(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 181 476 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
21.06.2017 Bulletin 2017/25

(51) Int Cl.:
B65D 65/40 *(2006.01)* ***G08B 13/12*** *(2006.01)*

(21) Application number: **16204312.9**

(22) Date of filing: **15.12.2016**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(30) Priority: **15.12.2015 IT UB20159837**

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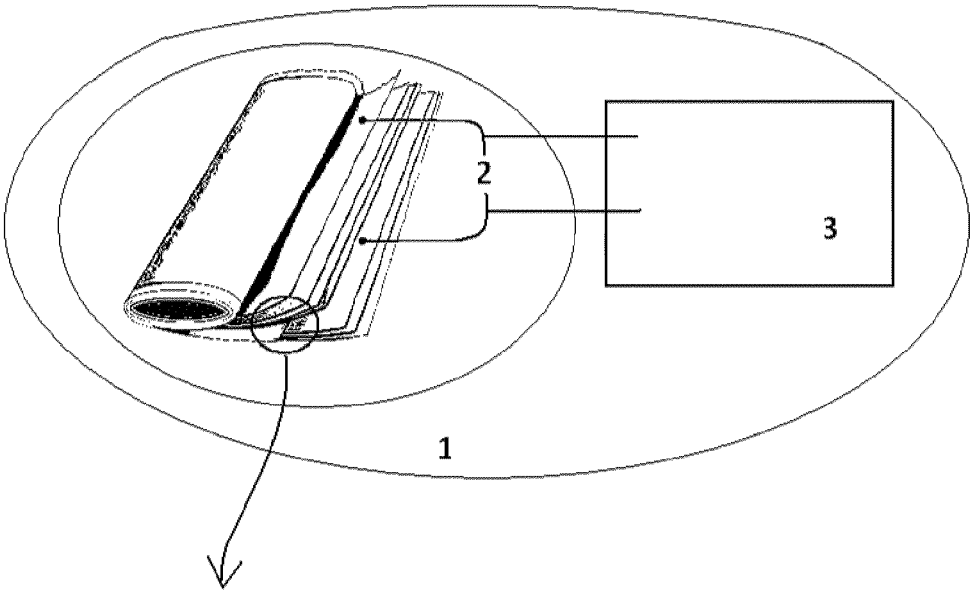
(54) **A MECHANICAL AND ELECTRONIC SENSOR ADAPTED TO DETECT CUTS AND LACERATIONS**

(57) A mechanical and electronic sensor (1) for a safety closure adapted to detect cuts and lacerations, comprising at least two layers of electrically conductive material (4) separated by a internal layer of electrically-insulating material (11) and an electronic circuitry (3) connected to each layer of electrically conductive material (4) and configured for detecting a variation of fundamental and/or derived electric magnitudes, between the two states of electrically conductive material (4), over time so as to detect a cut or laceration of the layers.

In particular, the layer of electrically-insulating material (11) is made of an elastically-deformable material having a form memory so that it returns from a crushed condition towards an original condition so as to reset the initial state of the electrical magnitudes detected by the electronic circuitry (3).

Fig. 4



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Description

[0001] The present invention concerns a mechanical and electronic sensor adapted to detect cuts and lacerations.

[0002] A multiplicity of packing and packaging systems are present on the market. The function of the packing and packaging systems of known type is to contain substances, objects and materials of any type. The use thereof is fundamental for movement, transfer, transport and storage of said substances, objects and materials of any kind contained therein.

[0003] The substances, objects and materials of any type, packed and contained with systems of known type with a certain frequency are the object of theft as they are often attractive.

[0004] One of the ways in which thefts can be carried out is through cutting or lacerating the pack or package of known type; following these activities the thieves partially or totally remove the packed or packaged substances, objects and materials.

[0005] When the thefts are carried out by cutting or lacerating the pack or the package of known type; following which the thieves partially or totally remove the substances, objects and materials of any type contained therein, the pack or package of known type has no function and effectiveness in terms of identifying, recording and signalling the event.

[0006] It would be desirable to have a sensor available to enable packing and packaging systems of known type not to be prone to the drawbacks and limits described above, but which enables the packing and packaging systems of known type to identify, record and signal the cutting or laceration (including the normal opening and closing) of the packaging or packs of known type.

[0007] **The main aim of the present invention** is to provide a mechanical and electronic sensor adapted to detect cuts and lacerations, which can recognise a series of damages at later times.

[0008] **A further aim of the present invention** is to realise a mechanical and electronic sensor adapted to detect cuts and lacerations, which is adaptable to many packing and packaging systems of known type and which enables the packing and packaging systems of known type to identify, record and signal the cutting or laceration (including the normal opening and closing) of the packs or packages of known type.

[0009] **A further aim of the present invention** is to provide a mechanical and electronic sensor adapted to detect cuts and tampering, which is economical to produce.

[0010] **A further aim of the present invention** is to provide a mechanical and electronic sensor adapted to detect cuts and lacerations, which can assume a receptacle or casing structure adapted to the packing and can be constructed with the aim of containing materials; further it is applicable to packs and packages of known type and already in existence, including in the form of overpacking.

[0011] According to the invention, this aim is attained through a mechanical and electronic sensor able to detect cuts and lacerations realised with the coupling of layers of materials of a known type, set in sequence with one another. Said sensor further comprises an electronic instrumentation of a known type that enables measuring the variation in fundamental and derived physical magnitudes among the various layers, over time, which variation is generated by the cut or laceration of the coupling of layers of materials of known type.

The objects indicated are substantially attained by a mechanical and electronic sensor according to what is described in the appended claims. Further characteristics and advantages of the present invention will more greatly emerge from the detailed description that follows of some preferred but not exclusive embodiments of a sensor illustrated in the appended drawings, in which:

Figure 1 is a schematic view of the circuit diagram of the mechanical and electronic sensor adapted to detect cuts and tampering by measuring the Voltage (Volts) applied to the layers.

Figure 2 is a schematic view of the circuit diagram of the mechanical and electronic sensor adapted to detect cuts and tampering by measuring the Resistivity (Ohms) applied to the layers (the resistance depends on some physical and geometrical characteristics of the conductor).

Figure 3 is a schematic view of the circuit diagram of the mechanical and electronic sensor adapted to detect cuts and tampering by measuring the Capacitance (Farads) applied to the layers with a comparative method (for this purpose a capacitive element known as a reference sample is used).

Figure 4 shows an axonometric view of the mechanical sensor according to the present invention;

Figure 5 shows a larger-scale axonometric view of the composition of the mechanical sensor according of claim 4.

[0012] With reference to the figures mentioned, reference numeral 1 denotes in its entirety a mechanical and electronic sensor for a security closure adapted to detect cuts or lacerations according to the present invention.

[0013] In particular, the sensor 1 comprises at least two layers of electrically conductive material 4 separated by an internal layer of electrically-insulating material 11. The layers of material are joined together to form a single body.

[0014] Further, the sensor 1 comprises an electronic circuitry 3 connected to each layer of electrically conductive material 4 and configured for detecting a variation of fundamental and/or derived electric magnitudes, between the two states of electrically conductive material 4, over time so as to detect a cut or laceration of the layers.

[0015] According to the present invention, the layer of electrically-insulating material 11 is made of an elastical-

ly-deformable material and is configurable between an original condition (in which it is swollen) and a crushed condition following cuts or lacerations in which the thickness of the material reduced relative to the preceding condition. In particular, the layer of electrically-insulating material 11 has a form memory so that it returns from a crushed condition towards an original condition so as to reset the initial state of the electrical magnitudes detected by the electronic circuitry 3 3.

[0016] In detail, the layer of insulating material 11 is of a spongey type and enables return thereof into the initial condition. In this way it is advantageously possible to return the two layers of electrically conductive material 4 into contact so as to reset the electrical magnitudes initially detected.

[0017] The layer of electrically-insulating material 11 is preferably made of expanded polyethylene and/or polypropylene.

[0018] Note that the sensor 1 has a casing shape adapted to contain and packing materials or objects or adapted to over-packing materials or objects already pre-packaged with other materials.

[0019] Alternatively, the sensor 1 can be in the form of a separating barrier for environments so as to detect an intrusion.

[0020] In any case, the sensor 1 is made in the form of a flexible and easy-to-handle surface made up at least of the above-cited layers.

[0021] In addition to the above-mentioned layers, the sensor 1 can comprise at least a layer of colourant or staining material so as to make cuts or lacerations visible.

[0022] As regards the layers of electrically conductive material 4, they are made in the form of a sheet. In detail, each sheet of electrically conductive material 4 is preferably made of aluminium.

[0023] By way of example, the layer of electrically conductive material 4 has a resistance of lower than 100 KOhm per metre.

[0024] In addition to what is described in the foregoing, the sensor 1 comprises a pre-identified zone in which it is possible to carry out an authorised opening of the closure. The electronic circuitry 3 is configured for detecting a predefined sequence of opening steps of the closure so as to recognise an authorised opening only if that sequence is respected.

[0025] As regards the electronic circuitry, it comprises a voltage generator between two heads 2 respectively connected to the layers of electrically conductive material 4 and a detector of electrical magnitudes (ammeter or voltmeter) in order to detect the variation (figure 1).

[0026] In figure 2, an alternative embodiment is illustrated in which the layer of electrically-insulating material 11 has a predefined resistivity of its own so as to generate a predefined passage of current between the layers. The electronic circuitry 3 is configured for detecting a variation of said predetermined passage of current so as to detect cuts or lacerations. In other words, in a case of cutting the resistive value changes as the materials come into contact or are interrupted.

[0027] In figure 3, a further and alternative embodiment is illustrated in which the layer of electrically-insulating material 11 is of a dielectric type so that the assembly of the layers of electrically conductive material 4 (which define the plates) and the layer of electrically-insulating material 11 form a condenser. The condenser is configurable between a pre-charged condition by the electronic circuitry 3 and a discharged condition, correlated to cuts or lacerations, which is detected by the electronic circuitry 3. In other words, in a case of cutting, the potential of the plates is modified and/or zeroed.

[0028] In any case, the number and composition of the layers (4,5,6,7,8) can vary; layers of known type can for example be used: conductive, semiconductive, dielectric, insulating, colourant/staining, layers composed of circuits and/or electrical coils, and others of known type.

[0029] For example, figure 5 denotes an example of composite layering in which the sensor 1 comprises a plurality of layers applied to one another and the electrical circuitry 3 is configured for comparing a plurality of electrical magnitudes contemporaneously. In this way it is advantageously possible to more accurately and precisely determine the cut of the sensor.

[0030] In other words, figure 5 represents the union of the single examples reported in figures from 1 to 3. In detail:

- The electrical potential is measured between the conductive layers 4 and 5 (figure 1);
- The electrical resistivity is measured between the conductive layers 5 and 6 (figure 2);
- The electrical capacitance is measured between the conductive layers 6 and 7 (figure 3).

[0031] The layer of electrically-insulating material 11 as described above is obviously present between the layers.

[0032] Further, it is possible to add further layers and further measurements of electrical magnitudes so as to detect the cut of the sensor 1.

[0033] It is further worthy of note that in order to realise the connection between the heads 2 of the electrical circuitry and the sheets of electrically conductive material 4, each electrically conductive layer 4 has a hole and a mechanical eyelet joint stretched about the borders of the hole at both surfaces of the layer of electrically conductive material 4 (a sort of rivet) so as to define a solid connecting point for the electrically circuitry 3.

[0034] Further, the sensor 1 comprises short and long-range transmission apparatus of a signal representing the variation of the electrical magnitudes in a case of cuts or lacerations. For example, the sensor 1 can comprise, by way of non-limiting example, RFID, GSM, GPS apparatus, etc., able to record and signal, including remotely, these variations in fundamental and derived physical magnitudes between the various layers. The functioning of the mechanical and electronic sensor 1 according to

the present invention is adapted to detect cuts and lacerations and is composed by layers of materials located in sequence one between another (heads 2) connected to a control system comprising electronic circuitry 3. In a case where an external element 10 lacerates the layers of materials located in sequence with one another (heads 2), said layers are cut, folded and in general modified 9 generating the variation of fundamental and derived physical magnitudes among the various layers, over time, which variation is detected by means of the control system comprising electronic circuitry 3 (3).

[0035] The present invention attains the set aims.

[0036] In particular, the present invention enables realising a sensor 1 in the form of a casing or barrier able to detect a cut or laceration and reset the original condition without replacing the whole sensor 1 so as to be able to proceed in detecting cuts or lacerations subsequent to the initial one.

Claims

1. A mechanical and electronic sensor (1) for a safety closure adapted to detect cuts and lacerations, comprising:

   - at least two layers of electrically conductive material (4) separated by an internal layer of electrically-insulating material (11); said layers of material being joined together for forming a single body;
   - an electronic circuitry (3) connected to each layer of electrically conductive material (4) and configured for detecting a variation of fundamental and/or derived electric magnitudes, between the two layers of electrically conductive material (4), over time so as to detect a cut or laceration of the layers;

   characterised in that the layer of electrically-insulating material (11) is made of an elastically-deformable material and is configurable between an original condition and a crushed condition following cuts or lacerations in which the thickness of the material is reduced relative to the preceding condition; said layer of electrically-insulating material (11) having a form memory so as to return from a crushed condition towards an original condition so as to reset the initial state of the electrical magnitudes detected by the electronic circuitry (3).

2. The sensor (1) according to claim 1, **characterised in that** it comprises a form of casing adapted to contain and packing materials or objects or adapted to over-packing materials or objects.

3. The sensor (1) according to claim 1, **characterised in that** it comprises a form of separating barrier for environments so as to detect an intrusion.

4. The sensor (1) according to any one of the preceding claims, **characterised in that** it comprises: at least a layer of colourant or staining material so as to make cuts or lacerations visible.

5. The sensor (1) according to any one of the preceding claims, **characterised in that** the layers of electrically conductive material 4 are made in the form of a sheet.

6. The sensor (1) according to claim 5, **characterised in that** each sheet of electrically conductive material (4) is made of aluminium.

7. The sensor (1) according to any one of the preceding claims, **characterised in that** each layer of electrically conductive material (4) has a resistance of lower than 100 KOhm per metre.

8. The sensor (1) according to any one of the preceding claims, **characterised in that** it comprises a pre-identified zone for carrying out an authorised opening of the closure.

9. The sensor (1) according to any one of the preceding claims, **characterised in that** the electronic circuitry (3) is configured for detecting a predefined sequence of opening steps of the closure so as to recognise an authorised opening.

10. The sensor (1) according to any one of the preceding claims, **characterised in that** the electronic circuitry comprises a voltage generator between two heads (2) respectively connected to the layers of electrically conductive material (4) and a detector of electrical magnitudes for detecting a variation thereof.

11. The sensor (1) according to claim 10, **characterised in that** the layer of electrically-insulating material (11) has a predefined resistivity of its own so as to generate a predefined passage of current; said electronic circuitry (3) being configured for detecting a variation of said predefined passage of current so as to detect cuts or lacerations.

12. The sensor (1) according to claim 10, **characterised in that** the layer of electrically-insulating material (11) is of a dielectric type so that the assembly of the layers of electrically conductive material (4) and the layer of electrically-insulating material (11) form a condenser; said condenser being configurable between a pre-charged condition by the electronic circuitry (3) and a discharged condition, detected by the electronic circuitry (3).

13. The sensor (1) according to any one of the preceding

claims, **characterised in that** each layer of electrically conductive material (4) has a hole and a mechanical eyelet joint stretched about the borders of the hole at both surfaces of the layer of electrically conductive material (4) so as to define a connecting point for the electrically circuitry (3).

14. The sensor (1) according to any one of the preceding claims, **characterised in that** it comprises short and long-range transmission apparatus of a signal representing the variation of the electrical magnitudes in a case of cuts or lacerations.

15. The sensor (1) according to any one of the preceding claims, **characterised in that** the layer of electrically-insulating material (11) comprises expanded polyethylene and/or polypropylene.

Fig. 1

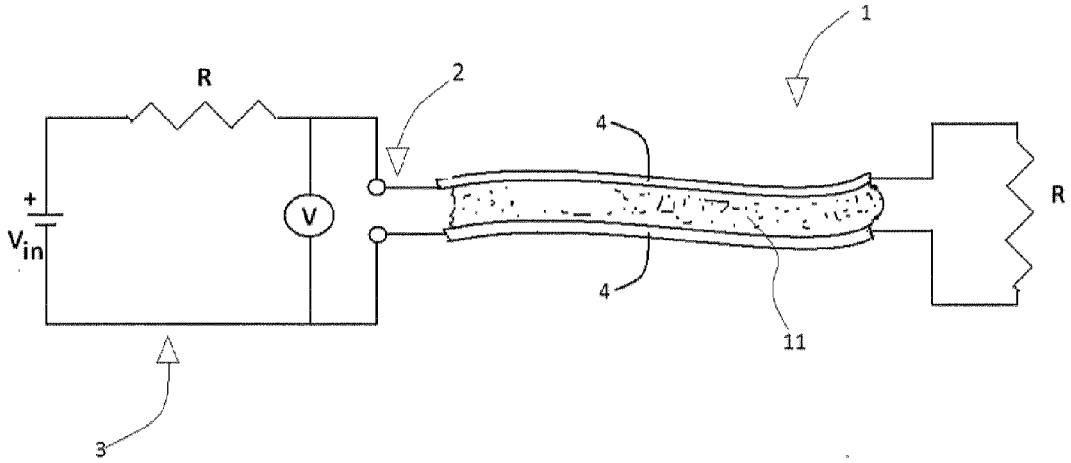


Fig. 2

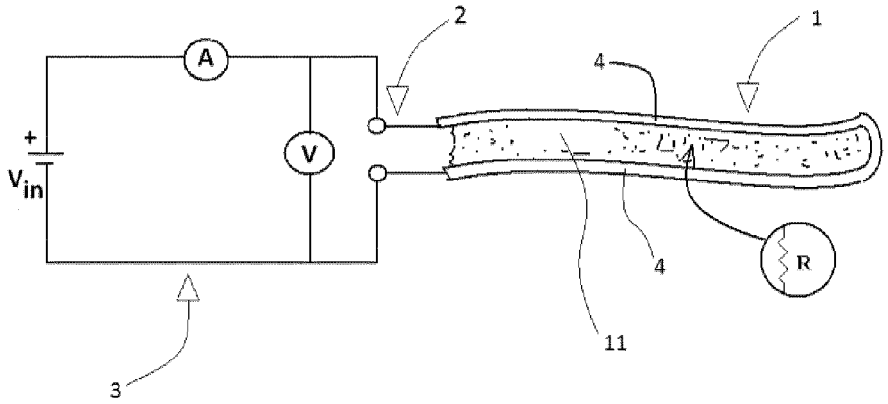
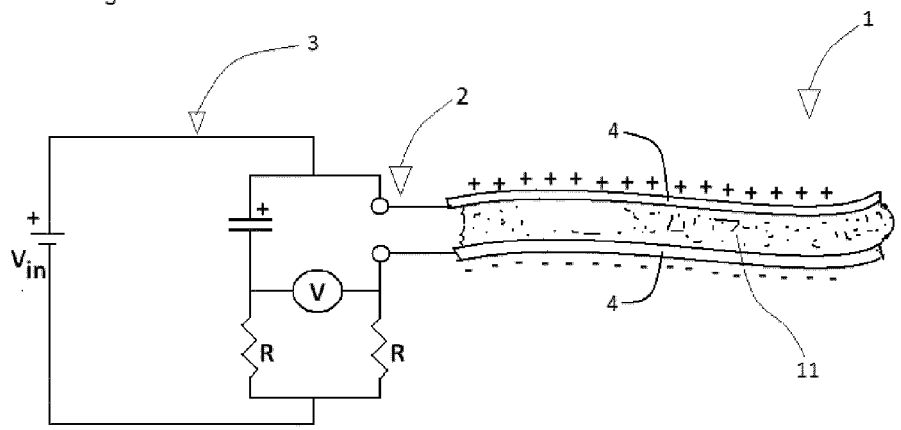


Fig. 3



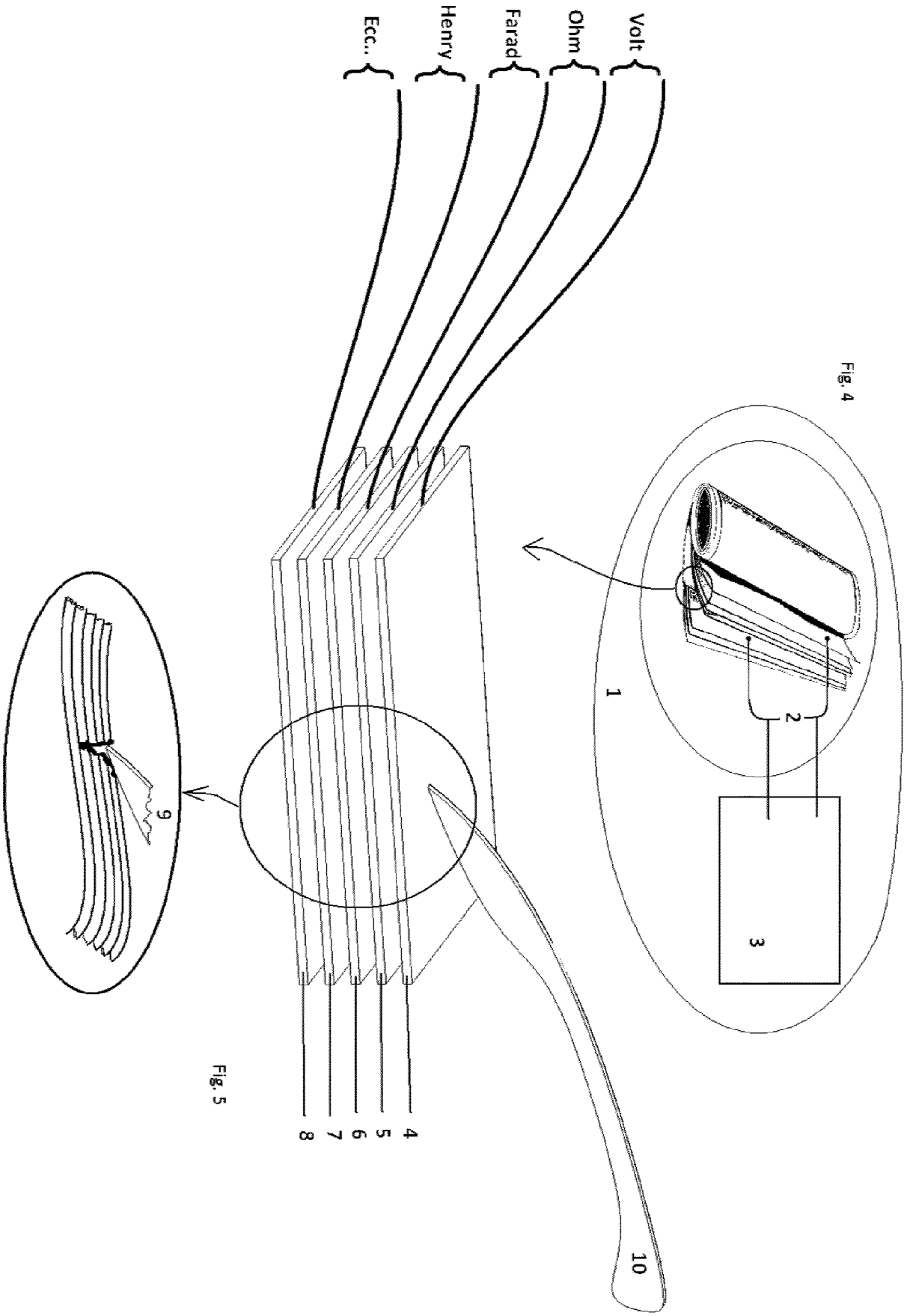


Fig. 4

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 16 20 4312

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	15 February 2017	Balz, Oliver

CATEGORY OF CITED DOCUMENTS

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