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(54) Flexible sheeting.

(57) Flexible sheeting 10 suitable for use in forming a security enclosure 20 comprises a plurality of flexible layers 11,12,13,14,15 which are laminated together. Layer 11 is made of an insulant and its opposite surfaces are laminated to layers 12,13 each of which is made of an electrically-conductive low-melt material which is solid at ambient temperatures and which fluidises at comparatively low temperatures generally in the range 70 to 130°C. Layers 14,15 are outer coverings with high colour (jetness) and minimum change to electrical resistance at those temperatures where layers 12,13 fluidise. Layers 12,13 are connected to an electrical monitor circuit 23 to detect fluidisation therein.

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This invention relates to flexible sheeting suitable for use in forming a security enclosure for an article, and to security enclosures formed from such sheeting.

Flexible sheeting suitable for use in forming a security enclosure is already known, for example, from European Patent Specification No. 89306035, wherein the sheeting incorporates electrically conductive elements which, when connected to a monitor circuit, give rise to an indication of attempted interference by an outside agency on penetration of the sheeting. The known sheeting provides security against penetration by a small diameter puncture tool, such as a needle, but there is a need to provide security against penetration by a small diameter radiant energy cutting tool, such as a laser beam.

It is an object of the present invention to provide a new and improved form of flexible sheeting suitable for use in forming a security enclosure for an article, and to security enclosures formed from such sheeting.

According to the present invention there is provided flexible sheeting suitable for use in forming a security enclosure for an article, said sheeting comprising a flexible layer of insulant material having adherent to its opposite surfaces respective layers of electrically-conductive low-melt material, said low-melt material being in solid form at ambient temperatures but being rendered fluid by the energy from a small diameter radiant energy cutting tool, so that, when the layers of low-melt material are connected to an electrical monitor circuit a change in electrical characteristic is detectable, in use, by flow of the fluidised low-melt material through the hole in the layer of insulant material formed by the cutting tool.

Preferably the thickness of each low-melt material layer is approximately the same as or slightly greater than that of the layer of insulant material, each such layer having a thickness of less than 25 microns. Conveniently each low-melt material layer is 8-12 microns in thickness and the insulant material layer is about 12 microns in thickness. The low-melt material preferably fluidises at about 100°C.

Preferably the insulant material layer is made of polyester film and each low-melt material layer is made of carbon-filled polyester, the latter being applied to the insulant material layer by screen printing. Typically the carbon-filled polyester is 50% filled with graphitic carbon to provide a resistivity of the order of 0.3 ohms-cm. Other materials may be used to form the electrically-conductive low-melt material for example certain thermoplastic resins such as polyamides, polyethers, polyurethanes, polyvinyl acetate and certain uncured silicones loaded with carbon or conductive salts such as caesium iodide. Primarily these materials are of low molecular weight and fluidise at temperatures in the range 70 to 130°C.

Preferably the sheeting incorporates outer coverings bonded to the layers of low-melt material. The outer coverings may be carbon-loaded polyester coated onto polyester film with the carbon content selected to provide high colour (jetness) with minimum change to electrical resistance on penetration or fluidisation due to its very high resistivity, the latter preferably being in excess of 10^{13} ohm-cm. The outer coverings may be adherent to the respective layers of low-melt material by an adhesive, such as polyester, providing a patterned coverage of the outer coverings sufficient in areal extent to laminate the sheeting. The adhesive layer may be over-printed on the low-melt material.

According to another aspect the present invention provides flexible sheeting suitable for use in forming a security enclosure for an article, said sheeting comprising two flexible layers of electrically-responsive fibrous material separated by a flexible layer of insulant material, each of said fibrous material layers being bonded substantially throughout its entire area to said insulant material layer by a flexible layer of electrically-responsive adhesive, said adhesive layer being a laminate comprising a layer of carbon bound at ambient temperatures in a matrix of low-melt material, and wherein the length of the fibres of the fibrous material is greater than the thickness of the layers of adhesive and insulant.

Preferably the thickness of each low-melt material layer is approximately the same as or slightly greater than that of the layer of insulant material, each such layer having a thickess of less than 25 microns. Conveniently each low-melt material layer is 8-12 microns in thickness and the insulant material layer is about 12 microns in thickness. The low-melt material preferably fluidises at about 100°C.

Preferably the insulant material layer is made of polyester film and each low-melt material layer is made of carbon-filled polyester, the latter being applied to the insulant material layer by screen printing and over-printed with an adhesive, such as polyester, providing a patterned coverage of the low-melt material layer sufficient in areal extent to laminate the sheeting. Typically the carbon-filled polyester is 50% filled with graphitic carbon to provide a resistivity of the order of 0.3 ohms-cm.

Preferably the layers of fibrous material are made of unsintered carbon-loaded PTFE having a volume resistivity in the range 1 to 10 ohm-cm and of the order of 75 microns in thickness.

Preferably the sheeting incorporates outer coverings bonded to the layers of fibrous material by non-conductive adhesive. The adhesive may be over-printed onto the fibrous material layers, and may be polyester, providing a patterned coverage sufficient in areal extent to laminate the sheeting. The outer coverings may be carbon-loaded polyester coated onto polyester film with the carbon content selected to provide high colour (jetness) with minimum change to electrical resistance on penetration or fluidisation due to its very high resistivity, the latter preferably being in excess of 10^{13} ohm-cm.

According to a further aspect the present invention provides a security enclosure formed of flexible sheeting according to the present invention, each layer of low-melt material being connected to an electrical monitor circuit. The monitor circuit may be an impedance monitoring bridge circuit.

By virtue of the provision of layers of low-melt material containing carbon or other electrically-conductive filler the sheeting and the enclosure provided by the present invention provides security against penetration by a radiant energy cutting tool such as a laser beam.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings in which:

Fig. 1 is an exploded view of a first form of flexible sheeting for use in forming a security enclosure;

Fig. 2 schematically illustrates a partly-formed security enclosure made of the Fig. 1 sheeting; and

Fig. 3 is a sectional view of a second form of flexible sheeting for use in forming a security enclosure.

The flexible sheeting 10 which is shown in Fig. 1 in exploded form comprises various layers each of which is flexible including layer 11 which is an insulant layer, layers 12, 13, each of which is electrically conductive having a resistivity of the order of 0.3 to 0.4 ohm-cm and outer cover layers 14, 15, each of which is essentially an insulating layer. Layer 11 is made of polyester film being about 12 microns in thickness for best results but which should not be more than 25 microns in thickness. The layers 12, 13, are screen printed on either side of layer 11 and are about 8 to 25 microns in thickness. layers 12, 13 are each composed of a polyester matrix which is loaded with graphitic carbon to a level of about 50% by weight in order to render layers 12, 13, electrically conductive and to provide these layers with low-melt characteristics, the latter being provided by the polyester which has a melting point of the order of 100°C. Outer cover layers 14, 15, are also made of polyester loaded with carbon and coated onto a polyester film carrier but the loading is selected to provide very high resistivity (of the order of 10^{13} ohm-cm or greater) and high blackness in colour. Cover layers 14, 15, are adherent to the layers 12, 13, by an adhesive such as polyester over-printed onto layers 12, 13, to provide a patterned coverage of about 30% in areal extent. By virtue of its construction sheeting 10 is a laminate and the layers 12, 13, are essentially homogeneous and complete over their entire areal extent. The areal extent of layer 12 is substantially identical to that of layer 13, each being slightly less in areal extent than layer 11 to provide insulation at the edges of the layers 12, 13.

Fig. 2 illustrates a partly formed security enclosure 20 made of the sheeting 10 by initially forming the layer 11 of the sheeting to a box blank shape and folding the shaped sheeting along lines 21 to provide a box-like configuration which can envelope or enclose an article (not shown) to be protected. The adjacent edges 22 of the folded sheeting 10 may abut or overlap and may be held in place by a wrapping (not shown). An electrical monitor circuit 23 is connected to the enclosure 20 to provide impedance monitoring across the insulant layer 11 by means of the conductive layers 12, 13, functioning as conductive termination pads. Circuit 23 may be connected to the layers 12, 13, via strip copper conductors.

Fig. 3 illustrates a modified form of flexible sheeting 30 which incorporates all of the components of sheeting 10 but additionally incorporates layers 31, 32, of electrically-responsive fibrous material, preferably carbon-loaded unsintered PTFE between the outer cover layers 14, 15, and the layers 12, 13. The fibres of layers 31, 32, are of sufficient length to extend from one of the layers 31, 32, to the other of the layers 31, 32, when penetrated by a piercing tool. Layers 31, 32, are secured by polyester adhesive to both cover layers 14, 15, and layers 12, 13, with the adhesive patterned to give about 30% coverage. Layers 31, 32, are accordingly in electrical contact with layers 12, 13, and may be used as interconnectors between the layers 12, 13, and the monitor circuit 23 in the Fig. 2 arrangement to avoid strip copper conductors. This has the additional benefit that, in use, only a single monitor circuit is required for both the layers 12, 13, and the layers 31, 32, the latter functioning as a security measure against piercing.

Claims

1. Flexible sheeting for use in forming a security enclosure for an article characterised in that the sheeting comprises a flexible layer (11) of insulant material having adherent to its opposite surfaces respective layers (12,13) of electrically-conductive low-melt material, said low melt material being in solid form at ambient temperatures but being rendered fluid by the energy from a small diameter radiant energy cutting tool, so that, when the layers (12,13) of low-melt material are connected to an electrical monitor circuit (23) a change in electrical characteristic is detectable, in use, by flow of the fluidised low-melt material through the hole in the layer (11) of insulant material formed by the cutting tool.

2. Flexible sheeting as claimed in claim 1, characterised in that the thickness of each low-melt material layer (12,13) is approximately the same as

or slightly greater than that of the layer (11) of insulant material.

3. Flexible sheeting as claimed in claim 1, characterised in that the low-melt material layer (12,13) is made of carbon-filled polyester applied to the insulant material layer (11) by screen printing.

4. Flexible sheeting as claimed in claim 3 characterised by further incorporating outer coverings (14,15) bonded to the layers (12,13) of low-melt material.

5. Flexible sheeting as claimed in claim 4, characterised in that the outer coverings (14,15) may be carbon-loaded polyester coated onto polyester film.

6. Flexible sheeting suitable for use in forming a security enclosure for an article, characterised in that said sheeting comprises two flexible layers (31,32) of electrically-responsive fibrous material separated by a flexible layer (11) of insulant material, each of said fibrous material layers (31,32) being bonded substantially throughout its entire area to said insulant material layer (11) by a flexible layer of electrically-responsive adhesive (12,13), said adhesive layer (12,13) being a laminate comprising a layer of carbon bound at ambient temperatures in a matrix of low-melt material, and wherein the length of the fibres of the fibrous material is greater than the thickness of the layers (11,12,13) of adhesive and insulant.

7. Flexible sheeting as claimed in claim 6, characterised by further incorporating outer coverings (14,15) bonded to the layers of fibrous material (31,32) by non-conductive adhesive.

8. Flexible sheeting as claimed in claim 7, characterised in that the outer coverings (14,15) may be carbon-loaded polyester with the carbon content selected to provide high colour (jetness) with minimum change to electrical resistance on penetration or fluidisation due to its very high resistivity.

9. A security enclosure formed of flexible sheeting which is multilayered and incorporates a layer (11) of insulant material having adherent to its opposite surfaces respective layers (12,13) of electrically-conductive low-melt material which is solid at ambient temperatures but fluidises at temperatures of about 100°C or less, and an electrical monitor circuit (23) connected to said low-melt material layers (12,13) to detect fluidisation therein.

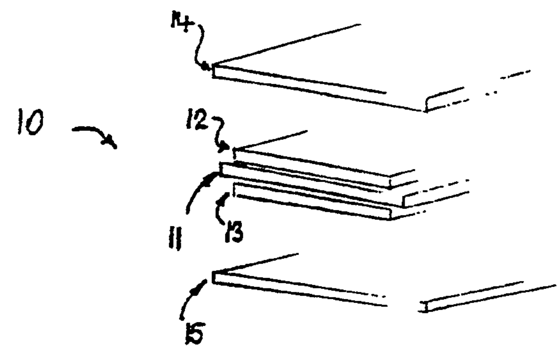

FIG 1

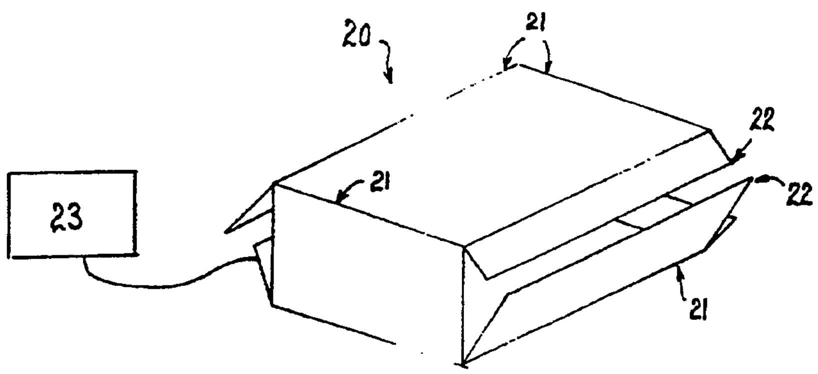

FIG 2

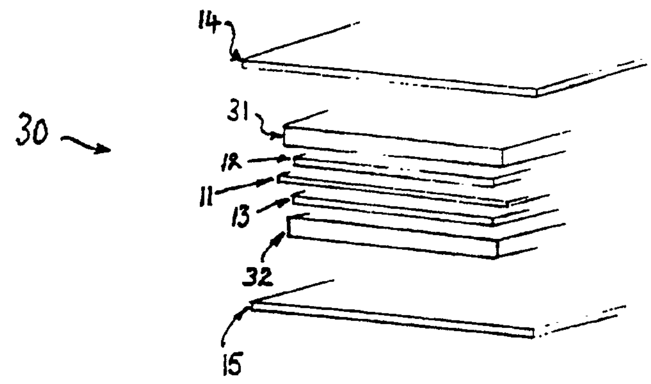

FIG 3