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(54) **Improvements in and relating to crack detectors for electrically heated windows**

Verbesserungen in und in Bezug auf Bruchdetektoren für elektrisch beheizbare Scheiben

Perfectionnements de et par rapport à des détecteurs de fissures pour vitrages à chauffage électrique

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Description

[0001] The present invention relates to crack detectors, to glazings, especially vehicle glazings, coupled to such crack detectors and to methods of detecting cracks.

[0002] It is known to provide a glazing, for example a windshield in a vehicle, with an electrically conductive coating to which electrical current can be applied for heating. This has the advantage that condensation, frost or ice can be either discouraged or removed from the glazing by such heating. Such glazings may be found in cars, trucks, lorries, vans, in the railway and aircraft industries, and also in items such as chiller cabinets.

[0003] There is, however, a problem in using such a glazing if damage in the form of a crack or the like develops in that excessive heating can arise around the crack site due to electrical current concentrations. This temperature build up can lead to the melting and possibly combustion of adjacent plastic layers risking delamination of the glazing and there are fears that it could harm a user if they were to touch a hot area. Accordingly, it is desirable to detect such cracks before these problems can occur.

[0004] DE 101 25 639 A1 discloses a method for the operation of a vehicle window heating system and a window heating control unit. In the method, the unit can be transferred into a training mode in which the actual resistance value of the window to be heated is determined and stored in a memory module in the unit. In a normal operating mode, the measured resistance can be compared to the stored resistance value to determine whether a crack is present.

[0005] US 5,981,907 discloses an apparatus and method for monitoring current flow through a resistive heating element (for example on a vehicle window), the current being passed through the heating element continuously, even when the vehicle ignition is turned off, and for detecting breakage of the heating element using a computer.

[0006] US 4,565,919 discloses a crack detector system for an electrically conductive windshield. The windshield incorporates an electrically conductive layer to which a current can be applied for heating. The system monitors the resistance of the conductive element and interrupts the power applied thereto when the resistance of the conductive element exceeds a predetermined fixed threshold value indicative of element cracking.

[0007] However, it is now known that the resistance of such conductive elements used in vehicle windshields varies over time. This variation can be to increase or decrease the resistivity or to do one then the other. It is, apparently, neither unidirectional nor, presently, predictable. Also because of the tolerances in manufacturing vehicle windshields, no two windshields are identical, which means that the resistance of a conductive element will often vary from windshield to windshield. Accordingly, a fixed resistance threshold is not believed to be the best measure of whether a crack in a windshield is causing a hotspot.

[0008] It is an aim of preferred embodiments of the present invention to provide an improved crack detector, an improved glazing coupled to such crack detectors and a method of crack detection for glazings incorporating a heatable layer.

[0009] According to the present invention in a first aspect, there is provided a crack detector for a glazing comprising a heatable layer, the detector comprising a resistance measurer arranged to measure a resistance of the heatable layer of the glazing and to output a resistance value; a threshold determiner arranged to determine a threshold resistance indicative of a resistance of the heatable layer characteristic of a crack; and a comparator arranged to compare the threshold resistance with the measured resistance value, characterised in that the resistance of the heatable layer is arranged to be repeatedly measured, and the threshold resistance is arranged to be repeatedly determined, which threshold resistance is determined based on a plurality of the previous resistance values, thereby to determine if a crack is present. Such a crack detector is effectively self-calibrating, which is advantageous because it may be used with a number of different glazings, even though there may be variation in the resistance of the heatable layers of each of them as a result of manufacturing tolerances.

[0010] Suitably, a crack is determined to be present if the current measured resistance value is greater than the threshold resistance.

[0011] Suitably, the detector comprises a data logger arranged to store a plurality of resistance values output from the resistance measurer.

[0012] Suitably, the crack detector comprises a timer arranged to activate the resistance measurer at intervals. Suitably, the intervals are regular intervals. Thus periodic tests of the heatable layer can be made.

[0013] Suitably, the crack detector is arranged whereby when first energised after a predetermined delay a resistance measurement is made by the resistance measurer. This enables the resistance of the heatable layer to stabilise.

[0014] Suitably, the threshold resistance is determined based on the resistance values of a predetermined number of previously measured resistance values. Suitably, the previous resistance values are a number of immediately preceding resistance values. In this way the threshold resistance will change over time and older data will be dropped. Suitably, if it is determined that a resistance value exceeds the threshold resistance value, the exceeding resistance value is excluded from the resistance values used for determining the resistance threshold. Suitably, the threshold resistance is determined as an average of a number of resistance values. Suitably, the average is of at least ten resistance values.

[0015] Suitably, if the predetermined number of resistance values is not present, it is determined whether the measured

resistance is grossly unreasonable, in which case it is determined that a crack is present.

[0016] Suitably, the threshold resistance is at least 0.001% above the average resistance value. Suitably, the threshold resistance is at least 0.01% above the average resistance value. Suitably, the threshold resistance is at least 0.1% above the average resistance value.

[0017] Suitably, the crack detector is arranged whereby the measured resistance value is temperature normalised before a comparison is made with the threshold resistance. The heatable layer may have a temperature coefficient α of resistance. This may be used to compensate and normalise the measured resistance value for the temperature according to the equation (1):

$$R_0 = R_T / (\alpha T + 1)$$

where:

T is the temperature (in °C) at which the resistance is determined;

R_T is the resistance measured at temperature T;

α is the temperature coefficient of resistance; and

R_0 is the corresponding resistance value at temperature 0°C.

[0018] Suitably, the crack detector comprises a temperature sensor arranged to measure the ambient temperature outside a vehicle carrying the crack detector.

[0019] Suitably the glazing is a laminate comprising two plies of glazing material having a ply of interlayer material extending therebetween, and the temperature sensor is provided within the laminate.

[0020] Suitably, if a crack is detected a driver information and communication unit of a vehicle carrying the crack detector is arranged to carry out at least one of the following operations:

a) locate the current position of the vehicle;

b) signal the location of an appropriate glazier;

c) provide directions to an appropriate glazier;

d) summon a repair service to the location of the vehicle or other suitable location;

e) activate a warning light;

f) supply the telephone number of a glazier local to the vehicle; and/or

g) switch off the power supply to the glazing.

[0021] According to the present invention in a second aspect, there is provided a vehicle glazing coupled to a crack detector according to the first aspect of the present invention.

[0022] According to the present invention in a third aspect, there is provided a method of detecting cracks in a glazing comprising a heatable layer, the method comprising the steps of measuring a resistance of the heatable layer of the glazing and outputting a resistance value; determining a threshold resistance indicative of a resistance of the heatable layer characteristic of a crack; and comparing the threshold resistance with the measured resistance value, characterised by repeatedly measuring the resistance of the heatable layer and repeatedly determining the threshold resistance, which threshold resistance is determined based on a plurality of the previous resistance values, thereby to determine if a crack is present.

[0023] Suitably, a crack is determined to be present if the current measured resistance value is greater than the threshold resistance.

[0024] Suitably, the method comprises the step of storing a plurality of resistance values output from the resistance measurer.

[0025] Suitably, the resistance measurer is activated at intervals. Suitably, the intervals are regular intervals. Thus periodic tests of the heatable layer can be made.

[0026] Suitably, when first energised after a predetermined delay a resistance measurement is made by the resistance measurer. This enables the resistance of the heatable layer to stabilise.

[0027] Suitably, the threshold resistance is determined based on the resistance values of a predetermined number of previously measured resistance values. Suitably, the previous resistance values are a number of immediately preceding resistance values. In this way the threshold resistance will change over time and older data will be dropped. Suitably, if it is determined that a resistance value exceeds the threshold resistance value, the exceeding resistance value is excluded from the resistance values used for determining the resistance threshold. Suitably, the threshold resistance is determined as an average of a number of resistance values. Suitably, the average is of at least ten resistance values.

[0028] Suitably, the threshold resistance is at least 0.001% above the average resistance value. Suitably, the threshold resistance is at least 0.01% above the average resistance value. Suitably, the threshold resistance is at least 0.1% above the average resistance value.

[0029] Suitably, if the predetermined number of resistance values is not present, it is determined whether the measured resistance is grossly unreasonable, in which case it is determined that a crack is present.

[0030] Suitably, the measured resistance is temperature normalised before a comparison is made with the threshold resistance, as described earlier.

[0031] Suitably, if a crack is detected a driver information and communication unit of a vehicle carrying the crack detector carries out at least one of the following operations:

- a) locate the current position of the vehicle;
- b) signal the location of an appropriate glazier;
- c) provide directions to an appropriate glazier;
- d) summon a repair service to the location of the vehicle or other suitable location,
- e) activate a warning light;
- f) supply the telephone number of a glazier local to the vehicle; and/or
- g) switch off the power supply to the glazing.

[0032] The present invention will now be described, by way of example only, with reference to the drawings that follow; in which:

Figure 1 is a plan view of a vehicle windshield glazing;

Figure 2 is a truncated cross-section of the glazing of Figure 1 on the line II-II with some layers enlarged in scale for ease of reference;

Figure 3 is a schematic illustration of a crack detector according to the present invention; and

Figure 4 is a functional flow diagram of a method of operation of the crack detector of Figure 3, and a method of crack detection according to the present invention.

[0033] Referring to Figures 1 and 2 of the drawings that follow, there is shown a laminated glazing 2, which may be a vehicle windshield, comprising an outer ply of glazing material 4, an inner ply of glazing material 6, a heatable conductive layer or coating 8 and a ply of plastics material 10 such as polyvinyl butyral, or polyethylene terephthalate interleaved between two plies of polyvinyl butyral. The heatable conductive layer or coating 8 may be provided on an inner surface of one of the plies of glazing material 4,6 (i.e. on a surface facing into the laminate), or on a surface of the ply of plastics material 10. The glazing material may be glass or a plastics material such as polycarbonate. The polyvinyl butyral ply acts as an interlayer which bonds the plies of glazing material together and, for glass plies, minimises the risk of the glazing shattering dangerously.

[0034] On the heatable layer 8 is provided an upper busbar 12 and a lower busbar 14. The busbars also provide exposed connectors 16, 18 for connection to a power supply (not shown) for heating and a crack detector as described below. The heatable conductive layer or coating 8 may be partitioned into two or more separate heating zones, each having its own busbars, and possible even its own crack detector.

[0035] The heatable layer 8 typically consists of an electrically conductive metal or doped oxide based layer. Such a glazing 2 is well known in the art.

[0036] Referring to Figure 3 of the drawings that follow, there is shown a crack detector 30, which comprises a resistance measurer 32, a timer 34, a data logger 36, a threshold determiner 38, a comparator 40, a temperature sensor 42, a control device 44, a driver interaction unit 46, switch 48 and communication unit 56.

[0037] Resistance measurer 32 can measure the resistance of the heatable layer 8 by any known method.

[0038] Timer 34 consists of a digital timer that can be used for a variety of purposes as set out below.

[0039] Data logger 36 typically comprises a random access memory data storage module. Data from the data logger 36 may be downloaded, using a suitable data downloader, by selected third parties, for example the vehicle manufacturer or a glazing manufacturer, so that each can access information regarding the durability and longevity of the glazing carrying a crack detector.

[0040] Threshold determiner 38 is embodied in a microprocessor for calculating a resistance threshold at which a crack is likely in the heatable layer 8.

[0041] Comparator 40 is also embodied in the microprocessor used for threshold determiner 38.

[0042] Temperature sensor 42 measures the ambient temperature outside the vehicle using a thermometer, a thermistor or a thermocouple. Whichever one or more of these temperature measuring means is used may be provided in the glazing, i.e. within the laminate. Alternatively or additionally a thermometer, a thermistor or a thermocouple could be on or near the windshield 2.

[0043] Control device 44 is typically embodied in the microprocessor used for threshold determiner 38 and is coupled to a switch 48 for disconnecting the heatable layer 8 from a power source (not shown).

[0044] Interaction unit 46 in this embodiment comprises an alert light 50 provided on the vehicle dashboard or adjacent to the monitored glass. Additionally the interaction unit can include a Global Positioning System (GPS) device 54.

[0045] Communication unit 56 can transmit information from the vehicle to a glazing or car service centre. The communication unit can also receive information to update the database of contacts, address and telephone numbers. The communication unit 56 is configured automatically to use a cellular telephone network where available for communication.

[0046] A mode of operation of the crack detector 30 according to the present invention will now be described with reference to Figure 4 of the drawings that follow.

[0047] A vehicle engine (not shown) is started at step 98.

[0048] In step 100, when the engine is started up, the crack detector is first energised, assuming that it is already switched on when the engine is started (the crack detector being provided with an on/off switch (not shown)). At step 101, temperature sensor 42 measures the temperature. This is an optional operation, used if temperature normalisation is utilised (see below). At step 102 a test current or voltage (not necessarily the full current or voltage) is passed through the heatable layer 8 of the windscreen long enough for the current or voltage to stabilise, which is typically within about 30 seconds (measured by timer 34). Resistance measurer 32 measures the resistance of the heatable layer 8 and outputs a resistance value to data logger 36.

[0049] Threshold determiner 38 then in step 104 checks whether data logger 36 has the required minimum predetermined number of resistance value entries. In this embodiment ten entries are required though this can be varied for different applications and requirements.

[0050] If there are not the required minimum number of resistance value entries (follow arrow 60), step 105 determines if the measured resistance is grossly unreasonable. In this embodiment a grossly unreasonable resistance value may be taken at >2.00 Ohms (though this clearly can be modified as desired according to the size of windscreen). If the measured resistance value is grossly unreasonable then it is determined that there is a likelihood of there being a crack in the heatable layer 8 (follow arrow 63), following which in step 111 control device 44 activates switch 48 to disconnect the heatable layer 8 from the power source and activates driver interaction unit 46 to light the alert light 50 on the vehicle dashboard to draw the driver's attention to the problem so that appropriate remedial action can be taken.

[0051] If step 105 determines that the measured resistance is not grossly unreasonable (follow arrow 62), then the resistance value is included in the list of historical measurements in step 112.

[0052] If the ten resistance value entries are available (follow arrow 61), in step 106 threshold determiner 38 averages the last ten values to generate an average resistance value.

[0053] The threshold resistance can be set in a number of ways. Currently, according to the present embodiment it is set as 0.01% above the average resistance value (in some embodiments this can be as low as 0.001%, as high as 0.1%, or any value in between).

[0054] Once an initial average resistance value has been calculated by the threshold determiner 38, each time a resistance value is measured by resistance measurer 32, in step 108 the value is compared by comparator 40 against the average resistance value to see if a threshold resistance is exceeded.

[0055] If an input resistance value exceeds the threshold resistance determined by threshold determiner 38, as determined by comparator 40, it is determined that there is a likelihood of there being a crack in the heatable layer 8, following which from step 110 (follow arrow 64), in step 111 control device 44 activates switch 48 to disconnect the heatable layer 8 from the power source and activates driver interaction unit 46 to light the alert light 50 on the vehicle dashboard to draw the driver's attention to the problem so that appropriate remedial action can be taken.

[0056] If the resistance value received from resistance measurer 32 does not exceed the threshold resistance calculated by threshold determiner 38 (follow arrow 65), the input resistance value is included in the list of historical measurements in step 112. If the resistance value exceeds the threshold resistance, the resistance value is not used in the historical list for generating an average value.

[0057] When the new value is within the threshold resistance, if windscreen heating has been requested by a user (step 113 - follow arrow 66) the windscreen is continued to be powered (step 114), until it is decided that power is no longer required (follow arrow 67). If windscreen heating has not been requested, follow arrow 68. In step 116, the apparatus waits a predetermined time, measured by timer 34 before returning to step 102.

[0058] The crack detector 30 repeats the resistance measurement at intervals and the flow chart continues from step 102. Normally, there will be a regular resistance value measurement every 30 minutes (though this clearly can be modified as desired) as set by timer 34 (step 116). If, when a resistance measurement is to be made, the heatable layer 8 is not currently heated then a test current or voltage is applied to the heatable layer for a period sufficient to allow the resistance heatable layer to stabilise, which in this embodiment is 30 seconds.

[0059] The threshold resistance value used by the crack detector 30 to determine whether a crack is likely to be present varies according to the resistance values obtained over time from measurements made of the heatable layer 8. It follows that, if there is a slow drift of the resistance of the heatable layer 8, with time there will, accordingly, be a

corresponding change in the average resistance value and hence the threshold determined for deciding whether a crack is present.

[0060] Although it is not necessary for all embodiments of the present invention, an embodiment of the present invention can use a temperature measurement from temperature measurer 42 to improve the resistance threshold as temperature can have some impact on the resistance of the heatable layer 8 as determined by resistance measurer 32.

[0061] In this embodiment the electrically conductive coating has a temperature coefficient α of resistance of approximately $0.001^{\circ}\text{C}^{-1}$ (α is expected to lie in the range 0.01 to $0.0001^{\circ}\text{C}^{-1}$). This can be used to compensate the measured resistance value for temperature according to the equation (1):

$$R_0 = R_T / (\alpha T + 1)$$

where:

T is the temperature (in $^{\circ}\text{C}$) at which the resistance is determined;

R_T is the resistance measured at temperature T;

α is the temperature coefficient of resistance; and

R_0 is the corresponding resistance value at temperature 0°C .

[0062] If this option is used then, with reference to Figure 4 as an additional sub-step in step 102, the resistance is compensated for the measured temperature by being normalised according to equation (1) above, using a predetermined value for α .

[0063] The value stored in the data logger is also adjusted in this manner such that all stored readings occur at a common reference temperature.

[0064] In addition to step 111 in which the control device 44 activates the switch 48 to disconnect the heatable layer 8 from the power source, disconnection may also be achieved by a safety timer or switch (not shown) which automatically switches off the power supply to the heatable layer 8 when it reaches a predetermined temperature or after a specified period of time.

[0065] In further embodiments of the present invention, if a crack is detected, the driver information unit can be arranged to perform a variety of other actions.

[0066] In one embodiment, the driver interaction unit can be coupled to a global positioning satellite (GPS) system within the vehicle and/or a communication unit using an in-car mobile phone. When a crack is detected one or more of the following actions can be performed:

- a) locating the current position of the vehicle;
- b) signalling to the user the location of an appropriate glazier;
- c) providing to the user directions to an appropriate glazier;
- d) summoning a glazier to the location of the vehicle by delivering an automated message; or
- e) providing a telephone number of a glazier local to the vehicle

Option a) can be undertaken by using GPS 54.

Option b) can be undertaken by:

- b1) locating the current position of the vehicle as in option a);
- b2) using a satellite navigation database including glazing data to determine the location of a nearby glazier, and
- b3) signalling to the user, for instance via a satellite navigation display, the location of the glazier.

Option c) can be undertaken by:

- c1) locating the current position of the vehicle as in option a); and
- c2) using a satellite navigation database including glazier data to provide directions to a user for a nearby glazier.

Option d) can be undertaken by:

- d1) locating the current position of the vehicle as in option a);
- d2) locating a nearby glazier using a satellite navigation database including glazier data;
- d3) sending to the located glazier an automated message including the location of the vehicle. Other data that may

optionally be included, some of which needs to be input by a user, includes:

- vehicle make and model; and
- contact telephone number for user.

The automated message may be, for instance, an automated e-mail or a voice message, either of which can be transmitted via the communication unit 56.

Option e) can be undertaken by:

- e1) locating the current position of the vehicle as in option a);
- e2) using a satellite navigation database including glazing data to determine the location of a nearby glazier; and
- e3) providing to the user, for instance using a satellite navigation display, a driver information display or a voice output, the telephone number of the glazier.

[0067] While the crack detector of the invention has been described in connection with a vehicle windshield, it will be appreciated that the invention may be employed in conjunction with any glazing which incorporates an electrically conductive heating layer, coating or film (whether on or within the glazing) of which the electrical resistance may vary with time as well as due to damage.

Claims

1. A crack detector (30) for a glazing (2) comprising a heatable layer (8), the detector (30) comprising a resistance measurer (32) arranged to measure a resistance of the heatable layer (8) of the glazing (2) and to output a resistance value; a threshold determiner (38) arranged to determine a threshold resistance indicative of a resistance of the heatable layer characteristic of a crack; and a comparator (40) arranged to compare the threshold resistance with the measured resistance value,
characterised in that
the resistance of the heatable layer (8) is arranged to be repeatedly measured, and the threshold resistance is arranged to be repeatedly determined, which threshold resistance is determined based on a plurality of the previous resistance values, thereby to determine if a crack is present.
2. A crack detector (30) according to claim 1, in which a crack is determined to be present if the current measured resistance value is greater than the threshold resistance.
3. A crack detector (30) according to claim 1 or claim 2, in which the detector (30) comprises a data logger (36) arranged to store a plurality of resistance values output from the resistance measurer (32).
4. A crack detector (30) according to any preceding claim, in which the crack detector (30) comprises a timer (34) arranged to activate the resistance measurer (32) at intervals.
5. A crack detector (30) according to claim 4, in which the intervals are regular intervals.
6. A crack detector (30) according to any preceding claim, in which the crack detector (30) is arranged whereby when first energised after a predetermined delay a resistance measurement is made by the resistance measurer (32).
7. A crack detector (30) according to any preceding claim, in which the threshold resistance is determined based on the resistance values of a predetermined number of previously measured resistance values.
8. A crack detector (30) according to claim 7, in which the previous resistance values are a number of immediately preceding resistance values.
9. A crack detector (30) according to claim 7 or claim 8, in which if it is determined that a resistance value exceeds the threshold resistance value, the exceeding resistance value is excluded from the resistance values used for determining the resistance threshold.
10. A crack detector (30) according to any of claims 7 to 9, in which the threshold resistance is determined as an average of a number of resistance values.

11. A crack detector (30) according to claim 10, in which the average is of at least ten resistance values.
12. A crack detector (30) according to any of claims 7 to 11, in which if the predetermined number of resistance values is not present, it is determined whether the measured resistance is grossly unreasonable, in which case it is determined that a crack is present.
13. A crack detector (30) according to any preceding claim, in which the threshold resistance is at least 0.001 % above the average resistance value.
14. A crack detector (30) according to claim 13, in which the threshold resistance is at least 0.01 % above the average resistance value.
15. A crack detector (30) according to claim 13 or claim 14, in which the threshold resistance is at least 0.1 % above the average resistance value.
16. A crack detector (30) according to any preceding claim, in which the crack detector (30) is arranged whereby the measured resistance value is normalised before a comparison is made with the threshold resistance.
17. A crack detector (30) according to claim 17, in which the glazing (2) is a laminate comprising two plies of glazing material (4,6) having a ply of interlayer material (10) extending therebetween.
18. A crack detector (30) according to claim 17, in which the detector (30) comprises a temperature sensor (42) arranged to measure the ambient temperature outside a vehicle carrying the crack detector (30).
19. A crack detector (30) according to claim 18, in which the temperature sensor (42) is provided within the laminate (2).
20. A crack detector (30) according to any preceding claim, in which if a crack is detected a driver information and communication unit (56) of a vehicle carrying the crack detector (30) is arranged to carry out at least one of the following operations:
 - a) locate the current position of the vehicle;
 - b) signal the location of an appropriate glazier;
 - c) provide directions to an appropriate glazier;
 - d) summon a repair service to the location of the vehicle or other suitable location;
 - e) activate a warning light (50);
 - f) supply the telephone number of a glazier local to the vehicle; and/or
 - g) switch off the power supply to the glazing.
21. A vehicle glazing (2) coupled to a crack detector (30) according to any of claims 1 to 20.
22. A method of detecting cracks in a glazing (2) comprising a heatable layer (8), the method comprising the steps of measuring a resistance of the heatable layer (8) of the glazing (2) and outputting a resistance value; determining a threshold resistance indicative of a resistance of the heatable layer (8) characteristic of a crack; and comparing the threshold resistance with the measured resistance value,
characterised by
repeatedly measuring the resistance of the heatable layer (8) and repeatedly determining the threshold resistance, which threshold resistance is determined based on a plurality of the previous resistance values, thereby to determine if a crack is present.
23. A method of detecting cracks according to claim 22, in which a crack is determined to be present if the current measured resistance value is greater than the threshold resistance.
24. A method of detecting cracks according to claim 22 or claim 23, in which the method comprises the step of storing a plurality of resistance values output from the resistance measurer (32).
25. A method of detecting cracks according to any of claims 22 to 24, in which the resistance measurer is activated at intervals.

26. A method of detecting cracks according to claim 25, in which the intervals are regular intervals.
27. A method of detecting cracks according to any of claims 22 to 26, in which when first energised after a predetermined delay a resistance measurement is made by the resistance measurer (32).
28. A method of detecting cracks according to any of claims 22 to 27, in which the threshold resistance is determined based on the resistance values of a predetermined number of previously measured resistance values.
29. A method of detecting cracks according to claim 28, in which the previous resistance values are a number of immediately preceding resistance values.
30. A method of detecting cracks according to claim 28 or claim 29, in which if it is determined that a resistance value exceeds the threshold resistance value, the exceeding resistance value is excluded from the resistance values used for determining the resistance threshold.
31. A method of detecting cracks according to any of claims 28 to 30, in which the threshold resistance is determined as an average of a number of resistance values.
32. A method of detecting cracks according to claim 31, in which the average is of at least ten resistance values.
33. A method of detecting cracks according to any of claims 28 to 32, in which if the predetermined number of resistance values is not present, it is determined whether the measured resistance is grossly unreasonable, in which case it is determined that a crack is present.
34. A method of detecting cracks according to any of claims 22 to 33, in which the threshold resistance is at least 0.001% above the average resistance value.
35. A method of detecting cracks according to claim 34, in which the threshold resistance is at least 0.01% above the average resistance value.
36. A method of detecting cracks according to claim 35, in which the threshold resistance is at least 0.1% above the average resistance value.
37. A method of detecting cracks according to any of claims 22 to 36, in which the measured resistance is normalised before a comparison is made with the threshold resistance.
38. A method of detecting cracks according to any of claims 22 to 37, in which if a crack is detected a driver information and communication unit (56) of a vehicle carrying the crack detector (30) carries out at least one of the following operations:
- a) locate the current position of the vehicle;
 - b) signal the location of an appropriate glazier;
 - c) provide directions to an appropriate glazier;
 - d) summon a repair service to the location of the vehicle or other suitable location;
 - e) activate a warning light (50);
 - f) supply the telephone number of a glazier local to the vehicle, and/or
 - g) switch off the power supply to the glazing.

Patentansprüche

1. Bruchdetektor (30) für eine, eine heizbare Schicht (8) umfassende, Verglasung (2), wobei der Detektor (30) eine Widerstandsmesseinrichtung (32), die zur Messung eines Widerstands der heizbaren Schicht (8) der Verglasung (2) und zur Ausgabe eines Widerstandswerts ausgebildet ist, eine Schwellwertbestimmungseinrichtung (38), die zur Bestimmung eines Schwellwiderstands ausgebildet ist, der einen, für einen Bruch der heizbaren Schicht kennzeichnenden Widerstand angibt, und eine Vergleichseinrichtung (40) umfasst, die zum Vergleichen des Schwellwiderstands mit dem gemessenen Widerstandswert ausgebildet ist, **dadurch gekennzeichnet,**

dass der Widerstand der heizbaren Schicht (8) zur wiederholten Messung ausgebildet ist und der Schwellwiderstand zur wiederholten Bestimmung ausgebildet ist, wobei der Schwellwiderstand auf der Grundlage einer Vielzahl von vorherigen Widerstandswerten bestimmt wird, um dadurch das Vorhandensein eines Bruchs festzustellen.

- 5 **2.** Bruchdetektor (30) nach Anspruch 1, worin das Vorhandensein eines Bruchs festgestellt wird, wenn der aktuell gemessene Widerstandswert größer als der Schwellwiderstand ist.
- 3.** Bruchdetektor (30) nach Anspruch 1 oder 2, worin der Bruchdetektor (30) eine Datenregistriereinrichtung (36) umfasst, die zum Speichern einer Vielzahl von Widerstandswerten ausgebildet ist, die von der Widerstandsmesseinrichtung (32) ausgegeben werden.
- 10 **4.** Bruchdetektor (30) nach einem der vorangehenden Ansprüche, worin der Bruchdetektor (30) einen Zeitgeber (34) umfasst, der zur Aktivierung der Widerstandsmesseinrichtung (32) in zeitlichen Abständen ausgebildet ist.
- 15 **5.** Bruchdetektor (30) nach Anspruch 4, worin die zeitlichen Abstände gleichmäßige Intervalle darstellen.
- 6.** Bruchdetektor (30) nach einem der vorangehenden Ansprüche, worin der Bruchdetektor (30) so ausgebildet ist, dass bei dessen erster Aktivierung von der Widerstandsmesseinrichtung (32) nach einer vorgegebenen Verzögerungszeit eine Widerstandsmessung vorgenommen wird.
- 20 **7.** Bruchdetektor (30) nach einem der vorhergehenden Ansprüche, worin der Schwellwiderstand auf der Grundlage von Widerstandswerten einer vorgegebenen Anzahl von zuvor gemessenen Widerstandswerten bestimmt wird.
- 8.** Bruchdetektor (30) nach Anspruch 7, worin die vorherigen Widerstandswerte von einer Anzahl unmittelbar vorausgegangener Widerstandswerte gebildet werden.
- 25 **9.** Bruchdetektor (30) nach Anspruch 7 oder 8, worin, falls festgestellt wird, dass ein Widerstandswert den Schwellwiderstandswert überschreitet, der überschreitende Widerstandswert von den Widerstandswerten ausgeschlossen wird, die zur Bestimmung des Schwellwiderstands heran gezogen werden.
- 30 **10.** Bruchdetektor (30) nach einem der Ansprüche 7 bis 9, worin der Schwellwiderstand als Durchschnittswert einer Anzahl von Widerstandswerten bestimmt wird.
- 11.** Bruchdetektor (30) nach Anspruch 10, worin der Durchschnittswert aus zumindest zehn Widerstandswerten gebildet wird.
- 35 **12.** Bruchdetektor (30) nach einem der Ansprüche 7 bis 11, worin, falls die vorgegebene Anzahl von Widerstandswerten nicht vorhanden ist, festgestellt wird, ob der gemessene Widerstand äußerst unwahrscheinlich ist, so dass in diesem Fall festgestellt wird, dass ein Bruch vorhanden ist.
- 40 **13.** Bruchdetektor (30) nach einem der vorangehenden Ansprüche, worin der Schwellwiderstand zumindest 0,001% oberhalb des durchschnittlichen Widerstandswerts liegt.
- 14.** Bruchdetektor (30) nach Anspruch 13, worin der Schwellwiderstand zumindest 0,01% oberhalb des durchschnittlichen Widerstandswerts liegt.
- 45 **15.** Bruchdetektor (30) nach Anspruch 13 oder 14, worin der Schwellwiderstand zumindest 0,1% oberhalb des durchschnittlichen Widerstandswerts liegt.
- 50 **16.** Bruchdetektor (30) nach einem der vorangehenden Ansprüche, worin der Bruchdetektor (30) dazu ausgebildet ist, dass der gemessene Widerstandswert vor einem Vergleich mit dem Schwellwiderstand normalisiert wird.
- 17.** Bruchdetektor (30) nach Anspruch 16, worin die Verglasung (2) von einem Verbundstoff gebildet wird, der zwei Schichten eines Verglasungsmaterials (4, 6) aufweist, zwischen denen sich eine Schicht aus einem Folieneinlagenmaterial (10) erstreckt.
- 55 **18.** Bruchdetektor (30) nach Anspruch 17, worin der Detektor (30) einen Temperatursensor (42) aufweist, der zur Messung der Umgebungstemperatur außerhalb eines Fahrzeugs ausgebildet ist, in dem der Bruchdetektor (30)

aufgenommen ist.

19. Bruchdetektor (30) nach Anspruch 18, worin der Temperatursensor (42) innerhalb des Verbundstoffs (2) angeordnet ist.

20. Bruchdetektor (30) nach einem der vorhergehenden Ansprüche, worin eine Fahrerinformations- und -kommunikationseinrichtung (56) eines den Bruchdetektor (30) aufnehmenden Fahrzeugs zur Ausführung von zumindest einer der folgenden Vorgänge ausgebildet ist:

- a) Feststellen der aktuellen Position des Fahrzeugs;
- b) Mitteilen des Standorts eines sachkundigen Glasers;
- c) Erstellen der Anfahrsbeschreibung zu einem sachkundigen Glaser;
- d) Anfordern eines Reparaturdienstes an den Fahrzeugstandort oder an einen anderen geeigneten Standort;
- e) Einschalten der Warnleuchte (50);
- f) Angeben der Telefonnummer eines in der Nähe des Fahrzeugs befindlichen Glasers; und/oder
- g) Abschalten der Stromversorgung der Verglasung.

21. Fahrzeugverglasung (2), die an einen Bruchdetektor (30) nach einem der Ansprüche 1 bis 20 gekoppelt ist.

22. Verfahren zum Erkennen von Brüchen in einer, eine heizbare Schicht (8) aufweisenden, Verglasung (2), wobei das Verfahren Schritte umfasst zum Messen eines Widerstands der heizbaren Schicht (8) der Verglasung (2) und zum Ausgeben einer Widerstandswerts, zum Bestimmen eines Schwellwiderstands, der einen Widerstand der heizbaren Schicht (8) angibt, der kennzeichnend für einen Bruch ist, und zum Vergleichen des Schwellwiderstands mit dem gemessenen Widerstandswert,

dadurch gekennzeichnet,

dass der Widerstand der heizbaren Schicht (8) wiederholt gemessen und der Schwellwiderstand wiederholt bestimmt wird, wobei der Schwellwiderstand auf der Grundlage einer Vielzahl von vorherigen Widerstandswerten bestimmt wird, um dadurch das Vorhandensein eines Bruchs festzustellen.

23. Verfahren zum Erkennen von Brüchen nach Anspruch 22, worin das Vorhandensein eines Bruchs festgestellt wird, wenn der aktuell gemessene Widerstandswert größer als der Schwellwiderstand ist.

24. Verfahren zum Erkennen von Brüchen nach Anspruch 22 oder 23, worin das Verfahren den Schritt zum Speichern einer Vielzahl von Widerstandswerten umfasst, die von der Widerstandsmesseinrichtung (32) ausgegeben werden.

25. Verfahren zum Erkennen von Brüchen nach einem der Ansprüche 22 bis 24, worin die Widerstandsmesseinrichtung in zeitlichen Abständen aktiviert wird.

26. Verfahren zum Erkennen von Brüchen nach Anspruch 25, worin die zeitlichen Abstände gleichmäßige Intervalle darstellen.

27. Verfahren zum Erkennen von Brüchen nach einem der Ansprüche 22 bis 26, worin nach der ersten Aktivierung von der Widerstandsmesseinrichtung (32) nach einer vorgegebenen Verzögerungszeit eine Widerstandsmessung vorgenommen wird.

28. Verfahren zum Erkennen von Brüchen nach einem der Ansprüche 22 bis 27, worin der Schwellwiderstand auf der Grundlage von Widerstandswerten einer vorgegebenen Anzahl zuvor gemessener Widerstandswerte bestimmt wird.

29. Verfahren zum Erkennen von Brüchen nach Anspruch 28, worin die vorherigen Widerstandswerte von einer Anzahl unmittelbar vorausgegangener Widerstandswerte gebildet werden.

30. Verfahren zum Erkennen von Brüchen nach Anspruch 28 oder 29, worin , falls festgestellt wird, dass ein Widerstandswert den Schwellwiderstandswert überschreitet, der überschreitende Widerstandswert von den Widerstandswerten ausgeschlossen wird, die zur Bestimmung des Schwellwiderstandswerts heran gezogen werden.

31. Verfahren zum Erkennen von Brüchen nach einem der Ansprüche 28 bis 30, worin der Schwellwiderstand als Durchschnittswert einer Anzahl von Widerstandswerten bestimmt wird.

32. Verfahren zum Erkennen von Brüchen nach Anspruch 31, worin der Durchschnittswert aus zumindest zehn Widerstandswerten gebildet wird.
- 5 33. Verfahren zum Erkennen von Brüchen nach einem der Ansprüche 28 bis 32, worin, falls die vorgegebene Anzahl von Widerstandswerten nicht vorhanden ist, festgestellt wird, ob der gemessene Widerstand äußerst unwahrscheinlich ist, so dass in diesem Fall festgestellt wird, dass ein Bruch vorhanden ist.
- 10 34. Verfahren zum Erkennen von Brüchen nach einem der Ansprüche 22 bis 33, worin der Schwellwiderstand zumindest 0,001% oberhalb des durchschnittlichen Widerstandswerts liegt.
35. Verfahren zum Erkennen von Brüchen nach Anspruch 34, worin der Schwellwiderstand zumindest 0,01% oberhalb des durchschnittlichen Widerstandswerts liegt.
- 15 36. Verfahren zum Erkennen von Brüchen nach Anspruch 35, worin der Schwellwiderstand zumindest 0,1 % oberhalb des durchschnittlichen Widerstandswerts liegt.
37. Verfahren zum Erkennen von Brüchen nach einem der Ansprüche 22 bis 36, bei dem der gemessene Widerstandswert vor einem Vergleich mit dem Schwellwiderstand normalisiert wird.
- 20 38. Verfahren zum Erkennen von Brüchen nach einem der Ansprüche 22 bis 37, worin eine Fahrerinformations- und -kommunikationseinrichtung (56) eines den Bruchdetektor (30) aufnehmenden Fahrzeugs beim Erkennen eines Bruchs zumindest einen der folgenden Vorgänge ausführt:
- 25 a) Feststellen der aktuellen Position des Fahrzeugs;
 b) Mitteilen des Standorts eines sachkundigen Glasers;
 c) Erstellen der Anfahrtsbeschreibung zu einem sachkundigen Glaser;
 d) Anfordern eines Reparaturdienstes an den Fahrzeugstandort oder an einen anderen geeigneten Standort;
 e) Einschalten der Warnleuchte (50);
 f) Angeben der Telefonnummer eines in der Nähe des Fahrzeugs befindlichen Glasers; und/oder
 30 g) Abschalten der Stromversorgung der Verglasung.

Revendications

- 35 1. Détecteur de fissures (30) pour une vitre (2) comprenant une couche chauffable (8), le détecteur (30) comprenant un élément de mesure de résistance (32) prévu pour mesurer une résistance de la couche chauffable (8) de la vitre (2) et pour fournir une valeur de résistance ; un élément de détermination de seuil (38) prévu pour déterminer une résistance de seuil, indicatrice d'une résistance de la couche chauffable, caractéristique d'une fissure ; et un élément de comparaison (40) prévu pour comparer la résistance de seuil à la valeur mesurée de la résistance, **caractérisé**
- 40 **en ce que**
- la résistance de la couche chauffable (8) est prévue pour être mesurée de manière répétée, et la résistance de seuil est prévue pour être déterminée de manière répétée, laquelle résistance de seuil est déterminée sur la base d'une pluralité des valeurs précédentes de résistance, pour ainsi déterminer la présence éventuelle d'une fissure.
- 45 2. Détecteur de fissures (30) selon la revendication 1, dans lequel il est déterminé qu'une fissure est présente si la valeur mesurée actuelle de la résistance est supérieure à la résistance de seuil.
- 50 3. Détecteur de fissures (30) selon la revendication 1 ou la revendication 2, dans lequel le détecteur (30) comprend un enregistreur de données (36) prévu pour stocker une pluralité de valeurs de résistance fournies par l'élément de mesure de résistance (32).
- 55 4. Détecteur de fissures (30) selon l'une quelconque des revendications précédentes, dans lequel le détecteur de fissures (30) comprend une horloge (34) prévue pour mettre en fonction l'élément de mesure de résistance (32) par intervalles.
5. Détecteur de fissures (30) selon la revendication 4, dans lequel les intervalles sont des intervalles réguliers.

6. Détecteur de fissures (30) selon l'une quelconque des revendications précédentes, dans lequel le détecteur de fissures (30) est prévu pour que, lorsqu'il est mis sous tension pour la première fois après un délai prédéterminé, une mesure de résistance soit effectuée par l'élément de mesure de résistance (32).
- 5 7. Détecteur de fissures (30) selon l'une quelconque des revendications précédentes, dans lequel la résistance de seuil est déterminée sur la base des valeurs de résistance d'un nombre prédéterminé de valeurs de résistance mesurées auparavant.
- 10 8. Détecteur de fissures (30) selon la revendication 7, dans lequel les valeurs antérieures de résistance sont un certain nombre de valeurs de résistance immédiatement précédentes.
- 15 9. Détecteur de fissures (30) selon la revendication 7 ou la revendication 8, dans lequel, s'il est déterminé qu'une valeur de résistance dépasse la valeur de résistance de seuil, cette valeur plus élevée de résistance est exclue des valeurs de résistance utilisées pour la détermination du seuil de résistance.
- 20 10. Détecteur de fissures (30) selon l'une quelconque des revendications 7 à 9, dans lequel la résistance de seuil est déterminée en tant que moyenne d'un certain nombre de valeurs de résistance.
- 25 11. Détecteur de fissures (30) selon la revendication 10, dans lequel la moyenne est établie sur au moins dix valeurs de résistance.
- 30 12. Détecteur de fissures (30) selon l'une quelconque des revendications 7 à 11, dans lequel, si le nombre prédéterminé de valeurs de résistance n'est pas présent, il est alors déterminé si la résistance mesurée est excessive outre mesure, auquel cas il est déterminé qu'une fissure est présente.
- 35 13. Détecteur de fissures (30) selon l'une quelconque des revendications précédentes, dans lequel la résistance de seuil est d'au moins 0,001 % supérieure à la valeur de résistance moyenne.
- 40 14. Détecteur de fissures (30) selon la revendication 13, dans lequel la résistance de seuil est d'au moins 0,01 % supérieure à la valeur de résistance moyenne.
- 45 15. Détecteur de fissures (30) selon la revendication 13 ou la revendication 14, dans lequel la résistance de seuil est d'au moins 0,1 % supérieure à la valeur de résistance moyenne.
- 50 16. Détecteur de fissures (30) selon l'une quelconque des revendications précédentes, dans lequel le détecteur de fissures (30) est prévu pour que la valeur mesurée de la résistance soit normalisée avant qu'une comparaison ne soit faite avec la résistance de seuil.
- 55 17. Détecteur de fissures (30) selon la revendication 17, dans lequel la vitre (2) est une vitre feuilletée comprenant deux nappes de matière formant vitre (4, 6) entre lesquelles s'étend une nappe de matière intercalaire (10).
18. Détecteur de fissures (30) selon la revendication 17, dans lequel le détecteur (30) comprend un capteur de température (42) prévu pour mesurer la température ambiante à l'extérieur d'un véhicule équipé du détecteur de fissures (30).
19. Détecteur de fissures (30) selon la revendication 18, dans lequel le capteur de température (42) est situé à l'intérieur de la vitre feuilletée (2).
20. Détecteur de fissures (30) selon l'une quelconque des revendications précédentes, dans lequel, si une fissure est détectée, une unité d'information et de communication au conducteur (56) d'un véhicule équipé du détecteur de fissures (30) est prévue pour exécuter au moins l'une des opérations suivantes:
 - a) repérer la position actuelle du véhicule;
 - b) signaler l'emplacement d'un vitrier approprié;
 - c) fournir des indications pour se rendre chez un vitrier approprié ;
 - d) faire venir un service de réparations à l'emplacement du véhicule ou à un autre emplacement adéquat ;
 - e) mettre en fonction un feu de signalisation (50) ;
 - f) fournir le numéro de téléphone d'un vitrier proche du véhicule ; et/ou

g) couper l'alimentation en courant de la vitre.

21. Vitre de véhicule (2) associée à un détecteur de fissures (30) selon l'une quelconque des revendications 1 à 20.

22. Procédé de détection de fissures dans une vitre (2) comprenant une couche chauffable (8), le procédé comprenant les étapes de mesure d'une résistance de la couche chauffable (8) de la vitre (2) et la fourniture d'une valeur de résistance ; la détermination d'une résistance de seuil, indicatrice d'une résistance de la couche chauffable (8), caractéristique d'une fissure ; et la comparaison de la résistance de seuil avec la valeur mesurée de la résistance, **caractérisé par**

la mesure de manière répétée de la résistance de la couche chauffable (8), et la détermination de manière répétée de la résistance de seuil, laquelle résistance de seuil est déterminée sur la base d'une pluralité des valeurs précédentes de résistance, pour ainsi déterminer la présence éventuelle d'une fissure.

23. Procédé de détection de fissures selon la revendication 22, dans lequel il est déterminé qu'une fissure est présente si la valeur mesurée actuelle de la résistance est supérieure à la résistance de seuil.

24. Procédé de détection de fissures selon la revendication 22 ou la revendication 23, dans lequel le procédé comprend l'étape d'enregistrement d'une pluralité de valeurs de résistance fournies par l'élément de mesure de résistance (32).

25. Procédé de détection de fissures selon l'une quelconque des revendications 22 à 24, dans lequel l'élément de mesure de résistance est mis en fonction par intervalles.

26. Procédé de détection de fissures selon la revendication 25, dans lequel les intervalles sont des intervalles réguliers.

27. Procédé de détection de fissures selon l'une quelconque des revendications 22 à 26, dans lequel, lors d'une mise sous tension pour la première fois après un délai prédéterminé, une mesure de résistance est effectuée par l'élément de mesure de résistance (32).

28. Procédé de détection de fissures selon l'une quelconque des revendications 22 à 27, dans lequel la résistance de seuil est déterminée sur la base des valeurs de résistance d'un nombre prédéterminé de valeurs de résistance mesurées auparavant.

29. Procédé de détection de fissures selon la revendication 28, dans lequel les valeurs antérieures de résistance sont un certain nombre de valeurs de résistance immédiatement précédentes.

30. Procédé de détection de fissures selon la revendication 28 ou la revendication 29, dans lequel, s'il est déterminé qu'une valeur de résistance dépasse la valeur de résistance de seuil, cette valeur plus élevée de résistance est exclue des valeurs de résistance utilisées pour la détermination du seuil de résistance.

31. Procédé de détection de fissures selon l'une quelconque des revendications 28 à 30, dans lequel la résistance de seuil est déterminée en tant que moyenne d'un certain nombre de valeurs de résistance.

32. Procédé de détection de fissures selon la revendication 31, dans lequel la moyenne est établie sur au moins dix valeurs de résistance.

33. Procédé de détection de fissures selon l'une quelconque des revendications 28 à 32, dans lequel, si le nombre prédéterminé de valeurs de résistance n'est pas présent, il est alors déterminé si la résistance mesurée est excessive outre mesure, auquel cas il est déterminé qu'une fissure est présente.

34. Procédé de détection de fissures selon l'une quelconque des revendications 22 à 33, dans lequel la résistance de seuil est d'au moins 0,001 % supérieure à la valeur de résistance moyenne.

35. Procédé de détection de fissures selon la revendication 34, dans lequel la résistance de seuil est d'au moins 0,01 % supérieure à la valeur de résistance moyenne.

36. Procédé de détection de fissures selon la revendication 35, dans lequel la résistance de seuil est d'au moins 0,1 % supérieure à la valeur de résistance moyenne.

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37. Procédé de détection de fissures selon l'une quelconque des revendications 22 à 36, dans lequel la résistance mesurée est normalisée avant qu'une comparaison ne soit faite avec la résistance de seuil.

5 38. Procédé de détection de fissures selon l'une quelconque des revendications 22 à 37, dans lequel, si une fissure est détectée, une unité d'information et de communication au conducteur (56) d'un véhicule équipé du détecteur de fissures (30) exécute au moins l'une des opérations suivantes:

a) repérer la position actuelle du véhicule ;

b) signaler l'emplacement d'un vitrier approprié ;

10 c) fournir des indications pour se rendre chez un vitrier approprié ;

d) faire venir un service de réparations à l'emplacement du véhicule ou à un autre emplacement adéquat ;

e) mettre en fonction un feu de signalisation (50);

f) fournir le numéro de téléphone d'un vitrier proche du véhicule ; et/ou

15 g) couper l'alimentation en courant de la vitre.

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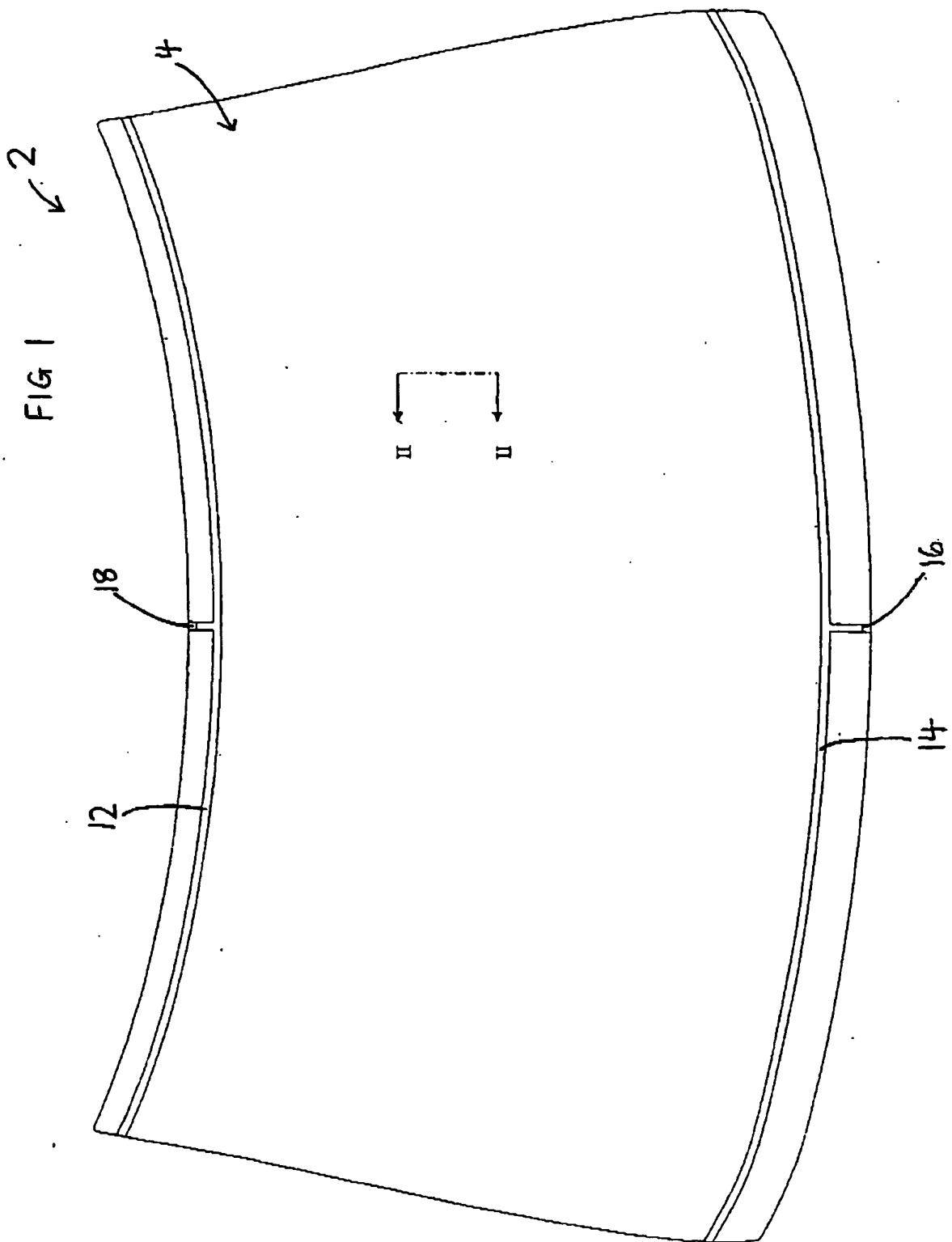
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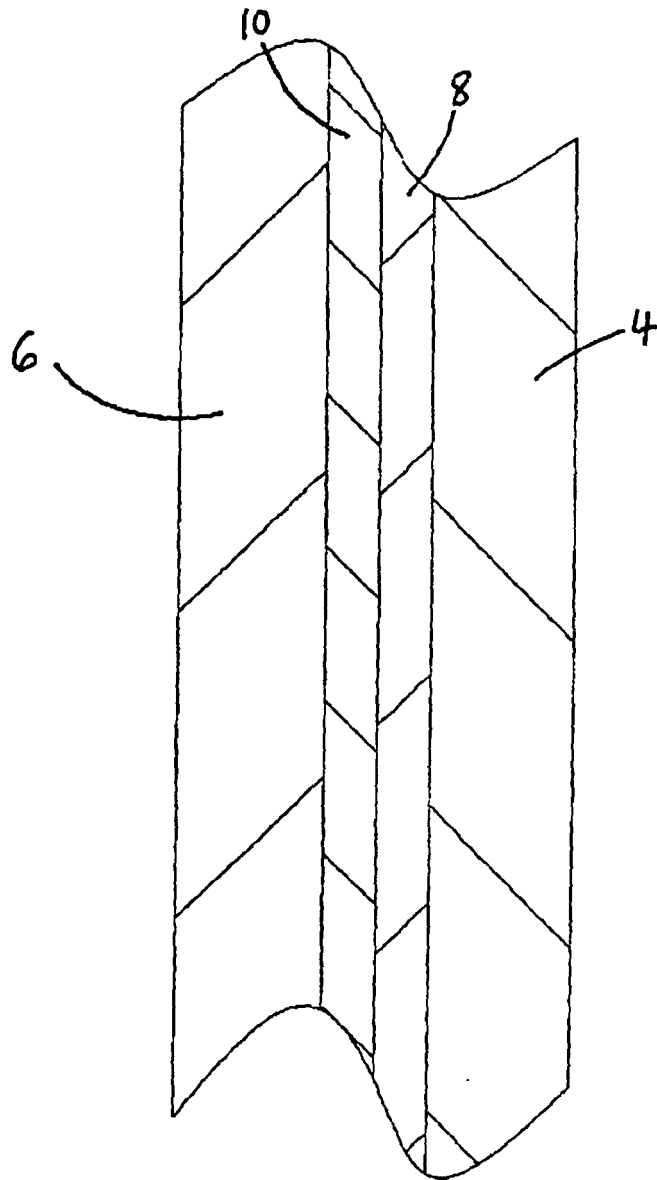


FIG 2

FIG 3

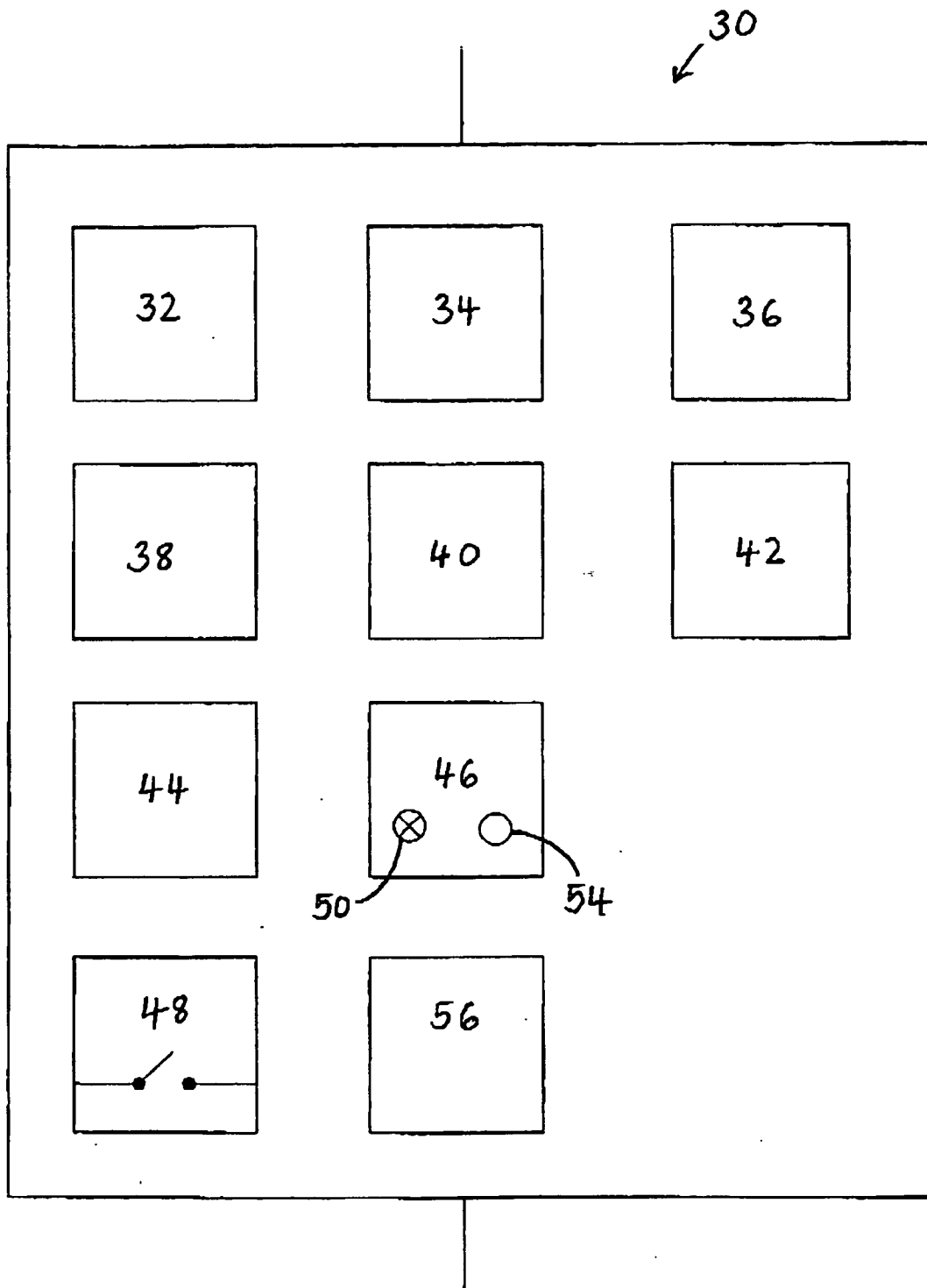
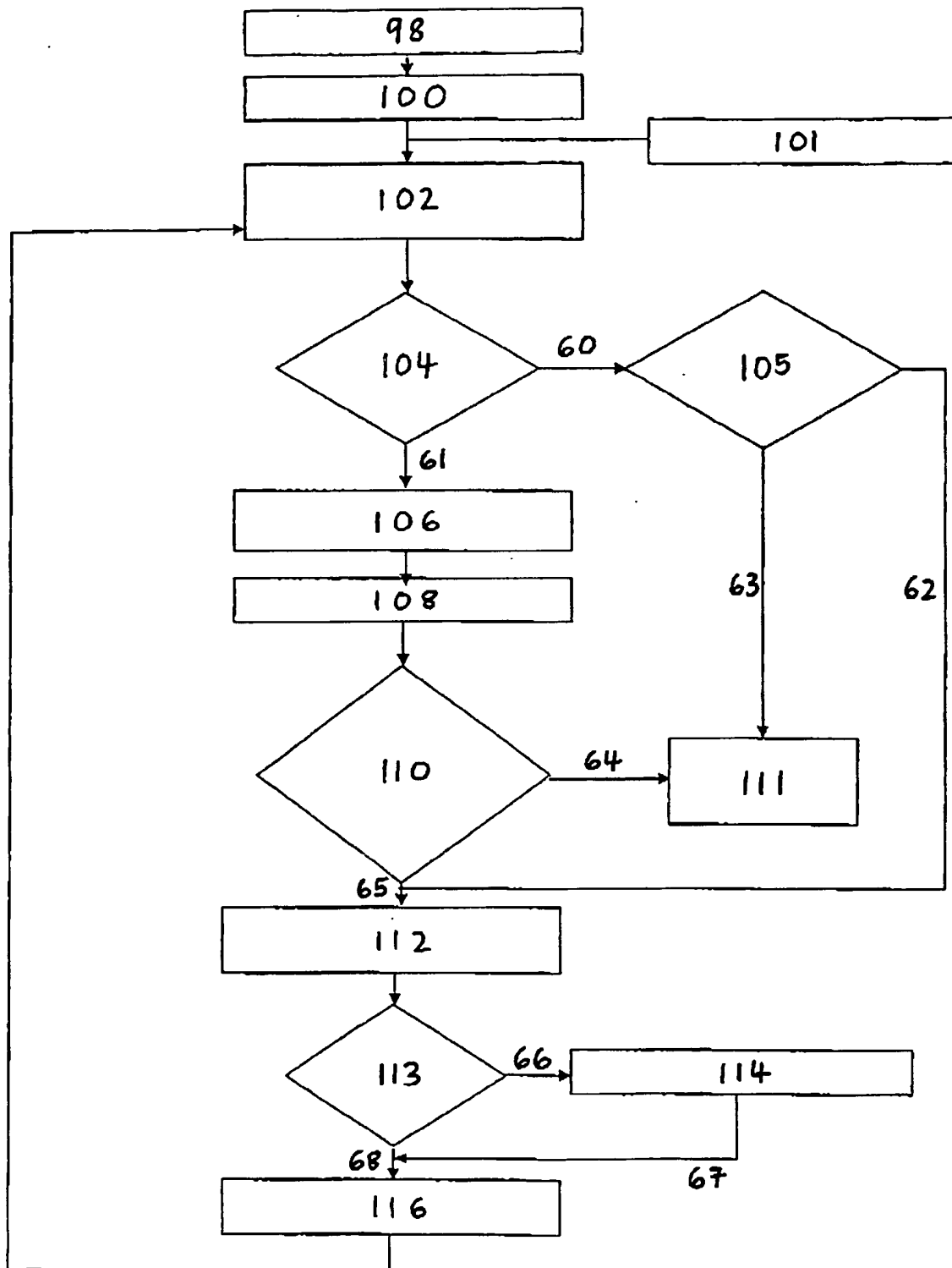


FIG 4



REFERENCES CITED IN THE DESCRIPTION

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