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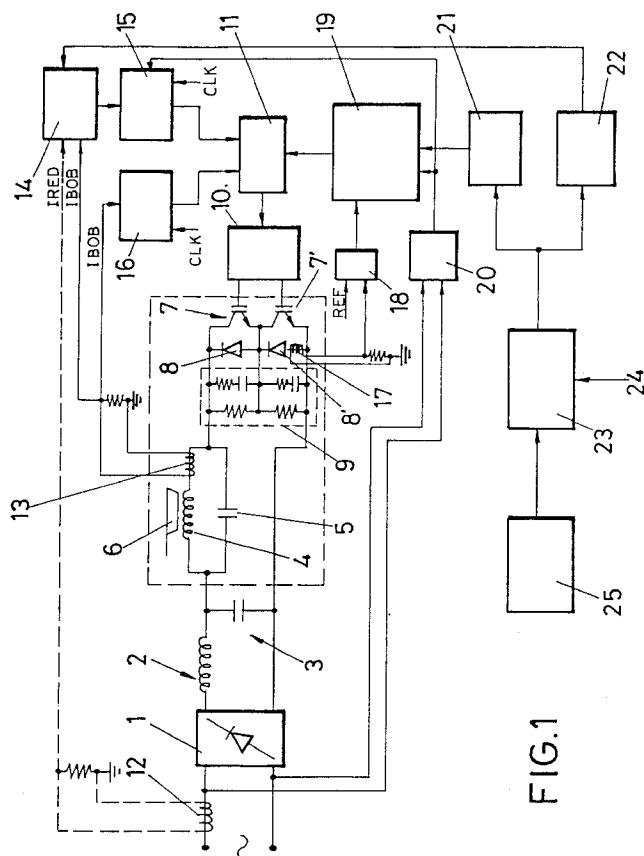
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**(54) Induction heating system**

(57) An induction heating system characterized by the fact that the power stage comprises a resonating system, coil (4) - capacitor (5), with two power devices (7-7') arranged in series, with their corresponding balance network (9). This topology, whose control circuit makes a soft switching in devices, allows the system to reach a higher overall power. This control system has also means for varying power at high levels and varying

energy at low power levels, a fixed power rate being applied at varied intervals.

Another system characteristic is that pot detection (6) on the coil (4) is performed using a comparison unit (18) which senses the current flowing through one of the compensating networks, and acts upon the control system to inhibit the system in the shortest possible time when there is no pot or it is not suitable.

**FIG.1**

## Description

The following invention, as explained in the statement of the present descriptive memorandum, consists of an induction heating system, the purpose of which is to supply the pot to be heated with high power with high efficiency and a minimized generation of electromagnetic interference, due to the soft switching of power devices.

The said system has two different power control paths, one for low powers and one for high. For high powers, the power reference level is varied, and for low powers, a fixed power rate is applied at varied intervals.

Achieving pot detection on coil in the shortest possible time is also an aim of this invention.

## BACKGROUND OF THE INVENTION

Conventionally, the known induction heating systems comprise a flat coil through which a high frequency current circulates causing the heating of the ferromagnetic pot, due to the phenomena of magnetic hysteresis and Joule effect by Foucault currents.

This type of device is connected to the network via the corresponding filter and rectifier bridge.

One example of such devices can be found in U.S. A. Patent 4757176 and in U.S.A. Patent 4686340.

The former, apart from the above mentioned elements, uses a power circuit basically determined by a transistor and its corresponding compensating network. This structure is designed for low powers and therefore has the inconvenience that the power device cannot withstand high powers of over 1400 watts

Besides, this Patent as well as some others, performs a slow pot detection, which is another inconvenience.

With respect to the second aforementioned Patent, the power device is similarly based on the use of a transistor, which presents the same inconvenience as above.

With this Patent, pot detection is performed by sensing input power, which also means the system is slow.

## DESCRIPTION OF THE INVENTION

In order to eliminate the aforementioned inconveniences, the invention is characterised by the fact that the power stage comprises two transistors, arranged in series, such that they can withstand rated powers of 2000 watts and peaks of 4000 watts.

The power control circuit counts on means for varying the power level which keeps it at a fixed level when the selected power is low and produces a power level variation at high powers.

In addition, it counts on energy variation means which apply a fixed power rate at varied intervals when the selected power is low, without causing low frequency

interference in the electric network.

Consequently, power control is performed through two different but interlinked paths, one for high powers and one for low.

The power variation means are determined by a digital/analog converter unit, which generates a reference signal in proportion to the power chosen when in high powers, and a fixed reference when in low. The digital/analog converter is connected to a power control circuit which compares the current circulating through the coil, or through the mains, with the reference signal, the activating signal of the power elements being thus generated by it.

Additionally, the power variation means count on a circuit that generates the deactivating signal of the power elements, which is connected, along with that of the activating signal, to a circuit processing both signals and applying them to the driver of the power elements, the proper power being thus obtained.

The deactivating circuit compares the current circulating through the coil with itself but out-of-phase to a certain degree, such that it controls the off time for the power elements.

Also, the energy variation means consist of a decoder that generates a signal proportional to the power selected when in low powers, and a fixed reference when in high. The decoder is connected to a switch-on/switch-off circuit which is in turn connected to the activating-deactivating circuit for the power elements as above mentioned, such that in low powers a constant power is supplied at different intervals, as established by the decoder, the energy being so varied. The fixed reference in high powers shows that power must be supplied continuously and not switched on and off at intervals.

Additionally, the switch-on/switch-off circuit and the circuit generating the activating signal are connected to a zero-point detector, in order to ensure smoother performance that prevents interference.

Similarly, the invention detects the pot on the coil using a comparison unit to detect the current flowing through one of the balance networks for the power elements and compares it with a fixed reference, such that, when no pot has been placed on the coil, or the pot is not suitable, a higher current will circulate through the balance networks. This is detected by the comparison unit, inhibiting the activation circuit and causing the system to disconnect in a minimal time.

As a supplement to the following description, and with the purpose of providing a better understanding of its characteristics, the present descriptive memorandum is accompanied by an illustrative but not limitative drawing, whose only figure shows the most significant details of the invention herein described.

## BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a functional block diagram of the

invention's induction heating system.

#### DESCRIPTION OF A PREFERRED EMBODIMENT

In view of the above figure and according to the numbers shown, we can see how the invention's induction heating system is connected to the mains via a rectifier 1, after which the corresponding filter as determined by the coil 2 and the condenser 3 is included, which constitutes the connecting means for the flat coil 4, via which the high frequency current is circulated to cause the heating of the ferromagnetic vessel 6, due to the phenomena mentioned in the above paragraph discussing similar previous inventions.

The power circuit is determined by two transistors 7 and 7', arranged in series. The execution in the example has used transistors IGBT, with their corresponding antiparallel diodes 8 and 8'. In addition, the corresponding static and dynamic compensation network 9 is included.

This arrangement of two transistors in series allows the withstanding of rated powers of 2000 W and peak powers of 4000 W. This means that the coil has to withstand very high voltages of around 900 volts.

The power is selected by the user via the user interface 25 which can be determined by electromechanical controls, capacitive sensors, etc. This module is connected to a circuit that generates the power level 23, to which a temperature feedback 24 is applied to correct the power selection made by the user, as a function of the existing temperature in the pot-coil and transistors 7 and 7', with NTC being included in each of these elements.

With these temperature sensors, apart from emitting warning signals of hot cooking areas and activating of the ventilation system of the power stage, the power supplied can be adjusted to prevent overheating in abnormal situations like leaving empty pots, ventilation blocks, etc. The feedback signal 24 for this adjustment is the measured temperature and its derivative or gradient.

Once the final value of the power the system will supply is determined by the power level generation system, the system supplies a signal proportional to the said value to the decodifier 21 and the digital/analog converter 22.

The digital/analog converter 22 is connected to the power control circuit 14, which in turn is connected via the current sensor 13 to the flat coil 4 or via the current sensor 12 to the network. The latter connection, being optional, has been represented by a dash line.

This way, the digital/analog converter 22 generates a reference signal for the power control circuit 14, which compares it with the network current or coil 4 current, in order to adjust power so that, if the signal in coil IBOB or the signal in mains IRED exceed the reference signal provided by the digital/analog converter 22, it means that the time the power elements 7 and 7' are switched

on must be reduced, and that if the said current signals do not reach the reference, the said time must be increased.

In order to achieve this increase or decrease in the on time, the power control circuit 14 is connected to a circuit that generates the activating signal 15 in which an algorithm is included. The said algorithm determines when increase, decrease or maintenance of the time the power elements 7 and 7' are switched on is necessary.

The time the power elements 7 and 7' are switched off is controlled by means of circuit 16, which receives the current from the coil and compares it with itself, but slightly delayed via an RC circuit, so that circuit 16 detects when it is necessary to re-trigger the said power elements 7 and 7'; that is to say, it controls the time the latter are switched off.

The signals from circuit 15 and 16 are processed in circuit 11, avoiding malfunctions and emitting a switch-on/switch-off signal which is amplified by the driver circuit 10, via which the connection to the power elements 7 and 7' is made.

The digital/analog converter 22 supplies a fixed reference at low powers and a varied reference at high powers, so that at high powers it adjusts the power to be supplied, and at low powers, the circuit 11 supplies a fixed power rate, which is adjusted by a second control path determined by decoder 21, which is connected to a switch-on/switch-off circuit 19, which is connected to circuit 11, the switching off and on of which is controlled from circuit 19.

At this point, it is vital to state that the decoder 21 supplies a fixed signal at high powers, with which the switch-on/switch-off circuit 19 keeps circuit 11 continuously activated, regulating the power at high powers selected in accordance with the procedure above mentioned, using the digital/analog converter 22. However, at low powers, the decoder 21 generates a variable signal proportional to the power selected by the user, so that the switch-on/switch-off circuit 19 selects the times for activation and deactivation of circuit 11, with which a variation of energy is performed, because a constant power determined by the fixed reference of the digital/analog converter 22 is supplied at the intervals established by the decoder 21.

Additionally, the switch-on/switch-off circuit 19 is connected to a zero-cross detector 20, which is similarly connected to the circuit that generates the activation signal 15 of the power elements 7 and 7'. This way, it is assured that switching on always takes place when voltage is zero, and that the change in duration of the switching on of circuit 18 takes place every time the mains voltage is zero. This avoids interference caused by the system and makes it work more "smoothly".

On the other hand, the switch-on/switch-off circuit 19 is connected to a comparison unit 18, to which a reference signal REF as well as a signal proportional to the current circulating through diode 8' as measured by the current sensor 17 are supplied, so that when there is no

pot 6 on the coil 4 or the pot is not suitable, the system vessel-coil behaves as an almost ideal coil and loses the resistivity characteristic provided by pot 6. This produces in the power elements 7 and 7' the effect that much more current than normal circulates through diode 8'.

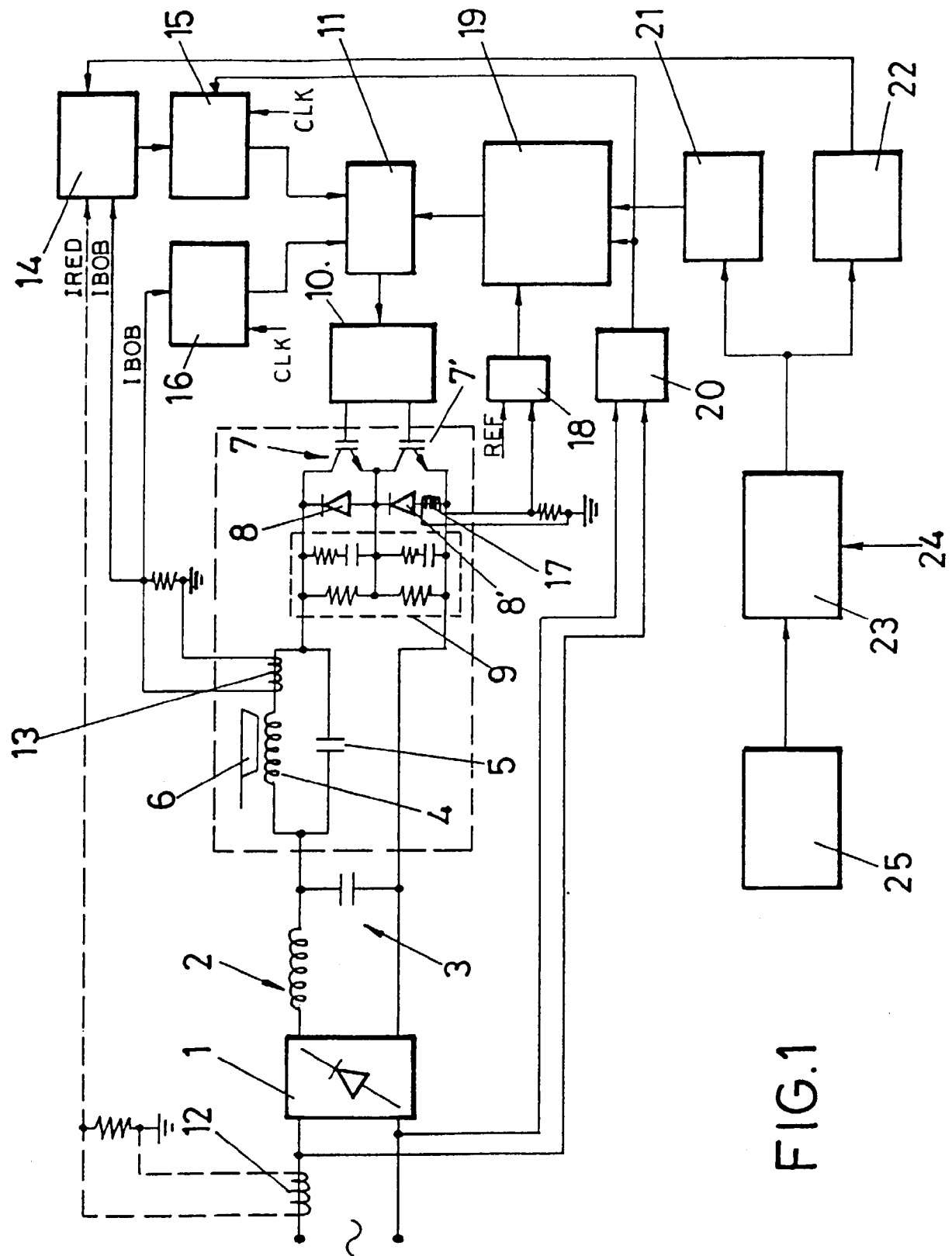
Therefore, by sensing the current circulating through the said diode, the presence or not of a vessel, or the placing of an unsuitable vessel, is detected, because if the current is higher than the fixed reference, it means that there is no pot or that the one placed is not suitable. This detection takes less than 50 nanoseconds.

The CLK signals applied to circuits 15 and 16 determine by how much an increase the switch-on signal and all signals are synchronised with the clock.

With the power controls above mentioned, the invention complies with the European regulations of low frequency interference in the electric network.

### Claims

1. INDUCTION HEATING SYSTEM, which counts on a flat coil (4) through which a low frequency current is circulated to cause the heating of the vessel (6). For this purpose, the coil (4) is connected to the mains via the corresponding rectifier bridge (1) with filter (2, 3) and to a power device which is governed by a control circuit, so that when the positioning on the vessel (6) on the coil (4) is detected, the power selected by the user is applied to the coil. It is mainly characterised by the fact that the power device is composed by two elements arranged in series (7) and (7'), with their corresponding balancing networks in order to withstand very high powers.
2. INDUCTION HEATING SYSTEM, in accordance with the 1st claim, characterised by the fact that the means of power variation are determined by a digital/analog converter (22) generating a reference signal proportional to the chosen power at high powers, and a fixed reference at low powers, the digital/analog converter (22) being connected to a power control circuit (14) which compares the current circulating through the coil IBOB or network IRED with the reference signal, and being connected to a circuit that generates the activation signal (15) of the power elements (7) and (7'), which in turn is linked to a switch-on/switch-off circuit (11) for the said power elements (7) and (7'), that is connected to the driver circuit (10) of the same, the proper power being thus obtained.
3. INDUCTION HEATING SYSTEM, in accordance with the 2nd claim, characterised by the fact that the deactivation signal for the power elements is supplied by a circuit (16) which is connected to the switch-on/switch-off circuit (11) and compares the current IBOB with itself, but out-of-phase to a certain degree, thus controlling the time the power elements (7) and (7') are switched off.
4. INDUCTION HEATING SYSTEM, in accordance with the 1st claim, characterised by the fact that the means of energy variation are determined by a decoder (21) which generates a signal proportional to the power selected at low powers, and a fixed reference at high powers, the said codifier (21) being connected to a switch-on/switch-off circuit (19) which is in turn connected to the activation-deactivation circuit (11) of the power elements (7) and (7').
5. INDUCTION HEATING SYSTEM, in accordance with the 2nd and 4th claims, characterised by the fact that the switch-on/switch-off circuit 19 and the circuit that generates the activation signal (14) are connected to a zero-point detector (20) in order to ensure that starting always takes place in zero-point areas.
6. INDUCTION HEATING SYSTEM, in accordance with the 1st claim, characterised by the fact that the detection of vessels (6) is performed from a comparison unit (18) which senses the current which circulates through one of the balancing networks of the power elements (7) and (7'), and compares it with a fixed reference (REF), so that when there is no vessel on the coil (4) or it is an unsuitable vessel, a higher current will circulate through the balancing networks and when the reference is exceeded, the comparison unit acts upon the switch-on/switch-off circuit (19), deactivating the system.





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# EUROPEAN SEARCH REPORT

Application Number

DOCUMENTS CONSIDERED TO BE RELEVANT			EP 95500161.5
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 6)
A	FR - A - 2 448 833 (OREGA) * Page 5, line 32 - page 8, line 8; fig. 1,2 * --	1	H 05 B 6/06 H 05 B 6/12
D,A	US - A - 4 686 340 (FUKASAWA) * Column 2, line 58 - column 3, line 47; claims 1,7; fig. 2 * --	1-3	
D,A	US - A - 4 757 176 (SUZUKI) * Column 2, lines 12-64; claim 1; fig. 1 * -----	1	
The present search report has been drawn up for all claims			
Place of search VIENNA		Date of completion of the search 04-03-1996	Examiner TSILIDIS
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>			

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