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Harnden, Jr.

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[54] **INDUCTION COOKING APPLIANCE INCLUDING COOKING VESSEL HAVING MEANS FOR WIRELESS TRANSMISSION OF TEMPERATURE DATA**

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[51] **Int. Cl.** **H05b 5/04**

[58] **Field of Search**....................... 219/10.49, 10.75, 219/10.77, 450, 501; 340/210; 220/9 R; 73/362, 343 R; 307/117

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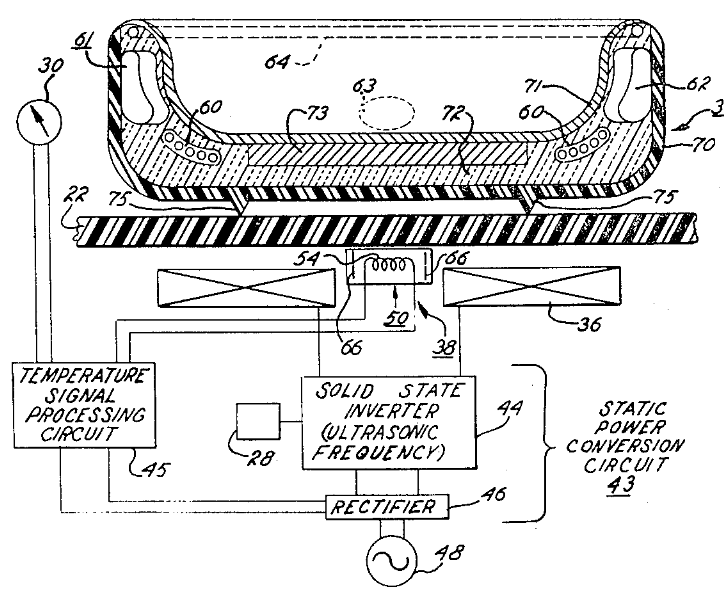
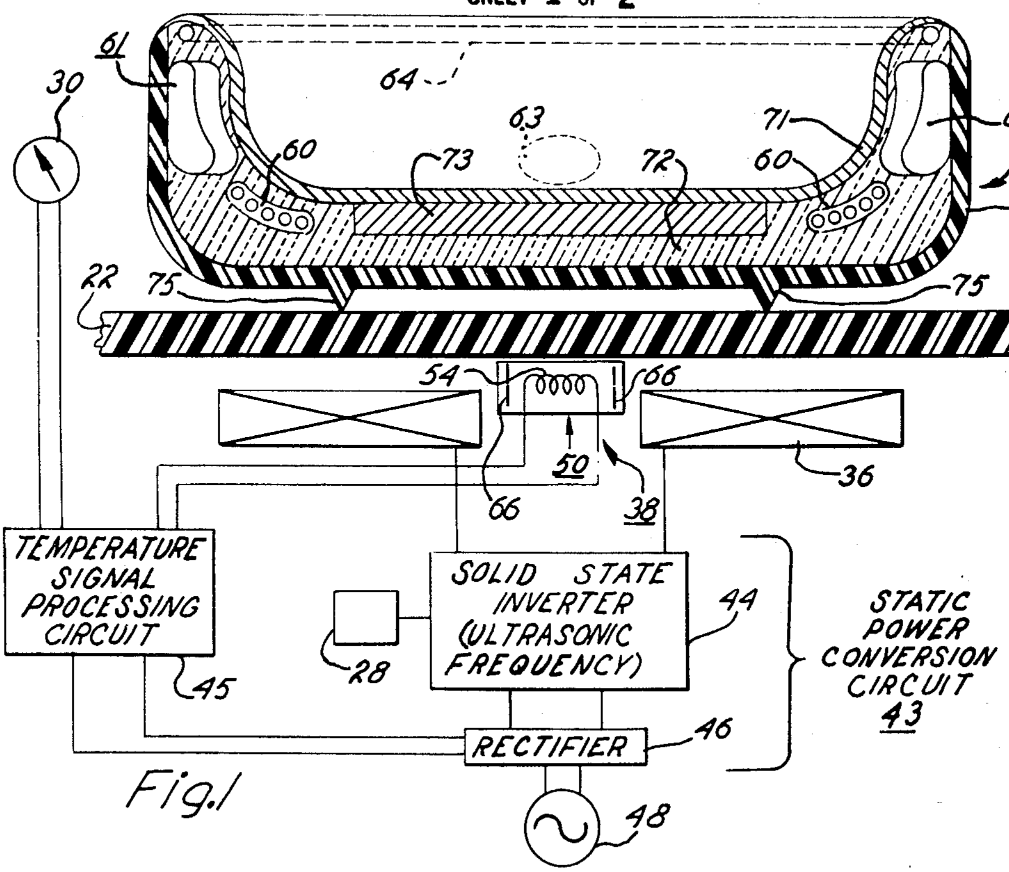
[57] **ABSTRACT**

Herein disclosed is an induction cooking range having a counter which supports a food-containing vessel. The vessel is heated by the range's induction coil which operates at high frequency. The invention includes a temperature sensing unit comprising a temperature detection unit and a temperature receiving unit. The former unit is incorporated in the cooking vessel while the latter unit is remotely located therefrom in the induction range. The aforesaid temperature receiving unit receives radio frequency transmissions of temperature data from the temperature detection unit in the vessel. The temperature detection unit in the vessel is powered by the main field produced by the induction coil.

4 Claims, 4 Drawing Figures

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71
62
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73
72
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34
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22
75
75
54
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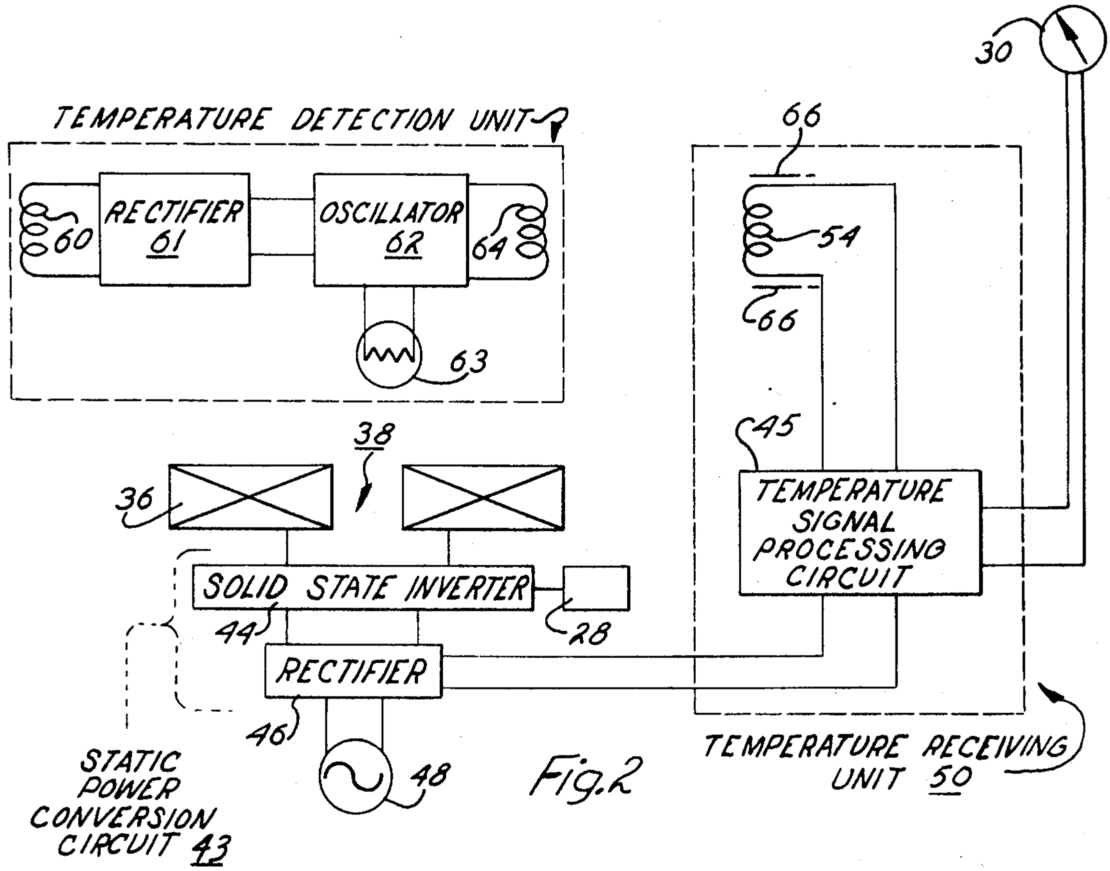
38
36
TEMPERATURE SIGNAL PROCESSING CIRCUIT
45
SOLID STATE INVERTER (ULTRASONIC FREQUENCY)
28
44
STATIC POWER CONVERSION CIRCUIT 43
RECTIFIER
46
48

Fig.1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RECTIFIER 61
OSCILLATOR 62
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54
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45
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TEMPERATURE SIGNAL PROCESSING CIRCUIT
SOLID STATE INVERTER
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44
RECTIFIER
46
48
STATIC POWER CONVERSION CIRCUIT 43
TEMPERATURE RECEIVING UNIT 50

Fig.2

Fig.3

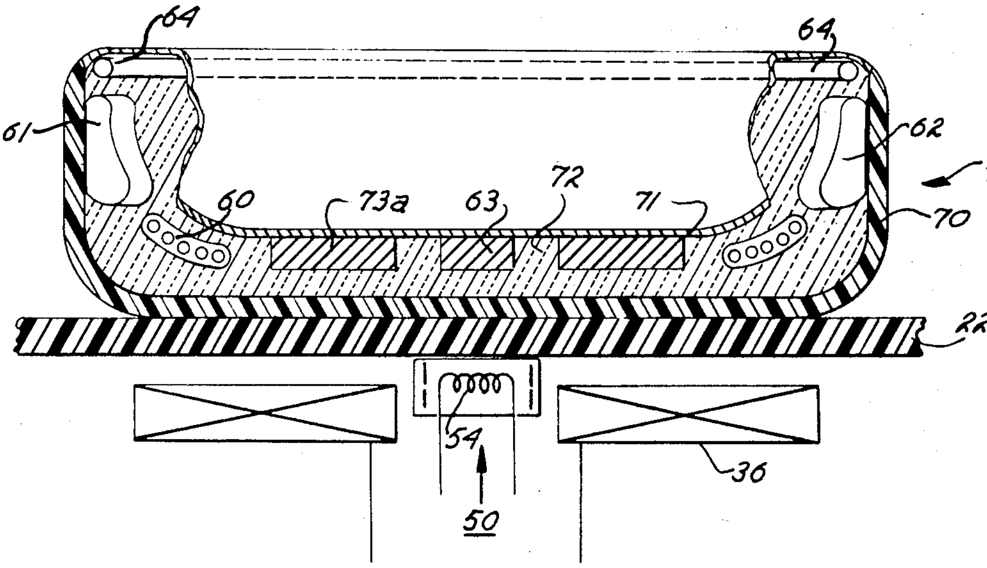
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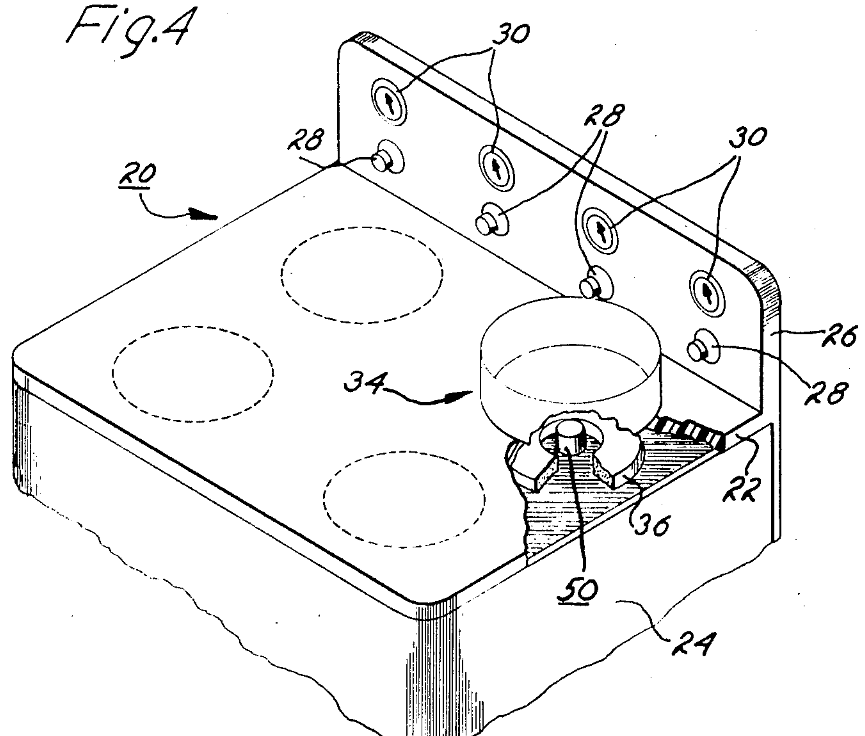
Fig.4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INDUCTION COOKING APPLIANCE INCLUDING COOKING VESSEL HAVING MEANS FOR WIRELESS TRANSMISSION OF TEMPERATURE DATA

CROSS-REFERENCES TO RELATED APPLICATIONS

A fuller appreciation of induction cooking appliances, generally, as well as some of the sophistications which may be embodied therein is to be had by referring to the following U.S. Patent applications: Ser. No. 200,526, filed Nov. 19, 1971, in behalf of David L. Bowers et al., titled SOLID STATE INDUCTION COOKING APPLIANCE; Ser. No. 200,424, filed Nov. 19, 1971, in behalf of J.D. Harnden, Jr. et al., titled SOLID STATE INDUCTION COOKING APPLIANCES AND CIRCUITS. The entire right, title and interest in and to the inventions described in the aforesaid patent applications, as well as in and to the aforesaid applications, and the entire right, title and interest in and to the invention hereinafter described, as well as in and to the patent application of which this specification is a part, are assigned to the same assignee.

BACKGROUND OF THE INVENTION

This invention pertains to induction cooking, or warming, appliances, generally; and, in particular to an induction cooking, or warming, appliance including an induction coil for heating a food-containing vessel and for energizing a temperature detection unit incorporated in the vessel whereby said temperature detection unit initiates wireless transmission of temperature data from the vessel to a receiving unit which may be remotely located on the appliance.

Prior art electric ranges (i.e., those employing resistance heater surface elements) and gas ranges present a number of problems with respect to temperature sensing. With such prior art ranges the approach most often employed is to directly sense the temperature of the vessel. For this purpose a contact-type temperature sensor unit is usually employed; i.e., the temperature sensor unit is placed so that it is in direct contact with the cooking vessel being heated. The vessels involved are usually fabricated from cast iron, stainless steel, copper, or copper-clad stainless steel, etc. These vessels are considered conventional and are abundantly available. Temperature sensing as done in the prior art has not proved entirely satisfactory for, among others, the following reasons:

First, with prior art electric and gas ranges the primary heating source (e.g., the surface mounted electrical resistance coils or the gas fed flames) spuriously heats the temperature sensing unit and, moreover, other heated parts of the range thermally perturb the temperature sensing unit as well.

Second, in prior art electric and gas ranges because of the relatively high temperatures involved, principally because of the nature of the primary heating source and its proximity to the vessel-contacting temperature sensor, the materials from which the temperature sensing units and their associated components may be fabricated are rather restricted.

Third, in prior art electric and gas ranges, principally because of the high temperatures occasioned by the nature of the primary heating source and its proximity to the contract-type temperature sensing unit extensive thermal shielding, or insulation, is required.

Fourth, in prior art electric and gas ranges because of the severe thermal stresses created in the vessel-contacting temperature sensing unit, as a consequence of the high tenperatures occasioned by the nature of the primary heating source and its proximity to the temperature sensing unit, relatively massive and sophisticated as well as somewhat mechanically complex spring arrangements and structures were required for the purpose of maintaining adequate contact between the temperature sensing unit and the cooking vessel.

The four problems, hereinbefore mentioned, are discussed in greater detail hereinafter.

In prior art electric and gas ranges the temperature sensing means and its associated components are directly heated, spuriously, in some measure by a high temperature primary heating source. For example, in the conventional electric range a temperature sensing unit is located at the center of a spirally wound resistance heating coil. This heating coil and the temperature sensing unit are both mounted on the top or the working surface of the range counter. A cooking vessel rests on and contacts the heating coil as well as the temperature sensing unit. Although the temperature sensing unit directly contacts the heated cooking vessel, it is also subjected to direct spurious heating by the range's heating coil; e.g., by radiation and convection. In addition, the temperature of the temperature sensing unit is influenced by, among other things, the metallic counter of the electric range. Similarly in a gas range, the flames directly heat the temperature sensing unit. Moreover, heated metallic gridirons as well as the heated metallic counter top thermally influence the temperature sensing unit.

Also, in prior art electric and gas ranges, because of the nature of the primary heating source and its proximity to the temperature sensing unit, various component parts of the temperature sensing unit have to be fabricated with materials which are capable of withstanding relatively high temperatures; e.g., approximately 1,400°F–1,600°F. For example, in the conventional prior art electric range wherein the temperature sensing unit is located at the center of the spiral resistance heating coil which is, in turn, mounted on the metallic counter top of the range, the temperature sensing unit and its associated components are subjected to the elevated temperatures hereinbefore set forth. Significant thermal stresses are, as a result, induced in the temperature sensing unit as well as in its associated components. Similar conditions occur in gas ranges.

In prior art electric and gas ranges, principally because of the nature of the primary heating source and its proximity to the temperature sensing unit contacting the cooking vessel, the temperature sensing unit as well as its associated components are required to have extensive thermal shielding, or insulation, for the purpose of minimizing the influences of spurious heating by the high temperature heating source as well as by the metallic range counter and metallic gridirons. Without some effective thermal shielding or insulation, the temperature sensing unit will provide a false indication of temperature unless temperature compensation is appropriately applied. However, such compensation is not feasible because of the wide range of cooking conditions. For example, it is very difficult to achieve a system in which both steady-state and transient, or dynamic, compensation is easily achieved. In any event, cooking performance is compromised. Moreover, without effective thermal shielding severe thermal stresses induced in the various component parts of the temperature sensing unit will cause a disabling, or sometimes destruction of the temperature sensing unit.

The prior art temperature sensing units, especially those which are employed with the prior art electric ranges for the purpose of contacting the cooking vessel, are generally massive and are of a rather sophisticated and somewhat mechanically complex structure and arrangement. The high temperature environment within which the temperature sensing unit is located permits severe thermal stresses to be induced in the various components of the temperature sensing unit. These stresses tend to promote warping of the various components. For example, because of the aforesaid thermal stresses, a relatively massive double-spring arrangement is usually employed in combination with a temperature responsive device. The temperature responsive device, acting against spring restraint, contacts the bottom surface of the cooking vessel. The vessel rests on a flat spiral heating coil disposed on the top surface of the range counter. The massive double-spring arrangement is rather stiff and this is due in large part to the need to make the arrangement structurally resistant to thermal deformation. Such a spring arrangement generally functions satisfactorily to enable the temperature sensing unit to contact a relatively smooth flat-bottom surface of a relatively heavy cooking vessel such as a cast iron pot containing foodstuff to be cooked. Being in contact with the surface of the vessel, it is conceptually possible for the temperature sensing unit to detect the temperature of the vessel. However, in the event that a relatively light weight pot is used or if a pot having a rather irregularly contoured bottom surface is used, such prior art contact type temperature sensing units employing the aforesaid stiff spring arrangement proved unsatisfactory. For example, if a cooking vessel is used which is not sufficiently heavy, there will be an insufficient weight to adequately compress the spring arrangement. One consequence will be that the vessel will not rest on the resistance heating coil in the most intimate contact possible therewith. The cooking vessel will, as a result, be raised or tilted and thereby allow inefficient heat transfer between the resistance heating coil and the vessel. In addition, a prior art contact-type sensor unit could not, obviously, be applied to a double-walled cooking vessel where no relationship exists between inner and outer wall temperatures; i.e., no relationship between the cook surface temperature and the outer wall temperature. Secondly, physical space or clearance resulting with vessels having feet which rest on counter tops in prior art ranges would require sensors having springs to make conventional temperature sensing heads travel rather large distances.

SUMMARY OF THE INVENTION

Although the invention is hereinafter described, and illustrated in the accompanying drawings, as being employed in combination with an induction range it is, nevertheless, to be understood that the invention's applicability is not limited to induction cooking ranges but may be embodied in, for example, portable counter top warming or cooking appliances, such as warming trivets, as well as in other types of induction heating apparatus which need not, necessarily, be used for cooking or warming food.

One object of the invention is the provision of an induction cooking/warming appliance including a cooking/warming vessel, said appliance including a temperature sensing unit for sensing or detecting the temperature of cooking/warming vessel or utensil being heated.

Another object of the invention is the provision of an induction cooking/warming appliance including the aforesaid temperature sensing unit wherein said sensing unit is free from spurious heating.

Another object of the invention is the provision of an induction cooking/warming appliance including the aforesaid temperature sensing unit, the materials of fabrication of said temperature sensing unit not being restricted by the elevated temperatures heretofore encountered in prior art electric and gas ranges.

Another object of the invention is the provision of an induction cooking/warming appliance including the aforesaid sensing unit, said temperature sensing unit not requiring the thermal insulation or shielding in the ways or to the extent heretofore employed in prior art electric and gas ranges.

Another object of the invention is the provision of an induction cooking/warming appliance including the aforesaid temperature sensing unit, said temperature sensing unit being capable of accurately sensing the temperature of the vessel regardless of the weight of the vessel and/or the weight of the food therein and/or regardless of whether the vessel has or has not an irregular outer surface or contour; said temperature sensing unit not requiring the prior art spring construction or arrangement.

Another object of the invention is the provision of an induction cooking/warming appliance including a temperature sensing unit which can accurately detect the temperature of the vessel regardless of the fact that the vessel may have an outer wall which is thermally non-conductive.

Another object of the invention is the provision of an induction cooking/warming appliance including the aforesaid temperature sensing unit for sensing the temperature of a vessel being heated; said vessel being supported by a vessel supporting means having an uninterrupted working surface.

Another object of the invention is the provision of an induction cooking/warming appliance including wireless means for transmitting temperature data from the vessel to a location which is relatively remote from the vessel.

Another object of the invention is the provision of an induction cooking/warming appliance including wireless means for transmitting temperature data from a vessel being heated to a location remote therefrom; said wireless means being powered by a portion of the main induction field which is employed for heating the vessel.

Another object of the invention is the provision of a novel cooking/warming vessel which is adapted for being inductively heated as well as for initiating the wireless transmission of temperature data from the vessel to a relatively remote location.

The invention, hereinafter described and illustrated in the accompanying drawings, enables the achievement of the aforementioned objectives, as well as others, in that there is provided an induction cooking or warming appliance and a vessel adapted for being inductively heated. The vessel includes a portion in which heating current may be induced for the purpose of heating said portion as well as food contained within said vessel. The cooking appliance is comprised of a vessel supporting means in which no substantial heating current is induced when the supporting means is subjected to a changing magnetic field. The vessel supporting means includes a surface which is adapted for supporting the vessel. Advantageously, the aforementioned surface of the vessel supporting means may be an uninterrupted surface which may also serve as a working surface for the preparation of food, among other things. The cooking appliance is provided with an induction coil which is energizable from a suitable power source so as to provide a changing magnetic field of at least ultrasonic frequency. The changing magnetic field causes heating current to be induced in the aforementioned inductively heatable portion of the cooking vessel. As a result, food contained within the vessel may be heated. Also provided is a temperature sensing unit which is comprised of a temperature detecting unit and a temperature receiving unit. Briefly, the temperature detecting unit is incorporated in the vessel and said unit derives power from the aforementioned changing magnetic field produced by the remote induction coil. With the power thus derived, the temperature detecting unit is enabled to transmit temperature data acquired by a temperature sensor unit located in the vessel to a temperature receiving unit which may be remotely located elsewhere on the cooking appliance. The temperature receiving unit includes a receiving coil which is coupled with a temperature signal processing circuit. Temperature data received by the receiving coil is processed in the temperature signal processing circuit and a signal is developed which is representative of the temperature of interest.

One feature of the invention resides in the transmission of temperature data from a temperature detection unit to a remotely located temperature receiving unit. Such transmission is made at sufficiently high frequency so that the energy contained in the harmonic distortion of the main field produced by the induction coil is far less than the transmitted frequency which contains the temperature data.

Another feature of the invention resides in the provision of a novel cooking/warming vessel in which there is incorporated various electrical and electronic components; i.e., those components of which the temperature detection unit is comprised.

Other objects and features, as well as a fuller understanding of the invention, will appear by referring to the following detailed description, claims and drawings.

DESCRIPTION OF THE DRAWING FIGURES

FIG. 1 is an enlarged cross section view of a cooking vessel supported on the counter of an induction cooking range, the vessel having incorporated therein a temperature detection unit which is part of the present invention.

FIG. 2 is a block diagram showing the electrical system for heating the vessel and for transmitting temperature data from the vessel by wireless means.

FIG. 3 is a cross section view similar to that shown in FIG. 1; the vessel and its various component parts exemplifying a modification of the vessel shown at FIG. 1.

FIG. 4 is a perspective view of an induction cooking range showing the top or working surface of the range on which there is supported a cooking vessel like that shown in either FIGS. 1 or 3.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring first to FIG. 4, there is illustrated an induction cooking range designated generally by the reference number **20**. The range **20** is provided with a counter **22** which is suitably supported by a range substructure **24**. Located at the rear of counter **22** and fastened to substructure **24** is an instrument and control panel **26**. On panel **26** there is mounted a number of controls **28** and a like number of temperature indicators, which may be dial-type thermometers **30**. On the top or working surface of counter **22** there is illustrated four dotted line circles. These circles suggest locations where four cooking vessels such as pots, pans, etc. may be located during the cooking process. As shown, a cooking vessel **34** is rested on the working or top surface of counter **22**, covering one of the dotted line circles. Below each of the dotted line circles under counter **22** is an induction coil **36**. Induction coil **36** is separated from the bottom surface of counter **22** by air gap; induction coil **36** being a relatively flat spirally-wound coil. The induction coil **36** has formed at the center thereof a central aperture designated generally by the reference number **38**. The induction coil **36** is electrically connected as shown in FIGS. **1** and **2** to the output of a solid state inverter **44** which, in turn, has an input which is electrically connected to the output of the rectifier **46**. The inverter **44** is a solid state inverter and as combined with rectifier **46** forms a static power conversion circuit designated generally by the reference number **43**. The rectifier **46** includes an input which is electrically connected to a conventional A.C. source **48** which may be a 60 Hz, single phase, 110 or 220 volt source. More specific details of the static power conversion circuit **43** including rectifier **46** and inverter **44** may be had by referring to the patent applications hereinbefore noted. Also shown in FIGS. **1** and **2** is one of the controls **28** which may, for example, be a switch which is electrically coupled with inverter **44** for the purpose of controlling the flow of power therefrom to the induction coil **36**. The control **28** is marked in degree F settings to enable a housewife to "call for" a particular temperature or temperature range performance. However, a temperature indicator **30** associated with a particular control **28** provides a visible indication of the actual temperature of vessel **34**. The temperature indicator **30** provides, in addition, an indication of the rate of temperature rise and fall. These rates of temperature change are considered to be an important aspect of the cooking process.

While a dial-type thermometer **30** is illustrated and disclosed herein, it is to be understood that a digital display of temperature or temperature range or rate may be employed.

The rectifier **46** may be a regulated full-wave bridge rectifier employing solid state devices and operating to convert A.C. input power to D.C. output power. Also, inverter **44** employs SCR's which, in the performance of their control switching function, enable the inverter **44** to deliver relatively high frequency power (ultrasonic or above) to drive, or power, the induction coil **36**.

As discussed in more detail hereinafter, the vessel **34** has incorporated therein a temperature detection unit which radiates a high frequency signal representative of the sensed temperature of the cooking vessel. This radiated signal is received by a temperature receiving unit designated generally by the reference number **50.** The temperature receiving unit being located, as shown in FIGS. **1** and **3,** below the range counter **22.** From the temperature receiving unit **50** the aforementioned radiated electromagnetic signal is converted to an electrical signal and delivered to an input of a temperature signal processing circuit **45** (FIGS. **1** and **2.**). The temperature signal processing circuit **45** then develops an output signal representative of the temperature of cooking vessel **34** and this output signal is ultimately delivered to the electrical temperature indicator **30.**

As indicated at FIGS. **1** and **2** the temperature signal processing circuit **45** includes: a first input coupled to the rectifier **46** for deriving therefrom a D.C. voltage; a second input in the form of a pair of electrical conductors which extend from a receiving coil **54** of temperature receiving unit **50,** and, an output comprising a pair of conductors directly connected to the thermometer **30.**

In the cross section view of FIG. **1** one embodiment of cooking vessel **34** is illustrated. As shown, vessel **34** is comprised of an outer cup, or cup-like, member **70.** Nested within the outer cup **70** is an inner cup **71.** At the top rim of vessel **34** where the inner and outer cups **71** and **70** contact each other they are bonded and sealed so as to provide a hermetically sealed double wall vessel **34.** The space between the inner wall surfaces of the cups **70** and **71** may, as shown, be filled with thermal insulation material **72.** In the alternative, the space between the inner wall surfaces of the cups **70** and **71** may be air filled or they may be evacuated. The inner cup **71** may be formed from a relatively thin sheet of magnetic stainless steel. Generally, the inner cup **71** is preferably formed from a material which: is magnetically permeable, is electrically conductive; has a relatively high electrical resistivity; and, is thermally conductive. Materials other than stainless steel may be used. The outer cup **70** may, as indicated, be formed from plastic materials, epoxies, or polyimides. Since no substantial heating current is induced in either counter **22** or in the outer cup **70** of vessel **34** the material from which the outer cup **70** is formed is not subjected to elevated temperatures. For example, in the embodiment of the vessel **34** shown in FIG. **1** the outer cup **70** will be subjected to temperatures significantly below 550°F. As an alternative material, the outer cup **70** may be formed from any of a number of ceramic materials.

As shown in FIG. **1** there is bonded to the bottom surface of the inner cup **71** a copper disk or plate **73.** Circulating heating currents are induced in the copper disk or plate **73** as well as in the stainless steel inner cup **71**; the rapidly changing magnetic field, produced by induction coil **36** being coupled beyond an air gap and counter **22** so as to ultimately intercept the disk **73** and cup **71** to induce heating currents in these latter members. Advantageously, the copper disk, or plate, **73** provides a relatively large thermal mass which is effective for the retension of a significant amount of heat in the vessel **34** over a relatively long period of time. Because induction heating is employed the cup **71** and the disk **73** thereof are not heated to a temperature higher than about 550°F. In specifying 550°F herein some margin for safety is included. Moreover, since no substantial amount of heating current is induced in counter **22,** it may be fabricated from materials which are not usable in conventional prior art electric or gas ranges. For example, counter **22** may be fabricated from epoxies, plastics, polyimides, or glass treated to withstand temperatures of about 550°F, etc. If required for purposes of electrostatic shielding and/or structural enhancement and/or decoration, the counter **22** may include some metallic content. However, the inclusion of metallic material in counter **22** is necessarily limited to a small amount or so distributed so as to prevent formation of ohmic electrical circuits, in order to permit substantial quantities of the power developed by induction coil **36** to be coupled with the disk **73** and inner cup **71** of cooking vessel **34,** for the purpose of heating them.

Referring now to FIGS. **1** and **2,** a temperature sensing unit in accordance with the present invention is comprised of a temperature detection unit, which is incorporated in the vessel **34,** and a temperature receiving unit **50.** While the induction coil **36** produces electromagnetic radiations in the ultrasonic or higher ranges for the purpose of inducing heating currents in disk **73** and inner cup **71** of vessel **34,** it also provides the energy for driving or powering the temperature detection unit incorporated in the vessel **34.** This is described in more detail hereinafter.

The various components of the temperature detection unit which are incorporated in vessel **34** are diagrammatically shown as being contained within the dotted line box which is appropriately labeled in FIG. **2.** Similarly, the various components of the temperature receiving unit **50** are located within a separate dotted line box which is also appropriately labeled in FIG. **2.**

Operationally, electromagnetic energy produced by induction coil **36** is coupled through an air gap and beyond counter **22** into the receptor disk **73** and inner cup **71** of vessel **34.** The major portion of this coupled energy is used for inducing heating currents in the members **73** and **71** as described hereinbefore. However, as suggested in FIG. **2,** a small portion of this radiant energy is coupled to a pick-up coil **60.** As shown in FIG. **1** the pick-up coil **60** is concentrically disposed around the copper disk **73** in vessel **34.** The voltage developed across the pick-up coil **60** is delivered to the input of a rectifier **61.** As shown in FIG. **1** rectifier unit **61** is packaged in a small space and located in vessel **34** between the cups **70** and **71** at a location which is relatively remote from the copper disk or plate **73.** Advantageously, the rectifier **61** being so located is not subjected to elevated temperatures. The rectifier **61** develops a regulated D.C. output which is delivered to an input of a voltage control oscillator **62** (hereinafter referred to as VCO **62**). The VCO **62** includes an additional input from a temperature sensor unit **63** which may be a thermistor unit. As suggested in FIG. **1** the thermistor unit **63** is also situated in the space between the nested cups **70** and **71** and is in direct contact with the inner stainless steel cup **71.** Thermistor unit **63** is in contact with that wall surface of the cup **71** which is disposed opposite the inner wall surface of the cup **70**; the thermistor **63** being located within the double wall structure of the vessel **34.** A transmit coil **64** is coupled to the output of VCO **62.** As shown in FIG. **1,** the transmit coil **64** is located in the space between the nested cup **70** and **71** above the rectifier package **61** and the oscillator package **62** toward the upper rim of vessel **34.** VCO **62** is also located directly below the transmit coil **64** in the space between the nested cups **70** and **71.**

The output frequency of the VCO **62** is very much greater than the frequency output of induction coil **36**. For example, VCO **62** in the embodiment shown develops an output signal voltage at a frequency of at least a megahertz or multiple thereof. The coil **36**, on the other hand, operates at about 18 kilohertz. In brief, the temperature sensor, or thermistor, unit **63** which is in contact with the metallic inner cup **71** changes its resistance, or impedance, in response to the temperature of the cup **71**. The change in the resistance or impedance of thermistor unit **63** changes the operating voltage of VCO **62** and thereby causes the VCO **62** to alter its frequency of oscillation in response to the voltage change introduced thereto by thermistor unit **63**. Thus, there is developed across the transmit coil **64** a signal voltage of a frequency which varies as a function of the resistance or impedance of thermistor unit **63**. The thermistor unit **63** varies its impedance or resistance as a function of the temperature of the member **71**. The high frequency developed across transmit coil **64** is coupled with the receiving coil **54** which is a part of the temperature receiving unit **50**. As indicated, receiving coil **54** may conveniently be secured to a lower surface of the counter **22** as suggested in FIG. **1** so as to be able to receive radiated electromagnetic energy from the transmit coil **64** in vessel **34**. The receiving coil **54** is preferably embedded, or potted, within a suitable matrix of polyimide material. Also embedded in the same matrix with the coil **54** is shielding means **66** which advantageously may be ferrite which serves the purpose of shielding the coil **54** from the field radiated by induction coil **36**. The ferrite shielding means **66** are, as suggested in FIG. **1**, located within the matrix on opposite sides of coil **54**; i.e., between the coil **54** and the induction coils **36**. However, the coil **54** remains relatively unshielded at other locations which allow the transmit coil radiations to be received by coil **54**, unimpeded by the shielding means **66**. The shielding means **66** are also diagrammatically illustrated in FIG. **2**.

Electromagnetic energy coupled to the receiving coil **54** from transmit coil **64** develops a voltage across the coil **54** which is delivered to an input of the temperature signal processing circuit **45**. The signal processing circuit **45**, which derives its power from rectifier **46** as indicated in FIG. **2**, develops an output signal representative of the temperature of the vessel **34** as detected by thermistor unit **63**. This output signal is delivered directly to a temperature indicator **30**. Thus, for a particular temperature developed in vessel **34**, thermistor unit **63** has a particular resistance or impedance corresponding to this temperature. The resistance of thermistor unit **63** causes a voltage change within VCO **62**. The output frequency of VCO **62** is a function of the voltage change occasioned by the resistance change of thermistor unit **63**. The output frequency developed by VCO **62** is impressed across transmit coil **64** which, in turn, electromagnetically drives the receiving coil **54**. The coil **54** has a signal of a particular frequency and voltage developed thereat and this signal is fed to the temperature signal processing circuit **45** which, in turn, develops an output signal corresponding to the temperature of vessel **34**. This output signal may be converted and the temperature displayed by indicator **30**.

As an alternative mode of operation, VCA **62** may operate in a pulsed mode so as to cause transmit coil **64** to be energized in a clocked type fashion with the result that interference from the main field produced by induction coil **36** is avoided.

In FIG. **1** for purposes of clarity, the cross sectional dimension of the outer cup **70** is shown as being larger than that of the inner cup **71**. However, it is to be understood that the cross section of the outer cup **70** may be smaller than shown in FIG. **1**. The cross section dimension may, for example, be the same size as the cross section dimension of the inner cup **71**, or it may be smaller. Also in FIG. **1** the vessel **34** is shown as having feet such as feet **75** molded in the outer cup **70**. It may be that an alternative form of vessel construction is desirable such as that shown in FIG. **3** where a modified vessel **34A** is shown. The modified vessel **34A** does not include feet.

The rectifier **61** and VCO **62** as shown in FIG. **1** may be fabricated and packaged as separate or combined integrated circuits. In one form these separate integrated circuits may have the general forms or configurations illustrated in FIG. **1**. Suffice it to say that: rectifier **61** and VCO **62** are preferably in the form of integrated circuits which have been miniaturized and packaged accordingly. Not shown in FIG. **1** or in FIG. **3** are the various electrical connections for the pick-up coil **60**, rectifier **61**, oscillator **62** and transmit coil **64**. The conductors interconnecting these various elements may be embedded in the insulation **72**.

In FIG. **3** there is shown a modified form of cooking vessel **34A**. As indicated the vessel **34A** is of a double wall construction which includes inner and outer nested cups **71** and **70**, respectively. These cups are formed from the same materials as hereinbefore indicated. The space between these nested cups may be filled with insulation **72**, as shown, or the space may be filled with air or evacuated. The outer cup **70** does not have feet (such as the feet **75** employed in the embodiment of the vessel **34** shown in FIG. **1**). In vessel **34A** there is bonded to the bottom surface of the inner cup **71** an annular copper disk or plate **73A**. The disk **73A** performs the same function as the disk **73** in vessel **34** of FIG. **1**. Also, as shown in FIG. **3**, the vessel **34A** has incorporated therein a pick up coil **60**, rectifier **61**, oscillator **62** and transmit coil **64**. Also located in the central aperture of the copper disk **73A** and bonded to cup **71** is a temperature sensor unit **63**, which may be a thermistor unit. Operationally, the system shown in FIG. **3** functions in the same way as hereinbefore discussed with reference to FIGS. **1** and **2**.

Accordingly, the invention hereinbefore described and illustrated in the accompanying drawings provides an induction cooking or warming appliance which includes, together with a vessel, a temperature sensing unit which is free from the spurious heating encountered in prior art electric and gas ranges. In this regard the nature of the heating source does not produce the same elevated temperatures at the same locations or within the same components. For example, the induction coil **36** induces heating currents in the cup **71** and disks **73** and **73A** in the vessel **34** or **34A** rather than in the counter **22**. The temperature detection unit which is located within the vessel and the temperature receiving unit **50** are located in a region of relatively low magnetic field intensity. Also, the thermistor unit **63** has a resistance of the order of 10^6 ohms so that, at best, only insignificant heating current is induced therein. Also the thermistor leads may be twisted to cancel induced voltages. The various electronic components incorporated within the vessel and under the counter are not subjected to a temperature as high as the specification temperature of 550°F. Certainly these components are not subjected to the elevated temperatures of 1,600°F which occur at certain regions in prior art electric and gas ranges. In this regard, the present invention discloses that the electronic components **60, 61, 62** and **64** are surrounded by thermal insulation **72** and some, or all, components may be remotely located from heated elements such as **73** and those parts of cup **71** which are at the more elevated temperatures. Also, in addition to locating the aforesaid components remotely from higher temperature parts of the vessel, they may be thermally connected to the outer cup member **70** and, hence, to a lower temperature environment.

Beneficially, with the present invention the materials of fabrication of the temperature sensing unit (temperature detection unit and components as well as the temperature receiving unit and components) are not restricted by the elevated temperatures encountered with prior art electric and gas ranges. Hence, many materials such as plastics, epoxies, polyimides are usable in the practice of the present invention.

Moreover, because there is no heat source as in prior art ranges, hereinbefore described, and because of the location of the various components of the temperature detection and temperature receiving unit, the various components herein used need not be thermally shielded or insulated in the ways or to the extent employed in prior art electric and gas ranges.

With the temperature sensing unit employed in the present invention an accurate sensing of the temperature of the vessel may be achieved. This may be done regardless of the weight of the vessel and, further, without regard to whether the outside surface of the vessel has an irregular surface or contour. Moreover, with the temperature sensing unit provided herein, the prior art spring construction or arrangement is not required. Nor, would springs be of any use in connection with temperature sensing as done with present inventions.

Another advantageous aspect of the subject invention is that the counter **22** or vessel supporting means may have an uninterrupted working surface on the top thereof. An important advantage of the present invention is that temperature data may be transmitted by wireless means to a location which may be relatively remote from the cooking or warming area.

Although the invention has been described and illustrated by means of specific embodiments thereof, it is nevertheless to be understood that many changes in materials, details of construction and in the combination and arrangement of parts or components may be made without departing from the spirit and the scope of the invention, which is defined by the claims hereinafter appearing.

What is claimed is:

1. In combination, an induction heating appliance and a vessel said appliance comprising vessel supporting means for supporting said vessel, said supporting means being of a non-magnetic material in which no substantial heating current is induced when subjected to a changing magnetic field, an induction coil proximate said supporting means but separated from the vessel by the supporting means which is situated between said coil and said vessel, said coil being energizable for producing a main changing magnetic field, means for energizing said coil with electric power, and a temperature receiving unit included in said appliance; said vessel comprising a portion in which heating current is induced by said main changing magnetic field when said vessel is supported by said supporting means, and a temperature detection unit supported by said vessel, said temperature detection unit including a temperature sensor unit for sensing the temperature of said vessel, said temperature detection unit being energizable by said main changing magnetic field to produce an auxiliary changing magnetic field which contains temperature data corresponding to the temperature sensed by said temperature sensor unit, said temperature receiving unit including means responsive to said auxiliary changing magnetic field for producing a signal representative of the temperature sensed by said temperature sensor unit, said temperature detection unit supported by said vessel being further comprised of a pick-up coil for developing a first voltage when subjected to said main changing magnetic field, a rectifier for converting said first voltage to a rectified second voltage, a voltage controlled oscillator energized by said second voltage for producing a variable frequency output signal, said temperature sensor unit providing an impedance corresponding to a temperature sensed by said sensor unit, said temperature sensor unit being electrically coupled with said voltage controlled oscillator whereby said oscillator produces an output signal of a frequency corresponding to the temperature sensed by said sensor unit, and a transmitting coil electrically coupled with said voltage controlled oscillator for producing said auxiliary changing magnetic field corresponding to the output signal produced by said oscillator.

2. An inductively heatable vessel comprising: a first metallic wall member and a second non-metallic wall member having portions thereof sealed together tc form a sealed double-walled vessel having an enclosed space between said wall members, said first wall member forming an inside wall surface of said vessel, said first wall member having heating current induced therein when said first wall member is subjected to a changing magnetic field, said second non-metallic wall member having no substantial heating current induced therein when subjected to a changing magnetic field, said second wall member serving as a supportable outside wall of said vessel, a temperature detection unit located within said space between said wall members, said temperature detection unit including a temperature sensor unit for sensing the temperature of at least said first wall member, said temperature detection unit being further comprised of a pick-up coil, a rectifier, an oscillator and a transmit coil, said pick-up coil producing a first voltage in response to the changing magnetic field to which said first wall member is subjected, said rectifier producing from said first voltage a rectified voltage, said oscillator being driven by said rectified voltage and producing a variable frequency output signal corresponding to a temperature sensed by said temperature sensor unit, said transmit coil in response to the output signal produced by said oscillator producing an auxiliary changing magnetic field, said auxiliary changing magnetic field containing temperature data corresponding to the temperature sensed by said sensor unit.

3. In combination, an inductively heatable vessel and a temperature receiving unit located remotely from said vessel, said vessel comprising a first metallic wall member and a second non-metallic wall member, said wall members having portions thereof sealed together to form a double-walled vessel having an enclosed space between said walled members, said first metallic wall member forming the inside surface of said vessel, said first wall member being adapted for having heating current induced therein when subjected to a changing magnetic field, said second non-metallic wall member having no substantial heating current induced therein when subjected to a changing magnetic field, a temperature detection unit located within said space between said wall members, said temperature detection unit including a temperature sensor unit for sensing the temperature of at least said first wall member, said temperatue detection unit including means for transmitting an auxiliary changing magnetic field containing data representative of the temperature sensed by said temperature sensor unit to said remotely located temperature receiving unit, said remotely located temperature receiving unit comprising a receiving coil adapted for being magnetically coupled with said auxiliary changing magnetic field and for producing an electrical signal therefrom representative of the temperature sensed by said temperature sensor unit of said temperature detection unit and a temperature signal processing circuit for processing the signal from said receiving coil to produce another signal representative of said temperature sensed by said temperature sensor unit, and display means coupled with said temperature signal processing circuit for indicating the temperature sensed by said temperature sensor unit, said temperature detection unit further comprising a pick-up coil, a rectifier, an oscillator and a transmit coil, said pick-up coil producing a first voltage in response to the changing magnetic field to which said first wall member is subjected, said rectifier producing from said first voltage a rectified voltage, said oscillator being driven by said rectified voltage and producing a variable frequency output signal corresponding to a temperature sensed by said temperature sensor unit, said transmit coil in response to the output signal produced by said oscillator producing the auxiliary changing magnetic field, said auxiliary changing magnetic field containing temperature data corresponding to the temperature sensed by said sensor unit.

4. In combination, an induction cooking appliance and a cooking vessel, said appliance comprising vessel supporting means in which no substantial heating current is induced when subjected to a changing magnetic field, an induction coil proximate said supporting means but separated from the vessel by the supporting means which is located between the vessel and the coil, said coil being energizable for producing a main changing magnetic field, means for energizing said induction coil with electric power, and a temperature receiving unit supported by said appliance, said vessel comprising a first metallic wall member and a second non-metallic wall member, said wall members having portions thereof sealed together to form a double-walled vessel with an enclosed space between said wall members, said first metallic wall member forming the inside surface of said vessel and being adapted for containing foodstuff to be cooked, said first wall member and also being adapted for having heating current induced therein when said vessel is supported by said vessel supporting means such that said first wall member of said vessel is subjected to said main changing magnetic field, a temperature detection unit located within said space between said wall members, said temperature detection unit including a temperature sensor unit for sensing the temperature of at least said first metallic wall member, said temperature detection unit being energizable by said main changing magnetic field to produce an auxiliary changing magnetic field containing temperature data corresponding to the temperature sensed by said temperature sensor unit, said temperature detection unit further comprising a pick-up coil for developing a first voltage when subjected to said main changing magnetic field, a rectifier for converting said first voltage to a rectified second voltage, a voltage controlled oscillator energized by said second voltage for producing a variable frequency output signal, said temperature sensor unit providing an impedance corresponding to a temperature sensed by said sensor unit, said temperature sensor unit being electrically coupled with said voltage controlled oscillator whereby said oscillator produces an output signal of a frequency corresponding to the temperature sensed by said sensor unit, and a transmitting coil electrically coupled with said voltage controlled oscillator for producing an auxiliary changing metallic field corresponding to output signal produced by said oscillator, said auxiliary magnetic field containing temperature data corresponding to the temperature sensed by said temperature sensor unit, said temperature receiving unit including means responsive to said auxiliary changing magnetic field for producing a signal representative of the temperature sensed by said temperature sensor unit.

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