A door-lock system for a household electrical appliance

The system comprises a first and a second electrical terminal (1, 2); a normally-open switch (10), arranged between the electrical terminals (1, 2) and intended to control the supply of current to consumer devices of the household electrical appliance which are connected to the second terminal (2), and including a movable contact (13) controlled by means of a bimetallic component (14); a movable lock part (9) operatively coupled to the switch (10) and able, when the switch (10) is opened and closed, to take up a rest position and a work position, respectively, in which it enables and prevents, respectively, the opening of the door; a third electrical terminal (3) intended to receive a supply voltage (V_{1-3}); a PCT resistive heating element (50) arranged between the first terminal (1) and the third terminal (3), in thermal exchange contact with the bimetallic component (14) associated with the switch (10); and an electric actuator device (25) set up to control, according to pre-established methods, the position of the movable lock part (9) and of the switch (10).

An electronic control circuit (30) is connected at its input to the first and third terminals (1, 3), and at its output to the actuator device (25), and is set up to drive the actuator device (25) according to predetermined characteristics of a supply and control voltage (V_{1-3}) applied across the first and third terminals (1, 3).
Description

[0001] The present invention relates to a door-lock system for a household electrical appliance, such as a washing machine or an oven.

[0002] More specifically, a subject of the invention is a door-lock system comprising a first and a second electrical terminal; a normally-open electrical switch, arranged between the first and second electrical terminals and intended to control the supply of current to consumer devices of the household electrical appliance which are connected to the second terminal, and including a movable contact controlled by means of a bimetallic component; a movable lock part operatively coupled to the switch and able to take up a rest position and a work position in which it enables and prevents, respectively, the opening of the household electrical appliance door; a third electrical terminal intended to receive during operation a supply voltage; a resistive heating element with a positive temperature coefficient, arranged between the first terminal and the third terminal, in thermal exchange contact with the bimetallic component associated with the switch; and an electrically controlled actuator device set up to control, according to pre-established methods, the position of the movable lock part and of the aforementioned switch.

[0003] Door-lock systems of this type are described and illustrated for example in European patent EP 0 354 191 B1 and in US patent 6,334,637 B1 (in the latter, see in particular Figures 10 to 12 and the relevant part of the description), both in the name of the same Applicant.

[0004] The door-lock devices described in these prior art patents have at least four electrical connection terminals. The wiring needed to connect such a door-lock device to the electrical plant and to the internal electronic systems of the household electrical appliance in which it is incorporated is correspondingly complex and expensive.

[0005] One aim of the present invention is to produce a door-lock system which has a smaller number of electrical terminals and therefore requires simplified connection wiring.

[0006] This and other aims are achieved according to the invention by a door-lock system, the salient features of which are defined in appended Claim 1.

[0007] Other features and advantages of the invention will become clear from the following detailed description which is given purely by way of non-limiting example and with reference to the appended drawings in which:

Figure 1 is a wiring diagram of a door-lock device according to the present invention;
Figure 2 is a wiring diagram of a door-lock system according to the present invention, including a door-lock device of the type illustrated in Figure 1; and Figures 3 and 4 are diagrams showing, over time T indicated on the abscissa, typical signal patterns developed during operation in a door-lock system according to the invention.

In Figures 1 and 2, a door-lock device according to the invention, for a household electrical appliance, is indicated as a whole by the reference 100.

[0008] The door-lock device 100 comprises only three electrical terminals, indicated as 1, 2 and 3.

[0009] With reference to Figure 2, the terminals 1 and 3 are intended to be coupled to the alternating voltage supply terminals A and B of the associated household electrical appliance, by means of a conductor 4 and an electronic board 5, respectively, the electronic board 5 being set up in this household electrical appliance.

[0010] The electrical terminal 2 of the door-lock device 100 is intended to be connected, in a manner not represented, to consumer devices inside the household electrical appliance.

[0011] With reference to Figure 1, a normally-open electrical switch 10 is arranged between the terminals 1 and 2 and intended to control the supply of current to the abovementioned consumer devices. In one example embodiment, which draws from the known solution of US 6,334,637 B1, the switch 10 in a manner known per se comprises a movable contact 13 held by a bimetallic strip 14 permanently connected at 15 to the terminal 1.

[0012] The bimetallic strip 14 and the associated contact 13 can move between two fixed electrical contacts, indicated 11 and 12 respectively. The terminal 11 is permanently connected to the terminal 2.

[0013] In a manner known per se, as described in detail in the abovementioned US patent, the bimetallic strip 14 is operatively connected to a movable lock part 9 which, when the switch 10 is opened and closed, takes up a rest position and a work position, respectively, in which it enables and prevents, respectively, the opening of the household electrical appliance door.

[0014] In a manner similarly known per se, a resistive heating element 50 with a positive temperature coefficient (PTC) is electrically connected between the first terminal 1 and the third terminal 3. In the embodiment illustrated and described in detail in the abovementioned US patent, the PTC resistive element 50 is arranged in thermal exchange contact with the bimetallic strip 14 of the switch 10 (see for example Figure 11 in patent US 6,334,637 B1).

[0015] In another embodiment, based on the known device of EP 054 191 B1 and not illustrated here, the switch 10 can comprise a non-bimetallic strip 14, bearing the movable contact 13 and controlled by means of one or more bimetallic components with which there is associated a PCT resistor.

[0016] In Figure 1, the reference 7 indicates an electrical position sensor associated with the household electrical appliance door. In the embodiment illustrated, this sensor is substantially a normally-open switch 8 placed between the terminal 3 and the resistive heating element 50. This position sensor is a redundant safety device: it
is open and prevents current from being supplied to the resistive element 50 when the household electrical appliance door is open, and it closes and allows current to be supplied to the resistive heating element 50 when the door is closed.

[0017] In Figure 1, the reference 25 indicates as a whole an electrically controlled actuator device, including a solenoid 26 and set up to control, according to pre-established methods, the position of the bimetallic strip 14 of the switch 10 and the position of the associated movable lock part 9. This actuator device is for example of the type described and illustrated in detail in the US patent mentioned above several times.

[0018] In Figure 1, the reference 30 indicates an electronic control circuit which is connected at its input to the terminals 1 and 3, directly and via the position sensor-switch 7, respectively. The output of this electronic control circuit 30 is connected to the control solenoid 26 of the actuator device 25.

[0019] With reference to Figure 2, the door-lock device 100 can conveniently be driven by an electronic control board 5 set up in the household electrical appliance. This electronic board 5 could, alternatively, be integrated with the same door-lock device 100. In that case, the door-lock system in its entirety would nevertheless present only three terminals, i.e. the terminals A and B, and the terminal indicated as 2.

[0020] In the example embodiment illustrated in Figure 2, the electronic board 5 comprises an electronic processing and control unit or CPU 40, implemented for example using a microprocessor. This unit has an output connected to the gate of a triac 41 which is placed on a line 42 that interconnects the supply terminal A with the terminal of the door-lock device 100.

[0021] A rectifier diode 43 is connected in parallel with the triac 41.

[0022] The door-lock system described above is set up to operate in a manner which will now be illustrated in detail, referring later to Figures 3 and 4.

[0023] At rest, the solenoid 26 of the actuator 25 is de-energized. In this situation, the actuator, as illustrated in the abovementioned US patent, prevents the switch 10 from closing and the lock part 9 from passing to its work position. Consequently, at rest the household electrical appliance door can be opened and closed at will.

[0024] When operation of the household electrical appliance is started, the alternating supply voltage is applied across the terminals A and B (Figure 2), such as the mains power supply at 50(60) Hz. Under the control of the CPU 40, the control board 5 applies an initial rectified voltage \( V_{1-3} \) across the terminals 1 and 3 of the door-lock device 100, corresponding for example to only the negative half-waves of the alternating supply voltage applied across the terminals A and B. The initial rectified supply voltage \( V_{1-3} \) is however sufficient to ensure that the PTC resistive element 50, in a minimum predetermined time period TP (of 6-8 seconds, for example), reaches a temperature such that the bimetallic strip 14 is capable of closing the switch 10, which nevertheless remains open under the control of the actuator device 25, 26. Over the aforementioned time period, indicated as TP in Figure 3, the control circuit 30 of the door-lock device 100 continues to maintain the solenoid 26 of the actuator device 25 in the de-energized state.

[0025] After the time period TP has passed, the electronic board 5 applies to the third terminal 3 or, preferably, across the terminals 3 and 1, of the door-lock device 100, one (and only one) positive half-wave of the alternating supply voltage, and therefore at the input of the electronic control circuit 30 there now appears a complete wave of the alternating supply voltage, this complete wave being indicated as CW in Figure 3. The electronic control circuit 30 is set up to then transmit as output, to the solenoid 26 of the actuator device 25, an excitation pulse, indicated as I in the second diagram of Figure 3, which illustrates the pattern over time of the signal T applied to this solenoid.

[0026] The excitation pulse I applied to the solenoid 26 causes at this point the switch 10 to close, or rather the bimetallic strip device 14 to be in the condition in which the movable contact 13 is pushing against the fixed contact 11, allowing the consumer devices of the household electrical appliance, which are connected to the terminal 2 of the door-lock device 100, to be supplied.

[0027] The state of the switch 10 is illustrated by the third diagram presented in Figure 3.

[0028] After the (only) complete wave CW, the electronic board 5 continues to apply across the terminals 1 and 3 of the door-lock device 100 a rectified voltage \( V_{1-3} \), with only negative half-waves, as shown in the righthand part of the first diagram of Figure 3, and in the lefthand part of the first diagram of Figure 4 (which represents the continuation in time of the corresponding diagram of Figure 3). In the continuation of the operating cycle of the household electrical appliance, the heating resistor device 50 continues to be supplied, and continues to maintain the strip 14 in the condition of closure of the switch 10.

[0029] At the end of the operating cycle of the household electrical appliance, at an instant indicated by \( t_1 \) in the diagrams of Figure 4, the electronic board 5 applies across the terminals 1 and 3 of the door-lock device 3 a first complete wave CW1, and then a second complete wave CW2, separated by a predefined pause time interval, preferably without interrupting the application of the negative half-waves of the supply voltage. The electronic control circuit 30 is set up to correspondingly apply to the solenoid 26 of the actuator device 25 two successive pulses I1 and I2 (Figure 4) which, by virtue of the features of the mechanism of the actuator device 25 (which is for example the one described in detail in US patent 6.334.637), causes, after the second pulse 12, or rather at an instant indicated as \( t_2 \) in Figure 4, the switch 10 to immediately reopen and the movable lock part 9 to return to its rest position in which it allows the household electrical appliance door to be reopened.

[0030] With the door-lock system according to the in-
vention, if the alternating supply voltage is cut during an operating cycle of the household electrical appliance, the door may be reopened only after the PTC resistor 50 has sufficiently cooled. This means that the door can be opened only after a minimum safety time has passed.

[0031] The door-lock system described above operates with inherent safety in the event that one of a plurality of possible failure conditions of the electronic board 5 occurs:

- if during an operating cycle of the household electrical appliance, the electronic board 5 starts to apply across the terminals 3 and 1 of the door-lock device 100 the complete alternating supply voltage, the electronic control circuit 30 would not transmit any excitation pulse to the solenoid 26 of the actuator device, and the mechanism of the latter prevents the switch 10 from opening, as well as the door from opening, since this mechanism requires two successive pulse actions to allow these manoeuvres;
- if during the operation of the household electrical appliance the triac 41 in the board 5 starts to operate like a diode, conducting only negative half-waves, the electronic control circuit 30 would not transmit any excitation pulse to the solenoid 26; if the triac 41 starts instead to conduct only positive half-waves, the electronic circuit 30 would transmit to the solenoid 26 only one pulse, which, as it is a single pulse, is incapable of reopening the switch 10 and of allowing the household electrical appliance door to be reopened;
- if the triac 41 "opens", the voltage $V_{1-3}$ falls, and after the PTC resistor 50 will have sufficiently cooled, the switch 10 can be opened and the door of the appliance may be opened, in safety.

[0032] Naturally, the principle of the invention remaining the same, the forms of embodiment and details of construction may be varied widely with respect to those described and illustrated purely by way of non-limiting example, without thereby departing from the scope of the invention, which scope is defined in the appended claims.

Claims

1. A door-lock system for a household electrical appliance, comprising
   a first and a second electrical terminal (1, 2);
   a normally-open electrical switch (10), arranged between the electrical terminals (1, 2) and intended to control the supply of current to consumer devices of the household electrical appliance which are connected to the second terminal (2), and including a movable contact (13) controlled by means of a bimetallic component (14);
   a movable lock part (9) operatively coupled to the switch (10) and able, when the switch (10) is opened and closed, to take up a rest position and a work position, respectively, in which it enables and prevents, respectively, the opening of the household electrical appliance door;
   a third electrical terminal (3) intended to receive during operation a supply voltage ($V_{1-3}$);
   a resistive heating element (50) with a positive temperature coefficient, arranged between the first terminal (1) and the third terminal (3), and arranged in thermal exchange contact with the bimetallic component (14) associated with the switch (10); and
   an electrically controlled actuator device (25) set up to control, according to pre-established methods, the position of the movable lock part (9) and of the switch (10);
   the door-lock system being characterized in that it comprises an electronic control circuit (30) which is connected at its input to the first and third terminals (1, 3), and which is connected at its output to the actuator device (25), and is set up to drive the actuator device (25) according to predetermined characteristics of a supply and control voltage ($V_{1-3}$) applied across the first and third terminals (1, 3).

2. A door-lock system according to Claim 1, in which the arrangement is such that
   - the actuator (25) at rest is able to prevent the switch (10) from closing and the lock part (9) from passing to the work position, and the door can be opened and closed at will.

3. A door-lock system according to Claim 2, in which the arrangement is such that, when operation of the household electrical appliance is started, a unidirectional supply voltage is applied to the third terminal (3), and the resistive heating element (50) is able, over a pre-established minimum time period (TP), to enable closure of the switch (10), which nevertheless remains open under the action of the actuator device (25).

4. A door-lock system according to Claim 3, in which the arrangement is such that when, after the pre-established time period (TP), there is applied at the third terminal (3) a voltage ($V_{1-3}$) exhibiting a first control characteristic (CW), the control circuit (30) is set up to drive the actuator (25) such that it releases the switch (10) and the lock part (9), enabling the latter to pass to the locked position of the closed door and the switch (10) to close, the voltage ($V_{1-3}$) being sufficient to supply the resistive heating element (50) so as to continue maintaining the switch (10) in the closed position.

5. A door-lock system according to Claim 4, in which the arrangement is such that when, at the end of an operating cycle of the household electrical appli-
ance, there is applied at the third terminal (3) a voltage \( V_{1,3} \) exhibiting a second predetermined characteristic \( (CW1, CW2) \), the control circuit (30) is set up to drive the actuator (25, 26) such that it causes the switch (10) to open and the lock part (9) to return to the rest position, enabling the door to be reopened.

6. A door-lock system according to any one of the preceding claims, in which a position sensor-switch (8) associated with the household electrical appliance door is placed between the third terminal (3) and the control circuit (30).

7. A door-lock system according to any one of the preceding claims, comprising an electronic board (5) including a processing and control unit (40) set up to drive a triac (41) arranged in series between a terminal (A) supplying an alternating voltage and the abovementioned third terminal (3) of the door-lock device (100), a rectifier diode (43) being connected in parallel with the triac (41).
FIG. 3

- $V_{1-3}$ (V)
- $T_{(ms)}$
- $T$ (V)
- $T_{(ms)}$

Status of switch:
- OPEN
- CLOSED

Time points:
- TP
- CW
REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 054191 B1 [0015]
- US 6334637 B [0029]