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DESCRIPTION OF INVENTION

Title: "Electronic temperature control means for cordless irons"

THIS INVENTION relates to temperature controls for electric irons, and more particularly to electronic temperature control means for cordless electric irons.

5 One of the most common of present day household appliances is the electric iron. While the modern electric iron, with variable temperature control, steam and spray features has much to recommend it over the old
10 sadirons resting on a pot belly stove to be heated, there is one disadvantage of today's iron over the sadiron - the cord. No matter how one tries to work around it, it seems the iron's cord is always in the way. Recognizing this disadvantage, manufacturers have recently begun producing
15 cordless electric irons, providing all of the conveniences of other modern irons without the inconvenience of the cord. Examples of such irons are disclosed in U.S. Patent
No. 3760149 and U.S. Patent No. 4528429.

20 In both of these prior art devices, the temperature of the sole plate is controlled by a mechanical adjustable thermostat mounted on the iron. While this manner of temperature control may be adequate for most uses, it is inferior to state-of-the-art electronic temperature control means currently in use in a variety of consumer
25 products.

It is an object of the present invention to provide a cordless electric ironing apparatus incorporating improved means for controlling the temperature of the

iron.

According to the invention, there is provided a cordless electric ironing apparatus including an iron having a sole plate, a heating element for heating said sole plate and an insulated handle to allow manipulation of said iron while in a heated state, the apparatus further including a base member connectable to a source of current, the base member and the iron having complementary electrical terminal arrangements whereby when said iron is placed in a predetermined position on said base member, said terminal arrangements are placed in operative connection with one another whereby heating current may be supplied to said heating element from said base member, the apparatus including control means in said base member for controlling the supply of current to said heating element, the iron including a thermistor for sensing the temperature of said sole plate and transmission means for transmitting a temperature-indicating signal to said control means in said base member, said transmission means including an astable multivibrator circuit including said thermistor and arranged to oscillate at a frequency dependent on the resistance of said thermistor and thus on the temperature of said sole plate, said transmission means further including a light emitting diode arranged to be switched on and off in alternate states of said multivibrator during oscillation thereof, whereby said light-emitting diode is, in operation, switched on and off at a frequency dependent on the temperature of said sole plate, said control means in said base member including a light sensor arranged to receive light emitted by said light emitting diode when the iron is placed in said predetermined position on said base member, the control means being arranged to utilise the light signal detected by said light sensor, and more particularly the frequency at which said light signal occurs, as a measure of the actual temperature of the sole plate, and to control the

supply of current to said heating element via said terminal arrangements in such a way as to tend to bring the sensed temperature into correspondence with a set temperature.

An embodiment of the invention is described below by way of example, with reference to the accompanying drawings, wherein:-

FIGURE 1 is a perspective view of a cordless electric ironing apparatus embodying the invention;

FIGURE 2 is a fragmentary sectional view of the apparatus illustrating how the iron is mounted in operational connection with the base member of the apparatus of Figure 1;

FIGURE 3 is a schematic representation of the temperature sensing circuitry contained within the iron;

FIGURE 4 is a schematic representation of the electronic control circuitry contained in the base, and

FIGURE 5 is a plan view of the key switch assembly and indicator lamps of the electronic temperature control means of the apparatus.

5 Referring to the drawings, Figure 1 shows a cordless electric iron 1 resting upon its base member 2. The base member 2 is connected by cord 3 to a source of alternating current (not shown) such as the mains supply, and houses electronic control means for controlling and maintaining
10 the temperature of the sole plate of iron 1. This control means is accessed through key switch assembly 11 for choosing a desired operating temperature for iron 1.

Figure 2 shows the operative interconnection
15 between the iron 1 and base member 2. Male connector pins 4 on the iron are engagable with corresponding female connectors 5 in the base for providing alternating current to the heating element of iron 1 whenever the iron is placed in base member 2. Also shown are an infrared light
20 emitting diode 13 mounted in the iron and an associated phototransistor PT1 mounted in the base. The diode 13 and phototransistor PT1 are primary parts of a communication system between an iron temperature sensor and electronic control means in the base 2.

25 The schematic drawing of Figure 3 is representative of the temperature sensing circuitry contained within iron 1. Terminals 8 are connected across the iron heating element (not shown) to male connector pins 4, which in
30 turn are connected through the female connectors 5 and through electronic control means to be described later to a source of alternating line current. A capacitive reactance voltage divider C21, R21 connected with terminals 8 supplies a reduced voltage (as compared with
35 the mains voltage) to a rectifier diode D21 and a filter C22 such that an unregulated DC voltage of 12 to 16 volts appears a node 8.

5 This unregulated voltage is applied to an integrated circuit voltage regulator VR2 and an associated bypass capacitor C23 to provide a 5 volt DC regulated source at node 9, which source is used to power the temperature sensing circuitry mounted in the iron 1.

10 The temperature circuitry includes an integrated circuit oscillator IC2, which performs as an astable multivibrator when connected as shown in Figure 3. The temperature sensing circuitry further includes a thermistor THM1 embedded in the sole plate of the iron. The thermistor THM1, in combination with resistors R23 and R24, trimming potentiometer R24 and capacitor C25, provides a frequency determining network for astable multivibrator IC2. IC2 produces an output in the form of a train of pulses at a frequency which is inversely proportional to the resistance of thermistor THM1, and therefore proportional to the temperature of the sole plate of the iron. This pulse output drives infrared light-emitting diode 13 through current limiting resistor R22 so that the LED 13 is switched on and off at the oscillating frequency of the multivibrator, whereby the signal representing the temperature of the sole plate can be transmitted to the base-mounted electronic temperature control means.

30 The base circuitry will now be described with reference to Figure 4. The base member is connected to a source of alternating line current through a power cord (not shown) connected to terminals 10. The "neutral" terminals 10 is also connected directly to one of two female connector terminals 5, to which the iron 1 is connected whenever it is placed on the base 2 and the "live" terminal 10 is connected with the other terminal 5 through a power relay RLY1. A step-down transformer T1 connected with terminals 10 supplies a reduced voltage to a full wave rectifier D1, D2, D3, D4. The resulting

unregulated DC voltage of approximately nine volts is filtered by capacitor C1 and applied to the input of integrated circuit voltage regulator VR1, which provides a regulated output of 5 volts DC, which is used to power a microprocessor IC1 and the remainder of the base circuitry.

Also connected to the secondary winding of transformer T1 is timing network R2, C2, Q2 which provides a pulse signal at mains frequency for use as a time base for microprocessor IC1 for measurement of the frequency of the signal received from the iron-mounted temperature sensing circuitry. The apparatus illustrated in the drawings is intended for use with a 120 volt, 60Hz A.C. mains supply.

As illustrated in Figure 5, the base 2 carries an assembly 11 of keys or press-button switches which can be operated manually to select any of various iron temperatures or modes of operation. Light emitting diodes, represented by black spots in Figure 5 and referenced LED1 to LED10 in Figure 4 indicate to the operator which temperature or operating mode is currently selected and provide signals to the operator as indicated by the text in Figure 5.

The switch assembly 11, also referred to herein, in relation to Figure 4, as switch matrix 11, provides user input to microprocessor IC1 for selection of the desired temperature programming function. Diodes D5 and D6 serve to isolate the switching function from the light-emitting diode drives.

Light-emitting diodes LED1 through LED 10, which provide visual indications of temperature selection and circuit status in accordance with the functions selected through microprocessor IC1 through switch matrix 11, are connected with microprocessor IC1 through associated

circuitry including resistors R⁴ to R¹¹ and transistors Q³ and Q⁴.

5 The resistance-capacitance network formed by R¹³ and C⁴ is the frequency-determining circuit for the instruction cycle oscillator of microprocessor IC¹.

10 Resistor R¹², diode D⁷ and capacitor C⁵ provide a power-up signal to microprocessor IC¹ to reset it to its first instruction after a predetermined delay from turn-on. Diode D⁷ prevents low voltage reset during operation.

15 An audible indication is provided to the user upon execution of certain functions by microprocessor IC¹, such as automatic turn-off, through application of a frequency pulse to a piezoelectric buzzer PB¹.

20 Iron in-base switch 12 is included to signal to microprocessor IC¹ whether or not the iron is in operational connection with the base. Switching current is provided through resistor R¹⁶.

25 When the iron is appropriately placed on base 2, the iron temperature frequency signal emitted by infrared LED 13 is received in the base by phototransistor PT¹. The received signal is amplified and squared by the network of transistor Q¹ and resistors R¹ and R³ to provide a suitable signal to microprocessor IC¹. The microprocessor measures the frequency of the received signal, which is
30 proportional to the temperature of the sole plate, and makes control decisions based upon its programming and key switch inputs provided by the user. Resistor R¹⁷ prevents destruction of transistor Q¹ if phototransistor PT¹ should saturate.

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Microprocessor IC¹ outputs its control decisions through the network of resistors R¹⁴ and R¹⁵ and

transistors Q5 and Q6, which drive power relay RLY1 for providing line current through the live female connector 5 to the iron heating element. Diode D8 across the winding of relay RLY1 protects transistor Q5 from negative spikes. Capacitor C6 provides current capacity during relay pull-in, and capacitor C3 provides bypassing.

As already indicated, Figure 5 shows the display panel which is applied over key switch assembly 11. Illustrated are labels for the various temperature ranges which may be selected, these labels being: "DELICATE", "PERM.PRESS", "WOOL", "COTTON" and "LINEN". Furthermore, a higher or a lower temperature within each range may be selected by operation of a button referenced "HIGH" or a button referenced "LOW" respectively. Also illustrated in Figure 5 is the ON/OFF switch, the indicator LEDs for the selected temperature and indicator LEDs for the status of the iron electronic control circuitry (referenced "WAIT", "READY" and "SELECT FABRIC").

The general operation of the microprocessor-controlled cordless electric iron will be described next, followed by a more detailed description of the functional operation of the various operative states of the control circuitry.

First, the base member 2 is plugged into a source of line current and the iron 1 is placed in operative connection with the base. Pressing the ON button generates a single beep and the SELECT FABRIC indicator will begin to flash. No power is applied to the iron until a fabric temperature setting has been selected. If no fabric setting is chosen within ten minutes after pressing the ON button, the control means will go into an automatic shut-off mode.

A temperature may be selected by pressing one of the five fabric settings and optional HIGH or LOW buttons for intermediate temperatures. As these settings are selected, the associated LED indicators will light, and a
5 beep will be generated for each switch pressed. Once a fabric setting is selected, the SELECT FABRIC indicator will go out, and the WAIT indicator will come on continuously until the temperature of the iron as measured by thermistor THM1 and its associated circuitry, (Figure
10 3), reaches the selected setting, at which point the WAIT indicator will be extinguished, and the READY indicator will light, accompanied by two beeps. When the iron is removed from the base, the fabric (temperature) indicators will remain lit, but both the WAIT and READY indicators
15 will extinguish until the iron is replaced on the base.

If the iron is replaced on the base, and the temperature of the iron is outside the selected range, the WAIT indicator will come on, accompanied by a single beep.
20 Power is applied to the iron only after the presence of the iron is sensed in the base, and the temperature control circuitry determines that the present iron temperature is out of range.

If the iron is left on the base for more than ten minutes without being removed, and the temperature setting is not changed, ten beeps will sound. If nothing is done within another two minutes, the iron will go into automatic shutdown. When this happens, the power to the
25 iron is disconnected and the temperature display is turned off. The WAIT indicator will come on until the iron has cooled enough to be stored, at which time the WAIT light is extinguished and a single beep is generated. The temperature control and display can be re-activated using
30 normal start-up procedures.
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Turning off the iron using the ON/OFF switch causes the WAIT indicator to come on until the iron has cooled enough to be stored, at which time the WAIT indicator goes out, and a single beep is generated.

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The following paragraphs describe the functional operation of the various operative states of the electronic cordless iron in detail.

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OFF STATE:

When the iron is in the off state, the power relay is off, all LED's are off, and all switches are disabled except for the ON/OFF switch. If the iron is not in the base, the "off base" state is entered. If the ON/OFF switch is pressed while in the off state, and the iron is in the base, a beep is generated and the SELECT FABRIC mode is entered. If the ON/OFF switch is pressed while in the off state, and the iron is not in the base, a beep is sounded, but the SELECT FABRIC mode is not entered.

SELECT FABRIC STATE:

When the iron control means is in the SELECT FABRIC state, the power relay is off, all LED's are off, except for the SELECT FABRIC LED which is flashing, and the keyboard switches are enabled if the iron is in the base. If the iron is not in the base, the "off base" state is entered. If the ON/OFF switch is pressed, a beep is heard, and the "off" state is entered. If one of the fabric select switches is pressed, and the iron is in the base, a beep is generated, the LED associated with the switch pressed is turned on, and the "wait" state is entered. If no switches are pressed for ten minutes, the "automatic shut-off" state is entered. If no infrared signal indicative of the temperature being measured at the sole plate is received, or the infrared signal is not increasing in frequency, the iron shuts off immediately.

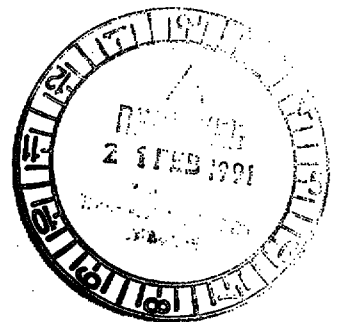
WAIT STATE:

When the iron control is in the "wait" state, the power relay can be on or off, depending upon the requirements of the heating element, the selected fabric LED is on, the WAIT LED is on, all other LED's are off, and all eight keyboard switches are enabled. If the iron is removed from the base, the "off base" state is entered. In the "wait" state, the control means is monitoring the heating or cooling of the iron to determine when the selected temperature range has been reached. When the selected temperature is reached, two beeps are generated, and the "ready" state is entered. While waiting for the iron to reach the selected temperature, the control is monitoring the keyboard. If the ON/OFF switch is pressed, a beep is heard, and the "off" state is entered. If the HIGH or LOW switch is pushed, a beep is generated, and the associated LED is turned on if it was previously off (indicating that a new temperature range has been selected), or if it was on, it is left on. If the currently selected fabric switch is pressed (LED is already on), a beep is generated, the HIGH or LOW LED's are turned off, and if either the HIGH or LOW LED was on, a new temperature range is set as the selected temperature. If a new fabric switch is pushed, a beep is generated, the HIGH and LOW LED's are turned off, the newly selected fabric LED is turned on, and a new temperature range is set as the selected temperature. If a new temperature is selected, a two-second timeout is set. The iron cannot reach the "ready" state until this two-second timeout has expired, even if the selected temperature is achieved beforehand.

READY STATE:

When the control is in the "ready" state, the power relay may be on or off as needed to maintain the selected temperature, the selected fabric LED is on, the HIGH or LOW LED may be on, the
5 READY LED is on, all other LED's are off, and all eight keyboard switches are in enabled. If the iron is removed from the base, the "off base" state is entered. In the "ready" state, the control is monitoring the heating or cooling of the iron to determine if the temperature is outside the selected temperature
10 range. When the temperature is outside of the selected temperature range, the power relay is on to maintain the selected temperature setting. The READY LED stays on during this maintenance cycle. If, during an "off base" state, the iron cools too far to be functional when the iron is replaced on the
15 base, the "wait" state is entered, and a single beep is generated. While waiting for the iron to be removed from the base, the control is monitoring keyboard. If no keys are pressed, or the iron is not removed for ten minutes, the "automatic shut-off" state is entered. If the ON/OFF switch is
20 pressed, a beep is heard, and the "off" state is entered. If the HIGH or LOW switch is pressed, a beep is heard, and the associated LED is turned on if it was turned off, indicating that a new temperature range has been selected, and if it was on, it is left on. If the currently selected fabric switch is pressed,
25 a beep is heard, the HIGH or LOW LED's are turned off, and if either the HIGH or LOW LED was on, a new temperature range is set as the selected temperature, and the "wait" state is entered. If a new fabric switch is pushed, a beep is heard, the HIGH and LOW

LED's are turned off, the newly selected fabric LED is turned on, a new temperature range is set as the selected temperature, and the "wait" state is entered. If a new temperature is selected, a two-second timeout is set before entering the "ready" state.



OFF BASE STATE:

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When the control is in the "off base" state, the power relay is off, the selected fabric LED is on, the HIGH or LOW LED may be on, all other LED's are off, and all keyboard switches are disabled except the ON/OFF switch. The control remains in the "off base" state until the iron is returned to the base. When the iron is replaced in the base, the state that the module was in just before the iron was removed from the base is reentered. If the iron is not replaced in the base, and the ON/OFF switch is not pressed for ten minutes, the "automatic shut-off" state is entered. If the ON/OFF switch is pressed, a beep is heard, and the "off" state is entered.

AUTOMATIC SHUT-OFF STATE:

When the control enters the "automatic shut-off" state, ten beeps are generated, and a two-minute timeout is started. If no keys are pressed or the iron is not removed from the base within the two-minute timeout, then the "off" state is entered. If the current fabric key is pressed, or the iron is removed and replaced during this two-minute timeout, then the state that the module was in just before the automatic shut-off state was entered is reentered. If a different fabric key is pressed, the control enters the "wait" state. If the iron is removed and not replaced during this two-minute timeout, the "off base" state is entered. If the ON/OFF key is pressed, the control enters the "off" state. Temperature is maintained during this two-minute period.

Operation of the preferred embodiment of the electronic temperature control means of the invention will now be described with reference to Figures 3 and 4. Once the iron has been turned on and a temperature has been selected, power is supplied through power relay RLY1, through connector terminal pairs 5 and 4 to the heating element of the iron, and to terminals 8 of the electronic temperature sensing circuitry.

The resistance of thermistor THM1 varies inversely proportionally in accordance with the temperature of the iron sole plate in which it is embedded. That resistance, in combination with resistors R23, R24 and R25, and capacitor C25, forms a frequency determining network for astable multivibrator IC2. The output frequency thus generated by multivibrator IC2 is also proportional to the temperature of the sole plate, and this frequency drives infrared LED 13 through current-limiting resistor R22.

This circuit functions only when the iron is operatively connected to the base, since the iron contains no source of power once it is removed from the base. As can be seen in Figure 2, whenever the iron is placed in the base, LED 13 is positioned directly above phototransistor PT1. Thus, the variable frequency signals representing sole plate temperature being transmitted by LED 13 are received directly by phototransistor PT1, processed by amplifying and squaring network R1, Q1, R3 and applied to the microprocessor control means IC1. The microprocessor is programmed to translate the received frequency into a control signal by measuring the frequency against the 60 Hz. time base generated by R1, C2 and Q2. The microprocessor IC1 then compares the measured temperature of the sole plate with the selected temperature from key switch assembly 11, and controls relay

driver R15, Q6, R14 and Q5 and power relay RLY1 to establish and maintain the selected temperature for as long as the iron is in operation.

The apparatus described with reference to the drawings provides an accurate electronic temperature control means which is accommodated in the base member 2, with only the temperature sensing and transmitting means being in the iron.

Eliminating the control means from the iron allows the iron to be more compact and lighter, and also allows the use of accurate, electronic temperature control circuitry mounted in the base to provide improved control and ease of operation of the cordless iron.

Other advantages include push button selection of the desired temperature, visual indications of the current status of the iron and its programmed temperature, audible indications of its operative functions, and automatic shut-off in case of various undesirable operating conditions.

CLAIMS

1. A cordless electric ironing apparatus including an iron having a sole plate, a heating element for heating said sole plate and an insulated handle to allow manipulation of said iron while in a heated state, the apparatus further including a base member connectable to a source of current, the base member and the iron having complementary electrical terminal arrangements whereby when said iron is placed in a predetermined position on said base member, said terminal arrangements are placed in operative connection with one another whereby heating current may be supplied to said heating element from said base member, the apparatus including control means in said base member for controlling the supply of current to said heating element, the iron including a thermistor for sensing the temperature of said sole plate and transmission means for transmitting a temperature-indicating signal to said control means in said base member, said transmission means including an astable multivibrator circuit including said thermistor and arranged to oscillate at a frequency dependent on the resistance of said thermistor and thus on the temperature of said sole plate, said transmission means further including a light emitting diode arranged to be switched on and off in alternate states of said multivibrator during oscillation thereof, whereby said light-emitting diode is, in operation, switched on and off at a frequency dependent on the temperature of said sole plate, said control means in said base member including a light sensor arranged to receive light emitted by said light emitting diode when the iron is placed in said predetermined position on said base member, the control means being arranged to utilise the light signal detected by said light sensor, and more particularly the frequency at which said light signal occurs, as a measure of the actual temperature of the sole



plate, and to control the supply of current to said heating element via said terminal arrangements in such a way as to tend to bring the sensed temperature into correspondence with a set temperature.

2. Apparatus according to any preceding claim, wherein said control means includes a microprocessor.

3. Apparatus according to claim 1 or claim 2 wherein said light-emitting diode is arranged to emit infrared light when switched on.

4. A cordless electric ironing apparatus, substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

