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Description

[0001] The invention relates to a device having a heatable surface of homogeneous heat distribution, comprising a highly electrically conductive non-woven fabric, which comprises electrically insulating fibres and electrically conductive fibres, a control device, by means of which a voltage is adjustable, to ensure the current flow in the device that is necessary to achieve the desired heating output; cables, by means of which the contact to the control device can be produced for data exchange and/or signal exchange and/or to supply the nonwoven fabric with electrical energy; and the density of the electrically conductive fibres is so high that, when a voltage is present, a current flow arises.

[0002] As electrical conductors, media are designated that can be used for the transport of electrically charged particles and can be constructionally realized with the use of conductive components, such as metals, such as copper, silver, steel but also carbon and polymers Thus, electrical conductors in the form of textiles manufactured from electrically conductive fibres can be realized, which are used in a wide range of fields of application, such as, for example, electrically operated textile heating surfaces, which have a relatively low constructional height and are therefore particularly to be recommended for direct laying below floor coverings such as carpets, tiles and laminate. Such heating surfaces are therefore suitable not only for application in residential building, but are also used as industrial heating surfaces in trade fair, sales and sports halls. With the systems available today, however, there is the problem on one hand that the technology employed or the material used is not suitable for a full surface or a large surface. On the other hand, some technologies or materials are susceptible to kinking, are not flexible or are too soft for an application of this kind.

[0003] The use of conductive fibres in a nonwoven is characterized by the fact that it is flexible and permits adequate homogeneous conductivity. However, such nonwovens are usually used as electromagnetic compatibility (EMC) protection and as discharge textile. These nonwovens do not show adequate stability of the electrical property profile.

[0004] Nevertheless, in the prior art some nonwovens with electrically conductive requirement profile are known, such as for example those in use as heating element. An electrically conductive nonwoven of this generic type is disclosed in the utility model DE 20 2011 100 936 U1, which describes a heating textile comprising a nonwoven composite. The properties of the nonwoven composite material are defined such that an areal heat output is made possible, wherein this is foldable, drapable, breathable and washable. The nonwoven composite material is incorporated as a layer with electrically conductive fibres between the cover layers, the electrical conductivity of the heating textile being in contact with carbon fibres. As a result, this material is outstandingly suitable for applications in the fields of clothing and surface heating.

[0005] Because of the very flexible design of the nonwoven composite material, however, this is not suitable for application as a nonwoven for heating large surface, since it lacks mechanical and chemical stability.

[0006] The application document (Offenlegungsschrift) DE 199 11 519 A1 discloses a resistance surface heater based on an electrically conductive nonwoven material based on glass/carbon fibres with self-extinguishing or non-flammable protection films. Contacting takes place by means of self-adhesive electrodes based on copper. However, it is a problem here that a nonwoven material based on glass fibre is used, which drastically increases the areal weight of the nonwoven fabric. Because of the high costs for laying this nonwoven material, it is only of limited suitability for use in large areas.

[0007] The utility model DE 20 2013 006 258 U1 discloses an electrically conductive nonwoven with homogeneous heat distribution, which is positioned on the surface to be heated and is contacted at an appropriate point. Contacting takes place such that the contact resistance between the electrical contact and the conductive textile is as low as possible in order to avoid energy losses. The described nonwoven is fixed by means of adhesive, conductive binders. In the case of the disclosed nonwoven, however, there is the problem that a binder is necessary, which makes the manufacture and laying of a nonwoven difficult and thereby leads to higher costs.

[0008] The application document (Offenlegungsschrift) WO 2007 110 06 181 A1 discloses a cellulose spun-bonded area heater. With an operating voltage up to 1000 V, an output up to 2 kW per square meter is achieved with a modular, contiguous contacted area unit of 1 m length x 1 m width. The area heater is characterised by a low manufacturing outlay and good utility properties. The unusual voltage level, with its high insulation requirements, results in an only minimal achievable surface resistance of the structure of 500 ohm for the aforementioned area.

The disclosed cellulose spun-bonded fabric is designed as a small-area heating system on a large surface for spot heating, which, because of the high heating output heats and/or dries the entire room. This nonwoven is thereby not suitable for use as a large-area heating system.

[0009] The electrically conductive nonwoven materials described in the prior art are, however, not only suitable for manufacturing a large-area surface heating, since the number of contact points of the electrically conductive fibres is all the greater the larger the distance between the two poles. The result of this is that the applied voltage is distributed to a large number of contact points and consequently only a small voltage is present at the individual contact point. Since the electrically conductive fibres can inevitably corrode and/or oxidize on their surface, high resistances may occur, which may be so high that the current flow is interrupted. A certain minimum voltage on one contact point is thus necessary to maintain the current flow. If the voltage is so low that the electrical line is interrupted, the useful purpose is ended. The experience is gained that with increasing duration of the use, a change of the resistance between adjacent fibres occurs, which is manifested in a sudden increase in the electrical resistance. This phenomenon is known and is described as “fritting”. In such a case, that is to say a case in which “fritting” occurs, the voltage must be increased to such an extent that it “breaks down” the insulation caused by corrosion and/or oxidation, in order to restore a current flow.

[0010] There is a large demand on a highly electrically conductive nonwoven, which maintains the heating of a large area and overcomes the aforementioned problems. In addition, the nonwoven is to remain fully functioning with large dimensions. In particular, solving the problem of "fritting", which describes the irregular sudden fluctuations in electrical resistance caused by variable contact resistances. Taking into account “fritting” offers the advantage that, to produce the desired heating performance, the application of electrical high voltage is unnecessary, but only a comparatively low voltage is required, which is not dangerous to adult humans and normal applications. This has significant advantages for safety aspects, as well as economic aspects.

[0011] The object of the invention is thus to provide a device with heatable surface of homogeneous heat distribution, comprising a highly electrically conductive nonwoven fabric, which, despite the low supply voltage, ensures a homogeneous heat distribution over the entire surface.

[0012] Furthermore, this device can be quickly and easily adapted to different sizes, as well as being economical to manufacture and install, and durable. Another object of the invention is to provide such a device with a low areal weight in order to ensure a wide application scope thereof.

[0013] This object is achieved by the device with heatable surface of homogeneous heat distribution with the features of the independent claim.

In particular in that, to increase the heating performance at a particular applied voltage, the operating voltage, the control unit briefly increases the voltage by the voltage surge "ΔU_1", subsequently returning to the initial voltage, for the case in which the actual value of the heating output still lies below the setpoint value, the control unit generates another voltage surge "ΔU_2" from the control unit generated by the control unit, wherein "ΔU_2" is larger than "ΔU_1", for the case in which the actual value of the heating output still lies below the setpoint value, the control unit generates another voltage surge "ΔU_3" from the control unit, wherein "ΔU_3" is larger than "ΔU_2", and for the case in which the actual value of the heating output still lies below the setpoint value, the above-described steps must be repeated n times, wherein the voltage surge "ΔU_n" is larger than "ΔU_i", where i = 1 to (n-1).

[0014] A device with heatable surface of homogeneous heat distribution, comprising an electrically highly conductive nonwoven fabric, which comprises electrically insulating fibres and electrically conductive fibres with adequate density, a control unit and lines is proposed.

[0015] The control unit changes the electrical property profile of the nonwoven fabric, the electrical conductivity of the nonwoven fabric being increased and/or the electrical resistance of the nonwoven fabric being reduced. The control unit does not regulate the nonwoven fabric via a voltage change in the sense that the operating voltage is adapted to the desired heating output. In the general case, such a control takes place by means of a sensor, which measures physical parameters, such as, for example, the temperature and the voltage and thereby the current flow required to achieve the desired heating output is increased or reduced respectively.

[0016] The control unit according to the invention changes the resistance of the nonwoven fabric in that the control unit briefly and stepwise increases the voltage via the operating voltage, until the operating voltage ensures the current flow required to achieve the desired heating output in the nonwoven fabric. Due to the brief increase of voltage via the operating voltage of the nonwoven fabric, that is to say via a voltage surge, “break down” occurs and the formation of bridges, so that the conductivity of the nonwoven fabric consequently increases or the resistance of the nonwoven falls. After the brief increase of the voltage, the control unit regulates it again to the operating voltage, so that at the same operating voltage the heating output of the nonwoven fabric is increased. This is based on the fact that, due to the voltage surge via the operating voltage of the nonwoven fabric, the contact points that have not yet “broken down”, which are still oxidized and/or corroded, break down and generate a conductive bridge. By this means, the conductivity of the nonwoven fabric is increased.

[0017] It is subsequently determined whether the brief increase of the voltage via the operating voltage of the nonwoven fabric is sufficient to ensure the current flow in the nonwoven fabric necessary to achieve desired heating output.

[0018] If that is not the case, the control unit, via a new voltage surge, briefly and stepwise increases the voltage via the operating voltage of the nonwoven fabric. The voltage of the new voltage surge in this case is higher than the preceding voltage increase. The control unit according to the invention changes the resistance of the nonwoven fabric in that the control unit briefly and stepwise increases the voltage via the operating voltage, until the operating voltage ensures the current flow required to achieve the desired heating output in the nonwoven fabric.

[0019] Here, it was found that in the nonwoven fabric according to the invention, in the case of fixed installation, that is to say with no mechanical movement, the effect of “fritting” and the necessity for “break down” only occurs once for a particular corroded and/or oxidized contact point. In the nonwoven fabric, stainless steel fibres, in particular stainless steel fibres, are used, which present an oxidation-free material. However, because of the large number of contact points between the steel fibres, at which a minimum oxidation and/or corrosion layer can occur, a large number of resistances, which in the end effect are configured chaotically in series and in parallel with one another. The effect of this minimum layer on an individual contact point is not measureable individually, but in total over the entire length of the nonwoven fabric. The problem of “fritting” thus only occurs and becomes measurable in that, in the entire nonwoven fabric, a large number of contact points occur, whereby, in turn, a large number of series and parallel resistances is generated.

[0020] Within the scope of the invention, it was discovered that, after the “break down” of the corroded and/or oxidized contact points of the fibres by means of an applied "breakdown voltage”, these contact points are activated in that, at precisely these “broken down” contact points, a type of plasma discharge and microwelding takes place, wherein conductive bridges are generated, which contribute to a significant increase of the current flow. That is to say that, by virtue of the “break down” and the generated bridges, the electrical property profile of the nonwoven fabric is changed, wherein the electrical conductivity of the nonwoven fabric is increased or the electrical resistance of the nonwoven is reduced.

[0021] In the case of a flexible installation, that is to say after the "breakdown", the applied voltage is reduced and, insofar as the nonwoven fabric is moved and/or mechanically loaded, it can occur that the contact points corrode and/or oxidize gain or the conductive bridges mechanically break up again. This can of course also occur during the ageing process of the nonwoven fabric.

[0022] By virtue of the large number of fibres that contact one another in the nonwoven fabric, the current flow occurs. Due to Ohm's Law, the entire voltage applied to the device is not present between adjacent fibres, but only a fraction thereof. As a rule of thumb, the voltage at adjacent fibres (neglecting the different electrical resistance in each case) is all the smaller the larger the number of transitions between the adjacent poles. It is determined by the distance of the electrical poles that are connected to the nonwoven fabric and serve for the current supply. For the same nonwoven fabric composition, the number of transitions will be larger than with a large distance between poles and vice versa.

[0023] Against the background of developing a device comprising an electrically highly conductive nonwoven fabric with low insulation requirements for use as a larger-area surface heating, “fritting” should not be prevented. Rather, it is provided that, by means of the control unit, a corresponding voltage is adjustable and controllable at the surface formed by the highly conductive nonwoven fabric, which is ensures a current flow in the device necessary for achieving the desired heating output. In principle, a corroded contact functions like a diode in blocking operation. Firstly, the resistance is so high that no current can flow. As from a particular “breakdown voltage”, the resistance collapses and the current can flow again. This “breakdown voltage” is at least 13 mV, preferably however 24 mV to 30mV. The current flow persists until the voltage falls below a particular (different) voltage again. In the end effect, the nonwoven changes its current intensity because of the large number of electrical contacts, and thereby the heating output changes in dependence on the supply voltage.

[0024] To reach a current flow of the desired heating performance in the nonwoven fabric at all, a sufficient density of the fibres contained in the nonwoven fabric is necessary. The sufficient density of the fibres contained in the nonwoven fabric, in particular of the electrically conductive fibres, it is necessary so that the latter can at least partly contact one another, and thereby a current flow can occur at all. The minimum fibre density is a steel content, in particular of stainless steel, of at least 7.5 vol. % in the entirety of the nonwoven fabric, to ensure a homogeneous current flow at all. Understandably, a higher steel content in the entirety of the nonwoven fabric is also conceivable.

[0025] In the most general case, the duration of the individual voltage surge is in the scope of the invention generally arbitrary. Practical tests have shown, however, that the duration of an individual voltage surge should be chosen such that it amounts to at least one millisecond, how maximum three seconds. As explained at the outset, by increasing the voltage a “breakdown” occurs and consequently the formation of an electrically conductive bridge between fibres, which are interrupted at relatively low voltages and thereby are not electrically conductive. The formation of a bridge has the consequence that this newly created current path continues in the manner of a ramification and in this way creates additional current paths, which arise in multiple and successive sequence. Essentially, it is a matter of effecting a cascade-like propagation of bridges over the entire surface of the nonwoven fabric. The formation of bridges does not take place simultaneously but chronologically in sequence, which requires a certain time. Experiences show that, with a voltage surge with a duration of less than one millisecond, the successive formation of bridges and consequently the formation of multiple current paths stops. On the other hand, measurements have shown that a time span of max. 3 seconds is completely sufficient for the formation of ramifications, even with relatively large surfaces and distances between the electrode poles. Longer voltage surges do not require an improvement and increase of the transmitted current intensity. For this reason, it is recommended that the duration of the voltage surface be chosen from the proposed time interval.

[0026] During the stepwise impacting of the nonwoven fabric with brief voltage surges, only those bridges are formed or those transitions activated for which breakdown occurs within the voltage interval, which can be bridged by the level of the voltage surge. The formation of further and additional bridges, on the other hand requires a surge with a higher voltage value. The stepwise increase of the voltages with the successive voltage surges leads to the formation of ever more bridges, and consequently of a higher conductivity or of a lower resistance of the nonwoven fabric and the formation of higher voltage strengths. After application of a particular number of voltage surges, the electrical resistance is so low that, for a return to the operating voltage, the current flow or the heating output will be greater than desired, the actual value thus comes to lie above the setpoint value. The lower the gap of the voltage surge from the preceding voltage surge, that is to say the difference is as low as possible, the small the exceeding of the actual value will be. The lower the voltage gap of adjacent voltage surges will be, the more precisely it will be possible to approach the actual value. The required accuracy of the application or the tolerable measurement errors provide an interval around the actual value in which the setpoint value is required to subsequently lie. With a large interval, the voltage values of adjacent successive voltage surges can be greater, so that the control operation is completed in fewer steps than if a very narrow value range is specified for the actual value. The increasing voltage values from control step to control step and success applied voltage surges are all the smaller in terms of their difference the higher the requirements on the accuracy of the desired actual value. Vice versa, with low requirements on the accuracy of the voltage difference of adjacent voltage surges, the deviations from the actual value can be correspondingly greater.

[0027] The term "device having a heatable surface of homogeneous heat distribution" relates to a device that comprises an electrically operated, heatable element and can be adapted to a size of less than 1m^2 to several 100 m^2. The device is preferably flame retardant and/or flame resistant in design.

[0028] In the most general case, the device comprises a highly electrically conductive nonwoven fabric, a control unit and cable, which can easily be mounted on the surface to be heated. That is to say that the device can be, for example, laid on, mounted on, laminated on bonded on, sewn to, needled and//or calendered on to the surface or integrated into the surface to be heated. The cables generally have to fulfil different functions. They serve for supplying the nonwoven fabric with electrical energy, which is emitted from the control unit in a defined manner. Additional lines for data and signal exchange are present, via which the corresponding information, starting from the nonwoven fabric, can be transferred further to the edge region and there undergoes a corresponding processing. Thus, for example, the application of a temperature sensor within the nonwoven fabric can serve for checking whether the heating output applied by means of the control unit corresponds to the desired value. If the temperature is too low, the control unit can be made capable of increasing the heating output or the supplied current in the sense described within the scope of the invention. The measured value of the temperature sensor must not inevitably be used the actuating the control unit, but can also be used exclusively for displaying and transferring the corresponding information via the temperatures. But also the use of sensors of a different type, which are used, for example for registering moisture content, pressure and/or extension, in which it is necessary to guide the measurement data via signal or data lines to a receiving or display unit. The device is preferably a surface heater with homogenous heat distribution in order to avoid irregularities in the heating of the surface. The surface heater emits the heat directly via the surfaces to be heated and/or indirectly via adjacent components, for example of a building, to its environment and is measurable in such a way that it is either integrated into the complete surface or only into a portion of the surface and covers it. A surface heater is suitable for heating any arbitrary surfaces, such as, for example, wall, ceiling, or roof and/or floor surfaces and/or for heating any arbitrary components of a building. For example, the surface heating is a wall heating, ceiling heating, roof heating, flooring and/or component heating.

[0029] In an advantageous embodiment, the device is lightweight and has an areal weight of maximum 1,000 g/sqr, in order to serve a broad application range. The “Square (sqr)” is a non-metrical area measurement, wherein 1 sqr. is a square area with a lateral length of 10 foot, that is to say 9.290304 square meters. Even more preferably, the device has an area weight of maximum 450g/sqr, 400g/sqr, 350g/sqr, 300g/sqr, 250g/sqr or 200g/sqr. Most preferably of maximum 190g/sqr, 180g/sqr, 170g/sqr, 160g/sqr, 150g/sqr, 140g/sqr, 130g/sqr, 120g/sqr, 110g/sqr or 100g/sqr. Most of all the areal weight of the nonwoven fabric is maximum 160 g/sqr.

[0030] The term “highly electrically conductive nonwoven fabric” relates to a structure of fibres of any kind and any origin, which in any desired manner have been joined together to form a nonwoven fabric and connected to on another in any desired manner. Such nonwoven fabrics or nonwovens are for the most part flexible areal structures, that is to say they are readily flexible, their main structural elements are fibres and they have a comparatively low thickness compared to their length and width. The structure of the nonwoven fabric is arbitrary, wherein a normally structured nonwoven fabric has an elevated strength and an open structured nonwoven fabric is especially suitable for a needling process. The nonwoven fabric is preferably flame retardant and/or flame resistant in design.

[0031] The nonwoven fabric according to the invention comprises a high proportion of stainless steel fibres, in particular stainless steel fibres, wherein a high degree of mechanical and chemical stability is provided. Additionally, the nonwoven fabric is designed such that it is light resistant and weathering resistant and stable in the long term, that is to say stable over a period of at least 1 year, 2 years, 3 years or 4 years. Even more preferably, the nonwoven fabric is stable over a period of at least 5, 10, 15, 20 or more years.. Furthermore, the nonwoven fabric is flexible and uniformly highly electrically conductive on average based on the area.

[0032] The term “cables” relates to cables by means of which the contact, in particular the electrical contact, to the control device can be produced for data exchange and/or signal exchange and/or to supply the nonwoven fabric with electrical energy. The data and/or signal exchange and the current/voltage supply can take place via a line or a cable.

[0033] The cables are preferably light resistant and weathering resistant and chemically stable. The basic component is therefore a low-reactive metal and/or a low-reactive metal alloy.

[0034] The term “control unit” relates to an electronic unit for controlling the voltage and current intensity in the device. In a preferred variant, the control of the voltage and of the current is regulated depending on the data and/or signal exchange from the nonwoven fabric and/or from external sensors.

[0035] Preferably the voltage and therefore the current flow to the control unit can be manually and/or automatically adjusted. In the case of automatic control of the voltage, the device regulates itself, which is additionally connected to and/or integrated in a control system for self-regulation and/or self-evaluation. It lies within the scope of a person skilled in the art, to produce a control unit designed in this way.

[0036] In a further developed, a d.c. voltage or a.c. voltage is applied to the control unit. Preferably, however, an a.c. voltage is applied, since the use of a.c. voltage additionally offers the advantage that polarization effects and/or electrochemical processes on the electrodes are avoided.

[0037] Advantage embodiments of the invention that are realised individually or in combination are described in the subclaims.

[0038] In another further development, the control unit regulates the current flow that is required to achieve the desired heating output by means of amplitude modulation and/or modulation of the pulse width in the case of square pulses.

[0039] By the term “amplitude modulation” is here meant, in the sense of the invention, a process in which the voltage applied to the control unit is interrupted phase-by-phase and the energy and power transmission is reduced in that the control unit is repeatedly switched on and off. In this manner, the energy supplied to the nonwoven fabric from the control unit is emitted pulse-wise, wherein pauses are in each case present between the pulses. The longer the pauses between the pulses, the lower is the transmitted energy quantity.

In the scope of the invention, it is thereby conceivable that the voltage applied to the control unit and the nonwoven fabric is constant,. Wherein the transmission power is increased or reduced by the pauses. It is conceivable to lengthen or shorten the impulse length with respect to the pause length, or vice versa. An amplitude modulation of the control in this manner is important for the safety system, since it leads to an increase in the recognisability of fault currents. The safety system serves for fire prevention.

[0040] By the term “modulation of the pulse width in the case of square pulses” is understood a type of modulation in which a technical parameter, such as, for example, the electrical voltage changes between two values, that is to say a minimum and a minimum, in a square pulse.

[0041] By means of the pulse width modulation, the signal is switched on and off again, wherein the gaps between switching on and off can be modulated. Depending on whether heating is to be continuous and/or the heating nonwoven fabric is to be switched on at particular intervals for certain duration, the heating output or the energy changes over time. In this manner, it is achieved that the output of the control unit can be control by changing the gaps.

[0042] In some embodiments, the nonwoven fabric comprises electrically insulating fibres and electrically conductive fibres, which are light resistant and weathering resistant and chemically stable. Furthermore, all fibres are preferably water absorbent. The electrically conductive fibres are either bare metal fibres or metal-coated fibres with an electrically insulating core, wherein the cores are coated with a metal, in particular silver, and/or a polymer and/or are electroplated polymer fibres. The jump/rebound of the contact resistance between the individual fibres, which indicates a change in the transmission property or transmission resistance can thus be sufficiently reduced by the addition of additives to the fibre material, for example silver or silver fibres. The metal used is preferably a low-reactive metal and/or a low-reactive metal alloy.

[0043] By modification of the mixing ratio of conductive coated/electroplated polymer fibres and metal fibres, an individual conductivity can be achieved.

[0044] The nonwoven of the invention if very readily conductive or highly conductive, so that outputs preferably in an order of magnitude of 1 to several kW/m^2 can be achieved with a supply voltage of only 42 volt alternating voltage. The alternating voltage is SELV (safety extra-low voltage).

[0045] Because of the current/voltage characteristic curve, large-area applications of the nonwoven fabric are possible, such as, for example, heaters in the floor, ceilings and/or wall area. This ensures a heating and/or drying of rooms, and deicing in outdoor areas, for example of bridges, roads, entrances, traffic systems, aircraft, commercial vehicles and/or roofs.

[0046] The nonwoven fabric is additionally breathable, by which means moisture can directly pass through the nonwoven fabric and surfaces can thus be rapidly dried. Because of the breathability, the nonwoven fabric is also suitable for use as a room air freshener in filter systems, wherein the through-flowing air is heated, purified and/or ionised.

[0047] The electrical contact resistance is preferably in the milliohm range. The surface resistance of the nonwoven is preferably between 1 – 1,000 ohm/sqr.

[0048] For the realization of high current densities, a very good contacting is necessary, in particular within the nonwoven fabric and between individual nonwoven fabrics. It is also important that the resistance of the connection contacts is also low, since otherwise the supply voltage has to increase.

[0049] The cables are integrated in the weft and/or warp direction in a woven fabric, in which strands, wires, conductive yarns, and /or conductive threads are woven.

[0050] The nonwoven fabric preferably forms at least two layers. The woven fabric is disposed between the layers of the nonwoven fabric.

[0051] The current flow preferably runs horizontally through the nonwoven fabric, that is to say the positive and negative poles are disposed in the same plane of the nonwoven fabric. The positive and negative poles are hereby disposed at a certain spacing from one another, preferably at an ideal spacing of e.g. 50cm. Of course, the chosen spacing may also be smaller or larger than the aforementioned spacing. The positive pole is preferably disposed on one edge of the nonwoven fabric and the negative pole is disposed at the opposite edge. To heat a large area, it is thus necessary for a plurality of nonwoven fabric to be laid side by side and contacted with one another. With a continuation of the aforementioned orientation of the nonwoven fabric, the positive and negative poles are alternately reversed. It is important here that the electrodes have the same distance from one another, so that the partial resistances of the nonwoven fabric sections are the same.

[0052] Alternatively, the current flow runs vertically through the nonwoven fabric, that is to say the positive and negative poles are disposed in different horizontal layers of the nonwoven fabric.

[0053] The fabrics with the integrated cables is preferably in areal contact with the nonwoven fabric and/or connected thereto. Due to the mechanical, chaotic metal-metal contacting of the individual fibres, an electrically conductive network with mechanically temporarily stable contacting bridges is formed.

[0054] Preferably the strands and or wires woven into the woven fabric are additionally needled, stitched, calendered and/or flame treated during the nonwoven fabric manufacturing process in order to permit optimum contacting. Here, the strands and/or wires of the woven fabric are directly contacted with the electrically conductive fibres in the needling process in that they penetrate the electrically conductive supply lines and make optimum use of the surface of the feeder cables. In the needling process, it is important that the nonwoven fabric has an open structure so that it is not destroyed during needling. The needles permit an optimum contacting between the fabric and the nonwoven fabric, since the conductive fibres are transported out of the open-structured nonwoven fabric into the woven fabric. The contacting can be fixed by further process steps, such as, for example, calendaring, flame treatment, needle loom finish, and/or laminating.

Alternatively, the fabric is contacted to the nonwoven fabric by means of the conductive yarns and/or conductive threads. Of course, the contacting can also take place in that a combination of strands, wires, conductive yarns, and/or conductive threads are used. Complete contacting of the entire surface can thereby be realized and a maximum contacting area can be achieved.

[0055] By the addition of additives to the fibre material, for example silver or silver fibres, an electrical basic network is created, which can be fixed in further process chains. In this manner, a cross-sensitivity of the nonwoven fabric can be adjusted, which is defined during manufacturing. The fixing or cross-sensitivity to moisture, pressure and/or stretching is performed, for example, by means of calenders, flame treatment, needle loom finish and/or laminating of films or by means of powder coating. Cross-sensitivity for lines concerning the data and/or signal exchange and/or actuating components can be eliminated in this case. Because of the mixing ratio of the electrically conductive metal fibres and the silver fibres, the selectivity can be defined in addition to the process chain.

[0056] The nonwoven fabric is additionally a sensor nonwoven fabric, wherein it is adjustable to a specified cross-sensitivity. The nonwoven fabric consequently responds to a change of the state with a change of the surface resistance at the surface and/or at the volume resistivity. In this manner, by compression of the nonwoven fabric, its compression hardness has been selectively adjusted by means of the areal weight and further process steps, such as, for example, calenders, the conductive materials have been compressed and the electrical properties of the nonwoven fabric have been changed. This change can be influenced as a function of the compression hardness. That is to say that, with a nonwoven fabric of this structure, designs as pressure sensors and/or force sensors are conceivable. Such a nonwoven fabric with the property profile of a pressure sensor serves, for example, for intelligent monitoring and/or intercommunication of floor systems. This permits an anonymous, large-area monitoring of activities on a surface.

[0057] The same applies for the case of extension of the nonwoven fabric, in which similar effects occur. The important thing here is the targeted setting, based on the elongation, of the characteristic values of the electrical property profile of the nonwoven fabric.

[0058] The nonwoven fabric is preferably water repellent and/or comprises water-absorbent fibres and/or treatment. The electrical property profile of the nonwoven fabric can here be influenced as a function of the moisture content by absorption or emission of water. In addition, a measurement of the moisture content is possible, wherein, in the case of a sensor, the nonwoven fabric only responds to a physical parameter with a known cross-sensitivity.

Large-area moist sensors localize and/or quantify moisture damage and/or actively prevent the latter by heating of the surface. This is appropriate for the monitoring of large areas, such as, for example, halls, dam walls and/or roof constructions. Advantageously, the monitoring takes place over the entire surface, that is to say not pointwise, wherein the installation or insertion of the nonwoven fabric is very simple, rapid and inexpensive.

[0059] In the scope of the present invention, it is also conceivable that different sensor nonwovens are combined with one another, so that the nonwoven, in its entirety, has the property profile of a temperature sensor, pressure sensor and/or moisture sensor.

[0060] It is assumed that the definitions and explanations of the aforementioned terms apply for all the aspects described in this description, unless otherwise stated.

[0061] Further details, features and advantages of the invention can be taken from the following description of the preferred embodiment in conjunction with the subclaims. Herein, the respective features can be realized independently or severally in combination with one another. The invention is not limited to the exemplary embodiments. The exemplary embodiments are illustrated diagrammatically in the figures. The same reference numerals in the individual figures designate elements that are the same or functionally the same, or which correspond to one another as regards their function.

[0062] In detail, the figures show:

Figure 1 shows the construction of the highly electrically conductive nonwoven fabric with the lines;.

Figure 2 shows a fabric of the lines in the weft and/or warp direction.

Figure 3 shows a woven fabric of the lines in the multilayer construction between two layers of the highly electrically conductive nonwoven fabric.

Figure 4 shows the voltage profile on application to the nonwoven fabric.

[0063] Figure 1 shows, in a diagrammatic isometric representation, the construction of the highly electrically conductive nonwoven fabric (101) with the lines (110), by means of which the electrical contact to a control unit for data and/or signal exchange and/or supply of the nonwoven fabric (101) can be produced by means of electrical energy. The cables (110) can be integrated in the weft and/or warp direction in a woven fabric (111), and are light, weathering and chemically stable. The fabrics (111) with the integrated cables (110) is preferably in areal contact with the nonwoven fabric (101).

[0064] The nonwoven fabric (101) comprises a high proportion of stainless steel fibres, wherein a high degree of mechanical and chemical stability is provided. Additionally, the nonwoven fabric is light resistant and weathering resistant and stable in the long term, that is to say stable over a period of at least 5 years. The nonwoven fabric (101) is furthermore flame retardant and/or flame resistant in design, as well as flexible and uniformly highly electrically conductive over its entire surface. The nonwoven fabric (101) is additionally breathable, by which means moisture can directly pass through the nonwoven fabric (101).

[0065] The nonwoven fabric (101) comprises electrically insulating fibres (103) and electrically conductive fibres (104), which are light resistant and weathering resistant and chemically stable. The electrically conductive fibres (104) are either bare metal fibres or metal-coated fibres with an electrically insulating core, wherein the cores are coated with a metal, in particular silver, and/or a polymer and/or are electroplated polymer fibres.

[0066] The highly electrically conductive nonwoven fabric (101) achieves outputs of an order of 1 to a multiplicity of kW/m^2 with a supply voltage of only 42 volt a.c., which is regarded as not potentially harmful for adult humans and normal applications. The nonwoven fabric (101) thus offers many advantages from safety aspects. In addition a variety of applications of the nonwoven fabric (101) are thereby opened up, for example heaters in the floors, ceilings and/or wall area, heating and/or drying of rooms and deicing in the exterior area

[0067] The nonwoven fabric (101) is additionally a sensor nonwoven fabric, wherein it is adjustable to a specified cross-sensitivity by the addition of highly conductive additives to the fibre material, such as, for example silver or silver fibres, in that an electric base network is realized, which can be fixed in further process chains. In this manner, a cross-sensitivity of the nonwoven fabric (101) can be adjusted during manufacturing. The nonwoven fabric (101) thus has the property profile of a temperature sensor, pressure sensor and/or moisture sensor. Although, in the case of a sensor, the nonwoven fabric (101) only responds to a physical parameter with a known cross-sensitivity, a nonwoven fabric (101), however, can be realized in which different sensor nonwoven fabric s (101) can be combined with one another, so that the nonwoven fabric (101), in its entirety, has a plurality of property profiles.

[0068] Figure 2 shows a schematic isometric representation of the woven fabric (111) with the integrated cables (110) in the weft and/or warp direction (112, 113), which are light resistant and weathering resistant and chemically stable. Into the woven fabric, strands, wires, conductive yarns, and /or conductive threads are woven.

[0069] Figure 3 shows, in a diagrammatic representation, the device (100) according to the invention, comprising the woven fabric (111) with the integrated lines (110), in multilayer construction between two layers (102) of the highly electrically conductive nonwoven fabric (101), the control unit not being illustrated. The device (100) according to the invention can be easily applied to a surface to be heated and, in this case, is very lightweight with an areal weight of maximum 160g/sqr.

[0070] It can be clearly seen that the nonwoven fabric (101) forms two layers (102), in which the cables (101) in the fabric (111) are disposed between the layers (102) of the nonwoven fabric (101). The current flow preferably runs horizontally through the nonwoven fabric (101), that is to say the positive and negative poles are disposed in the same layer (102) of the nonwoven fabric (101), or run vertically through the nonwoven fabric (101), that is to say the positive and negative poles are in different layers (102) of the nonwoven fabric (101)..

[0071] The nonwoven fabric (111) with the integrated cables (110) is in full-area contact with the nonwoven fabric (101), so that because of the mechanical, chaotic metal-metal contacting of the individual fibres, a highly electrically conductive network with mechanically temporarily stable contacting bridges is formed. During the nonwoven fabric manufacturing process, the strands and or wires woven into the woven fabric (111) are additionally needled, stitched, calendered and/or flame treated with the fibres (103, 104) or the conductive yarns and/or conductive threads are contacted with the nonwoven fabric (101). The enables optimum contacting.

[0072] Figure 4 shows a diagram of the voltage profile during voltage application of the device according to the invention for generating a low electrical resistance. As ordinate, the voltage U is plotted and as abscissa, the time t. Starting from an operating voltage U_0, a voltage surge ΔU_1 is briefly given to the device. Here, ΔU_1 is that voltage that lies above the operating voltage during the first voltage surge and exceeds it by the given value. After the applied voltage, with the ending of the voltage surge, which in a simplification represented was here as a rectangle, has returned back to the operating voltage U_0, a check is carried out as to whether the existing current flow that is now present is adequate at the operating voltage U_0 to produce the desired heating output. As soon as this is not the case, the application with the second voltage surge takes place, wherein the peak value of the voltage now lies above the value of the first voltage surge, that is to say that ΔU_2 is greater than ΔU_1. Then the prerequisites are provided that additional bridges for increasing the conductivity can develop.

[0073] After termination of the second voltage surge by returning to the operating voltage U_0, a further check then takes place about whether a corresponding current intensity is present. This is then negated in the example shown in the drawing and two further voltage surges are additionally applied in the above-described manner. Nevertheless, the magnitude of the voltage surge of the next step must be larger than that of the preceding steps, sin on in such a case is there hope of forming additional electrically conductive bridges.

With the conclusion of the fourth voltage surge a current intensity is then achieved, which corresponds to the desired value, the actual value.

As a result, by the proposed measures, with uniform operating voltage U_0, a higher current intensity is realized. In contradiction to the prevailing concept that, when a higher current intensity is required the voltage must be correspondingly raised, the invention takes a completely different approach, that, in its essential gist, has the content that, to increase the heating output, reducing the electrical resistance. This is made possible in an electrical method by means of the steps described in the invention.

List of Reference Characters

[0074]

100 Device according to the invention

101 Highly electrically conductive nonwoven fabric

102 Layers of the nonwoven fabric

103 Electrically insulating fibres

104 Electrically conducting fibres

110 Cables

111 Woven fabric

112 Weft direction of the cables

113 Warp direction of the cables

Patentkrav

1. Apparat med opvarmelige flader med homogen varmefordeling omfattende

- et elektrisk let ledende skindmateriale (101), som omfatter elektrisk isolerende fibre (103) og elektrisk ledende fibre (104),
- et styreapparat, ved hjælp af hvilket en spænding er indstillelig med henblik på at sikre en til opnåelsen af den ønskede varmeydelse benyttet strømtæthed i apparatet,
- ledninger (110), ved hjælp af hvilke kontakten til styreapparatet er etablerbar til en data- og/eller signaludveksling og/eller en forsyning af skindmaterialet (101) med elektrisk energi, og
- tætheden af de elektrisk ledende fibre er så høj, at ved påført spænding etableres der en strømtæthed, **kendetegnet ved,** at
- til øgningen af varmeydelsen ved en bestemt påført spænding, driftsspændingen, øger styreapparatet korttidigt spændingen med spændingsstødet ”ΔU_1” for efterfølgende at vende tilbage til udgangsspændingen,
- i det tilfælde, at varmeydelsens arbejdsværdi ikke som før ligger under den nominelle værdi fremstiller styreapparatet et nyt spændingsstød ”ΔU_2”, hvorved ”ΔU_2” er større end ”ΔU_1”,
- og i det tilfælde, at varmeydelsens arbejdsværdi stadigvæk ligger under den nominelle værdi fremstiller styreapparatet et nyt spændingsstød ”ΔU_3”, hvorved ”ΔU_3” er større end ”ΔU_2”,
- og i det tilfælde, at varmeydelsens arbejdsværdi som før ligger under den nominelle værdi, gentages ovennævnte trin n gange, hvorved spændingsstødet ”ΔU_n” er større end ”ΔU_1” hvor i = 1 (til n-1).

2. Apparat ifølge krav 1, **kendetegnet ved,** at varigheden af det enkelte spændingsstød ligger i tidsintervallet fra mindst 1 ms til max. 3 sek.

3. Apparat ifølge krav 1 eller 2, **kendetegnet ved,** at spændingsstødenes difference $\Delta U_i - \Delta U_{i-1}$ vælges så lille, at for det tilfælde at varmeydelsens nominelle

værdi overskrides, ligger den på grund af det senest gennemførte spændingsstød opnåede arbejdsværdi i et på forhånd givet område over den nominelle værdi.

4. Apparat ifølge et af de foregående krav,
kendetegnet ved, at styreapparatet regulerer den til opnåelsen af den ønskede varmeydelse benyttede strøm ved hjælp af amplitudemodulation og/eller modulation af pulsbredden ved firkantimpulser.

5. Apparat ifølge et af de foregående krav,
kendetegnet ved, at skindmaterialet (101) er vandafvisende og/eller omfatter vandabsorberende elektrisk isolerende fibre (103) og elektrisk ledende fibre (104) og/eller udrustninger.

6. Apparat ifølge et af de foregående krav,
kendetegnet ved, at skindmaterialet (101) omfatter mindst to lag (102).

7. Apparat ifølge et af de foregående krav, **kendetegnet ved,** at ledningerne (110) er integreret i skud- og/eller kæderetning (112, 113) i et vævet materiale (111), hvorved det vævede materiale (111) er anbragt imellem skindmaterialets (101) lag (102).

8. Apparat ifølge et af de foregående krav,
kendetegnet ved, at de elektrisk ledende fibre (104) er blanke metalliske fibre eller metallisk belagte ikke-ledende fibre.

9. Apparat ifølge det foregående krav, **kendetegnet ved,** at de metallisk belagte ikke-ledende fibre (104) er belagt med et metal, især sølv, og/eller et plastmateriale og/eller er galvaniserede plastfibre.

10. Apparat ifølge et af de foregående krav,
kendetegnet ved, at skindmaterialets (101) er et sensorisk skindmateriale, hvorved dette er indstilleligt på en fastlagt tværfølsomhed.

11. Apparat ifølge det foregående krav, **kendetegnet ved,** at skindmaterialet (101) har en temperaturføler, trykføler og/eller fugtighedsføler.

12. Apparat ifølge et af de foregående krav, **kendetegnet ved,** at apparatet (100) er indrettet til at kunne anbringes på en flade, der skal opvarmes.

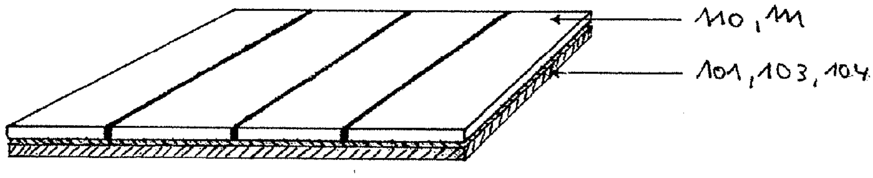

Fig. 1

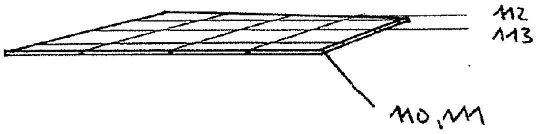

Fig. 2

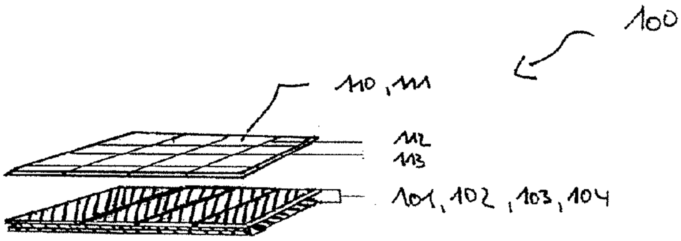

Fig. 3

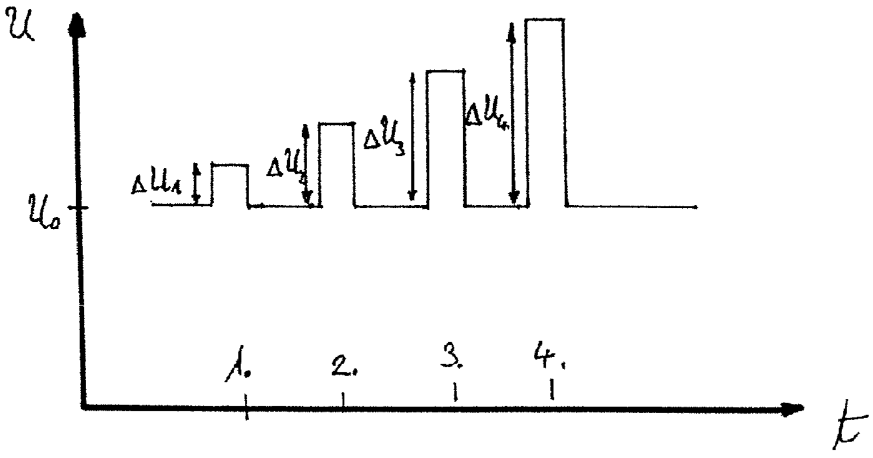

Fig. 4