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Schafer et al.

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[45] **Feb. 4, 1975**

[54] **APPARATUS AND METHOD FOR HEATING SOLID SURFACES**

[75] Inventors: **Wolfgang Schafer; Helmut Brook,** both of Aachen, Germany

[73] Assignee: **Saint-Gobain Industries,** Neuilly sur Siene, France

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[21] Appl. No.: **292,770**

[30] **Foreign Application Priority Data**

Sept. 30, 1971 France 71.35161

[52] **U.S. Cl.** **219/203,** 219/522, 338/195

[51] **Int. Cl.** **B60l 1/02**

[58] **Field of Search** 219/203, 522, 543, 549; 338/195, 307–309

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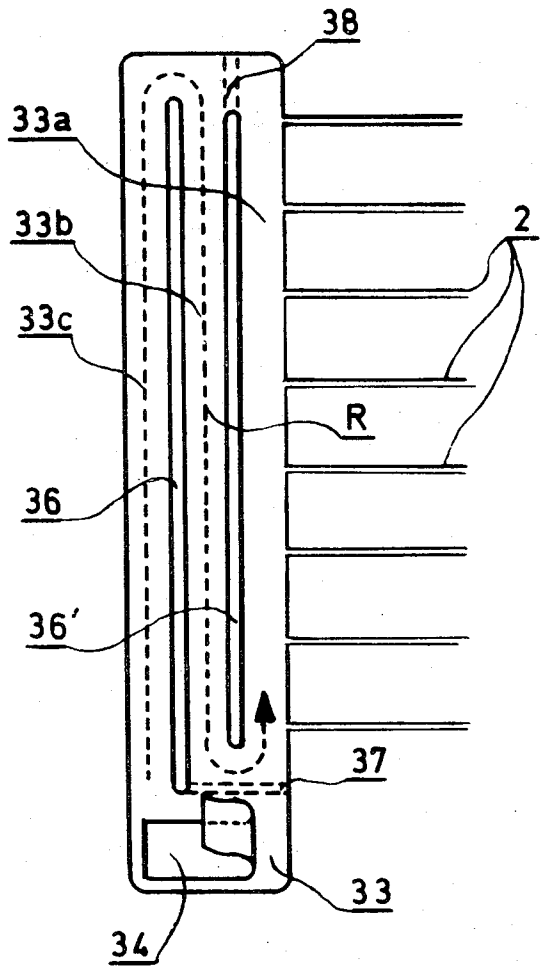
Primary Examiner—C. L. Albritton

Attorney, Agent, or Firm—Pennie & Edmonds

[57] **ABSTRACT**

The heating of solid surfaces by grids of fine line is made balanceable and controllable by building into the grid a network of resistances which can be altered at will by the severance or introduction of current carrying conductors which form part of the grid.

6 Claims, 7 Drawing Figures



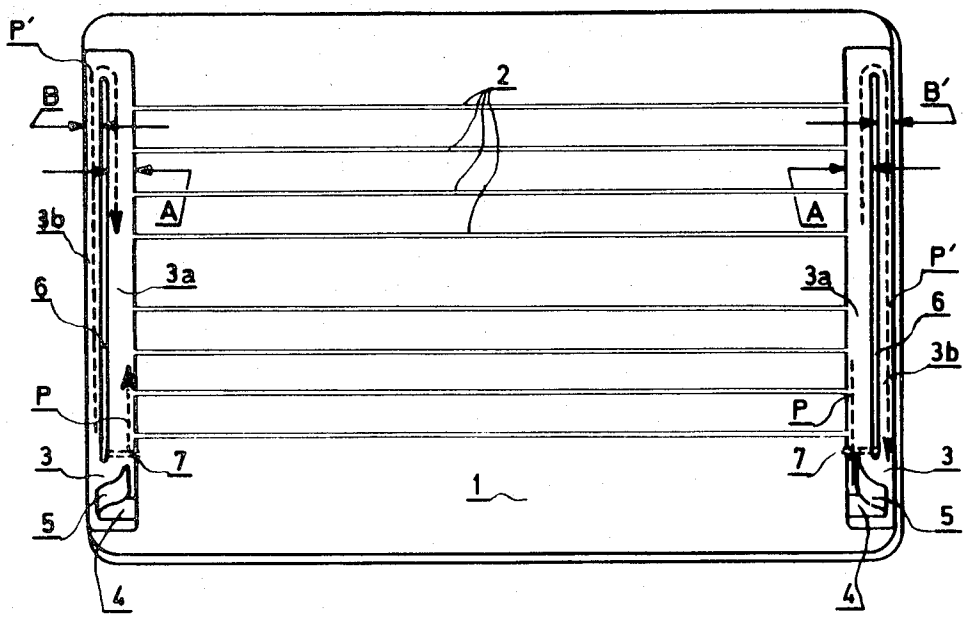


Fig. 1

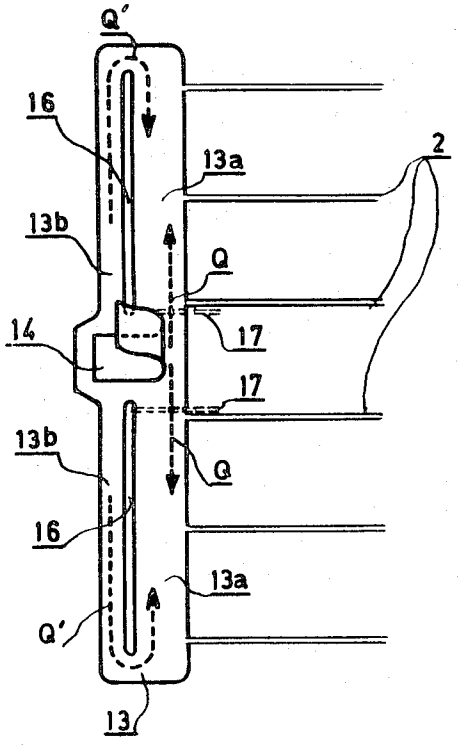


Fig. 2

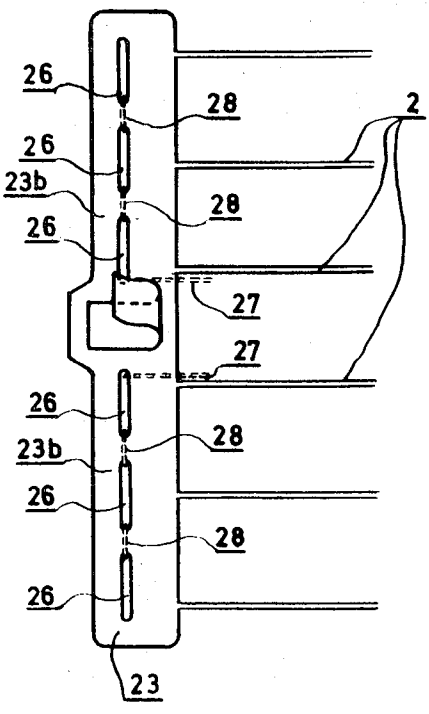


Fig. 3

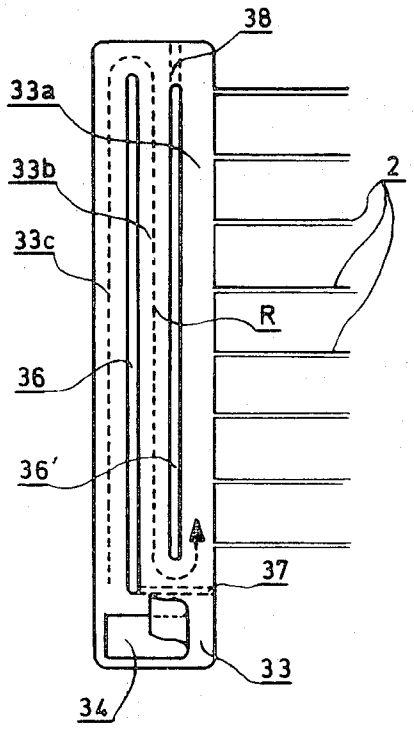


Fig. 4

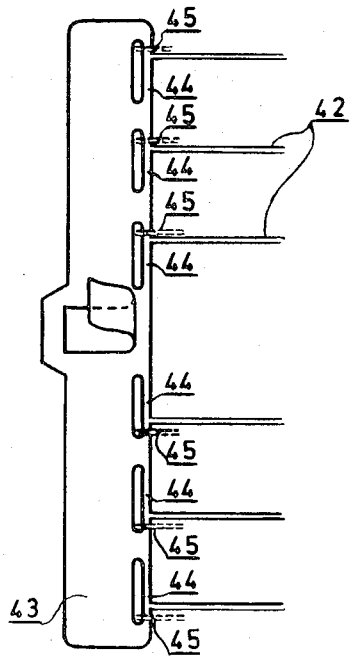


Fig. 5

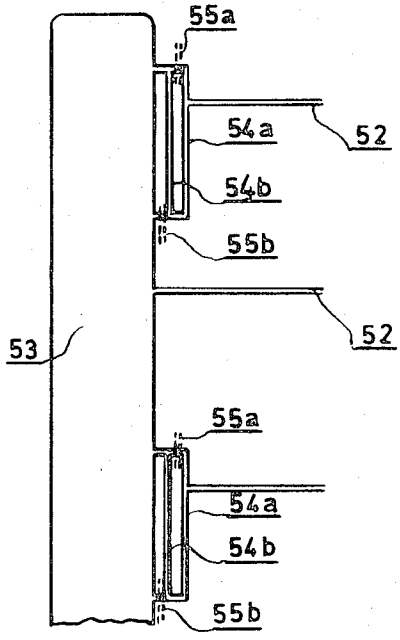


Fig. 6

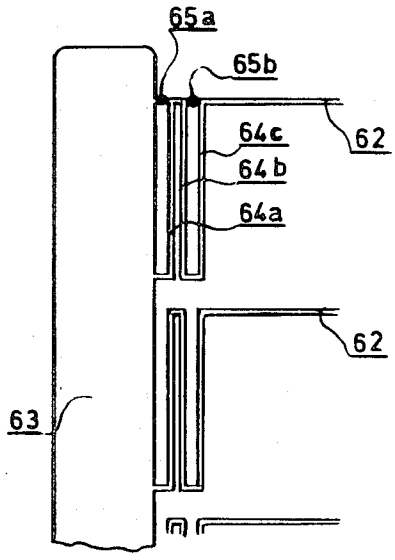


Fig. 7

APPARATUS AND METHOD FOR HEATING SOLID SURFACES

This invention relates to the heating of surfaces by resistance grids. It is particularly concerned with an apparatus and a process for balancing the electrical resistance of heating grids applied to vehicle windows. Such grids include conductive lines applied to the window, of such fineness as not to impair vision, which are connected to bus bands which receive their current from a battery or other source and which are advantageously composed of a frit of glass and metal fused onto the surface of the glass.

Several processes of manufacturing such heated windows are known. In one which is much used an electrically conductive metallic paste capable of being fused is applied to the surface of the glass in an appropriate design, for example application may be by the silk screen technique, after which the assembly is baked at high temperature. In all such applications by impression or coating, difficulty has been experienced in producing with certainty a thickness of layer or width of line which is constant. For example, in applying heating resistances there are departures from one screen to another and it follows that during the course of production the width of the heating bands, which is on the order of .5 mm., varies. A certain number of factors are reponsible for these variations of section, for example the viscosity of the paste which is being applied, variations in room temperatures, speed of application, and the state or physical condition after usage of the silk screen or other apparatus of application. Even in taking severe precautions, it is not possible in industrial practice to maintain all of these factors absolutely constant and slight variations appear in the section of the conductors and entrain similar and undesirable variations in the electrical resistance of the heated windows thus produced.

It is an object of this invention to produce heating grids on solid surfaces within close tolerances, that is to say, producing resistance values and heated effects as precise as possible. Heretofore it has been proposed to reinforce the heating conductors after baking, by electroplating in order to achieve that desired degree of conductability but that process is complex and expensive.

The present invention achieves its objects by means for heating a solid surface including a resistance grid, comprised of thin resistance lines and bus bands, composed of severable, conductive material fused to the solid surface, said grid comprising a plurality of electrically connected parts capable of separation or interconnection to change the resistance of the part thereof which supplies the resistance lines, and means electrically attached to the bands to pass current through the bands and the lines; and by a method of establishing a current pattern in a heating grid which comprises fusing a grid comprised of lines and bus bands to a solid surface and excising parts of the bus bands to establish the desired pattern.

In the region of the window occupied by the bus band or in the region where the heating lines are attached to the bus bands there are applied to the surface conductive figures which can be severed in particular parts so as to change the current supplied to the heating lines. These figures have parts or branches which can be readily cut to remove some of the material so as to

lengthen or shorten the particular course through which the current flows to reach the heating lines.

Due to the present invention the use of electroplating is eliminated and as a consequence, the heating lines, after baking, are of such accurately constructed resistance as to be within the limits of tolerance requiring no supplemental treatment. The correction of the electrical resistance of windows which do not conform to the required tolerances in the first instance is made easy by this invention because it suffices to change the conformation of the bus bands or other conductors which supply the heating lines.

Notably, the electroconductive layer, for example the bus band figure, can be cut in one or more regions with the aid of an appropriate tool, so that the current will be obliged to follow a longer path, which will increase resistance. It is also within the invention to provide such windows by normal procedure with bus band figures which will only be short-circuited when it becomes necessary to lower the resistance, but the preceding construction is usually simpler. In general, it suffices in the first instance to prepare windows of which the resistance is close to the lower limit, while additional resistances are provided in shunt and, consequently, out of the path of the current, these resistances being put in circuit as desired by cutting in the shunts when an increase in the resistance becomes necessary.

Following a first form of the invention, at least one of the bus bands is provided with internal gaps, for instance longitudinal slits, arranged so that the conductive material on both sides of the slit may be removed in appropriate locations. Whenever the current input is situated at one end of the bus band one may use a single slit; to increase the electrical resistance the bus band can be cut between the slit and the heating conductors at a location somewhere between the current input and the base of the heating lines. When the current input is placed in the middle of the bus band it is recommended to provide two longitudinal slits which are to be separated by a conductive part of the bus band. If an increase in resistance becomes necessary the bus band is cut between the slits so that the direct passage of current from the point of input to the portion of the bus band situated between the incision and the heating lines will be interrupted.

When relatively large corrections of electrical resistance are to be produced, one may according to another form of the invention provide the bus bands with several slots placed side by side and substantially parallel to one another, extending up to the ends of the bands, establishing in one or more of the strands, by cutting, separations which result in a conformation such that the total length of the additional resistance can represent several times the length of the bus band itself.

A finer adjustment of the resistance may be obtained by subdividing the longitudinal slots into a series of aligned slots between which a series of bridges of conductive material are left which can be individually severed in variable numbers according to need.

According to a variation of the invention, one may provide in the immediate vicinity of the junction between the heating lines and the bus bands some supplementary figures which affect only a limited number of lines. These figures are advantageous networks of conductors parallel to the bus band properly so called and at a short distance from them. If an increase in the re-

sistance becomes necessary this network is cut in immediate proximity to the bus bands so that the current is obliged to follow a longer path, which may be composed of one or several lines of which the greater or lesser number may be made to carry the heating current.

The above and further objects and novel features of the present invention will more fully appear from the following detailed description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for the purpose of illustration only and are not intended as a definition of the limits of the invention.

In the drawings wherein like reference characters refer to like parts throughout the several views;

FIG. 1 is a plan view of a first and major form of the invention as embodied in the rear light of an automobile;

FIG. 2 is a partial view of a modification on an enlarged scale;

FIG. 3 is a partial view of a further modification;

FIG. 4 is a partial view in plan of a third modification;

FIG. 5 is a partial view in plan of a further modification; and

FIGS. 6 and 7 are partial views in plan of variations of the fifth modification.

FIG. 1 represents a heated vehicle windshield **1** on the surface of which have been applied lines of heating resistance **2** which are composed of a composition containing a proportion of conductive metal. Such compositions are known and need no description; they are applied by the silk screen method and baked onto the surface of the glass at a temperature around 600°C. The resistive heating conductors **2** are connected at their extremities to bus bands **3**, which are advantageously composed of the same material as the lines **2** and may be applied to the window in the course of the same operation as the lines. Upon the bus bands **3** are soldered the current inputs **4—4** which carry contacts **5** to which the input and output current lines are attached. The bus bands **3** have elongated slots **6** which extend throughout the extent occupied by the lines **2**. The slots **6** are obtained by masking that area during the silk screen operation so that in that region the conductive metallic paste does not touch the surface of the glass and thus divides the bus bands into two strips **3*a*** and **3*b*** which are connected at their ends. The width A of the inner of these strips **3*a*** is chosen so that it alone will carry the heating current to the lines **2** without opposing any substantial resistance to its flow. The exterior strip **3*b*** is narrower and has a resistance to the heating current which is about 5 percent of the overall resistance of the grid. The heating current therefore flows essentially through the inner strips **3*a*** and the lines **2**. This flow is indicated by the arrows P. If it appears that the overall resistance of the heating unit is too low, one of the strips **3*a*** or both bands **3*a*** can be cut at **7** near the lower extremity of the slot **6**. Because of the cut which extends through to the slot the current follows a different path and flows through strip **3*b***, or through both strips **3*b*** when a double cut is made, following the direction of arrows P'. When a small increase in the resistance suffices one is content to make the cut **7** in only one of the bus bands. If the cut **7** is made in both bus bands, the increase in resistance is doubled. In some cases, the widths B and B' of the exterior strips may be different. When, by the foregoing method, one does not wish to increase the resistance the mode of operation may be changed so that the change in the electrical resistance involves a diminution. In this case, the cuts **7** are made in advance during the manufacture of the windshield and are later short-circuited, producing a diminution. Short-circuiting can be accomplished by applying some tin solder. It is equally possible to make in advance a cut in only one of the two bus bands. The overall resistance of a heated window thus made can thus be either increased by making a cut in the inner strip which feeds the lines or it can be reduced by short-circuiting the break initially introduced in the first bus band. Thus, the overall resistance can be corrected in both directions.

FIGS. 2 to 4 represent advantageous variations of the same principle. In the form represented in FIG. 2 the input contact **14** is located in the middle of the length of the bus band **13**. Slots **16** are provided above and below the contact. The heating current flows principally along the inner strips **13*a*** in the directions of arrows Q but if one makes cuts **17** as indicated in dash lines, the current is forced to flow along paths Q', along the outside strips, around the ends of the slots and along strips **13*a*** and **13*b*** thus increasing the length of the path and the resistance. According to the dimensions given to strips **13*b*** the electrical resistance may be thus increased in a predetermined degree.

In FIG. 3 the bus band **23** contains a series of aligned slots **26** and this construction makes for greater facility of adjustment. In the drawing, each heating conductor **2** is opposite one of the slots. If one makes cuts **27** through the inner strips the current is compelled to flow through outer strips **23*b***, around the ends and then along the inner strips to reach the heating lines. Now, by making one or more cuts **28** between the slots one can make slight variations and achieve a high degree of modification in the resistance approaching each line and secure a fine adjustment of the current supply.

FIG. 4 is a modification which enables one to increase the overall resistance greatly. The bus band **33** has two parallel slots **36** and **36'** which divide the bus band into three conductive strips **33*a***, **33*b*** and **33*c***. Initially the flow of current from the contact **34** will be along the inner strip **33*a*** to the heating lines **2** but by making the cut **37** the current will be compelled to flow through **33*c*** toward the top of the figure and over to **33*a***. If a still further increase in resistance is desired the cut **38** can be made, which will require the current to flow along the path of the arrow R through strips **33*c***, **33*b*** and **33*a***. It will be observed that in each of FIGS. **1** to **4**, and also in FIG. **5**, the bus bands are broader than the conductors **2** (**42** in FIG. **5**).

FIGS. 5 to 7 show modifications in which the supplementary resistances are involved individually with the heating lines **42**. The slots **44** are made near the inner border of the bus band in alignment and opposite the heating conductors. The heating conductors are connected to the bus band off center of the slots. Only a small part of the heating current passes through the longer branches **44** which now may be inserted one by one into the circuit of the heating conductors. If cuts are made along the lines **45** in this way it will not only correct the overall resistance of the heating grid but may also correct the resistance of a particular heating line, thus achieving the maximum possible flexibility of control. This flexibility of control can be increased by adopting the structures of FIGS. **6** and **7**.

In the form shown in FIG. 6, the bus band **53** is directly connected to central heating conductor **52** but is connected to the upper and lower heating conductors through a network of multiple strands **54***a* and *b* which are in series with their respective heating conductors. By making cuts **55***a* one puts the line **54***a* into the circuit and by making the cut **55***b* one aids the resistance of line **54***b*.

FIG. 7 exemplifies a network of lines **64***a*, *b*, *c* which are initially provided with gaps as shown in the lower end of the two networks. The bus band **63** thus delivers its current through a network of three parallel conductor to heating line **62.** If one wishes to reduce the resistance one may make one or more solderings at **65***a* and **65***b* as indicated in the upper part of the figure eliminating one or more of the current-carrying parallel lines. If one applies tin solder at **65***a* the line **64***a* is cut out of the circuit. If the gap **65***b* is alone closed, the two conductors **64***b* and **64***c* are cut out of the circuit, and if both gaps are closed at **65***a* and **65***b* all three lines **64***a*, *b* and *c* are eliminated from the circuit.

The following example illustrates the invention. It relates to the rear light of an automobile operating with the following characteristics:

Supply Voltage	$-U$	$= 12$ V
Power Needed	$-W_m$	$= 150$ W
Maximum Power Consumable	$-W_M$	$= 180$ W

If the heating circuit has a resistance R and is operated directly, the power consumed is expressed by the formula

$$W = U^2/R$$

from which one may deduce the permissible limits at the resistance of the window and its manufacturing tolerance ΔR

$$R \leq U^2/W_m = 144/\mathbf{150} = 0.96\Omega,$$

$$R \geq U^2/W_M = 144/\mathbf{180} = 0.8\Omega$$

which is to say that $\Delta R = \pm 0.08\Omega$, or 9.1 percent.

If one mounts a corrective resistance r in series, which reduces the intensity of the heating current, one derives the following formulas:

For the total power consumed

$$W_M = (U^2/R + r)$$

For the power useful in heating

$$W_m = W_M\,(R/R + r);$$

Now, therefore,

$$R + r \geq U^2/W_M = 144/\mathbf{180} = 0.8\Omega$$

with

$$(R/R + r) \geq W_m/W_M = 150/\mathbf{180},$$

that is to say

$$r \leq 0.2\ R$$

from which one derives

$$r \leq 0.13\Omega$$

$$R \leq 0.67\Omega$$

and consequently $\Delta R = \pm 0.145\Omega$, which is to say 18 percent, which establishes the fact that the tolerance of manufacture has been practically doubled.

This invention has been described in its application to the heating of a window or a light of an automobile but it is to be understood that the same principles are applicable to the control of the heating of any solid surface to which the grid can be applied including plates, walls and panels.

As many apparently widely different embodiments of the present invention may be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments.

What is claimed is:

1. A window comprising a transparent sheet, a plurality of opaque resistive conductors substantially coextensive in length adhered in spaced substantially parallel relation to a surface of the sheet, said conductors having a width small compared to their spacing, at least two bus bands made of electrically conductive material and having a width wider than said conductors, said bus bands adhered to said surface of the sheet and connecting said conductors electrically in parallel, a current terminal connecting to each of said bus bands, and at least one of said bus bands having elongated aperture means therethrough extending lengthwise of said bus band with an end of said aperture means close to said terminal, said conductive material being removable selectively from said sheet whereby upon said selective removal over a path extending from said aperture means to the outer periphery of said at least one bus band the current path between the current terminal connecting to said at least one bus band and said conductors will be increased in length.

2. A window according to claim **1** in which said aperture means defines in said one bus band two elongate conductive portions of unequal width.

3. A window according to claim **1** wherein each said terminal connects to one of said bus bands in the region of one end, and said elongated aperture means comprises at least one slot.

4. A window according to claim **3** wherein said elongated aperture means comprises a pair of slots, one of said slots extending between points closer to and further from said terminal than any one of said conductors, the other of said slots being arranged parallel to said one slot ahd having a length less than said one slot, and wherein said conductive material is removed from said bus band between said one slot near said closer point and said periphery of said bus band.

5. A window according to claim **4** wherein additional conductive material is removed over a path between an end of said other slot remote from said terminal and said bus band periphery to further increase the current path between said terminal and said conductors.

6. A window according to claim **1** wherein each of said terminals is connected to said bus bands between the ends, and said elongated aperture means includes at least two individual slots, at least one of said slots being arranged to one side of said terminal and at least one of said slots being arranged to the other side of said terminal, and said selective removal of conductive material from said sheet being carried out over paths each extending substantially from a proximal end of each slot closest to said terminal to said periphery of said bus band to increase the current path between said terminal and said conductors.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,864,545

DATED : February 4, 1975

INVENTOR(S) : Wolfgang Schafer and Helmut Brook

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, line 13, for "line" substitute --conductor--;
line 44, rewrite the equation as follows:
$--W_M = U^2/(R + r)--$;
line 46, rewrite the equation as follows:
$--W_m = W^M R/(R + r)--$;
line 51, rewrite the left-hand limb of the inequality as follows: $--R/(R + r)--$.
Column 6, line 41 (claim 4, line 6), for "ahd" substitute --and--.

Signed and sealed this 29th day of April 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks

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