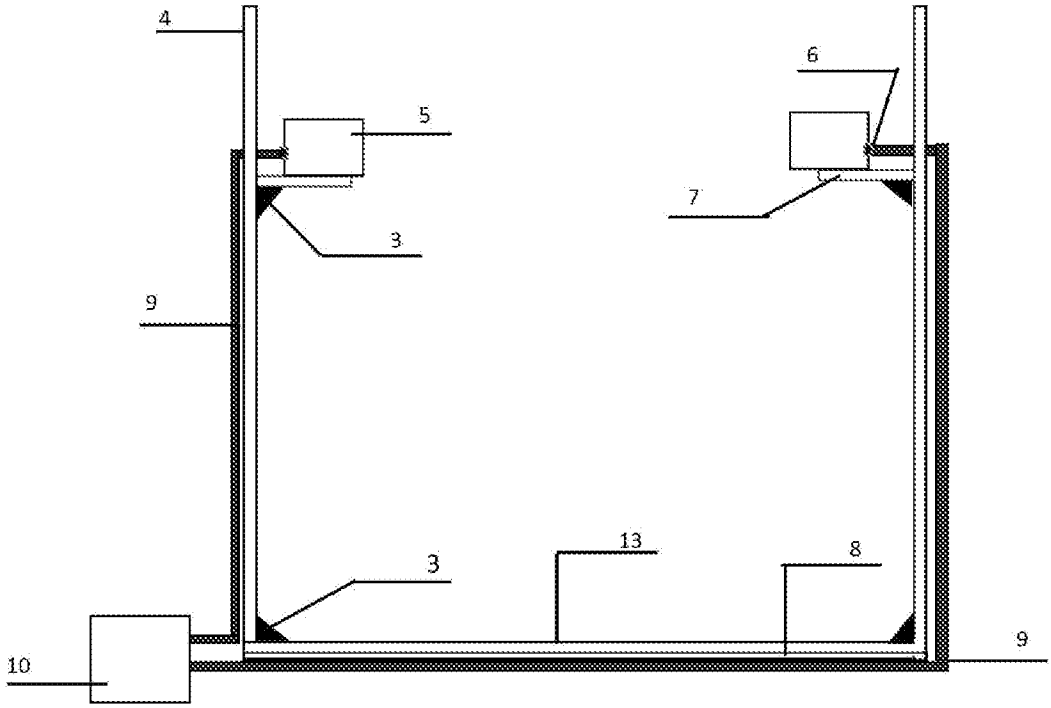

Fig. 2

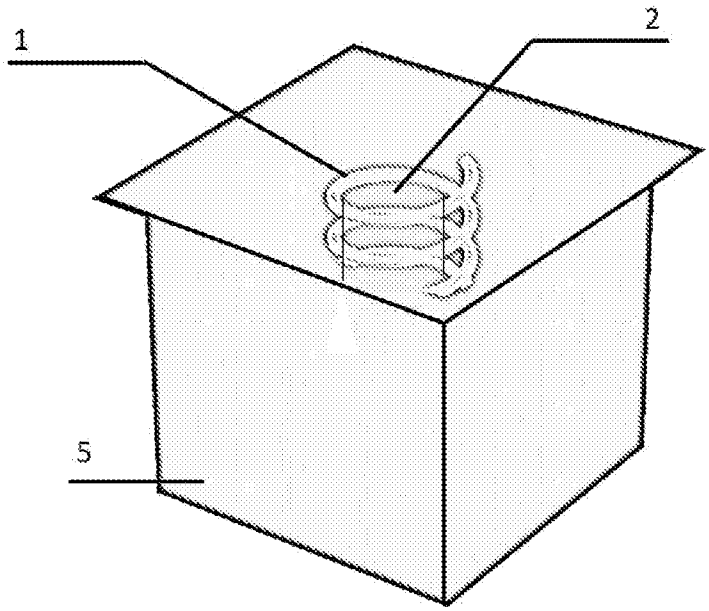

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/0507 A61B5/08 A61B5/00
ADD.

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B. FIELDS SEARCHED

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2017/135598 A1 (WEINSTEIN URIEL [IL] ET AL) 18 May 2017 (2017-05-18) figures 1, 4 paragraph [0079] - paragraph [0080] -----	1-5
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Knoop, Jan

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2023/055570

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 2010/249633 A1 (DROITCOUR AMY [US] ET AL) 30 September 2010 (2010-09-30) figure 1A	1-5
A	US 2016/270686 A1 (DIAMOND SOLOMON G [US] ET AL) 22 September 2016 (2016-09-22) figures 1-7, 10 paragraph [0033]	1-5
A	US 2018/049669 A1 (VU TAM [US] ET AL) 22 February 2018 (2018-02-22) figures 9A, 9B	1-5

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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