

THERMAL CAMOUFLAGE MATERIAL

5 This invention relates to thermal camouflage material having a support layer and an outer plastics layer which has different-coloured areas in the visible wavelength range for visual camouflage effect.

 Camouflage materials of this kind are already
10 known, although the earlier ones have generally had a very heavily perforated structure and more or less the character of nets. The percentage of covering for such conventional structures is 50 to 65%. This has been found to be insufficient when warm objects
15 are to be masked against infrared reconnaissance. One objects of the present invention is to provide a camouflage which shields such warm objects and which is also capable capable of giving a picture, e.g. for heat-sensitive camera, which does not differ from
20 what is normally present in nature.

 A shield provided by a material of the tarpaulin type will be heated by the hidden warm object, the structure and contours of which will be impossible to observe, but the high temperature of a
25 surface will be clearly apparent even so, such masking therefore normally not being particularly servicable.

 Infrared reconnaissance is a military scouting method where large practical advances have been made
30 lately, which now makes it necessary to provide good counter-measures. What has been proposed so far in this direction has above all been double-layered structures of the type where two fabrics have been kept spaced from each other so that the outer layer
35 has been insulated from the inner one. The outer layer does indeed obtain thermal energy from the outside, but in its thermal equilibrium it will even

so be heavily affected by the outside surrounding nature which has the prevailing air temperature, and partly by the sky, at least in clear weather, which has a very low temperature.

5 Such a double structure is not particularly practicable in field conditions, and it is therefore one of the objects of the invention to provide a thermal camouflage material which is easy to lay out, which may be folded in about the same way as a
10 tarpaulin and which is easy to transport, but still gives good masking effect against infrared reconnaissance.

 The infrared spectrum is distinguished in that large sections thereof are heavily absorbed in air,
15 except in certain wavelength intervals. In reconnaissance at distances over a couple of kilometres there are thus only two wavelength bands of interest at present, namely 3-5 μm and 8-14 μm . The latter range affords the greatest difficulties
20 since the detector in a reconnaissance system must be cooled very heavily, in many cases by liquid helium (4.2K). In the 3-5 μm range already, cooling with liquid nitrogen (77K) is required as a rule.

 According to the present invention, a thermal
25 camouflage material comprises a support layer and an outer plastics layer which in the visible wavelength range has different-coloured areas for visual camouflage effect, characterised in that between the support layer and the outer layer there is a metal
30 reflection layer, in that the plastics material of the outer layer is transparent in the wavelength ranges 3-5 μm and 8-14 μm , in that the outer surface of the outer layer is matt-finished so as to reduce its specular reflection, and in that the metal
35 reflection layer is broken up to a mosaic structure for avoiding radar reflection.

Therefore, the present invention, instead of using the conventional insulation of the observed outer layer, uses a combination of a reflecting surface without notable specular reflection which reflects heat radiation coming from the outside, and on the outside of the reflecting surface a layer with a low self-emission factor. This low factor is achieved by selecting a plastics material which is transparent in the spectrum ranges in question.

A suitable plastics material is polyethylene which is coloured all the way through with infrared-transparent camouflage pigment for giving the visible camouflage effect.

It is possible to use a polyethylene film which is coated with a vapour-deposited aluminium coating acting as the reflection layer, this film being laminated together with the support layer by means of a fusion adhesive layer. If a roll having a textured surface is used, or an opposing web of matted viscous weave which is stripped off after lamination, a matt surface is obtained on the polyethylene film. Furthermore, the aluminium coating will be broken up during rolling into a kind of three-dimensional mosaic form, so that specular reflection in the infrared range as well as in radar wavelength range will be avoided.

The emission factor can be put at 0.6-0.8, depending on material and thickness. In accordance with the preferred embodiment, there is arranged different layer thicknesses of the plastics during lamination. This can be provided by applying patches of different sizes and shapes (which can have different colours in the visible range). Another method is to layer a partially perforated film above the metal-coated plastics layer, immediately before the laminating roll nip. A variegated effect is thus obtained in an infrared picture, depending on

different emission factors, so that the range which actually does have the same temperature appears to have completely different temperatures, and that there may be varying equilibrium temperature.

5 A further possibly for differentiating the temperatures can be achieved by ventilation openings in certain zones in the fabric. Both cooling and heating in different zones is thus effected by wind and convection. The ventilation openings should
10 however have a rather small area. In accordance with a particular embodiment, which is made the subject of applicants' own co-filed patent application, there is utilized the fact that a heat-laminated film of
15 polyethylene will have stresses. If open slits, e.g. incomplete circular slits, are made in such a film there will be openings since the partially attached flaps over the holes curl outwards, the covering effect at right angles to the surface not being diminished so much, but the possibility of tangential
20 through-flow is increased very heavily. There is further achieved a three-dimensional surface which is good for masking effect in the visible wavelength range.

 Preferably, the support layer is a weave
25 containing conductive metal wires for radar camouflage effect.

 The material may have at least over part of its surface, holes, which occupy 5% of the total surface area.

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The thermal camouflage may suitably be supplemented by a fret-cut film layer, e.g. in accordance with the U.S. Patent 3 069 796. As will be apparent from another simultaneously filed patent application, it is suitable to make the fret-cutting with S-shaped slits "hooked into" each other, whereby the artificial foliage only covers about 30%. This three-dimensional foliage, insofar as its emitting equilibrium temperature is concerned, will be substantially determined by the temperature and radiation conditions of the surroundings.

The invention will be described in more detail with reference to the figures which illustrate embodiments of the invention not limiting its scope.

Fig. 1 schematically illustrates a section through an embodiment of a thermal camouflage. Fig. 2 illustrates a second embodiment with coatings on either side of the strengthening layer. Fig. 3 illustrates a third embodiment where the outer layer has, in patches, different thicknesses. Fig. 4 schematically illustrates a laminating operation. Fig. 5 schematically illustrates a modified laminating operation. Fig. 6 illustrates the result of the operation according to Fig. 5. Fig. 7 schematically illustrates a further modified laminating operation, and Fig. 8 illustrates the result thereof.

Fig. 1 illustrates the structure of a first example. Uppermost, for facing outwards, there is a polyethylene layer with a mat surface, and thereinunder a crackled metallic layer 2, an adhesive layer 3 and a strengthening layer 4.

The strengthening layer 4 may be a woven material of polyester or polyamide, and it may contain material effective for radar wavelengths. This layer may also be non-woven or of similar material, or to advantage band-woven from HD polyethylene or polypropylene. Such material gives high tearing strength in relation to its weight, and is thin. It can be coated with thin films of polyethylene or polypropylene, for example.

The adhesive layer 3 may be an adhesive film of the EVA "hot melt" type.

5 The metallic layer 2 shall reflect within the wavelength range 2-15 μm , and may also be reflecting within other wavelengths as well. Vaporized aluminium coatings over 50 $\text{\AA}$ give such properties. Thicknesses of 500 $\text{\AA}$ function well, and such may be obtained from several manufacturers who can deposit them on polyethylene, for example.

10 The layer 1 is suitably a polyethylene film coloured with a green pigment which has moderate absorption for infrared. This material is usually obtained "blown", i.e. in manufacture it is blown to tubes which are cut up, flattened and rolled up.
15 These films are provided with the metallic deposit 2. This deposit may also be a metal foil, e.g. aluminium, which in such a case must be very thin however in order to be crackled during lamination. Cracking occurs with great reliability, particularly
20 if the strengthening layer 4 is structured, e.g. woven.

A camouflage material is illustrated in Figure 2, which differs from the one shown in Figure 1 by it being coated with a laminated adhered layer 2' on the
25 opposite side, and with the adhering layer 3'. There is also metallizing 2'. The camouflage sheet is thus doubly usable. It can either be the same on both sides and thereby turned with either side outwards, or there can be a different coating on the underside
30 such as polyvinyl chloride secured by an adhesive layer of fusion adhesive. Another colour can also be used, e.g. for winter camouflage.

In Figure 3 there is illustrated an example where the layer 1 is supplemented in patches with a
35 further layer 5' of the same material, possibly differently coloured and which has been attached during the laminating operation.

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schematically illustrated laminating plant 8 and come out fused together. The finished web is pulled off from the carrier 7 and the final product is rolled up on the roll 10, while the carrier 7 is rolled up on roll 9. The carrier 7 can be used several times.

In Fig. 5 there is illustrated a similar laminating operation with the laminating machine 8 only indicated. In this case, loose patches 5 of the same material, possibly differently coloured, are laid on the polyethylene web 6, and the whole is rolled together to form the structure obtained according to Fig. 3. A plan view of the example shown in Fig. 5 will be seen from Fig. 6. Alternatively, a similar result with less manual work can be obtained according to Fig. 7 by a web 10 being provided with unconnected cuts which form depending flaps when the web is rolled from the supply roller, and these flaps will lay double. A structure is then obtained with two layers on the main portion and, as will be seen from Fig. 8, three layers at places 5'' and only one layer at places 5'''.

Example:

In one example there was used a weave having 16x16 threads of polyamide multifilament solid drawn 235 dtex with a superficial weight of 100 g/m². The adhesive layer was Xiro type 240, superficial weight 30 g/m², and the polyethylene layer with a superficial weight of 30 g/m² metallized to 40 µm thickness on one side, the polyethylene being blown LDPE.

Mechanical properties:

Weight 160 g/m²
Tensional strength 700 N for the entire sheet
Tear strength 70 N
Pattern-embossed with repeat length 6 m, repeat width 1.5 m.
Coverage degree in embossed area 8-100%, average value for the whole material 95%.

Optical properties:

Visual: Uniform green with lightness 5.9, colour tone 23.9 and saturation 7.7.

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Measured specular reflection at different wavelengths:

360-440 nm 5.0%

680 nm 4.5%

750 nm 9.5%

5 850 nm 57%

950 nm 61%

1200 nm 67%

The measured lustre of the surface (Zeiss GP3 $1^{\circ}/4.4^{\circ}$ +
filtre 75° angle) was 0.5%.

CLAIMS



1. A thermal camouflage material comprising a support layer and an outer plastics layer which in the visible wavelength range has different-coloured areas for visual camouflage effect, characterised in that between the support layer and the outer layer there is a metal reflection layer, in that the plastics material of the outer layer is transparent in the wavelength ranges 3-5 μm and 8-14 μm , in that the outer surface of the outer layer is matt finished so as to reduce its specular reflection, and in that the metal reflection layer is broken up into a mosaic structure for avoiding radar reflection.

2. The thermal camouflage material according to claim 1, wherein the plastics material of the outer layer is polyethylene coloured through with a camouflage pigment which is transparent in the infrared wavelength range.

3. The thermal camouflage material according to claim 1 or claim 2, wherein the support layer is a weave containing conductive metal wires for radar camouflage effect.

4. The thermal camouflage material according to any one of the preceding claims, wherein the metal reflection layer is laid on the outer layer, and in that an adhesive layer of fusion adhesive joins the support layer to the metallized side of the outer layer.

5. The thermal camouflage material according to claim 4, wherein, on the side of the support layer remote from the reflection layer, there is attached by an adhesive layer of fusion adhesive a second plastics layer.

(24)



6. The thermal camouflage material according to claim 5, wherein the second plastics layer is PVC.

5 7. The thermal camouflage material according to any one of the preceding claims, wherein the material has, at least over part of its surface, holes, which occupy 5% of the total surface area.

10 8. The thermal camouflage material according to any one of the preceding claims, wherein, outside the plastics outer layer, there is attached a sparsely fret-cut plastics material.

15 9. A thermal camouflage material substantially as described with reference to the accompanying drawings.

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