(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 395 301 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **90304197.8**

(51) Int. Cl.⁵: **H05B 3/86**

(22) Date of filing: **19.04.90**

(30) Priority: **26.04.89 GB 8909520**

(43) Date of publication of application: **31.10.90 Bulletin 90/44**

(84) Designated Contracting States: **DE FR GB**

(71) Applicant: **TRIPLEX AIRCRAFT AND SPECIAL PRODUCTS LIMITED**
Eckersall Road, Kings Norton
Birmingham B38 8SR(GB)

(72) Inventor: **Hand, Derek Lionel Augustus**
25 Arley Road
Solihull, West Midlands B91 1NJ(GB)

(74) Representative: **Jenkins, Peter David et al**
PAGE, WHITE & FARRER 54 Doughty Street
London WC1N 2LS(GB)

(54) Electroconductive heated window and manufacture thereof.

(57) A transparent window comprising a glazing material having a tapering region, an electroconductive heating film which extends over at least the tapering region of the glazing material and is divided into a plurality of areas, an electrical connecting means which electrically connects together at least two of the areas so as to define at least one sheet resistor in the electroconductive film, the electrical connecting means comprising at least two rows of spaced electrical connections to the film, each of which rows extends along a respective tapering edge of a respective area which is electrically connected to another area, a plurality of electrical connectors external to the film which electrically connect together respective electrical connections, and electrical contacts for the or each sheet resistor, a respective electrical contact extending across each of two ends of the or each sheet resistor for application of an electrical power supply. The invention also provides a method of manufacturing such a transparent window.

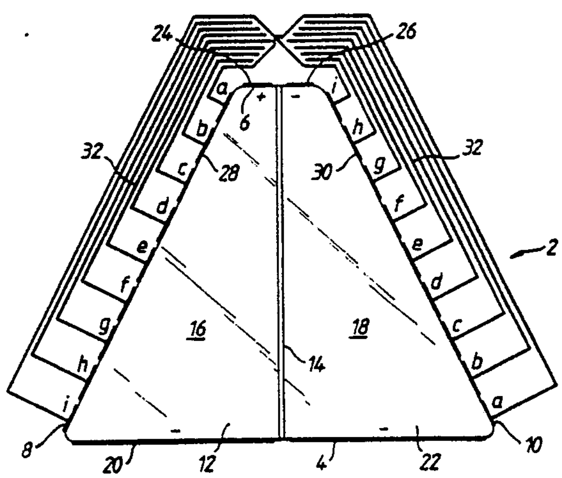

Fig.1.

EP 0 395 301 A2

ELECTROCONDUCTIVE HEATED WINDOW AND MANUFACTURE THEREOF.

The present invention relates to an ectroconductive heated window and to a method of manufacturing such a window. In particular, the present invention relates to such windows which taper in breadth.

It is well known to provide on glazings, such as vehicle windows, a continuous thin electroconductive heating film which may be composed of a metal or a metal oxide. The thin film has a high visible light transmission so that it is substantially transparent. The glazing is heated by applying an electrical potential difference across the film, the current being fed to the film through busbars which are disposed on opposing sides of the electroconductive film area. Such heating is used to prevent ice and/or mist forming on the surfaces of the glazing and is required to be of uniform heating intensity. Accordingly, for a rectangular area, the sheet resistance "r", which is understood to be the resistance per square area of the film, requires to be the same at each point on the film. For a rectangular area, it is possible to provide a uniform sheet resistance by providing an electroconductive heating film of uniform thickness. When the area to be heated has tapered sides, it is possible to provide uniform heating of the film by providing a film having graded sheet resistance which is achieved by grading the thickness of the film. The busbars are disposed on either the parallel or the tapered sides of the tapered area.

When the taper is very severe, this can result in a wide range of values of sheet resistance "r" being required, and this result has been confirmed by experiments which grade the resistance of the film. As the film thickness varies inversely with the sheet resistance "r", at the extremities of the sheet resistance range the film can be either too thin to withstand the application of electrical power or too thick to provide adequate transparency of the film. Such heavily graded films are difficult to manufacture consistently and present wide variations of light transmission and colour. Accordingly, there is a need for tapered windows which provide good heating characteristics which do not encounter these problems resulting from film thickness variations.

US-A-2878357 discloses an electrically conducting laminated glass panel having an electroconductive film which is composed of a plurality of sections. The glass panel suffers from the disadvantage that a plurality of isolation lines parallel to the shorter parallel sides of the panel are required between the sections and this can cause undesirable visual effects, for example the lines appearing as artificial horizons, when the panel is used as an aircraft window. In addition, the disclosed panel is limited in application since the disclosed heat ng system can be used only for particular geometries of window.

Furthermore, in certain military applications, low sheet resistance "r" electroconductive metal and metal oxide films are used to reflect electromagnetic radiation at greater wave lengths than those of the visible portion of the spectrum. In such applications, the sheet resistance has to be fairly uniform as well as not greater than about 20 ohms per square area, depending upon the particular requirements. If in a military application it is required not only to provide a glazing with an electromagnetic radiation reflectance capability but also the capability to heat the glazing, when the glazing is non-rectangular (i.e. tapered) so that it is required to employ a graded sheet resistance to provide constant heating intensity, then it becomes necessary to have two separate films on the same glazing, one to provide the required reflection and one to provide the required heating. This need for two separate films leads to a very poor light transmission capability of the glazing. Accordingly, there is a need to provide a heating capability of tapered areas by employing a heating film having a constant sheet resistance which can then additionally be employed to provide the necessary electromagnetic radial on reflectance. The appropriate required value of the sheet resistance is usable subject to selection of an appropriate applied voltage.

The present invention provides a transparent window comprising a glazing material having a tapering region, an electroconductive heating film which extends over at least the tapering region of the glazing material and is divided into a plurality of areas, an electrical connecting means which electrically connects together at least two of the areas so as to define at least one sheet resistor in the electroconductive film, the electrical connecting means comprising at least two rows of spaced electrical connections to the film, each of which rows extends along a respective tapering edge of a respective area which is electrically connected to another area, a plurality of electrical connectors external to the film which electrically connect together respective electrical connections, and electrical contacts for the or each sheet resistor, a respective electrical contact extending across each of two ends of the or each sheet resistor for application of an electrical power supply.

The present invention also provides a method of manufacturing a transparent window which has a tapering region and which is heatable by an electroconductive film, the method comprising providing a transparent substrate ply; providing on a tapering region of the substrate ply an electroconductive film which is divided into a plurality of areas, and electrically connecting together at least two of the areas so as to define at least one sheet resistor in the electroconductive film, the said areas being electrically connected together by an electrical connection means comprising at least two rows of spaced electrical connections to the film, each of which rows extends along a respective tapering edge of a respective area which is electrically connected to another area and a plurality of electrical connectors external to the film which electrically connect together respective electrical connections, the or each sheet resistor having a respective electrical contact extending across each of two ends thereof for application of an electrical power supply.

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

Figure 1 is a plan view of a transparent glazing layer for an aircraft window in accordance with a first embodiment of the present invention;

Figure 2 is an electrical schematic diagram of the transparent glazing layer of Figure 1;

Figure 3 is a plan view of a transparent glazing layer for an aircraft window in accordance with a second embodiment of the present invention;

Figure 4 is an electrical schematic diagram of the transparent glazing layer of Figure 3; and

Figure 5 is a plan view of a transparent glazing layer for an aircraft window in accordance with a third embodiment of the present invention.

Referring to Figure 1, there is shown a transparent glazing ply 2 for a vehicle window. The substrate of the glazing ply 2 may be composed of glass or any other thermoplastic material, which may be rigid, which is used in the manufacture of transparent glazings for vehicles. In general, the transparent glazing ply 2 is laminated to other transparent plies to form a composite laminated window. The transparent glazing ply 2 may be planar or, more usually, curved, normally having two dimensional curvature. The transparent glazing ply 2 tapers in breadth and is in the form of a trapezium having longer and shorter parallel edges 4,6 and two opposed tapering edges 8,10. The transparent glazing ply 2 is coated with an electroconductive heating film 12. The heating film 12 covers the entire area of the glazing ply 2 except for a narrow linear discontinuity, referred to as an isolation line 14, which is typically 1.5mm wide and divides the electroconductive heating film 12 into two areas 16 and 18. The isolation line 14 extends along the central line of symmetry of the illustrated trapezium of Figure 1 resulting in two mirror image areas 16 and 18. The electroconductive heating film 12 may be composed of any metal or metal oxide film having suitable properties for the appropriate application such as, for example, indium tin oxide or gold. The isolation line may be formed after the film has been coated on the substrate or during the coating step.

A pair of spaced power busbars 20,22 are disposed along the longer parallel edge 4 of the trapezium and a pair of spaced power busbars 24,26 are also disposed along the shorter parallel edge 6 of the trapezium. Along each tapered edge 8,10 of the trapezium is disposed a respective row 28,30 of spaced busbars. In the illustrated embodiment, each row, 28,30 of spaced busbars consists of nine busbars, these being individually designated by the letters a to i in each row 28,30. A plurality of electrical connectors 32 electrically connect the two rows 28,30 of spaced busbars together thereby electrically to connect the two areas 16,18 together. Since there are nine busbars in each row 28,30 of spaced busbars, there are nine electrical connectors 32, these also being individually designated by the letters a to i. The arrangement is such that any given busbar of the row 28 of spaced busbars is connected to a busbar of the second row 30 of spaced busbars which has the same reference letter by a connector 32 which also has the same reference letter. It will be seen that accordingly the busbar a of row 28, which is nearest to the power busbar 24 of area 16 at the narrow end of the trapezium, is connected electrically to the busbar a of row 30 of area 18 which is nearest to power busbar 22 of area 18 which is at the broader end of the trapezium.

The operation of the electroconductive heating film will now be described with reference to Figure 2. In use, a single phase AC or DC supply is connected to the power busbars 20, 22, 24 and 26. As is clear from the drawings, if a DC supply is used, the power busbars 20 and 26 which are disposed at, respectively, the broader and narrower ends of the trapezium and are connected to different respective areas 16 and 18, are connected to a negative voltage and conversely the remaining power busbars 22 and 24 are connected to a supply of positive voltage. Figure 2 is intended to show schematically the resultant circuit. The two areas 16 and 18 are electrically connected together so as to define a composite sheet resistor 34 in the electroconductive heating film 12. The sheet resistor 34 has respective electrical contacts 36,38 extending across each of the two ends 40,42 thereof, one electrical contact 36 being comprised of the power busbars 20 and 26 and the other electrical contact 38 being comprised of the power busbars 22 and 24. The tapered sides 8,10 of the trapezium are electrically connected together by the low resistance electrical connectors which do not substantially affect the resistance of the sheet resistor 34. The rectangular sheet resistor 34 is powered across the two opposing ends 40 and 42 and requires a constant value of sheet resistance "r" to provide uniform heating intensity. If the thickness of the electroconductive heating film 12 is substantially constant the sheet resistance "r" will generally be substantially constant so as to provide the uniform heating intensity. By providing such a rectangular sheet resistor 34 there is provided a resistive load between the contacts 36,38 which is substantially constant across the width of the resistor. An example of a simple current flow line is shown by the broken line 44.

The total number and shape of the busbars in the rows 28,30 of spaced busbars may be chosen to optimize the heating design for any particular application. There will be a crowding of current flow line at the ends of the spaced busbars resulting in greater local heat dissipation and, conversely, lower heat dissipation along the spaced busbars themselves. The magnitude of this non-uniformity of heating will tend to decrease with an increasing number of busbars in each row 28,30. However, some smoothing out of the hot spots can take place due to thermal conductivity in the window. Furthermore, since the non-uniformly heated regions are along the frame edge of the window which acts as a heat sink, this also tends to smooth out the hot spots. It is also possible to reduce the hot spot power constant differential by the provision of local heat sinks along the edge. It will be seen that a large number of electrical connectors 34 and corresponding busbars can be provided. In any particular application, there is likely to be a practical limit to the number of electrical connections that can be made between the busbars although it will be understood that the electrical connectors 34 do divide the total current by the number of electrical connectors 34. The electrical connectors 34 can therefore be crowded into a space along the edge of the glazing layer of very small cross section. The electrical connectors 34 may comprise a ribbon cable laminated into a windscreen along the edge thereof and a suitable ribbon cable is manufactured by the British Company called Racal Co..

The result of the electrical arrangement of Figures 1 and 2 is that the whole of the trapezium of the transparent glazing layer can be heated uniformly by an electroconductive heating film of constant sheet resistance (and thickness). Furthermore, provided that a suitable voltage supply is applied for the required heating intensity, the sheet resistance can be within the range required for reflecting electromagnetic radial on having wavelengths beyond the visible as is required for certain military applications.

Figure 3 shows a transparent glazing layer 50 in accordance with a second embodiment of the present invention. In some applications, it is undesirable to have an isolation line which extends down the centre line of the glazing ply and thus of a windscreen as in the embodiment of Figure 1. The isolation line would be visible as a result of film interference effects at its edges. In addition, in certain applications it is preferable to apply a three phase power supply to the electroconductive heating film. The embodiment of Figure 3 has been developed to meet either or both of those needs. In the embodiment of Figure 3, a transparent glazing ply 50 in the form of a trapezium carries an electroconductive heating film 52 which is divided into five areas 54, 56, 58, 60, 62 by four parallel isolation lines 64, 66, 68, 70 which are parallel and each of which is at right angles to the parallel opposed ends 72,74 of the trapezium. The five areas are constituted by a substantially rectangular central area 58, two triangular end areas 54,62 and two intermediate areas 56,60. It will be seen that the central area 58 ensures that an isolation line does not extend down the centre line of the windscreen. At the longer parallel edge 72 of the trapezium is disposed a series of five power busbars 76, 78, 80, 82, 84 and at the shorter edge 74 of the trapezium is disposed a single power busbar 86. Along the two tapering edges 88,90 of the trapezium are disposed respective rows 92,94 of spaced busbars. In the illustrated embodiment, five spaced busbars extend along the tapering edge of each of the end areas 54 and 62 and also along the tapering edge of each of the intermediate areas 56 and 60. Two sets 96,98 of electrical connectors respectively connect each busbar of a respective end area 54,62 to a respective busbar of the adjacent intermediate area 56,60. In Figure 3, the busbars of each end and intermediate area are identified by letters a to e and the connectors are correspondingly identified. That busbar of an end area 54,62 which is nearest to the longer parallel edge 72 of the trapezium is connected to that busbar of respective adjacent intermediate area 56,60 which is nearest to the shorter parallel edge 74 of the trapezium and the remaining busbars are similarly sequentially connected.

Figure 4 shows a schematic diagram of the electrical arrangement resulting from the busbars and connectors of Figure 3. In use, the power busbars 78, 80 and 82 are each connected to a respective supply of negative voltage and the power busbars 76, 74 and 84 are each connected to a respective supply of positive voltage. The electroconductive heating film 52 so divided and so electrically connected can be seen from Figure 4 to comprise three parallel sheet resistors each of which has respective electrical contacts extending across each of the respective two ends thereof. In a manner similar to the embodiment of Figure 1, each busbar of end regions 54, 62 is directly electrically connected to a busbar of the respective adjacent intermediate layer 56, 60 so that in each sheet resistor which is comprised of the combination of an intermediate area and an end area, the resistive load between the contacts is substantially constant across the width of the resistor. In the central area 58 the resistive load between the contacts is also substantially constant across the width of the resistor. The embodiment of Figure 3 permits a three phrase electrical supply to be employed to heat the electroconductive heating film 52 which forms, together with the busbars and the connectors, three sheet resistors, whereas the embodiment of Figure 1 merely employes a single phase electrical supply. The three phase electrical supply employed with theembodiment of Figure 3 can either be delta or star connected.

It will be understood that whilst the two embodiments illustrated in Figures 1 to 4 both employ a glazing layer in the shape of trapezium which may be used for wrap around front windscreens or quarter lights of fighter aircraft, the present invention could also be applicable to the use of triangular glazing layers, such as for the flat developed area of a fighter aircraft quarter light. Typically, such a triangular area could be seen to be equivalent to the triangular area which is formed from a combination of end area 54 and intermediate area 56 of the embodiment of Figure 3. Such a triangular area tapers in breadth in a manner similar to the trapezia illustrated in Figures 1 and 3.

Furthermore, in the case of a trapezium for use as the flat developed area of a fighter aircraft wrap around front windscreen, the embodiment of Figure 3 can be modified by dispensing with the isolation lines 66 and 68 and connecting the power busbars 78, 80 and 82 together to constitute a composite single power busbar. The power busbars 76 and 84 would remain spaced from the busbars 78 and 82 respectively. The power busbars 76 and 84 are physically separated by their respective positions on the windscreen itself but would be connected electrically to each other and to the busbar 86. The power supply would be single phase with, for example, combined busbars 78, 80 and 82 connected to a commmon supply of negative voltage and the busbars 76, 84 and 86 connected to a common supply of positive voltage.

Figure 5 shows a transparent glazing layer 100 in accordance with a third embodiment of the present invention. The glazing layer 100 comprises a glass face ply of a cockpit side windscreen of a passenger jet aircraft. The layer 100 is coated with a film 102 of indium tin oxide having a uniform sheet resistance which achieves the designed aircraft heating intensity. The layer 100 is substantially in the shape of an irregular trapezium and has two parallel top and bottom edges 104,106, a straight inclined side edge 108 and a kinked inclined side edge 110. The corners joining the edges are rounded. A linear discontinuity 103 in the film 102 extends between the top and bottom edges 104,106.

Along the bottom edge 106 are located two busbars 112,114 which are disposed end to end in spaced relation and on opposed sides of the linear discontinuity 103. Along the top edge 108 is located a single busbar 116. The busbar 112 faces the side edge 110. A series of seven spaced busbars 118 is disposed along the side edge 110. The busbar 114 faces the busbar 116 over a part of its length but is longer than the busbar 116 whereby the extended part of the busbar 114 faces the side edge 108. A series of seven spaced busbars 120 is disposed along the side edge 108. An electrical connector 122 connects the bottom busbar 112 to the top busbar 116 and to a first common terminal 124 of a source of AC power 126. The bottom busbar 114 is connected to a second terminal 128 of the source of AC power 126. The series of seven busbars 118 is connected to the series of seven busbars 120 by a respective series of seven connectors 130. Each connector of the series 130 connects a busbar 118 which is relatively near to the bottom edge 106 to a busbar 120 which is correspondingly relatively near to the top edge 104 and this continues in turn with the seven pairs of busbars 118,120 are connected together by the seven connectors 130, in a manner similar to the earlier embodiments.

In an alternative arrangement, a series of fifteen busbars is disposed along each inclined edge of the glazing ply, these being connected together by a series of fifteen connectors.

In use, the busbars 118,120 act to equilibrate the current flow over the area of the heating film 102 in the manner described hereinbefore in relation to the first two embodiments. The linear discontinuity 103 constitutes a phase line separating the two current regions of the film 102.

Although the illustrated embodiments disclose the use of spaced busbars along the tapering edge(s) of the heated area, in an alternative arrangement the busbars are substituted by spaced electrical connection spots which provide sufficient electrical connections at the tapering edges of the electroconductive film to ensure uniform heating intensity of the heated window.

The following examples illustrate the present invention.

Example 1

A 300mm square of glass coated with indium tin oxide having a uniform sheet resistance "r" of 10 ohms/square was provided with busbars on opposite sides of the square. An isolation line in the electroconductive heating film of indium tin oxide was made diagonally across the film thereby dividing the busbars in a length ratio of 5 to 1. The film on either side of the diagonal isolation line was bridged at thirteen equidistant points by means of silver contact strips. A low voltage was applied to the film via the opposing busbars thereby to achieve an average temperature of the glass of 40°C when the glass was resting horizontally in still air. The uniformity of the temperature was similar to that expected from heating a similar film without the diagonal isolation line having been made.

Example 2

Example 1 was repeated but on a larger scale. Using the scale of a typical wrap round fighter aircraft canopy, an indium tin oxide film of 20 ohms/square was laminated between two pieces of acrylic. The heating film layoutwas made to conform to areas 54 and 56 of Figure 3, except that a total of eight interconnections were made (employing a total of sixteen busbars 92). Thermocouples were placed close to the heating film in various positions and power applied at 0.11 watts/square cm. (0.7 watts/square in.) until the average temperature rose to 40°C. The maximum temperature which occurred at the interconnecting busbars was 49°C. There were no signs of damage resulting from these hot spots and the variation in temperature over the rest of the filmed area was within ± 2.5 C.

Example 3

Example 1 was repeated employing a 45.7 cm. (18 inch) square of acrylic sheet having an electroconductive heating film of gold. The film was powered up to 0.31 watts/square cm. (2 watts/square in.) and controlled at an average area temperature of 40°C. There was no visible damage to the film or acrylic sheets.

Example 4

Example 1 was repeated on the glazing ply of Figure 5. A low voltage was applied to the film via the feed busbars in order to obtain a steady mean temperature of 42°C with the glass sitting horizontally in still air. The total temperature variation across the entire area of the glass was from 39 to 45°C. This may be compared to a temperature variation of 31 to 49°C for an aircraft windscreen of the same shape having a graded heating film and not having the series of busbars along the inclined edges under similar test conditions. In a further test, an AGA infra-red scanner (available from Agema) showed only slight hot spots in the heating distribution over the glazing ply.

The experiment was repreated on a glazing ply of Figure 5 which has been modified so as to have fifteen busbars along each inclined edge. This gave a temperature variation of 39 to 44°C and the infra-red scanner showed no hot spots.

The embodiments of the present invention can provide a primary advantage over the prior art by employing an electroconductive heating film on a severely tapered window which will provide uniform heating with a sheet resistance "r", and correspondingly a sheet thickness, which are constant over the entire area. The embodiments can also provide a second advantage in that such an electroconductive heating film can be employed additionally to reflect electromagnetic radiation of wavelengths greater than the visible portion of the spectrum and this overcomes the problem in the prior art of requiring two separate films, one for heating and the other for reflecting electromagnetic radiation. The present invention additionally provides a further advantage over the prior art in that whether the film is employed solely for heating or for heating and reflection of electromagnetic radiation, the uniform visible light transmission over the entire area of the vehicle window can be maximized and the visible reflection which is apparent by viewing the window from inside of the vehicle is minimized.

Claims

1. A transparent window comprising a glazing material having a tapering region, an electroconductive heating film which extends over at least the tapering region of the glazing material and is divided into a plurality of areas, an electrical connecting means which electrically connects together at least two of the areas so as to define at least one sheet resistor in the electroconductive film, the electrical connecting means comprising at least two rows of spaced electrical connections to the film, each of which rows extends along a respective tapering edge of a respective area which is electrically connected to another area, a plurality of electrical connectors external to the film which electrically connect together respective electrical

connections, and electrical contacts for the or each sheet resistor, a respective electrical contact extending across each of two ends of the or each sheet resistor for application of an electrical power supply.

2. A transparent window according to claim 1 wherein the heated region is shaped as a trapezium.

3. A transparent window according to claim 2 wherein the electroconductive heating film is divided into two areas by a central isolation line extending between opposed parallel sides of the trapezium, each area having respective spaced electrical connections extending along a respective tapering edge thereof, with the plurality of connectors connecting respective spaced electrical connections of one area to respective spaced electrical connections of the other area.

4. A transparent window according to claim 2 wherein the trapezium is irregular in shape and wherein the electroconductive heating film is divided into two areas by an isolation line extending between opposed parallel sides of the trapezium, each area having respective spaced electrical connections extending along a respective tapering edge thereof, with the plurality of connectors connecting respective spaced electrical connections of one area to respective spaced electrical connections of the other area and wherein two spaced electrical contacts are serially disposed along one parallel side of the trapezium on opposed sides of the isolation line and one electrical contact is disposed along the other parallel side of the trapezium.

5. A transparent window according to claim 2 wherein the electroconductive heating film is divided into five areas by four parallel isolation lines extending between opposed parallel sides of the trapezium, the five areas comprising a substantially rectangular central area, two triangular end areas and two intermediate areas, each of the triangular and intermediate areas having respective spaced electrical connections extending along a respective tapering edge thereof, with the plurality of connectors electrically connecting respective spaced electrical connections of each end area to respective spaced electrical connections of a respective intermediate area.

6. A transparent window according to any foregoing claim wherein the electroconductive film is divided into a plurality of areas by means of one or more linear discontinuities in the film.

7. A transparent window according to any foregoing claim wherein the electroconductive film has a substantially constant sheet resistance.

8. A transparent window according to claim 7, wherein the sheet resistance is not greater than about 20 ohms per square area such that, in use, with a chosen voltage applied across the said electrical contacts, the electroconductive film provides the required heating intensity and uniformly reflects electromagnetic radiation having wavelengths above the visible.

9. A transparent window according to any foregoing claim which is a single-ply window.

10. A transparent window according to any one of claims 1 to 8 which is a multi-ply laminate.

11. A method of manufacturing a transparent window which has a tapering region and which is heatable by an electroconductive film, the method comprising providing a transparent substrate ply; providing on a tapering region of the substrate ply an electroconductive film which is divided into a plurality of areas; and electrically connecting together at least two of the areas so as to define at least one sheet resistor in the electroconductive film, the said areas being electrically connected together by an electrical connection means comprising at least two rows of spaced electrical connections to the film, each of which rows extends along a respective tapering edge of a respective area which is electrically connected to another area and a plurality of electrical connectors external to the film which electrically connect together respective electrical connections, the or each sheet resistor having a respective electrical contact extending across each of two ends thereof for application of an electrical power supply.

12. A method according to claim 11 wherein the heated region is shaped as a trapezium.

13. A method according to claim 12 wherein the electroconductive heating film is divided into two areas by a central isolation line extending between opposed parallel sides of the trapezium, each area having respective spaced electrical connections extending along a respective tapering edge thereof, with the plurality of connectors connecting respective spaced electrical connections of one area to respective spaced electrical connections of the other area.

14. A method according to claim 12 wherein the trapezium is irregular in shape and wherein the electroconductive heating film is divided into two areas by an isolation line extending between opposed parallel sides of the trapezium, each area having respective spaced electrical connections extending along a respective tapering edge thereof, with the plurality of connectors connecting respective spaced electrical connections of one area to respective spaced electrical connections of the other area and wherein two spaced electrical contacts are serially disposed along one parallel side of the trapezium on opposed sides of the isolation line and one electrical contact is disposed along the other parallel side of the trapezium.

15. A method according to claim 12 wherein

the electroconductive heating film is divided into five areas by four parallel isolation lines extending between opposed parallel sides of the trapezium, the five areas comprising a substantially rectangular central area, two triangular end areas and two intermediate areas, each of the triangular and intermediate areas having respective spaced electrical connections extending along a respective tapering edge thereof, with the plurality of connectors electrically connecting respective spaced electrical connections of each end area to respective based electrical connections of a respective intermediate area.

16. A method according to any one of claims 11 to 15 wherein the electroconductive film is deposited as a continuous film and is then divided into a plurality of areas by forming one or more linear discontinuities in the film.

17. A method according to any one of claims 11 to 15 wherein the electroconductive film is deposited as a continuous film over one or more masking strips and then the masking strips are removed thereby to divide the film into a plurality of areas.

18. A method according to any one of claims 11 to 17 wherein the electroconductive film has a substantially constant sheet resistance.

19. A method according to any one of claims 11 to 18 further comprising the step of laminating the substrate ply to one or more additional plies.

20. A method of heating a window as claimed in any one of claims 1 to 10 and wherein the electroconductive film has a substantially constant sheet resistance of not greater than about 20 ohms per square area, the method comprising applying a particular voltage across the said electrical contacts of the or each sheet resistor whereby the film is heated to the desired uniform heating intensity and can reflect electromagnetic radiation having wavelengths above the visible region of the electromagnetic spectrum.

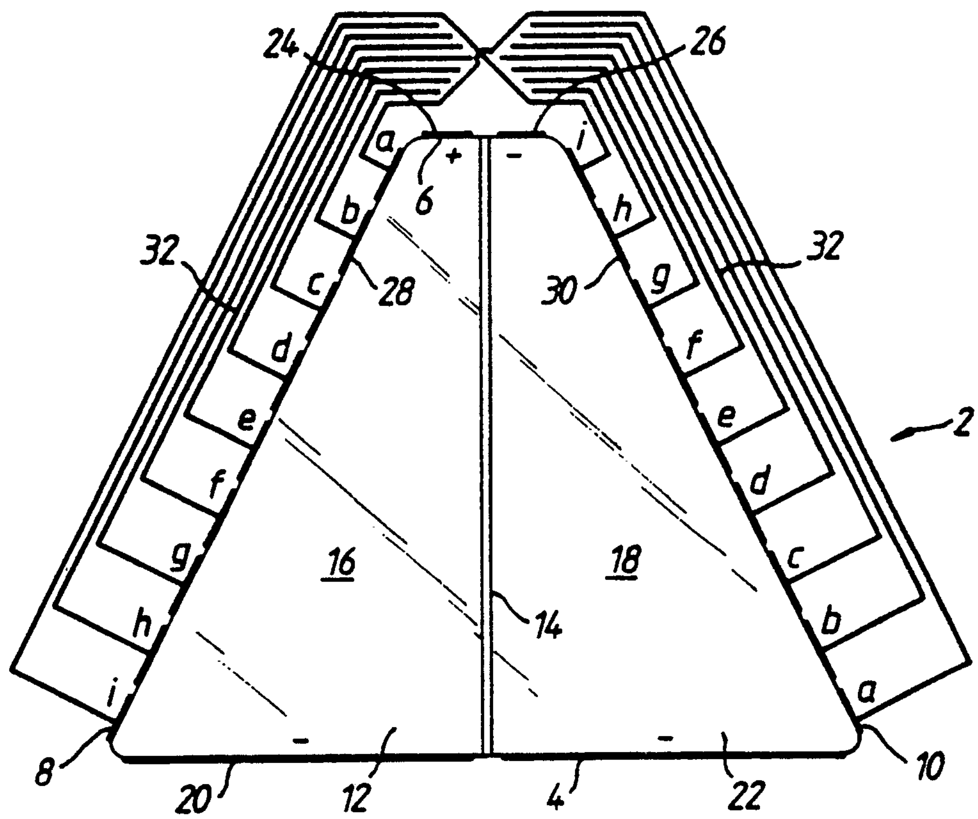
24
26
a
+
-
i
6
b
h
32
28
30
32
c
g
d
f
e
e
2
f
d
g
16
18
c
h
14
b
i
a
-
-
8
20
12
4
22
10

Fig.1.

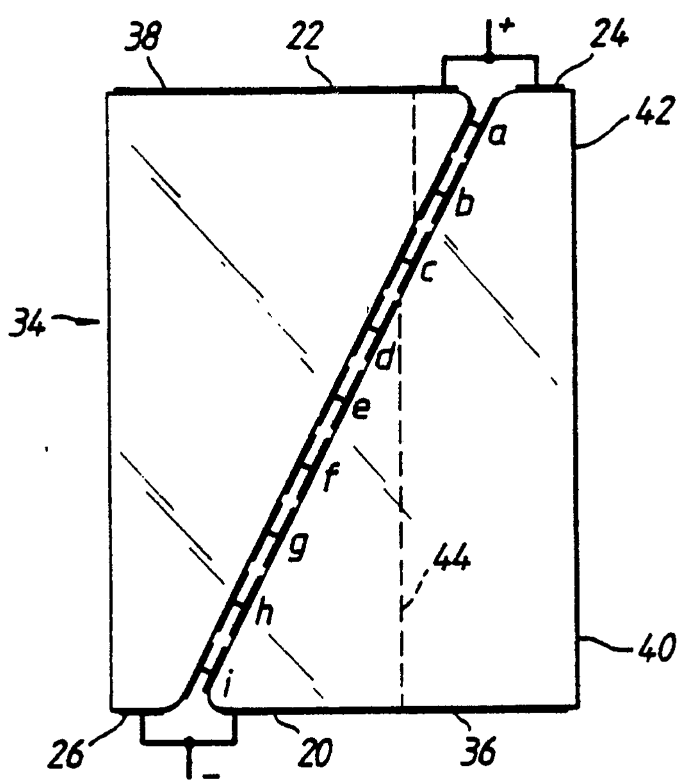
+
38
22
24
42
a
b
c
34
d
e
f
g
44
h
40
i
26
20
36
-

Fig.2.

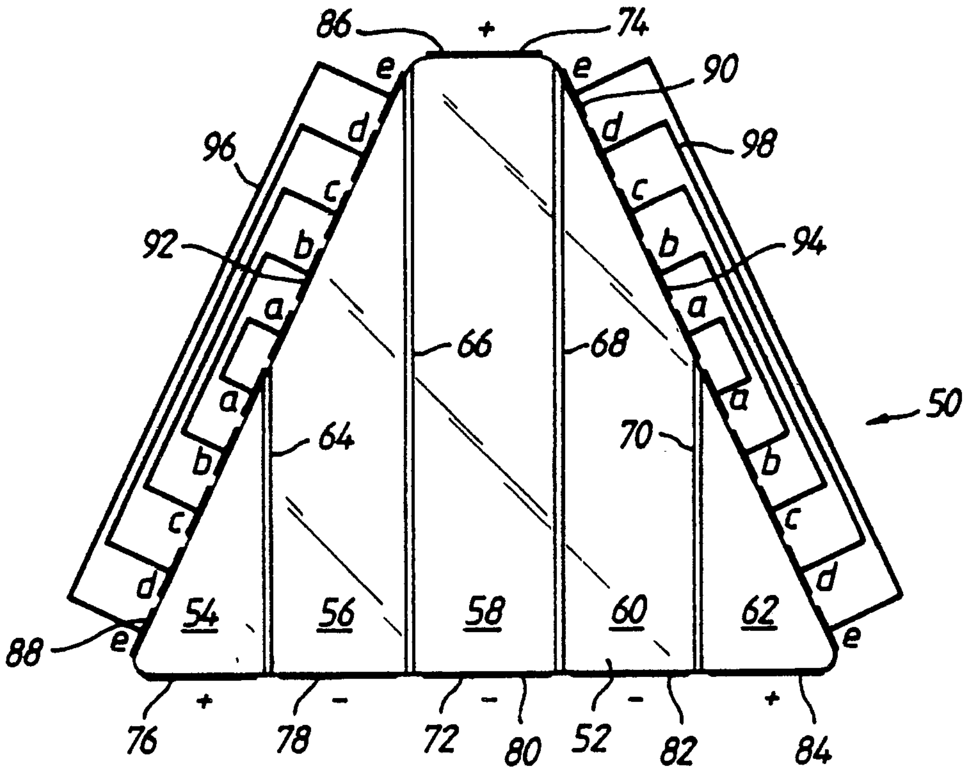
86
+
74
e
e
90
d
d
96
98
c
c
b
b
92
94
a
a
a
a
66
68
50
64
70
b
b
c
c
d
d
54
56
58
60
62
88
e
e
76
+
78
-
72
-
80
52
-
82
+
84

Fig.3.

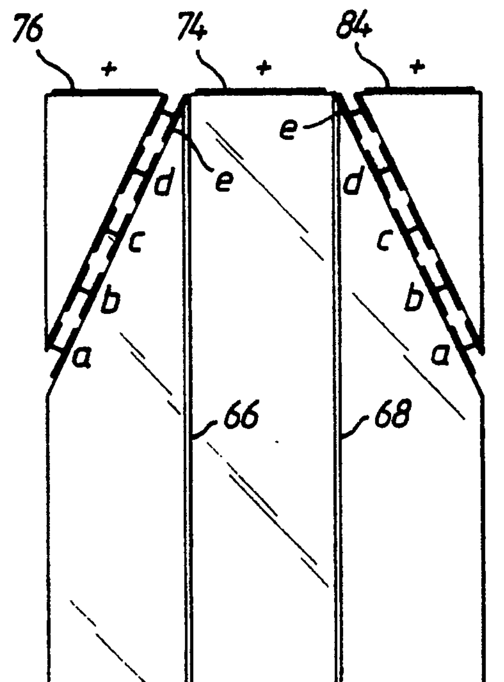
76
+
74
+
84
+
e
e
d
d
c
c
b
b
a
a
66
68
-
78
-
80
-
82

Fig.4.

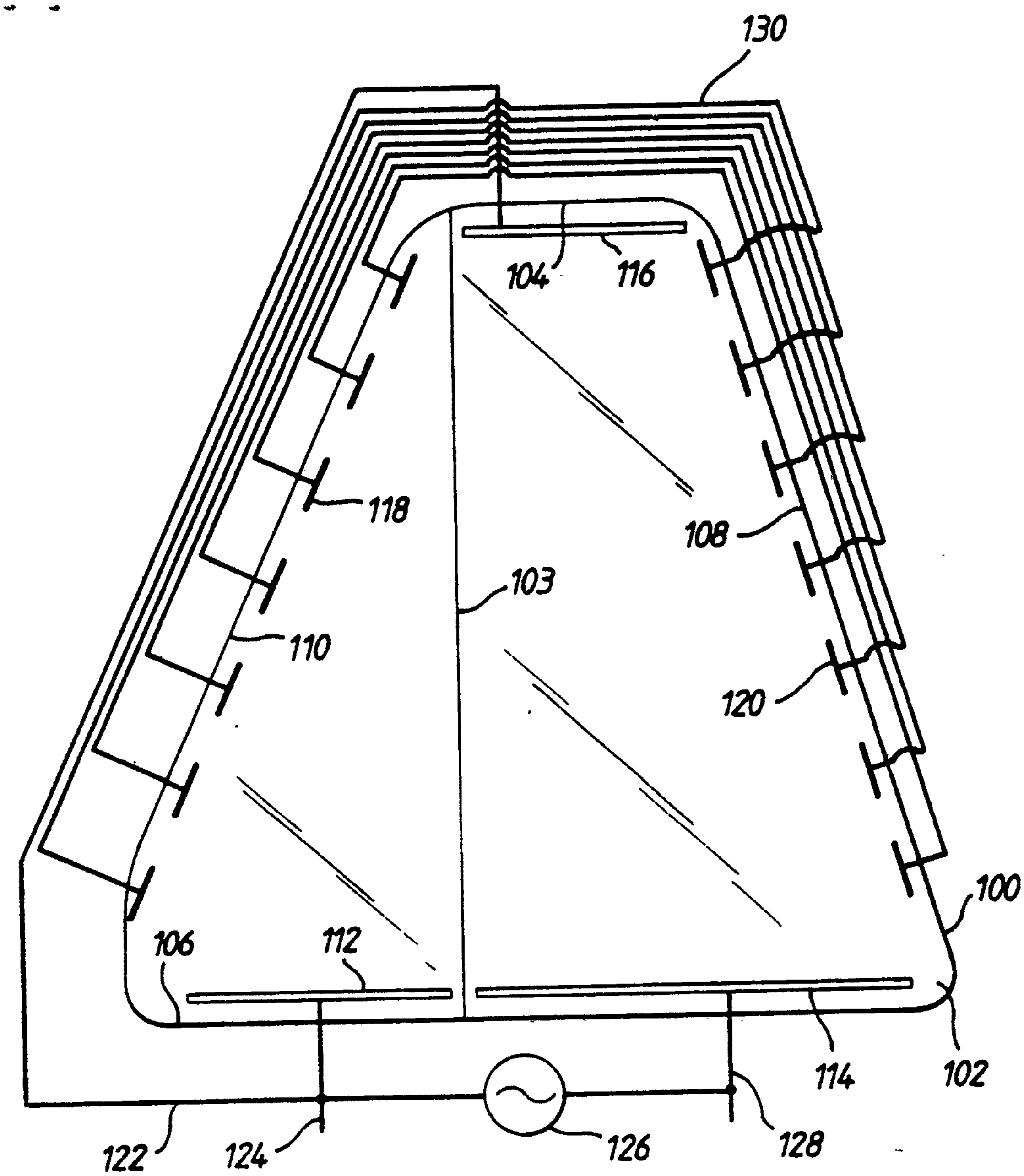
130
104
116
118
108
103
110
120
100
106
112
102
114
122
124
126
128

Fig.5.