

PATENT SPECIFICATION (11)

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(21) Application No. 8072/75 (22) Filed 26 Feb. 1975 (19)

(23) Complete Specification filed 26 May 1976 /

(44) Complete Specification published 10 May 1979

(51) INT. CL.² E06B 7/124 B60R 18/04

(52) Index at acceptance

H2H 25G B8 HV

GIN 1A3A 1D13 3S1B 4C 7A2 AHG

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(54) IMPROVEMENTS IN VEHICLE WINDOW HEATING CONTROLS

(71) We, TARKA CONTROLS LIMITED, a British Company, of The Park, Buxton, Derbyshire, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention concerns improvements in vehicle window heating controls and in particular relates to the control of heaters for removing vision-obscuring condensation from vehicle windows.

In a heated rear window in a car an electric heating element is generally either embedded in or mounted on the interior surface of the vehicle rear window and the heating element is powered from the vehicle battery either continuously so long as the vehicle ignition is switched on or intermittently as desired by operation of a manual control switch. It has been recognised that the continuously energised heating element and the inadvertently not-switched-off manually controlled heating element constitute a serious and unnecessary drain upon the vehicle battery which is required to accommodate large power demands from other electrically-operated components of the vehicle. To avoid this problem and yet retain the facility of a heated rear window, it has been proposed to provide a manually-operable control which will automatically switch off the window heating element a predetermined period after it has been manually switched on. While such a delayed switch-off automatic control is advantageous in that it ensures that the heater is switched off once condensation is cleared from the window to the driver's satisfaction, the pre-selection of the on period is necessarily arbitrary and the duration of the on period may not suit conditions without being unduly long so that the heater element again constitutes an undesirably high drain upon the battery.

Another disadvantage of such previous demister arrangements, other than those of

the continuously powered type, is that they required the visual stimulus of a misted-up window to initiate the manual switch-on of the demister and there is then a time lag before the window clears; i.e. these known arrangements only operate to clear a window after condensation has formed thereupon to such an extent as to be visually noticeable.

It has been proposed to sense automatically the condensation of moisture upon the vehicle window and, in dependence thereupon, to control the energisation of the heater element so that it is powered for so long as the amount of condensation upon the window exceeds a predetermined level. This has been effected by employing spaced electrodes energised by a D.C. power source and arranged so as to be bridged resistively by condensation upon said surface thereby to conduct a D.C. current to actuate a switching circuit to switch on the heater element.

It has been found that the D.C. current flow through the moisture film between the electrodes causes deterioration of the electrode material by electro-chemical action. Such electrochemical action may also create a layer of gas (e.g. Hydrogen) bubbles around an electrode which insulates the electrode from the moisture film and thus prevents operation of the heater element.

In addition dirt films which inevitably form over the electrodes may insulate the electrodes from a moisture film and again prevent operation of the heater element.

We have found that by applying an AC voltage to the electrodes and detecting AC current flow through a moisture film to actuate the heater element, the problems discussed above of the D.C. method can be avoided.

A problem however with an AC method of detection is that of capacitance around the electrodes and electrode leads which may cause erratic operation of the heater element.

It is an object of the present invention to provide an arrangement for reducing the condensation upon the interior surface of a

window of a road vehicle employing an AC method of detection in which capacitive effects mentioned above may be accommodated without causing faulty operation. Since the arrangement is for a road vehicle it must be simple, robust, inexpensive, able to be powered directly from the vehicle's battery without any necessity for transforming the battery voltage, and preferably requires little or no adjustment during installation.

The present invention provides, in a road vehicle, an arrangement for reducing condensation upon the interior surface of a window of the vehicle, the arrangement including spaced electrodes disposed to be bridged resistively by condensation upon said surface, means for generating an alternating voltage connected to one electrode, detecting means connected to another electrode for detecting alternating current flowing through condensation between the electrodes to actuate in dependence thereon a heating element for heating said surface, and gating means arranged to prevent said detecting means from detecting current during part of each cycle of the alternating voltage in which current due to capacitance between the electrodes is significant.

The alternating voltage may be of any waveform in which capacitive effects are significant only over part of each cycle; a sinusoidal waveform for example would not be suitable. For simplicity and convenience, a rectangular pulse waveform is preferred in which, provided they are not excessive, capacitive effects are significant only at the beginning and at the end of the pulse of current flowing through condensation.

With a rectangular pulse waveform therefore, the gating means should be arranged so that the detecting means only detects the central portion of current pulses through condensation and is inhibited at the beginning and end of such current pulses; hence the detecting means will detect current substantially wholly due to resistance of the condensation film.

Circuits for the above may be designed employing widely available and inexpensive integrated circuits which can be powered directly from a vehicle's battery without any voltage transformation being necessary.

It is preferred to use a detection circuit which operates to detect currents of one polarity only (a suitably biased single rail-circuit is preferred) so that the detecting means is automatically gated and inhibited from detecting capacitive currents of the opposite polarity which would arise during the fall time of a current pulse due to a rectangular voltage pulse.

The gating means preferably includes pulse generating means responsive to the electrode voltage waveform generator for

generating a pulse defining the interval during which the detecting means is enabled. Whilst any of the common methods of generating such a pulse may be employed, for example by detecting the leading edge of the electrode voltage pulse and generating a pulse of predetermined width at a fixed delay after the leading edge, a particularly simple and effective method is to integrate the electrode voltage pulse to provide a triangular waveform, clip such triangular waveform, and to employ such clipped waveform to gate the detecting means.

It has been found that by employing the arrangement according to the invention, it is possible to use a wide variety of materials for the electrodes since it is not necessary to consider electrochemical action. In addition, very thin insulating dirt films over the electrodes, which would prevent current flow in a DC arrangement and which act in an AC arrangement to increase the effective resistance and capacitance between the electrodes, are tolerated.

A preferred embodiment of the invention will now be described with reference to the accompanying drawings in which:—

Figure 1 is a block diagram of a circuit for use in an arrangement according to the invention;

Figure 2 is a detailed circuit diagram of the arrangement according to the invention;

Figure 3 shows some of the waveforms generated in the circuit of Figure 2; and

Figure 4 shows various electrode arrangements for reducing D.C. current flow.

The overall arrangement shown in Figure 1 comprises an oscillator 2 generating a square wave coupled via a capacitor C_1 to an electrode E_1 . Electrodes E_1 and E_2 are disposed to be bridged resistively by condensation upon the interior surface of a window of a road vehicle. Electrode E_2 is coupled via a capacitor C_2 to a detector 4 which detects current flowing between the electrodes. The detector 4 is inhibited from operation in part of each cycle of the voltage applied to E_1 by means of a gate 6 connected between the oscillator 2 and detector 4. The detector 4 controls a switch 8 which is switched on when current is detected by the detector to actuate an output stage 10. The output stage energises a relay to turn on a heater which acts to reduce condensation upon the interior surface of a window.

The arrangement of Figure 1 is particularly suited for a road vehicle since it enables simple robust and inexpensive circuits to be used employing an integrated circuit. A preferred IC comprises a Motorola (R.T.M.) MC 3401P having four independent operational amplifiers each having an inverting and a non-inverting input. The main advantage of the IC is that it is designed for use on a single power

supply of from +5V to +18V and is thus suitable to be powered directly from a motor car battery.

Each of the amplifiers of the I C is used to provide one of the functions indicated in Figure 1 Oscillator 2 (Figure 1) employs one of the amplifiers A_1 and generates square waves of an amplitude approximately equal to the supply voltage and of a frequency about 200 Hz (See Figure 3—wave form (a)).

The square wave voltage is applied to electrode E_1 . The DC isolating capacitor C_1 may be considered large compared with the stray capacitance across the electrodes. Current flows between the electrodes via moisture resistance R and stray capacitance C_s to detector 4 comprising amplifier A_3 of the I C. The output of the amplifier A_3 is a waveform which represents the current through the electrode circuit R, C_s . The initial peak is due to current through C_s on the leading edge of the square wave input. The flat portion is due to current through R during the upper level of the input. The level of the flat portion of the output varies with moisture resistance whereas the peak depends on C_s .

Amplifier A_3 is operated on a single rail supply and is biased so that its output is near ground potential when the waveform (a) is low and hence the negative-going peak arising from capacitive effects at the trailing edge of the square wave voltage is suppressed as the amplifier limits. The output of the detector would thus be, if no gate 6 were provided, effectively an amplified and half-wave rectified version of the input to the amplifier—see waveform (b), Figure 3.

Clearly the actual height of the capacitative peak and its width are dependent on the amount of stray capacitance. This is kept to a minimum by design of the electrodes and by employing short electrode leads having low capacitance (300 ohm twin feeder cable is suitable) so that capacitative effects are significant only in the initial part of the current pulse.

The waveforms in Figure 3 show that square wave input to E_1 (a). If (a) is integrated and inverted, a triangular waveform is obtained as at (c). If (c) is clipped at a level shown by the dotted line a waveform as at (d) is obtained. Such clipped waveform can be used to gate the amplifier A_3 such that the amplifier is enabled only during a flat portion (or part of it) of (b) in which capacitative current is not significant. Amplifier A_3 thus provides an output as at (e) where the amplitude of the pulses are at the level X in (b) and are due substantially wholly to resistive current flow between the electrodes E_1 and E_2 .

The output (e) is peak-detected and smoothed to provide a D.C. level propor-

tional to the current through the moisture resistance between the electrodes. Such D.C. level may be employed to actuate a heater element.

A gate circuit 6 for providing waveforms (c) and (d) employs amplifier A_2 of the I C. The time constant of integration and the biasing of the amplifier are such as to ensure that the clipped waveform (d) is such as to block amplifier A_3 of detector 4 during capacitative peaks.

Amplifier A_3 provides a detector circuit 4 having a gating input for the waveform generated by the gate circuit 6. When the gating input is positive a diode $D1$ conducts and the amplifier A_3 output limits at its negative level. When the gating input is at its most negative level the diode $D1$ is cut off and the amplifier output is a non-inverted, amplified version of the input from the electrodes. A diode $D2$ within the feedback loop and a $1\mu F$ capacitor C_3 peak-detect the pulses at the amplifier output to give a D.C. level proportional to the current through the moisture resistance. A resistor R_1 limits the current drawn from the amplifier in charging the capacitor.

The D.C. output is applied to a threshold switch in the form of a regenerative comparator. The comparator employs amplifier A_4 of the I C. The D.C. output from the detecting circuit is applied to the non-inverting input of A_4 . When this input is low the amplifier output limits at its negative level and the relay driver transistor is off. When the input rises to a level determined by a resistor R_R the amplifier regeneratively switches by virtue of a feedback resistor R_F to its positive limit and the relay driver transistor is switched on.

Because R_F introduces hysteresis the input must fall to a lower level before the transistor is switched off. The switch-on level is largely independent of R_F and may be set prior to installation of the arrangement by choice of R_R . Having set the ON level with R_R the amount of hysteresis may be set by means of R_F .

The output switch stage comprises an output transistor T , having a relay coil 14 connected in its collector path. The relay contacts 16 are arranged to control current flowing through the heater.

Figure 4 shows various electrode arrangements in relation to a heater element E on an interior surface of a window. Moisture resistance between the electrodes is indicated as R_M and this may produce a direct current I_{DC} between the electrodes and the heater element itself, which will have a certain voltage level adjacent the electrodes Fig. 4 (a) to (d). Such direct current may cause the electrodes and/or heater material to deteriorate and may cause faulty operation of the circuit. To eliminate such undesired

direct current, isolating capacitors C_1 and C_2 are employed. If the electrodes and heater are considered as receiving aerials, Figure 4 (f) is more liable to stray pick-up and therefore the preferred arrangement is as in Fig. 4 (e).

WHAT WE CLAIM IS:—

1. In a road vehicle, an arrangement for reducing condensation upon the interior surface of a window of the vehicle, the arrangement including spaced electrodes disposed to be bridged resistively by condensation upon said surface, means for generating an alternating voltage connected to one electrode, detecting means connected to another electrode for detecting alternating current flowing through condensation between the electrodes to actuate in dependence thereon a heating element for heating said surface, and gating means arranged to prevent said detecting means from detecting current during part of each cycle of the alternating voltage in which current due to capacitance between the electrodes is significant.

2. An arrangement as claimed in claim 1 wherein said generating means is arranged to generate a rectangular pulse wave form and said gating means is arranged to prevent the detecting means detecting the leading edge of each current pulse.

3. An arrangement as claimed in claim 2 wherein said gating means is arranged to provide pulses at said leading edge and said detecting means is responsive to said gating pulses to be blocked thereby.

4. An arrangement as claimed in claim 3 wherein said gating means includes means to integrate the rectangular pulse wave form to provide a triangular wave form and to clip such triangular wave form thereby to provide triangular pulses at the leading edge of the rectangular pulses.

5. An arrangement as claimed in any

preceding claim wherein said detecting means is arranged to detect currents of one polarity only.

6. An arrangement as claimed in any preceding claim wherein said detecting means includes an amplifier arranged to charge a capacitance by way of a diode to provide a d.c. voltage level representative of current flowing through the condensation between the electrodes.

7. An arrangement as claimed in claim 6 including a further amplifier having a positive feed-back loop and being connected to said detecting means and arranged to switch between positive and negative limiting levels in response to a predetermined d.c. level provided by said detecting means.

8. An arrangement as claimed in claim 7 including an output switch controlled by said further amplifier and arranged to drive a relay, the relay contacts being arranged to control current flow through said heating element.

9. An arrangement as claimed in any preceding claim wherein the said generating means, said detecting means and said gating means comprise an integrated circuit.

10. An arrangement as claimed in any preceding claim wherein isolating capacitors are connected to said electrodes.

11. An arrangement as claimed in any preceding claim wherein said one electrode is positioned nearer said heater element than said other electrode.

12. In a road vehicle, an arrangement for reducing condensation upon the interior surface of a window of the vehicle, substantially as described with reference to the accompanying drawings.

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5 direct current, isolating capacitors C_1 and C_2 are employed. If the electrodes and heater are considered as receiving aerials, Figure 4 (f) is more liable to stray pick-up and therefore the preferred arrangement is as in Fig. 4 (e).

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- 10 1. In a road vehicle, an arrangement for reducing condensation upon the interior surface of a window of the vehicle, the arrangement including spaced electrodes disposed to be bridged resistively by condensation upon said surface, means for
15 generating an alternating voltage connected to one electrode, detecting means connected to another electrode for detecting alternating current flowing through condensation between the electrodes to actuate in dependence
20 thereon a heating element for heating said surface, and gating means arranged to prevent said detecting means from detecting current during part of each cycle of the alternating voltage in which current due to
25 capacitance between the electrodes is significant.
- 30 2. An arrangement as claimed in claim 1 wherein said generating means is arranged to generate a rectangular pulse wave form and said gating means is arranged to prevent the detecting means detecting the leading edge of each current pulse.
- 35 3. An arrangement as claimed in claim 2 wherein said gating means is arranged to provide pulses at said leading edge and said detecting means is responsive to said gating pulses to be blocked thereby.
- 40 4. An arrangement as claimed in claim 3 wherein said gating means includes means to integrate the rectangular pulse wave form to provide a triangular wave form and to clip such triangular wave form thereby to provide triangular pulses at the leading edge of the rectangular pulses.
- 45 5. An arrangement as claimed in any

preceding claim wherein said detecting means is arranged to detect currents of one polarity only.

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