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(54) Infrared shielding and radar attenuating textile material

(57) The material consists of a distance fabric (1) made up of a first textile layer (2), a second textile layer (3) and spacer yarns (4) extending from the first to the second textile layer. The first and the second textile layers have radar attenuating properties and the distance fabric is free of any conductive layer having a surface resistivity smaller than 50 W/sq. Compared to the known two-dimensional radar attenuating textile materials a more effective radar attenuation can be achieved without having to use a closed material. The first and the second textile layers (2, 3) of the distance fabric (1) have indeed an open texture comprising openings (5) of between 2 and 400 mm² which form at least 25% of the surface of the first and respectively the second textile layer. Due to the aeration of the textile material, an infrared reflecting layer is not required to avoid a too strong heating of the textile material thus providing an effective infrared shield without requiring any layer which is highly reflective for radar radiation.

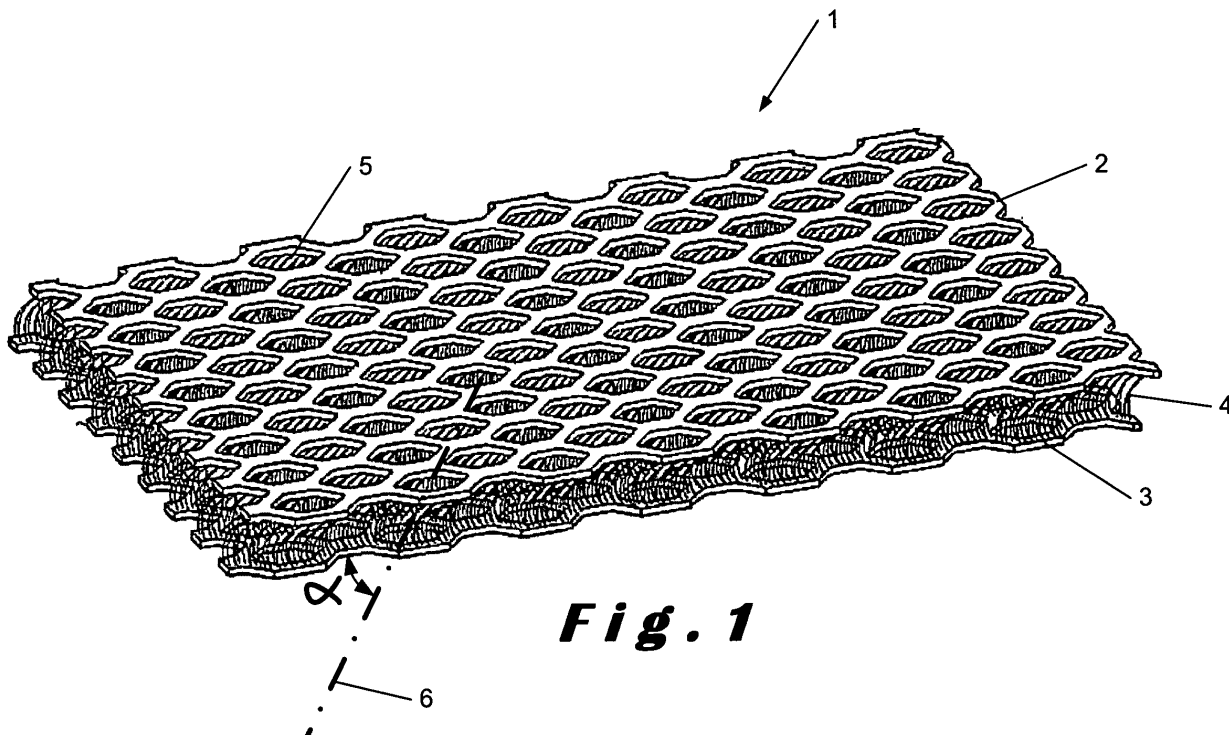


Fig. 1

Description

[0001] The present invention relates to an infrared shielding and radar attenuating textile material comprising a distance fabric made up of a first textile layer, a second textile layer facing the first textile layer and spacer yarns extending from the first to the second textile layer and vice versa to link the first and the second textile layers to one another and to keep them at a predetermined distance from one another.

[0002] EP-A-0 367 091 discloses a textile material, more particularly a tarpaulin, which comprises a three dimensional fabric, at least one surface of which is provided with a radar absorbent layer and/or with an infrared reflecting layer. The three dimensional fabric is a woven fabric comprising two woven external layers which sandwich a support fabric. In one embodiment, this support fabric consists only of cross-filaments supporting the external textile layers and forms thus a so-called distance fabric, more particularly a woven distance fabric.

[0003] In order to achieve an infrared camouflage EP-A-0 367 091 teaches to provide at least one of the external surfaces of the textile material with an infrared reflecting coating, in particular with a non-emitting paint. A disadvantage of such paints is however that non-emitting paints, or even low emissivity paints, are difficult to produce in camouflage colours since low emissivity paints tend indeed to be silvery and highly specular visually. A further important drawback of such paints is that they have a significant impact on radar absorbent material (RAM) performance, i.e. they significantly increase the reflection of radar waves due to their content of radar reflective material, e.g. metals.

[0004] For achieving a radar camouflaging tarpaulin EP-A-0 367 091 teaches to provide at least one of the external layers with a radar absorbent layer. This coating layer is made of a synthetic resin pigmented with carbon black or fibres and may moreover contain magnetic powders or pigments and magnetic spherical iron oxide granules. It provides an impermeable screen absorbing high frequency electromagnetic radiation over a wide frequency band. At the same time the tarpaulin would also provide, to a certain extent, an insulation against heat radiation emitted by the object which is to be camouflaged.

[0005] For a skilled person it is however clear that if no infrared reflecting coating layer is provided, the radar absorbent tarpaulin will also absorb heat radiation, will heat up and will thus emit heat radiation which is detectable by thermal imaging. To reduce the heating up of the tarpaulin, EP-A-0 367 091 discloses different measures such as to make cuts in the two external layers or to enlarge to macroscopic surface of the tarpaulin to enhance the transfer of heat by convection from the tarpaulin to the atmosphere. EP-A-0 367 091 also discloses to use a three dimensional fabric having one or two grid-shaped external textile surfaces to enhance the convective heat transfer. However, when the tarpaulin has to be used also for radar camouflage, at least one of the two grid-shaped external surfaces is provided with the radar absorbent coating layer which forms a closed layer.

[0006] An important drawback of the tarpaulin disclosed in EP-A-0 367 091 is therefore that when it has to provide an effective radar camouflage, the infrared camouflage properties are worse. Indeed, even when using a three dimensional fabric having two grid shaped external surfaces and providing the radar absorbing coating layer only on one external surface thereof, the convective heat transfer will still not be sufficient to adapt the temperature of the tarpaulin sufficiently to the ambient temperature. The convective heat transfer would only be sufficient when the tarpaulin is coated with a non-emitting paint. However, as explained hereabove, such a paint poses problems with respect to maintaining the radar attenuation properties.

[0007] Providing one side of a distance fabric with a metallised layer to reflect heat radiation is moreover disclosed in WO 2004/020931. Due to the fact that the heat radiation is reflected, the distance fabric can provide an effective infrared camouflage. The distance fabric disclosed in WO 2004/020931 is however not suited at all for radar camouflage purposes since the metallised layer forms a reflective surface for radar radiation and is thus easily detectable by radar.

[0008] The prior art also discloses radar and infrared camouflage means comprising a layer which is reflective for both infrared and radar radiation and a radar absorbent layer. An example of such camouflage means, in particular a camouflage jacket for the personal protection of an infantryman, is disclosed in US-A-5 950 237. The disclosed jacket has a thickness of about 4 mm and comprises different layers. It comprises as reflective layer an electrically conductive layer having a surface resistivity of some Ω to some tens of Ω and as radar absorbent layer a resistive layer having a resistance of about 330 Ω . According to US-A-5 950 237 the distance between the different layers should be optimised. Since the electrical field component of an electromagnetic wave is equal to zero when arriving at an electrically conductive surface, it is clear for a skilled person that electrically absorbent radar attenuation materials are to be situated at a distance of about one quarter of the wavelength of the radar waves from the reflective plane. An important drawback of such camouflage means is that they are only suited for particular radar frequencies since the other radar frequencies are reflected but substantially not absorbed. In other words, such camouflage means are not effective for a wide radar frequency range.

[0009] An object of the present invention is therefore to provide a new infrared shielding and radar attenuating textile material which enables to achieve an effective radar and infrared camouflage and this for a relatively wide radar frequency range.

[0010] To this end the textile material according to the invention is characterised in that the textile material consists

of the distance fabric, both the first and the second textile layers of which have radar attenuating properties, in that the distance fabric is free of any conductive layer having a surface resistivity smaller than $50 \Omega/\text{sq.}$, and preferably free of any conductive layer having a surface resistivity smaller than $100 \Omega/\text{sq.}$; and in that the first and the second textile layers of the distance fabric have an open texture comprising openings of between 2 and 400 mm^2 which form at least 25%, preferably at least 40%, and more preferably at least 55% of the surface of the first and respectively the second textile layer.

[0011] According to the invention it has been found that when providing both textile layers of a distance fabric with radar attenuating properties, the radar attenuation of the distance fabric is considerably higher than what could be expected based on the radar attenuation properties of each of the two-dimensional textile layers. In other words, it appears that synergetic effects in radar attenuation can be achieved. As a result thereof, both textile layers of the distance fabric may have an open structure without having to be provided with an additional closed radar absorbent layer applied on top of at least one of the textile layers to achieve the required radar attenuation properties. The textile material may thus consist of only the distance fabric and the two textile layers of the distance fabric may comprise openings of between 2 and 400 mm^2 which form at least 25%, preferably at least 40%, and more preferably at least 55% of the surface of the respective textile layer. Due to this open structure of the entire textile material, it is not necessary to provide an infrared reflecting layer to avoid a too strong heating of the textile material. The textile material according to the invention is more particularly free of such an electrically conductive layer, having the defined relatively low surface resistivity, so that the desired radar attenuating properties can be achieved over a wide frequency range. An additional advantage of the textile material according to the invention is that it is a relatively light weight material.

[0012] In a particular embodiment of the textile material according to the invention, the average thickness of the distance fabric is greater than 1 mm, preferably greater than 2 mm and more preferably greater than or equal to 3 mm but smaller than 25 mm and preferably smaller than 15 mm.

[0013] An advantage of this embodiment is that the thickness of the material is greater than or at least an important fraction of one quarter of the wavelength of the most important radar waves used for radar detection thus improving the radar attenuation properties of the textile material.

[0014] In a preferred embodiment of the textile material according to the invention the openings in the first textile layer are shifted with respect to the openings in the second textile layer to enhance the infrared shielding properties of the textile material.

[0015] Due to the fact that the openings in both textile layers are shifted or displaced with respect to one another, the textile material is more visually closed and thus provides a more effective shielding of heat radiation. Preferably, both textile layers have the same texture so that a uniform increase of the infrared shielding properties is achieved by shifting both layers with respect to one another.

[0016] Other particularities and advantages of the invention will become apparent from the following description of some particular embodiments of the textile material according to the present invention. The reference numerals used in this description relate to the annexed drawings wherein:

Figure 1 is a schematic perspective view of a textile material according to the present invention; and
Figure 2 is a top plan view on the textile material illustrated in Figure 1.

[0017] The textile material according to the present invention is intended as camouflage against thermal imaging and against detection by radar. In case the object or person to be camouflaged has a higher temperature than the environment, the heat radiated by that object or person should be shielded off without causing a too strong heating of the textile material itself, in particular of the outer layer directed away from the object or person. This should be done without providing any infrared reflecting conductive layer which has a surface resistivity smaller than $50 \Omega/\text{sq.}$, or preferably even without providing any infrared reflecting conductive layer which has a surface resistivity smaller than $100 \Omega/\text{sq.}$, since the presence of such layers do not enable to achieve an effective radar attenuation over a wide frequency range.

[0018] The heat radiation which is used for thermal imaging is infrared radiation having either a wavelength of between 3 and $5 \mu\text{m}$ or between 8 and $12 \mu\text{m}$. For providing a camouflage in the visible and in the near infrared (NIR) range, paints are available by means of which the textile material can be painted in the desired camouflage colours and patterns. Since this is known for the skilled person, this painting of the textile material will not be discussed further into detail.

[0019] Radar detection is usually done with radar frequencies of between 1 and 100 GHz, the radar frequencies of between 3 and 20 GHz, more particularly of between 8 and 10 GHz, being the most important in battle fields. Another important radar frequency is situated between 90 and 100 GHz. Radar waves of 10 GHz have a wavelength of about 30 mm, radar waves of 20 GHz a wavelength of about 15 mm and radar waves of 100 GHz a wavelength of about 3 mm. Radar detection is based on the emission of radar waves and on the detection of reflected radar waves. Radar attenuation can be achieved by absorption or diffraction of the radar radiation. In this way the so-called radar cross section of an object can be reduced so that it more difficult to detect that object.

[0020] The textile material according to the present invention consists of a so-called distance fabric. Since different types of distance fabrics are already disclosed in the prior art (see for example DE-U-90 16 062 and EP-A-0 662 538,

the detailed structure of such a distance fabric will not be described here further into detail. As illustrated in Figure 1 the distance fabric 1 is made up of a first textile layer 2, a second textile layer 3 facing the first textile layer 2 and spacer yarns 4 extending from the first to the second textile layer and vice versa to link those layers to one another and to keep them at a predetermined distance from one another. Usually, the two textile layers will be situated at a substantially constant distance from one another but it is also possible to vary the distance between the textile layers, in particular in such a manner that grooves or a grit of grooves are formed in the distance fabric.

[0021] The spacer yarns 4 have to have a certain rigidity to maintain the textile layers at a distance from one another. The spacer yarns are preferably monofilament yarns having for example a titer of between 15 and 1100 dtex, for example a titer of about 55 dtex. The spacer can however also be constructed out of combinations of monofilament and multifilament yarns. The textile layers 2 and 3 may also comprise monofilament yarns. However in order to achieve a more flexible textile material, the textile layers are preferably made of multifilament yarns.

[0022] The monofilament yarns can for example be made of polyamide or polyester. The multifilament yarns may consist out of thermoplastic or natural fibres such as polyester, cotton, viscose, polyamide, polyaramide, acrylics, etc, or combinations of those fibres possibly in combination with glass fibres. The monofilament yarns are mostly polyester or polyamide or other thermoplastics, but may also consist out of glass fibres.

[0023] An important feature of the textile material according to the present invention is that it does not contain a conductive layer having a surface resistivity, which can be measured in accordance with ASTM D-257, smaller than 50 Ω/sq . (Ohms/square : surface resistivity is independent of the size of the surface used to measure the surface resistivity). Preferably the textile material does not contain a conductive layer having a surface resistivity smaller than 100 Ω/sq . In other words, the textile material does not contain a layer which is highly reflective for radar radiation so that the textile material can absorb radar radiation over a wider frequency range. Since a conductive layer is highly reflective for radar radiation, the presence of such a conductive layer can also be determined by measuring the radar reflection of the textile material.

[0024] In order to obtain the desired infrared camouflage properties, it is not necessary to coat the surface of the textile material with a low emissivity paint (which is normally reflective for radar radiation) but the distance fabric of the present invention is arranged to transfer its heat sufficiently effectively to the ambient atmosphere even when not painted with a low emissivity paint. The textile material according to the invention is more particularly a camouflage net, both textile layers 2 and 3 of which have an open texture comprising openings 5 of between 2 and 400 mm^2 . These openings 5 form at least 25%, preferably at least 40%, and more preferably at least 55% of the surface of the textile layer. The textile layers 2 and 3 comprise more preferably openings of between 4 and 100 mm^2 , more preferably openings of between 6 and 100 mm^2 , which form at least 25%, preferably at least 40%, and more preferably at least 55% of the surface of the textile layer. Since the textile material of the present invention consists of the distance fabric 1, it has an open structure enabling air to flow or circulate through the textile material. This air flow or circulation, which will usually mainly be due to wind or other atmospheric air streams, is effective to cool the inner textile layer which absorbs most of the heat energy emitted by the object or person which is to be camouflaged. Moreover, the air flow or circulation through the textile material will not only cool down the textile material itself but also the air enclosed by the textile material around the object to be camouflaged will be refreshed. This also contributes to a better cooling of the textile material. Since it is not necessary to use a low emissivity paint to avoid a too strong heating of the textile material, the textile material is preferably painted with a camouflage paint (providing preferably a camouflage both in the visible and in the NIR range) having an emissivity greater than 0.4 or even greater than 0.6, measured according to ASTM C1371-98, in the infrared ranges of 3 to 5 μm and 8 to 12 μm . Such paints are available in the required camouflage colours and enable to avoid more easily the formation of a radar reflective surface.

[0025] The distance fabric is preferably a knit fabric, in particular a warp knit fabric, since by using a knitting technique, the size, shapes and relative positions of the openings in the two textile layers 2 and 3 can be selected more freely. In fact, in practice it would be quite difficult to provide openings in the two textile layers 2 and 3 of a woven distance fabric since the openings would give rise to a loose weft structure which would have to be fixed immediately, for example by applying a coating. Since knitting techniques are already known for producing warp knitted distance fabrics, they will not be described herein in further detail.

[0026] In practice, the two textile surfaces 2 and 3 will usually each be made up of a substantially regular mesh structure, preferably of a mesh structure wherein the meshes or openings 5 all have substantially the same size and shape and are all regularly distributed over the textile surface. In order to improve the shielding of infrared radiation, the openings in the first textile layer 2 are preferably shifted or displaced with respect to the openings in the second textile layer 3. Further the two textile layers 2 and 3 have preferably the same open texture. In this way, the textile material is more visually closed (see Figure 2) so that no or less heat radiation can directly pass through the textile material. The fact that the openings 5 in both textile layers 2 and 3 are shifted with respect to one another has substantially no influence on the air permeability of the textile material, i.e. of the possibility of air flow therethrough, especially when the distance between the two textile layers 2 and 3 is sufficiently large, in particular larger than 0.5 mm, preferably larger than 1 mm and more preferably larger than 2 mm. The openings 5 in both textile layers 2 and 3 are preferably shifted in such a

manner with respect to one another that the straight lines 6 connecting the centres (of area) of openings located opposite one another in both textile layers form an angle α with the surface of the textile material which is smaller than 80° , preferably smaller than 75° and more preferably smaller than 70° . In this way the effective openings through which a portion of the infrared waves might pass is always substantially smaller than the actual size of the openings, even when the infrared waves fall in under a sharp angle.

[0027] In order to achieve the required radar attenuating properties, at least the two textile layers 2 and 3 have radar attenuating properties. To further improve the radar attenuating properties, also the spacer yarns 4 are preferably provided with radar attenuating properties. Due to the thickness of the distance fabric according to the invention, much better radar attenuating properties are achieved compared to a two-dimensional fabric comprising a same amount of radar attenuating materials. In this respect, the distance fabric has preferably an average thickness greater than 1 mm, more preferably greater than 2 mm and most preferably greater than or equal to 3 mm (the average thickness can be calculated by determining the volume occupied by the textile material and dividing this volume by its surface area). In view of the required mechanical properties and the weight of the textile material, its average thickness is preferably smaller than 25 mm and more preferably smaller than 15 mm.

[0028] The radar attenuating properties of the textile layers 2 and 3 and optionally of the spacer yarns 4 can be obtained in different ways. The textile layers 2 and 3 and the spacer yarns 4 may comprise yarns which comprise a radar attenuating material. The yarns may comprise for example electrically conductive fibres such as carbon and metallic fibres so that the resistance of the yarns is decreased and radar radiation can be absorbed. The yarns may also comprise one or more continuous conductive metal or carbon fibres, in particular a carbon core fibre embedded in a polymeric material. Depending on the size of the fibres in the yarn, they can also diffract the incident radar radiation in different direction so that in this way also a reduction of the radar cross section of the camouflaged object is achieved.

[0029] Instead of or in addition to incorporating the radar absorbent or diffractive material in the yarns itself, the textile layers 2 and 3 may also comprise a radar attenuating coating. Also the spacer yarns 4 may comprise a radar attenuating coating. This coating can either be applied onto the yarns used to produce the distance fabric, or onto at least a portion of these yarns, before producing the distance fabric. However, the coating is preferably applied after having produced the distance fabric, for example by spraying or by impregnating the distance fabric with a coating forming composition. This coating is only applied in such a thin layer that the size of the openings 5 in the textile layers 2 and 3 remain within the above described ranges. In practice it is possible to apply a different coating on both sides of the distance fabric, for example on the side of the distance fabric which is intended to be directed to the object to be camouflaged a coating which is more reflective for radar radiation thereby reducing the radar transmission through the textile material.

[0030] The coating material may comprise a conductive polymer such as polypyrroles or polyanilines but usually comprises a binder material, in particular a polymeric material such as PVC, neoprene, acrylate, polyurethane or PVA filled with one or more radar attenuating materials, in particular radar absorbent and/or diffractive materials. Those materials may be selected from the group comprising conductive carbon, conductive polymers (such as polypyrroles and polyanilines), carbon nanotubes (i.e. small tubes having a diameter of between 10 and 100 nm and preferably a length of a few tens of a micron up to a few mm), metal fibre parts, metallic flakes and polymer flakes coated with a radar absorbent material. Also ferromagnetic materials can be used either in the yarns itself or in the coating to absorb radar radiation. These ferromagnetic radar absorbent materials include metals like iron, cobalt and nickel, iron oxides and ferrites.

[0031] In the textile material according to the invention, most of the radar radiation is preferably absorbed. In this respect, at least one but preferably both textile layers 2 and 3 comprise a resistive layer enabling the respective textile layer to absorb radar radiation. The resistive layer is either achieved by the coating of the distance fabric and/or by the resistive nature of the yarns used to produce the distance fabric. The resistive layer has in particular a surface resistivity larger than $300 \Omega/\text{sq.}$, preferably larger than $450 \Omega/\text{sq.}$, more preferably larger than $550 \Omega/\text{sq.}$ and most preferably larger than $650 \Omega/\text{sq.}$ This surface resistivity can again be measured in accordance with ASTM D-257. However it is clear that when the resistive layer is covered for example by a dielectric paint layer, the surface resistivity should be measured without that paint layer, for example before the paint layer is applied. The surface resistivity of the resistive layer can also be determined by measuring the radar reflection since the lower the surface resistivity the more radar reflections will be produced.

[0032] The above described minimum resistivities enable to avoid too much radar reflection. It has been found that for the distance fabric according to the invention, higher surface resistivities are preferred than for two dimensional fabrics in order to reduce the amount of reflected radar energy. The surface resistance of the resistive layer is preferably smaller than $100 \text{ k}\Omega/\text{sq.}$, more preferably smaller than $50 \text{ k}\Omega/\text{sq.}$ and most preferably smaller than $20 \text{ k}\Omega/\text{sq.}$ The smaller the surface resistance, the less radar radiation will be able to pass through the textile material. The surface resistance of the resistive layer formed by the inner textile layer, i.e. the textile layer directed towards the object to be camouflaged, may be smaller than the surface resistance of the resistive layer formed by the outer textile layer. Any radar radiation directly reflected by the inner textile layer has indeed to pass the outer textile layer again and will thus be attenuated by that outer layer. The more reflective inner textile layer will reduce the transmission of the radar waves through the textile

material and this both for the radar radiation coming from the radar and for the radar radiation reflected by the object to be camouflaged.

[0033] The textile material as described hereabove has different advantages which can be summarised as follows:

[0034] The third dimension of the camouflage material can first of all be achieved easily in one production step. This third dimension renders the radar attenuation much more effective. Furthermore the structure of the two surface layers can be chosen either very open or more dense and in this way also can be fine-tuned to one or more specific radar wavelengths or also to the climate wherein it will be used. In a hotter climate, for example in a desert, the openings can be made smaller than in a camouflage net intended to be used in a more continental climate. As the distance fabric has thermal insulating properties, the distance fabric creates a temperature gradient over the thickness of the net. If the structure of the distance fabric is chosen in such a way that it is relatively open the net is aerated and climatized by air passing through. Compared to a two dimensional net, the net may in this way be "opener" so creating a better ventilation whilst maintaining the desired radar attenuation and infrared shielding properties. Emitted infrared radiation is indeed better absorbed by the two planes and the interstitial spacer yarns and the textile material is on itself better thermoregulated by its open structure.

[0035] In order to achieve the desired flame retardant properties the distance fabric may be treated with conventional flame retardants such as antimony compounds, halogenated flame retardants, phosphorus derivatives or phosphorus compounds, borates, etc. or the fabric itself may be produced out of inherently flame retardant fibres.

Example 1

[0036] A warp knitted distance fabric was made having a total weight of 100 g/m². The spacer yarns 4 were polyester monofilament yarns having a titer of 33 dtex. The upper and the lower textile layers 2 and 3 of the distance fabric were made of polyester warp threads having a titer of 55 dtex and of polyester threads knitted around these warp threads and having at titer of 55 dtex.

[0037] The distance fabric had a thickness of about 3 mm. Both the upper and the lower textile layers had a thickness of about 0.4 mm and were situated at a mutual distance of about 2.2 mm. The upper and the lower textile layers had a same open structure and were more particularly formed by the same substantially regular mesh structure illustrated in Figures 1 and 2. The openings 5 in both textile layers 2 and 3 had all the same shape and size and were more particularly hexagonal. They had a size of about 15 mm² and formed about 60 % of the surface of the textile layers 2 and 3.

[0038] To achieve the radar attenuating properties, the entire distance fabric was provided with a radar attenuating coating comprising a mixture of radar absorbent carbon and ferromagnetic particles. After this coating process, the distance fabric had a weight of about 140 g/m² (weight of the coating was about 40 g/m²) and the surface resistivity of both textile layers was reduced to about 455 Ω/sq.

[0039] The radar attenuating properties were tested by placing the distance fabric in front of a flat metallic surface and by measuring the reflected radar energy at 10 GHz. An attenuation of about 33 dB was achieved.

[0040] The infrared shielding properties were tested by measuring the IR transmission. The transmission was about 19% at band III.

Comparitive example

[0041] A two dimensional fabric was made from a traditional warp knitted 2D fabric, being a rasha fabric with a 3 by 3 contecture and with a weight of the fabric of about 85 g/m². The rasha fabric has rectangular openings of about 2.5 by 2.5 mm. The 2D fabric was coated with the same coating composition and the same amount of about 40 g/m² as in Example 1. This yielded a surface resistivity of about 430 Ω/sq. With the same experimental set up as in Example 1, the radar attenuation comprised however only about 3-5 dB. As to the infrared shielding properties, a transmission of 21 % was obtained at band III.

[0042] With the distance fabric used in Example 1 an even somewhat smaller transmission could be obtained this however with a more open fabric. Due to this more open nature of the distance fabric, and due to the two textile layers, a heating of the fabric is much more difficult to detect by thermal imaging so that the infrared camouflaging properties are considerably improved by the use of a distance fabric.

Example 2

[0043] Example 1 was repeated except that the radar absorptive material was diluted in the binder so that the effective radar absorptive material applied was about 4 times less for the same weight of coating applied. The conductivity (surface resistivity) of the fabric was about 680 Ω/sq. The radar attenuation still comprised about 6-8 dB at 10 GHz.

[0044] Measurements performed at 94 GHz showed for this concept attenuations of 10-12 dB.

Example 3

[0045] The same concept of the fabric of Example 1 was used but with a weight of the 3D fabric of about 150 g/m² and where the openings were about 2mm by 2mm. After impregnation with the same amount of radar absorptive material as in Example 1 the radar absorption was measured. At 10 Ghz the results were about 30 dB. Infrared transmission at band III was about 14 to 16%.

Claims

1. An infrared shielding and radar attenuating textile material comprising a distance fabric made up of a first textile layer, a second textile layer facing the first textile layer and spacer yarns extending from the first to the second textile layer and vice versa to link the first and the second textile layers to one another and to keep them at a predetermined distance from one another, **characterised in that**

- the textile material consists of said distance fabric, both the first and the second textile layers of which have radar attenuating properties;
- the distance fabric is free of any conductive layer having a surface resistivity smaller than 50 Ω/sq., and preferably of any conductive layer having a surface resistivity smaller than 100 Ω/sq.; and
- the first and the second textile layers of the distance fabric have an open texture comprising openings of between 2 and 400 mm² which form at least 25%, preferably at least 40%, and more preferably at least 55% of the surface of the first and respectively the second textile layer.

2. A textile material according to claim 1, **characterised in that** the distance fabric is a knit fabric, in particular a warp knit fabric.

3. A textile material according to claim 1 or 2, **characterised in that** the average thickness of the distance fabric is greater than 1 mm, preferably greater than 2 mm and more preferably greater than or equal to 3 mm but smaller than 25 mm and preferably smaller than 15 mm.

4. A textile material according to any one of the claims 1 to 3, **characterised in that** the spacer yarns comprise monofilament yarns which have preferably a diameter of between 0.004 and 1 mm, and more preferably of between 0.004 and 0.3 mm.

5. A textile material according to any one of the claims 1 to 4, **characterised in that** at least one of the first and the second textile layers comprises a radar attenuating coating, in particular a radar absorbent and/or diffraction coating, preferably a radar absorbent coating.

6. A textile material according to any one of the claims 1 to 5, **characterised in that** the spacer yarns comprise a radar attenuating coating, in particular a radar absorbent and/or diffraction coating, preferably a radar absorbent coating.

7. A textile material according to any one of the claims 1 to 6, **characterised in that** at least one of the first and the second textile layers comprise yarns which comprise a radar attenuating material, in particular of a radar absorbent and/or diffraction material, preferably a radar absorbent material.

8. A textile material according to any one of the claims 1 to 7, **characterised in that** the spacer yarns comprise yarns which comprise a radar attenuating material, in particular of a radar absorbent and/or diffraction material, preferably a radar absorbent material.

9. A textile material according to any one of the claims 1 to 8, **characterised in that** at least one but preferably both of the first and the second textile layers comprise a resistive layer enabling the respective textile layer to absorb radar radiation, the resistive layer having in particular a surface resistivity larger than 300 Ω/sq., preferably larger than 450 Ω/sq., more preferably larger than 550 Ω/sq. and most preferably larger than 650 Ω/sq. but smaller than 100 kΩ/sq., preferably smaller than 50 kΩ/sq. and more preferably smaller than 20 kΩ/sq.

10. A textile material according to any one of the claims 1 to 9, **characterised in that** both the first and the second textile layers have an emissivity, measured according to ASTM C1371-98, in the infrared ranges of 3 to 5 μm and

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8 to 12 μm , greater than 0.4 and preferably greater than 0.6.

5 11. A textile material according to any one of the claims 1 to 10, **characterised in that** the predetermined distance between the first and second textile layers is on average larger than 0.5 mm, and preferably larger than 1 mm, more preferably larger than 2 mm.

10 12. A textile material according to any one of the claims 1 to 11, **characterised in that** the openings in the first textile layer are shifted with respect to the openings in the second textile layer to enhance the infrared shielding properties of the textile material.

13. A textile material according to any one of the claims 1 to 12, **characterised in that** and the first and second textile layers are each made up of a substantially regular mesh structure.

15 14. A textile material according to any one of the claims 1 to 13, **characterised in that** the first and the second textile layers of the distance fabric comprise openings of between 4 and 100 mm^2 which form at least 25%, preferably at least 40%, and more preferably at least 55% of the surface of the first and respectively the second textile layer, the first and the second textile layers of the distance fabric comprising preferably openings of between 6 and 100 mm^2 which form at least 25%, preferably at least 40%, and more preferably at least 55% of the surface of the first and respectively the second textile layer.

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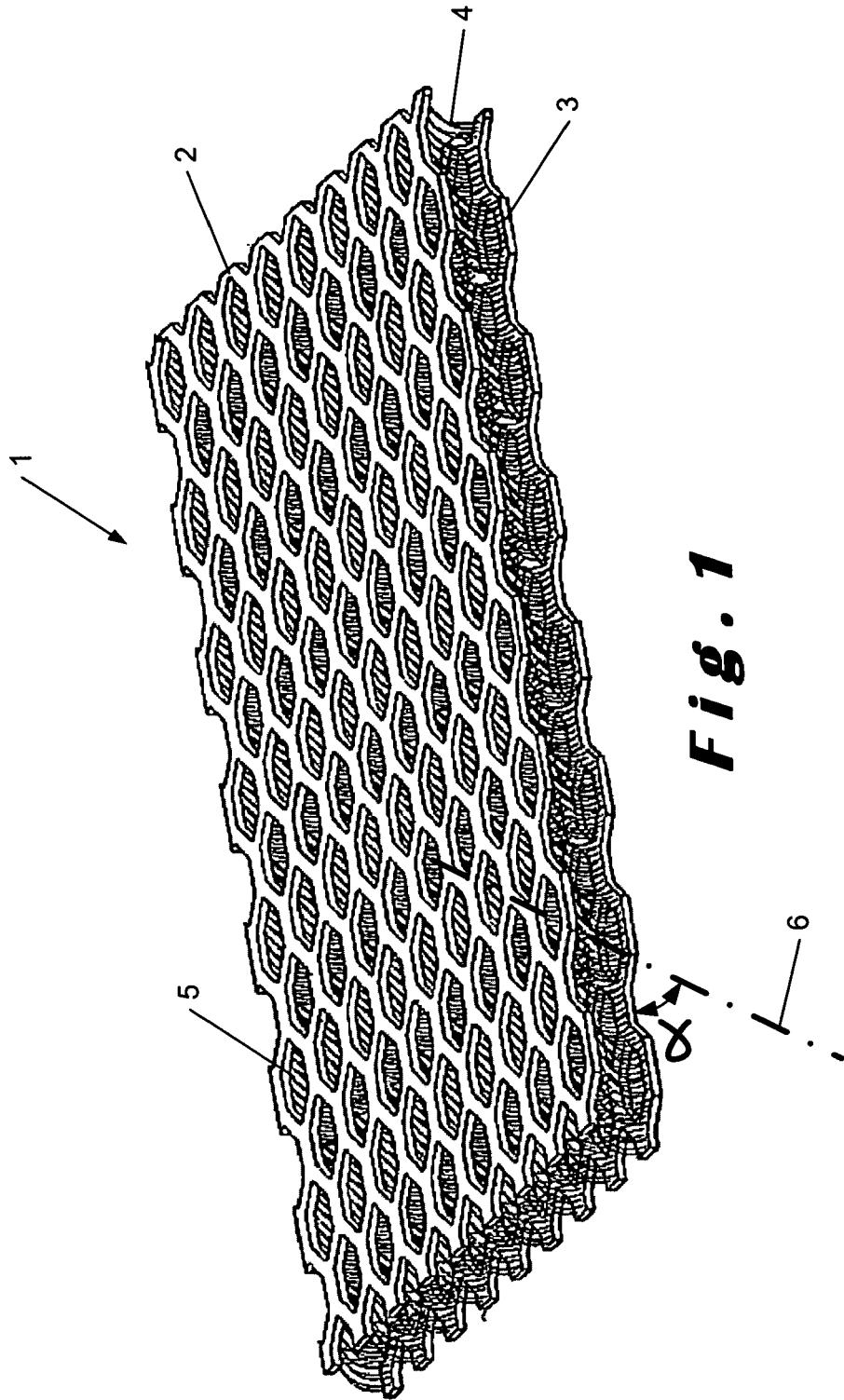


Fig. 1

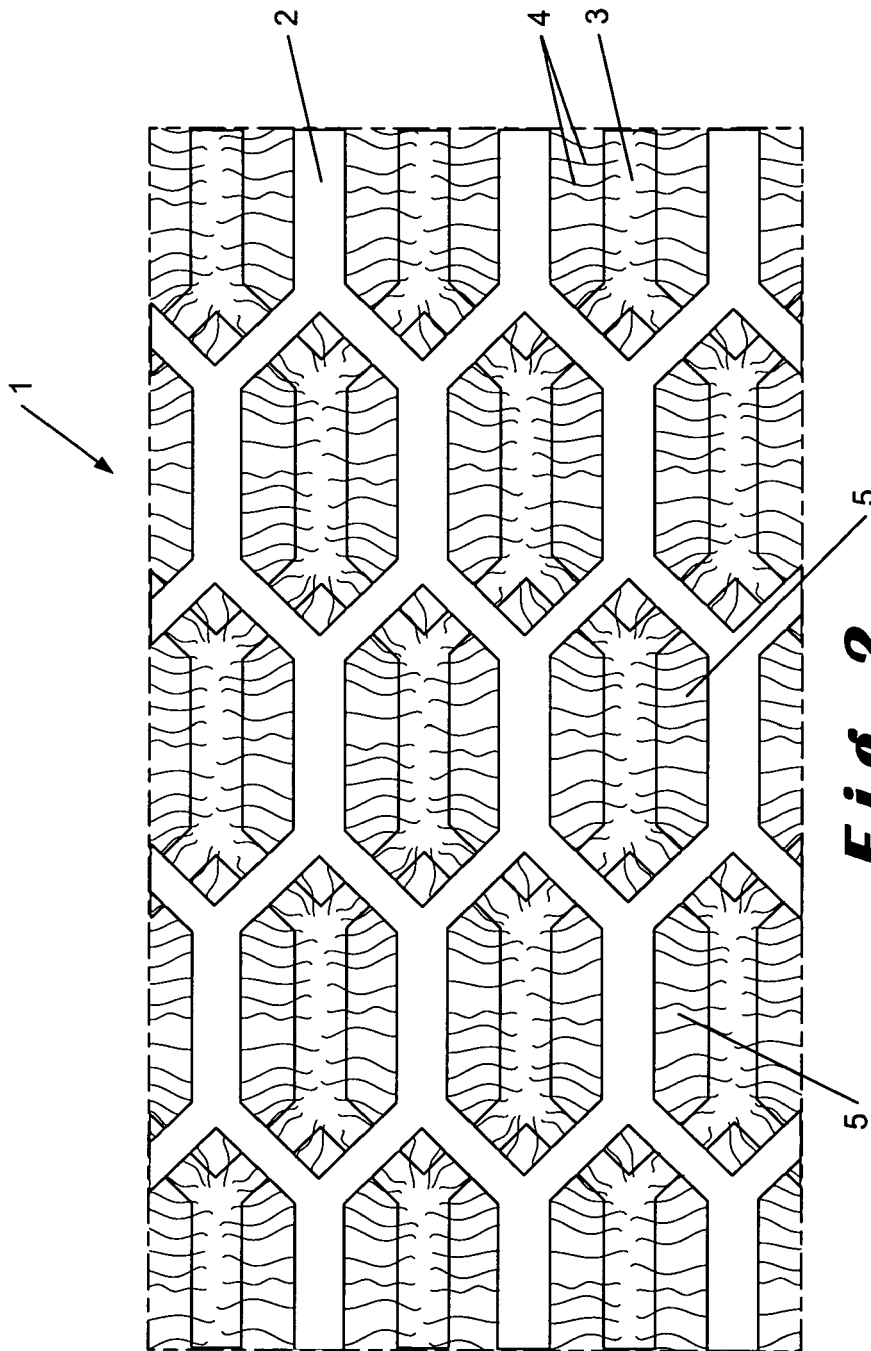


Fig. 2



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