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Taylor et al.

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[54] **HEATED WINDOWS IN ROAD VEHICLES AND CONTROL CIRCUITS THEREFORE**

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[21] Appl. No.: **360,433**

[30] **Foreign Application Priority Data**

Oct. 27, 1972 United Kingdom..... 49726/72

[52] **U.S. Cl.** **219/203;** 52/171; 219/491; 219/492; 219/522; 219/547; 307/118; 340/235

[51] **Int. Cl.** **H05b 1/02;** E06b 7/12

[58] **Field of Search** 219/203, 522, 547, 489, 219/492, 509; 307/293, 118; 340/234, 235; 52/171, 172; 15/250.05, 250.12; 73/336.5

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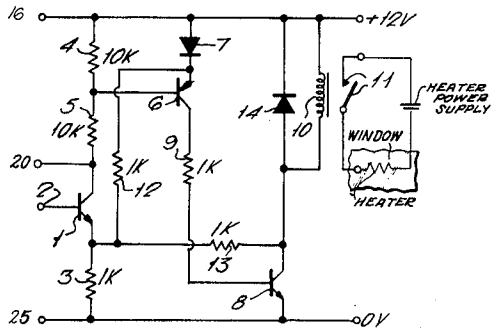
Primary Examiner—A. Bartis

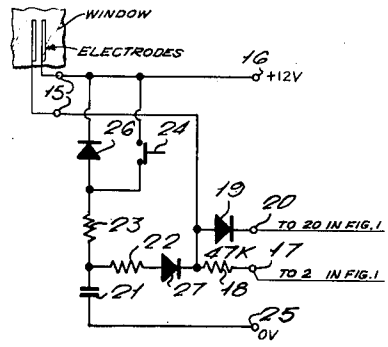
Attorney, Agent, or Firm—Bacon & Thomas

[57] **ABSTRACT**

An electrically heated window in a road vehicle is provided with sensing electrodes for detecting the formation of condensation on the surface thereof. An electronic switching circuit responsive to the sensing electrodes is provided for energizing the window heater when formed condensation is sensed. A manually operable overide allows for energization of the heater through an RC or mechanical timer operable to place the electronic switching circuit in condition for energizing the heater irrespective of the presence or absence of condensation on the window.

6 Claims, 7 Drawing Figures





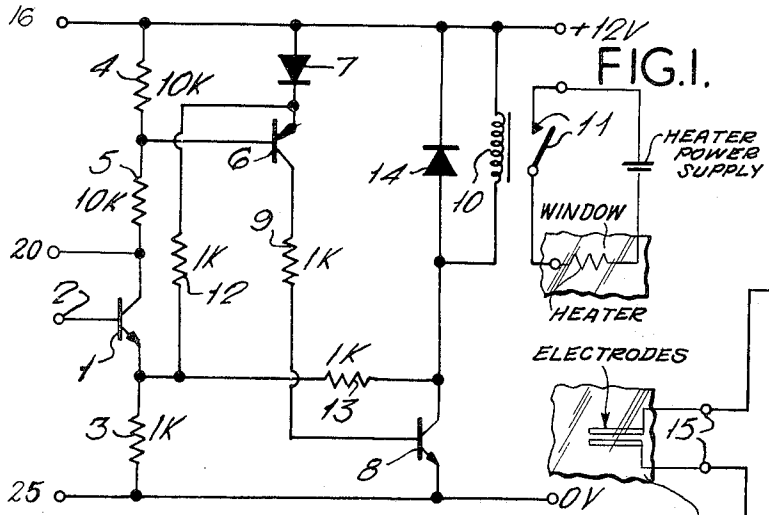


FIG. 1.

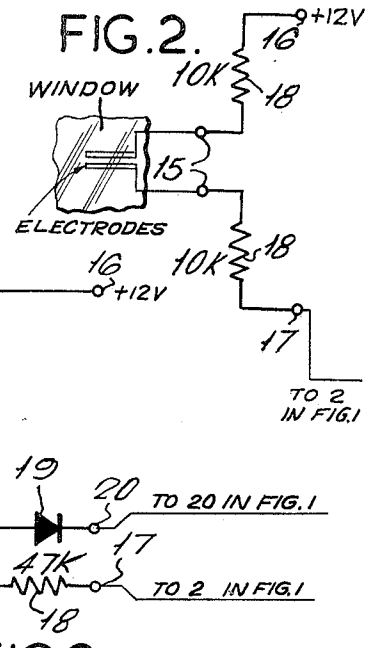


FIG. 2.

FIG. 3.

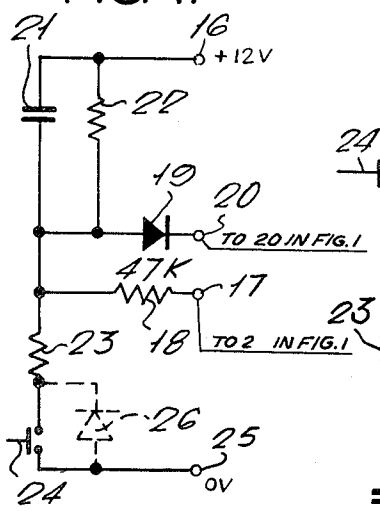


FIG. 4.

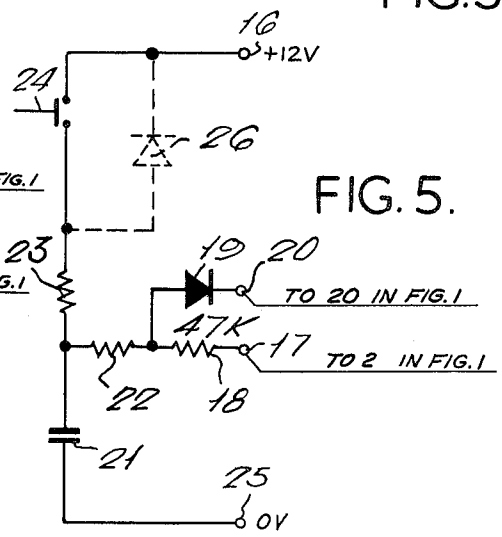


FIG. 5.

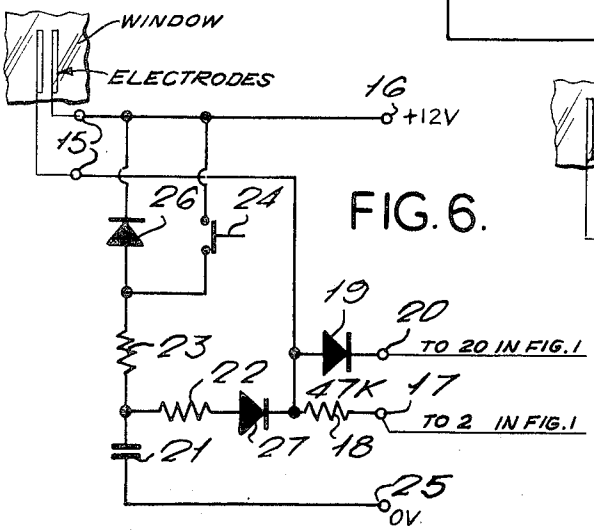


FIG. 6.

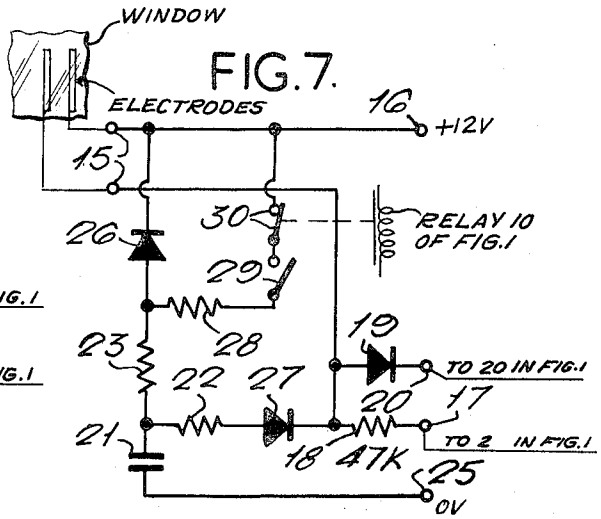


FIG. 7.

HEATED WINDOWS IN ROAD VEHICLES AND CONTROL CIRCUITS THEREFORE

This invention relates to control circuits, and more particularly but not exclusively to electronic switching circuits for the control of heaters for removing vision-obscuring condensation from vehicle windows.

In copending United States Patent Application of John C. Taylor, Serial No. 360,434 filed, May 15, 1973 there is described an arrangement for reducing condensation upon the interior surface of a window of a road vehicle, the said arrangement including spaced electrodes arranged so as to be bridged resistively by condensation upon said surface, a solid state electronic switching circuit responsive to the resistance between said electrodes, and a heating element responsive to the condition of said electronic switching circuit for heating said surface, the arrangement being such that in operation the switching circuit is in a condition for energising the heating element for so long as the resistance between said electrodes is lower than that characterizing a predetermined degree of condensation upon said surface. The disclosure of the aforesaid copending application of John C. Taylor is incorporated herein by way of reference.

There is further disclosed in the above identified copending Patent Application, a particularly suitable form of solid state electronic switching circuit which, broadly stated, includes a first transistor the control electrode of which is connected to receive current via the spaced electrodes when resistively bridged by condensation and a second transistor arranged to control a switching device the condition of which determines the energisation of a heating element for removing the condensation from said surface, said first transistor having in its controlled circuit a load formed by two serially connected resistors the junction between which is connected to the control electrode of the second transistor. Inter alia, the present invention is concerned with electronic switching circuits of this broadly stated type.

The above mentioned first and second transistors are preferably bipolar transistors of opposite polarity, the two serially connected resistors being of equal value and being connected in the collector circuit of the first transistor. The first and second transistors preferably have in their respective emitter circuits a resistor and a forward-biassed diode respectively, a further resistor being connected between the emitters of the two transistors.

Preferably the switching device for determining the heater opertion includes a third bipolar transistor, of the same polarity as the first and connected in common emitter configuration, and a resistor connected to provide positive feedback from the collector of the third transistor to the emitter of the first transistor to ensure that the switching circuit responds rapidly to an input condition thereby to reduce dissipation in the transistors.

Preferably one of the pair of condensation sensing electrodes is connected to one of the power supply terminals for said circuit and the other electrode is connected via a current limiting resistor to the base and via a diode to the collector of the first transistor, the diode being poled such that it will be forward-biassed should the electrodes be short circuited together. This ensures that should the electrodes inadvertently be short circuited, the second transistor will not conduct and the heating element will not be energised.

According to another aspect of this invention, the above-defined arrangement disclosed in the aforementioned copending Patent Appliciation may advantageously include a manually-operable timer adapted, when operated, to cause energization of the heating elements for a predetermined period irrespective of whether or not there is condensation upon the interior window surface; such a facility might be useful for deicing the outer surface of the window. One way of providing this facility is to arrange the timer so that, upon operation thereof, the electronic switching circuit is placed in a condition for energizing the heating element irrespective of the resistance between the sensing electrodes, such condition of the switching circuit prevailing for a predetermined period. One suitable form of electronic timer comprises a capacitor/resistor network in which the capacitor is connected in series with a manually-operable normally-open switch across the power supply terminals for the switching circuit and the resistor is connected between the capacitor and the input circuit of the aforementioned first transistor via an isolating diode, the arrangement being such that after a temporary closure of the switch to charge the capacitor, the capacitor discharges via the resistor and isolating diode to provide base current to the first transistor, thereby causing the heating element to be energised for a period determined by the rate of discharge of the capacitor. Alternatively the timer could be electromechanical, being constituted for example by a manually-operable switch incorporating a thermal delay to determine the predetermined period.

The invention will be better understood from the following description with reference to the accompanying drawings, in which:

FIG. 1 shows, by way of example, an electronic switching circuit in accordance with the invention; and

FIGS. 2 to 7 show, by way of example, alternative input circuits which may be used in conjunction with the switching circuit shown in FIG. 1. In all of FIGS. 2 to 7 similar reference numerals have been used to denote similar parts.

Referring to FIG. 1, the electronic switching circuit shown therein includes an NPN input transistor 1 the base electrode of which is connected to a terminal 2. This transistor has an emitter resistor 3 and a divided collector load formed by the resistors 4 and 5. The junction between the resistors 4 and 5 is connected to the base electrode of a PNP transistor 6 which has in its emitter circuit a diode 7 and which is arranged to drive an NPN switching transistor 8 via a resistor 9. The transistor 8 is arranged to switch the current applied to a relay 10, the normally open contacts 11 of which are connected in series with the heating element shown the energisation of which is to be controlled. The circuit also includes two feedback resistors 12 and 13 and a reverse-biassed diode 14 connected in parallel with the coil of the relay 10. The circuit receives power from a 12 volt supply, which could be the battery of a road vehicle, e.g., a motor car, in which the circuit may be installed.

The circuit of FIG. 1 operates as follows: With no potential applied to the terminal 2, none of the transistors conduct and the relay contacts 11 are open. When a positive potential (which may be derived via a resistive connection from the terminal 2 to the positive 12 volt

supply line as is more fully explained below) sufficient to cause the transistor 1 to conduct is applied to the terminal 2, the transistor 6 also conducts and the transistor 8 saturates to cause the relay 10 to be energised and the contacts 11 to close. The resistor 13 provides regenerative feedback from the collector of transistor 8 to the emitter of transistor 1 to reduce the transistor switching time, and hence to reduce the power dissipated in the transistor 8 during its switching time. If the potential at the terminal 2 is reduced to cause the transistor 1 to be cut off, the transistors 6 and 8 also cease to conduct and the relay contacts 11 open, any voltages induced by the coil of the relay 10 then being shunted by the diode 14 to prevent damage to the transistor 8.

FIG. 2 shows an input circuit for the switching circuit of FIG. 1 which is suitable for use with an arrangement of a pair of spaced electrodes for sensing condensation upon a surface as is described in the copending Patent Application of John C. Taylor referred to above. The two electrodes of such an arrangement are connected to two terminals 15 of the circuit of FIG. 2, the terminals 16 and 17 of which are in operation connected respectively to the positive supply line and the terminal 2 of the circuit of FIG. 1. The circuit of FIG. 2 merely comprises two current-limiting resistors 18 which protect the transistor 1 from damage due to excessive base current should the terminals 15 or the electrodes connected thereto be inadvertently shor-circuited.

The combined circuit arrangement of FIGS. 1 and 2 in conjunction with a pair of spaced condensation-sensing electrodes coupled to terminals 15, operates as described below:

When the window is completely clear of condensation, the resistance between the sensing electrodes coupled to terminals 15 is very high, typically of the order of several megohms. The resultant base current of the transistor 1 is insufficient to cause this transistor, and hence the transistors 6 and 8, to conduct. Accordingly no current flows through the relay coil 10 to cause the contact 11 to close, and no power is supplied to the heater.

As soon as there is a trace (which need not necessarily be visible) of condensation or mist on the window, the resistance between the electrodes coupled to terminals 15 falls to a much lower value, and the transistor 1 receives a greatly increased base current. Transistor 1 conducts, causing the transistors 6 and 8 to conduct and current flows through the relay coil 10 causing the contact 11 to be closed. Power is then supplied to the heater until the window is cleared of mist, whereupon the increased resistance between terminals 15 causes transistors 1, 6 and 8 to cease to conduct whereupon current ceases to flow through the relay coil 10 and the contact 11 opens. The diode 14 is provided to prevent transient voltages, generated in the relay coil 10 when the transistor 8 ceases to conduct, from being applied to the transistor 8 and possibly damaging this transistor.

Referring now to FIG. 3, an alternative input circuit is shown which prevents operation of the relay 10 of the switching circuiit if the terminals 15 or the electrodes connected thereto are shorted together. Only one current limiting resistor 18 is provided in this circuit, which also includes a diode 19 which is connected between that one of the terminals 15 which is not connected to the terminal 16 and an additional terminal 20 which is in use connected to the collector of the transistor 1 in the switching circuit. If the terminals 15 are short-circuited together, the diode 19 prevents the collector of the transistor 1 from falling below a potential of approximately 11.3 volts (the supply voltage minus the diode voltage drop in its forward-biassed state). Consequently the base of the transistor 6 is maintained at too high a potential for the base-emitter junction of this transistor and the diode 7 to be forward-biassed, and the transistor 6 does not contact. Accordingly the transistor 8 does not conduct and the relay contacts 11 remain open.

The combination of the circuits of FIGS. 1 and 3 operates to energise the relay 10 and hence close the contacts 11 when the resistance between the terminals 15 is between about 500 ohms and 10 megohms, but the relay 10 is not energised if the resistance between the terminals 15 is outside this range.

FIGS. 4 and 5 show alternative input circuits which adapt the switching circuit of FIG. 1 for use as a timer. Each of these input circuits includes a timing capacitor 21, a timing resistor 22, a charging current limiting resistor 23, and a manually-operable normally-open switch 24 operation of which commences the timing cycle. These circuits also include the resistor 18 and diode 19 described above with reference to FIG. 3, and are connected to the circuit of FIG. 1 in the same manner as is the circuit of FIG. 3 with an additional terminal 25 connected to the 0 volt supply line of the circuit of FIG. 1.

With the circuit of FIG. 4 connected to that of FIG. 1, the relay 10 is normally energised to close the contacts 11, base current to the transistor 1 being supplied via the timing resistor 22. Operation of the switch 24 to close its contacts causes the timing capacitor 21 to charge rapidly via the resistor 23, which has a low resistance typically of 47 ohms. The potential applied to the terminal 2 from terminal 17 therefore falls, causing the transistors 1, 6 and 8 to cease conducting and hence opening the relay contacts 11. Upon release of the switch 24 the timing resistor 22 and the potential applied to the terminal 2 thus gradually rises. After a time delay determined by the time constant of the capacitor 21 and the resistor 22 this potential reaches a value sufficient to allow the transistors 1, 6 and 8 to again conduct and the relay contacts 11 are therefore closed again.

With the circuit of FIG. 5 connected to that of FIG. 1, the relay 10 is normally not energised. Upon operation of the switch 24 to close its contacts, base current is supplied to the transistor 1 via the resistors 18, 22 and 23, and the transistors 1, 6 and 8 conduct to energise the relay 10 and close its contacts 11. At the same time the timing capacitor 21 is rapidly charged via the resistor 23, which in this case has a typical value of 33 ohms. Upon release of the switch 24 the timing capacitor 21 slowly discharges via the timing resistor 22 and a circuit including the resistor 18, the diode 19, the transistor 1, and the resistor 3. After a time delay determined by the discharge time constant of the capacitor 21 and its discharge path the potential applied to the terminal 2 from terminal 17 falls sufficiently to cut off the transistor 1, and consequently the transistors 6 and 8 cease to conduct and the contacts 11 are again opened.

In the circuits of each of FIGS. 4 and 5 a normally reverse-biased diode 26 may be connected in parallel with the switch 24 as shown in dashed lines to provide a discharge path of the timing capactor 21 when the

power supply to the circuit of FIG. 1 is removed. This discharge path is via the resistor 23, the diode 26 (which becomes forward-biased by the charged capacitor 21), either the diode 7 and resistor 12 or the coil of the relay 10 and the resistor 13, and the resistor 3.

In the circuits of both FIGS. 4 and 5 the inclusion of the diode 19 determines a minimum value for the timing resistor 22, which must be greater than about 500 ohms. The maximum value for this resistor is limited by the sensitivity of the switching circuit of FIG. 1. However, a large range of delay times can still be obtained by varying the values of the timing resistor 22 and timing capacitor 21, and with the circuit of FIG. 4 with values respectively of 4.7 megohms and 400 microfarads a delay time of 48 minutes has been obtained.

The circuits of FIGS. 4 and 5 provide a time delay which commences only after release of the switch 24. The time delay may be made to commence upon operation of the switch 24 by including, in series with the switch 24, and additional pair of relay contacts, normally open in the case of FIG. 4 and normally closed in the case of FIG. 5. In each case the timing capacitor 21 must be charged from the supply before the relay opens or closes the contacts.

FIG. 6 shows an input curcuit which is a combination of the circuits of FIGS. 3 and 5 and which is particularly suited in conjunction with the circuit of FIG. 1 to operate as a control circuit for a heated rear window of a motor car. The circuit of FIG. 6 normally operates exactly as described above with reference to FIG. 3 to sense the resistance between the terminals 15, an additional diode 27 being provided to isolate the timing components 21 to 26 during such operation. Upon operation of the switch 24 this normal operation is temporarily interrupted and the circuit operates in exactly the same manner as described above with reference to FIG. 5 to close the relay contacts 11 for a time determined by the rate of discharge of the capacitor 21. After this time the circuit resumes its normal operation until the switch 24 is again operated.

The input circuit of FIG. 6 is particularly advantageous when used in a control circuit for a heated rear window, since during the nornal operation of the circuit condensation on the window may be sensed automatically and removed upon energisation of a heating element by closure of the relay contacts 11, whereas this normal operation may be interrupted upon operation of the switch 24 to energise the heating element for a predetermined period. Such interruption may be necessary where, for example, there is no condensation on the interior window surface but moisture or ice on the outside window surface must be removed. In such a case the provision of a temporary rather than a permanent interruption to the normal automatic operation is desirable to avoid the possibility that the heating element might inadvertently be left energised after the window has been cleared of moisture and/or ice. The circuit of FIG. 6 provides such a temporary interruption.

The input circuit of FIG. 7 is similar to that of FIG. 6 with the exception that the normally open push-button switch 24 is replaced by a series circuit comprising a resistor 28, an on/off switch 29, and a pair of normally closed contacts 30 of the relay 10 in the circuit of FIG. 1. When the switch 29 is off (i.e., its contacts are open) this circuit arrangement operates in the same manner as does the circuit of FIG. 6 before the switch 24 is operated, but upon operation of the switch 29 to close its contacts this circuit arrangement provides intermittent operation of the relay 10 rather than a temporary interruption to the normal automatic operation as is the case for the circuit of FIG. 6.

With the circuit of FIG. 7 connected to that of FIG. 1 upon closure of the switch 29 the capacitor 21 charges via the low-value resistor 23 and the resistor 28 until the voltage across the capacitor 21 is sufficient for the transistor 1 in the circuit of FIG. 1 to conduct. Transistors 6 and 8 then also conduct and the relay 10 is energised, closing the contacts 11 and opening the contacts 30. The capacitor 21 then discharges via the timing resistor 22, the isolation diode 27, and a circuit including the resistor 18, the diode 19, the transistor 1, and the resistor 3. After a time delay determined by the rate of discharge of the capacitor 21 the transistor 1 ceases to conduct and the energisation current of the relay 10 is interrupted by the transistor 8. The contacts 11 then open, the contacts 30 close, and the capacitor 21 again charges via the resistor 23 and 28. This cycle is repeated until the switch 29 is opened to interrupt the capacitor charging current. It will be apparent that the values of the resistors 22 and 28 may be varied to vary the times for which the relay contacts 11 are respectively closed and open. These times are also dependent upon the hysteresis of the combined circuits of FIGS. 1 and 7, i.e., the difference in the voltages across the capacitor 21 at which the transistor 1 commences to conduit and ceases to conduct. For the particular circuit described above this voltage difference is approximately 4 volts.

Although particular embodiments of the invention have been described above it will be appreciated that the invention is not restricted in scope to these embodiments but also extends to control circuits including other input circuits and switching devices. In addition, the control circuit of this invention is not limited in its application to the control of heating elements but may also be used to control other devices. For example, the combined circuits of FIGS. 1 and 7, omitting the terminals 15, could be used to control the flashing of an indicator lamp. Furthermore, whereas the circuit arrangements particularly described herein and constructed with bipolar transistors, it might be advantageous in some circumstances (particularly for condensation detection and dispersion) to utilize field effect transistors at least for the aforementioned first transistor.

In the arrangement of the condensation-sensing electrodes particularly described in the aforementioned copending Patent Application of John C. Taylor the situation may arise that if the heating element extends over only part of the window surface, for example only over a central area thereof, condensation may be present to resistively bridge the sensing electrodes in a region remote from the heating element even though in the region of the heating element the window surface may be completely clear of condensation and vision may not be obscured. This situation results in the heating element being unnecessarily energized. This disadvantage may be avoided by so arranging the sensing electrodes on the window surface that they are only in sufficiently close proximity to each other to be resistively bridged by condensation in the region of the heating element; one such arrangement has the two sensing electrodes in the form of linear conductors which extend towards one another from opposite sides of the window and

overlap for resistive bridging by condensation only in a central area of the window which central area carries the heating element.

We claim:

1. In a road vehicle, an arrangement for reducing condensation upon the interior surface of a window of the vehicle, the said arrangement including spaced electrodes arranged so as to be bridged resistively by condensation upon said surface; an electronic switching circuit responsive to the resistance between said electrodes; a heating element responsive to the condition of said electronic switching circuit for heating said surface; the heating element and switching circuit being arranged so that in operation the switching circuit is in a condition for energizing the heating element for so long as the resistance between said electrodes is lower than that characterizing a predetermined degree of condensation upon said surface; and a manually-operable timer adapted, when operated, to cause energization of the heating element for a predetermined period, said manually-operable timer including means operable to place said switching circuit in a condition for energizing said heating element irrespective of the resistance between the sensing electrodes and to maintain such condition for said perdetermined period.

2. In a road vehicle, an arrangement as claimed in claim 1 wherein the manually-operable timer comprises an electronic timer incorporating a capacitor/resistor timing network.

3. In a road vehicle, an arrangement as claimed in claim 2 wherein the capacitor of said capacitor/resistor network is connected in series with a manually-operable normallyopen switch across the power supply terminals for the switching circuit, and the resistor of said capacitor/resistor network is connected between the capacitor and said switching circuit via an isolating diode, the arrangement being such that, after a temporary closure of said switch to charge the capacitor, the capacitor discharges via said resistor and diode to provide an input to the switching circuit such as to cause it to energize the heating element for a period determined by the rate of discharge of the capacitor.

4. In a road vehicle, an arrangement as claimed in claim 3 wherein the electronic switching circuit includes a first transistor the control electrode of which, in operation, is connected to receive current via the spaced electrodes when these are resistively bridged by condensation and a second transistor arranged to control a switching device the condition of which determines the energisation of the heating element for removing the condensation from said surface, said first transistor having in its controlled circuit a load formed by two serially connected resistors the junction between which is connected to the control electrode of the second transistor, and said resistor of the capacitor/resistor network being connected via said diode to the base of said first transistor.

5. In a road vehicle, an arrangement as claimed in claim 4 wherein the electronic switching circuit incorporated a switching device for determining the heater operation including a third bipolar transistor, of the same polarity as the first transistor and connected in common emitter configuration, and a resistor connected to provide positive feedback from the collector of the third transistor to the emitter of the first transistor to ensure that the switching circuit responds rapidly to an input condition thereby to reduce power dissipation in the transistors.

6. In a road vehicle, an arrangement as claimed in claim 5 wherein one of the electrodes is connected to one of the power supply terminals for the electronic switching circuit and the other electrode is connected via a current limiting resistor to the base and via a diode to the collector of the first transistor, the diode being poled such that it will be forward-biased should the electrodes be short circuited.

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