EN

EUROPEAN QUALIFYING EXAMINATION 2023

Paper A

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Client’s letter

Dear Ms Vande,

[001] Our company sells healthcare devices to doctors and the general public. We are specialised in wearable devices for treating skin wounds and other skin problems.

[002] It is known that the application of an electric field to a skin wound accelerates its healing. When an electric field is applied to a skin wound, cell regrowth is stimulated and necrotic tissue is destroyed. On the basis of this finding, we developed and sold for several years a special plaster (see our granted patent D1 in attachment) containing a battery and capable of applying an electric field to the skin.

[003] The device of D1 is effective, yet it presents problems in so far as the battery can fall off if the plaster becomes deformed due to body movement. Furthermore, the battery makes the plaster bulky and difficult to use on curved skin surfaces. We wish to patent a new device wearable on the skin which does not rely on a battery for applying an electric field to the skin and thus overcomes these issues. We came up with the idea of exploiting the deformations of the plaster to generate the electric field.

[004] The invention is based on the well-known "triboelectric effect", according to which electricity is generated upon friction between two objects. Fig. 1(a) shows a typical arrangement for obtaining the triboelectric effect. It comprises a first copper sheet 2a, which is electrically conductive, and a layer 15 of Teflon (trade name of polytetrafluoroethylene or PTFE), which is electrically insulating and has a tendency to capture electrons. The Teflon layer 15 is attached to a second copper sheet 2b. The triboelectric effect occurs when a mechanical action makes the first copper sheet 2a adhere to and separate from the Teflon layer 15. In the adhesion phase (Fig. 1(b)), electrons from the surface of the first copper sheet 2a are captured by the surface of Teflon layer 15. In the separation phase (Fig. 1(c)), the electrons remain attached to the Teflon layer 15. Therefore, the first copper sheet 2a and the Teflon layer 15 respectively acquire positive (+) and negative (-) electrical charges. As a result, a voltage appears between the copper sheets 2a, 2b as if a battery were present.

[005] The attached publication D2 shows an example of a wearable device using the triboelectric effect for sensing muscular activity. The device of D2 is quite bulky however and still requires a battery.

[006] In summary, the triboelectric effect transforms a mechanical action into a voltage, which in turn generates an electric field. Surprisingly, we found that the triboelectric effect induced in a wearable device by movement of the body wearing the device can generate an electric field sufficient for healing wounds without requiring a battery.

[007] Fig. 2(a) shows schematically in cross-section a first example of our invention. This device 14, which is wearable on the skin, has the shape of a plaster and includes a substrate 1 made of PET, a first copper sheet 2a and a second copper sheet 2b, both attached to the top face of the substrate 1. A Teflon layer 15 is attached to one end 3b of the second copper sheet 2b. The first copper sheet 2a comprises one end 3a, which is not fixed to the substrate 1. The end 3a overlays the Teflon layer 15 and is able to adhere to and separate from said layer 15 when the substrate 1 is deformed. As in the product of D1, the bottom face of the substrate 1 comprises two copper layers 4a, 4b acting as first and second electrodes and forming a gap 8. The first electrode 4a and the second electrode 4b are electrically connected respectively to the first copper sheet 2a and the second copper sheet 2b via electrical wires 5a and 5b extending through the substrate 1. Adhesive layers 7 are also provided underneath the substrate 1.

[008] In use (Fig. 2(b)), the plaster 14 is attached to the skin 11 by the adhesive layers 7 so that the wound 13 is located in proximity to the gap 8. The plaster 14 is flexible and deforms through movement of the body or muscle contractions, as schematically indicated by the arrows in Fig. 2(b). Upon deformation of the substrate 1, the end 3a of the first copper sheet 2a adheres to and separates from the Teflon layer 15. By means of the triboelectric effect, the first copper sheet 2a becomes electrically charged. A voltage appears between the first and second copper sheets 2a, 2b and, due to the electrical connection, also between the first and second electrodes 4a and 4b. Consequently, an electric field E (dashed lines) is generated in the gap 8. Therefore, when the plaster 14 is worn on the skin 11, the electrodes 4a, 4b are arranged so as to apply the electric field E to the skin.

[009] In principle, any pair of electrically conductive elements separated by a gap functions as electrodes generating an electrical field in the gap when subject to a voltage. Therefore, we have devised another example of the invention shown schematically in Fig. 3. In this device 16, which is also wearable on the skin, the first and second copper sheets 2a, 2b are folded around the substrate 1 and extend along the bottom face of the substrate 1 forming the gap 8. The electrodes 4a, 4b are formed by the ends of the copper sheets 2a, 2b at the gap 8, which are therefore arranged so as to apply an electric field to the skin as in the previous example. The necessary electrical connection between each of the electrodes 4a, 4b and the respective copper sheets 2a, 2b is provided by the copper sheets themselves: no wires are needed.

[010] A third example of our invention, schematically shown in cross-section by Fig. 4, is a device 17, wearable on the skin, having the shape of a bandage and particularly suited for wounds on body parts such as arms, wrists or legs. The shape and the flexibility of the bandage 17 allow it to be held in place around these body parts by elastic force without adhesives. In this example, the substrate 1 is a strip of PET bent into a closed shape, e.g. to form a circle. A first copper sheet 2a is attached to an inner face of the substrate 1 and a second copper sheet 2b is attached to an outer face of the substrate. A Teflon layer 15 is attached to one end 3b of the second copper sheet 2b. The first copper sheet 2a and the second copper sheet 2b are thus attached to opposite faces of the substrate 1, wherein the substrate is bent so that one end 3a of the first copper sheet 2a overlays the Teflon layer 15. Upon deformation of the substrate, this end 3a of the first copper sheet 2a adheres to and separates from the Teflon layer 15. The other end of the first copper sheet 2a acts as the first electrode 4a. The second electrode 4b is provided as a copper layer on the inner face of the substrate 1 and is electrically connected to the second copper sheet 2b via the wires 5. The first and second electrodes 4a, 4b form the gap 8.

[011] In use, the bandage 17 is applied, e.g. around the wounded arm, so that the wound is located in proximity to the gap 8. Muscle contractions of the arm cause the substrate 1 to deform. Upon deformation of the substrate 1, the end 3a of the first copper sheet 2a adheres to and separates from the Teflon layer 15. Due to the triboelectric effect, as in the previous examples, an electric field E (dashed lines) is generated in the gap 8 between the electrodes 4a, 4b. Therefore, when the bandage 17 is worn on the skin, the electrodes 4a, 4b are arranged so as to apply the electric field E to the skin.

[012] In slight modifications of the examples shown above, it is not one end 3a of the first copper sheet 2a that adheres to and separates from the Teflon layer 15 but another part of the first copper sheet 2a. Similarly, the Teflon layer 15 may be attached to other parts of the second copper sheet 2b as long as the first copper sheet 2a is able to adhere to and separate from the Teflon layer 15 upon deformation of the substrate 1. The devices of our invention may be made in shapes other than a plaster or a bandage provided that they are wearable on the skin.

[013] Instead of PET, other materials are suitable for the substrate 1 as long as the substrate is flexible and electrically insulating so as to avoid a short circuit between the first and second copper sheets 2a, 2b. These sheets 2a, 2b may be made of other electrically conductive materials, e.g. of aluminium or other metals but, for reasons of compactness and flexibility, must be in the form of sheets. Teflon is a known triboelectric material. Other known triboelectric materials suitable for the layer 15 are Kapton (trade name of poly (4,4'-oxydiphenylene-pyromellitimide)) and polydimethylsiloxane (PDMS). The electrodes 4a, 4b may be made of the same electrically conductive material as the sheets 2a, 2b or of a different electrically conductive material.

[014] We tested the device of Fig. 2(a) with different choices of materials. The time for healing a wound was found to depend on the choice of the materials for the triboelectric layer 15 and for the electrically conductive sheets 2a,2b, as reported in the following table:

	Copper	Aluminium	Zinc
Teflon	48 hours	120 hours	72 hours
Kapton	40 hours	100 hours	66 hours
PDMS	95 hours	150 hours	110 hours

Similar results are also expected with the other examples of our invention. Without application of the device, the wound took approximately 200 hours to heal. The best results were obtained with Teflon or Kapton and with copper or zinc. A particularly advantageous combination was found in Kapton and copper. We have further tested electrodes made of a silver layer, whose antibacterial properties provided a further improvement. It is furthermore possible to coat the electrodes with an antibacterial composition.

[015] The devices of our invention have proven effective not only for healing wounds but also for smoothing skin wrinkles, for which the effect of an electric field is known. In this cosmetic use, a device of our invention is worn on intact wrinkled skin. When worn on intact wrinkled skin, the device has no therapeutic effect but only the cosmetic effect of smoothing out the wrinkles. Especially for this use, it is advantageous to apply the electric field to a relatively large area of the skin. For this purpose, the invention may include electrodes having the shape shown in Fig. 5 (view from above), which are known in the art as "inter-digitated electrodes". These electrodes have a gap 8 extending over a large area and thus provide the desired effect.

[016] Please draft a set of claims and an introductory part of the description for a European patent application to protect our invention, also with regard to its uses. It should be assumed that the drawings accompanying this letter will form part of the application. Unfortunately, we have no financial budget for claims fees or for further patent applications.

Best regards,

Dr Graaff

Client's drawings

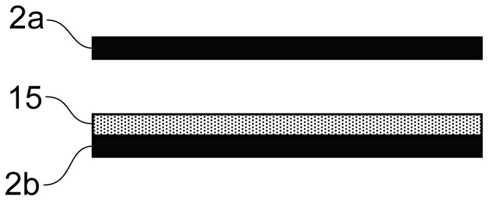

Fig. 1(a)

Fig. 1(b)

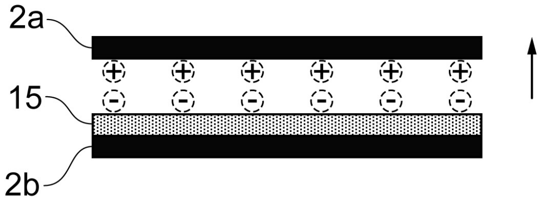

Fig. 1(c)

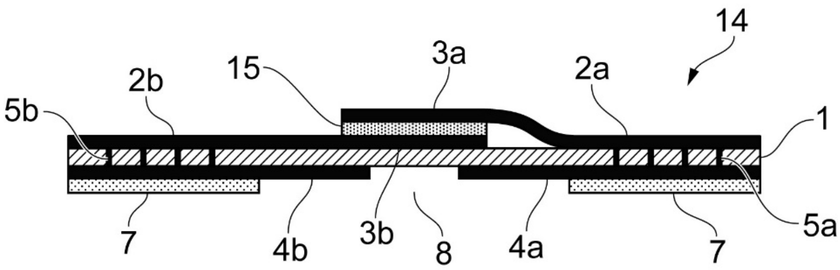

Fig. 2(a)

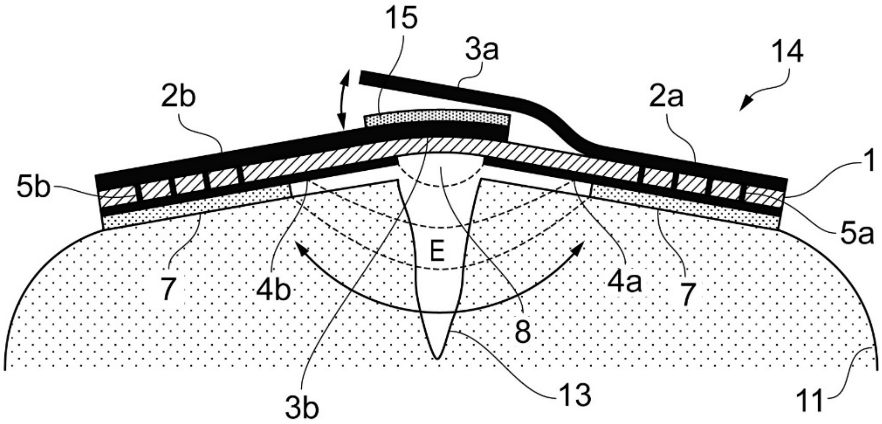

Fig. 2(b)

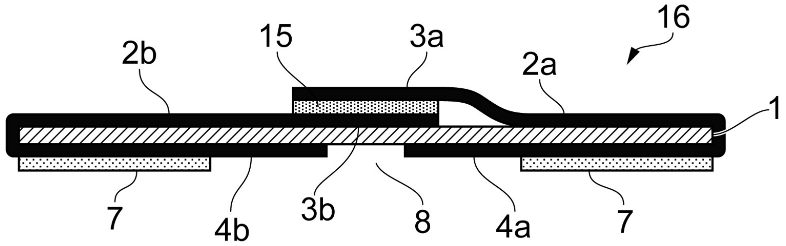

Fig. 3

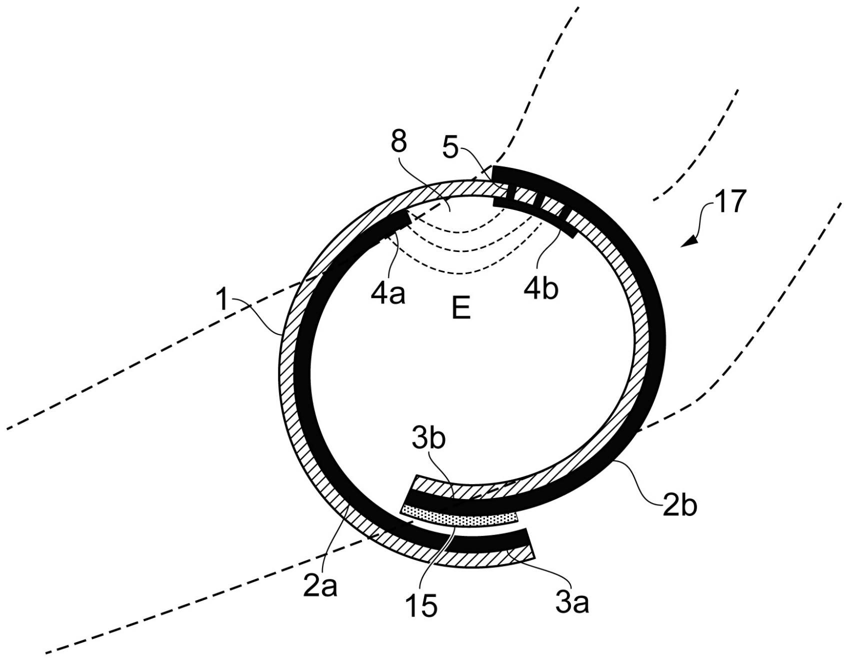

Fig. 4

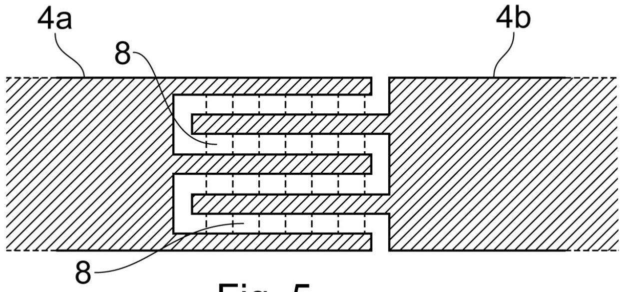

Fig. 5

Document D1: EP11071982 - Electric plaster

[001] The present invention, shown schematically in Fig. 1, is a device 18 wearable on the skin, having the shape of a plaster and capable of applying an electric field to a skin wound for accelerating the healing of the wound. It comprises a substrate 1 of PET, a flexible and electrically insulating material, a first copper sheet 2a and a second copper sheet 2b, both attached to a top face of the substrate 1. One end 3a of the first copper sheet 2a is not fixed to the substrate 1 so that a button-shaped battery 6 can be held in a space between the two copper sheets by the elastic force of the first copper sheet 2a. The bottom face of the substrate 1 comprises two copper layers 4a, 4b acting as first and second electrodes and forming a gap 8. The first and second electrodes 4a, 4b are electrically connected respectively to the first and second copper sheets 2a, 2b via wires 5a, 5b extending through the substrate 1. When the battery 6 is inserted, the voltage of the battery is applied across the copper sheets 2a, 2b and, via the electrical connection, also across the electrodes 4a and 4b. When the voltage of the battery is applied across the electrodes 4a, 4b, an electric field E (dashed lines) is generated in the gap 8. Adhesive layers 7 are also provided underneath the substrate 1.

[002] In use (see Fig. 2), the device 18 of the invention is attached to the wounded skin 11 by the adhesive layers 7 so that the wound 13 is located in proximity to the gap 8. Therefore, when the device 18 is worn on the skin 11, the electrodes 4a, 4b are arranged so as to apply an electric field E (dashed lines) to the skin. This electrical field accelerates the healing of the wound 13.

[003] Claim

1. A device (18) wearable on the skin and having the shape of a plaster, comprising:

a substrate (1) made of PET,

first (2a) and second (2b) copper sheets attached to the top face of the substrate (1) so that a battery (6) can be held in a space between the first (2a) and second (2b) copper sheets, characterised by:

first (4a) and second (4b) electrodes made of copper layers, electrically connected respectively to the first (2a) and second (2b) copper sheets by wires (5a, 5b), and arranged so as to apply an electric field to the skin (11) when the device is worn on the skin.

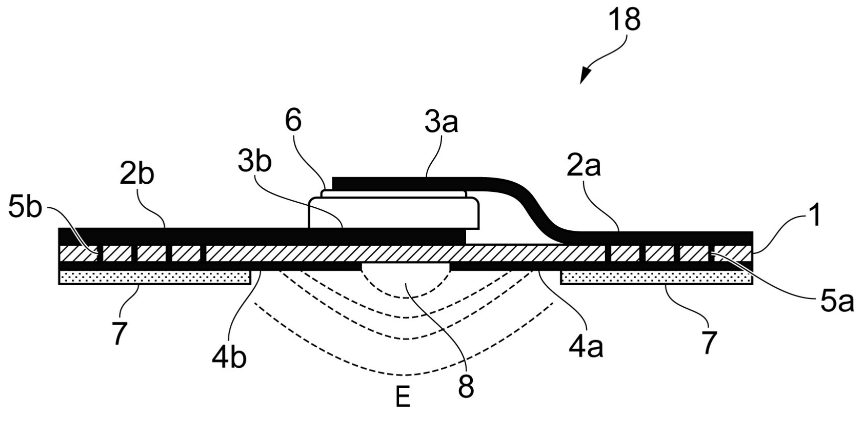
18
6
3a
3b
2b
2a
5b
1
5a
7
4b
4a
7
8
E

Fig. 1

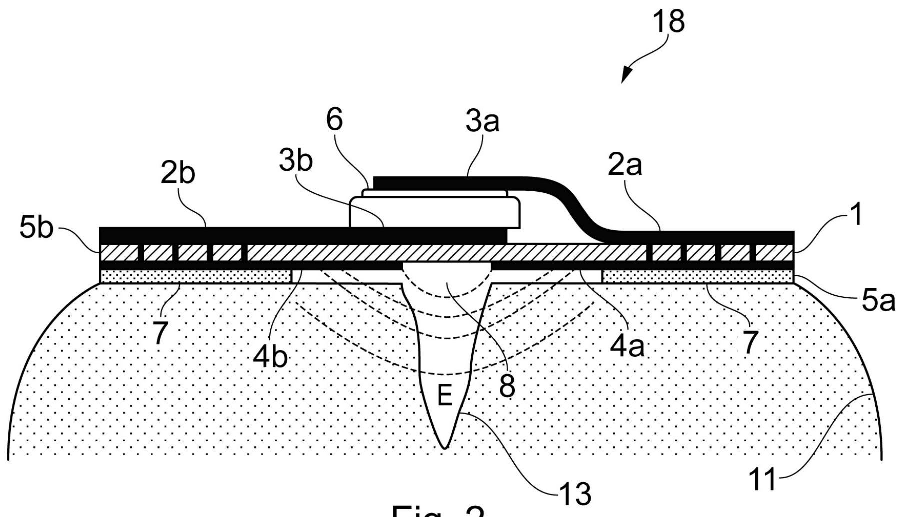
18
6
3a
3b
2b
2a
5b
1
5a
7
4b
4a
7
8
E
13
11

Fig. 2

Document D2: Muscular activity sensor

[001] Record your daily exercise with our new wearable sensor ! Our sensor (Fig. 1) comprises a soft rubber pad 6 that can be worn directly on the skin. Inside the rubber pad, an elastic and electrically insulating substrate 1 supports two thin aluminium sheets 2a and 2b. These sheets are longer than the substrate and extend into cavity 7, forming a gap 8. In the cavity 7, a layer 3 of Kapton is attached to the sheet 2b. Kapton is a material with triboelectric properties. The aluminium sheets are connected by wires 4 to a microchip 5 capable of transmitting a radio-frequency signal. The microchip 5 is powered by a replaceable battery (not shown).

[002] The sensor can be worn on the skin using an armband or a sock. Wearing the sensor is comfortable because the rubber pad is thick enough to avoid the skin coming into contact or proximity with the metallic sheets 2a, 2b and the substrate 1. Our special rubber pad also provides a full electrical shield between the skin and the electrical parts. During exercise, a muscular contraction causes the compression (see the arrow in Fig. 2) of the rubber pad 6 and of the substrate 1 so that the aluminium sheet 2a adheres to the triboelectric layer 3 (Fig. 2). Upon relaxation, the aluminium sheet 2a separates from the triboelectric layer 3 (Fig. 3) and becomes electrically charged due to the triboelectric effect so that a small voltage arises between the sheets 2a and 2b. When the microchip 5 detects this voltage between the sheets 2a and 2b, it transmits a radio-frequency signal to your smartphone via Bluetooth™. A dedicated smartphone app records the received radio-frequency signal and thus determines how much muscular exercise you have had.

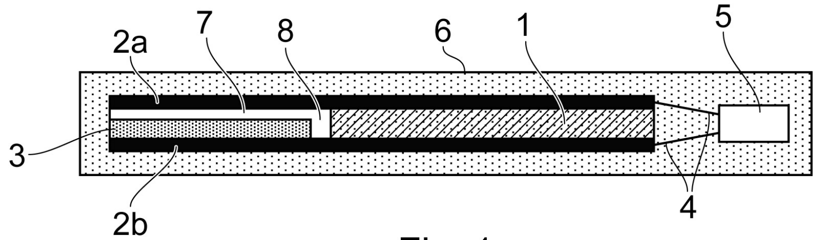

Fig. 1

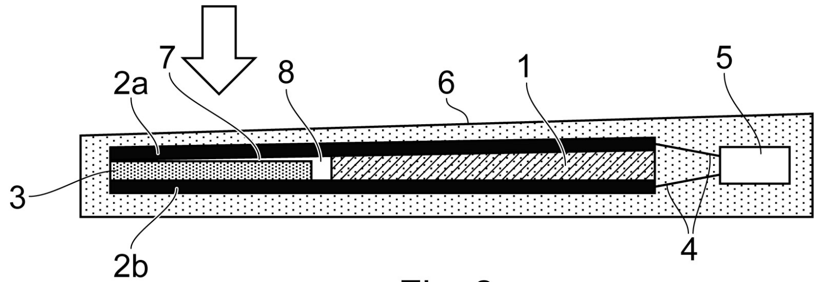

Fig. 2

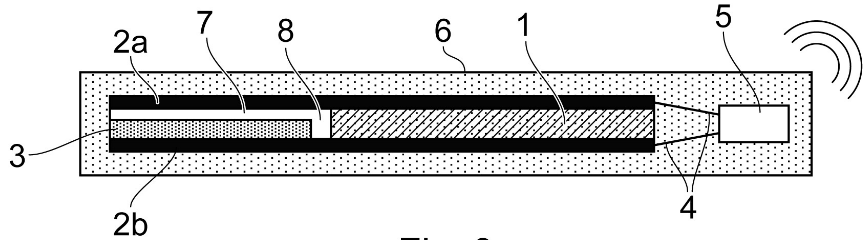

Fig. 3