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(54) **System for detecting the presence of a cooking utensil on a cooking hob**

(57) A system for detecting the presence of a cooking utensil on a cooking hob comprises an array of heating elements and electronic sensors whose impedance changes due to the presence of said cooking utensil on the hob. The system further comprises an electronic circuit adapted to drive the alloy of the heating elements towards magnetic saturation.

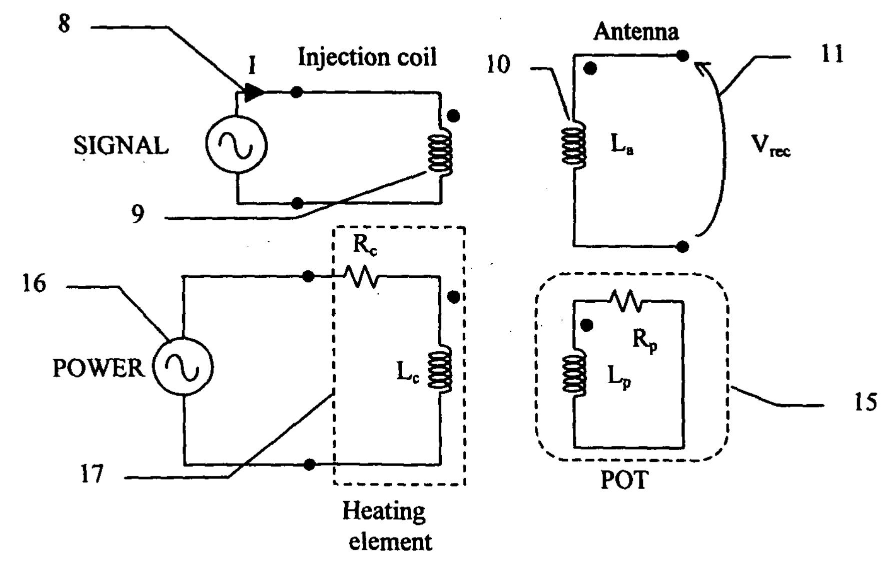

Fig. 5

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Description

[0001] The present invention relates to a system for detecting the presence of a cooking utensil on a cooking hob comprising detection means whose impedance changes in relation to the presence or absence of said cooking utensil on the hob. The system according to the invention is particularly useful for use with cooking utensils detection system on glass ceramic electric cooking hob.

[0002] The invention further relates to a temperature compensation method for inductive and cross-inductive pot-detection methods, used in glass-ceramic electric cooktops.

[0003] The known detection systems may be divided into two categories. The conventional inductive systems, as described in EP-A-0553425, and the cross-inductive systems, as described in EP-A-328092 or EP-A-1206164.

[0004] Conventional inductive methods are based on a sensor coil, placed inside the heater and connected to some form of electronic oscillating circuit, whose oscillation frequency or amplitude changes when a metal cooking utensil is placed over the hob.

[0005] The electrical model of such known system is shown in figure 1, where an electronic circuit 8 is connected to a pickup coil 9 placed just beneath the cooktop (not shown), over the heater. Said electronic circuit detects variations of the pickup coil impedance. The presence of a cooking utensil 10 (shown in figure 1 as an equivalent electrical loop circuit having impedance Lp and resistance Rp) modifies the coupling coefficients Kp of the equivalent transformer, thus causing output signal variation when the cooking utensil is placed on the cooktop.

[0006] The cross-inductive methods are based on the idea of injecting a radiofrequency signal into a first coil and detecting the signal induced into a second coil (receiving coil) placed in the vicinity of the cooktop surface. Detected voltage variations are related to the coupling strength variation caused by the presence or absence of the cooking utensil. The above-mentioned EP-A-328092 describes the technique for a single hob where both the emitting coil and the receiving coil are different from the heating coil. EP-A-1206164 describes a method for using the same heating coil also as electromagnetic field emitter and, for this reason, it is particularly well suited for detecting cooking utensils on a cooking hob with discrete distributed heating elements as described in EP-A-1 303168.

[0007] Both said known methods produce an output signal suffering from a strong variation induced by the variation of the magnetic characteristics of the heating element caused by temperature variations. Said variation of the magnetic characteristics can be, in some cases, of the same order of magnitude of the variation induced by the presence/absence of the cooking utensil, therefore rendering the pan detection quite unreliable.

[0008] It is well known that the main physical phenomena behind such variation is the Curie temperature crossing of the heather alloy (the Curie temperature being the temperature over which the magnetic permeability (μ_r) of the material abruptly falls from a typical value of some tenth to unity, as shown in the attached figure 2).

[0009] All the above systems are similar in the sense that they all rely on the processing of the output quantity "as it is", so suffering of thermal variations, while no precautions are taken to improve the system working conditions.

[0010] US-A-5900174 describes a method for rejecting the temperature-induced variation of the output signal by knowing the power control switching times. Said method has the disadvantage of being applicable only with ON/OFF power control methods (hence not being applicable to continuos or quasi-continuos power controls). In addition said known method is able to compensate only for the sharp variation caused by the Curie temperature crossing and not for the smooth variations or "drifts" experienced at temperatures below that temperature.

[0011] It is an object of this invention to overcome or minimise the above technical problem.

[0012] This and further objects which will be more apparent from the ensuing detailed description are attained by a system and a method in accordance with the accompanying claims. According to the present invention there is provided a special circuitry that minimize the influence of the temperature on the pan detection signals.

[0013] According to the invention, the system comprises an electronic circuit adapted to drive said detection means towards magnetic saturation. If the detection means of the system detect the impedance of a probing coil placed below the cooking surface or the complex cross-impedance between an emitting coil and a pick-up coil, the impedance, or cross-impedance, is preferably measured when the heating element alloy, or any ferromagnetic object affecting such measurement, is driven into magnetic saturation by means of a strong enough current injection. According to another feature, the sampling of the voltage/current induced into the probing coil is preferably performed synchronously with the injection of a saturating current, which is preferably obtained by direct application of the mains voltage to the heating element. According to a further feature, the pan detection is carried out when the current flowing into the heating element is high enough to have a relative permeability lower than at room temperature.

[0014] The invention will be more apparent from the detailed description of preferred embodiments thereof given hereinafter by way of non-limiting example and illustrated in the accompanying drawings, in which:

- figure 1 is a schematic circuit of a known general model for inductive pan detection systems, showing mutual coupling;

- figure 2 is a typical example of a diagram showing alloy relative permeability vs. temperature;
- figure 3 is a diagram showing flux density B vs. applied field H of a typical heating element alloy;
- figure 4 is a diagram showing an example of alloy relative permeability vs. applied field H;
- figure 5 is a simplified circuit model for a mutual inductive pan detection method, in which the injection coil is different from the heating element;
- figure 6 is a simplified view of a mutual inductive pan detection measuring chain;
- figure 7 is a simplified circuit model for mutual inductive method, in which the injection coil is also the heating element;
- figure 8 is an example of the coupling network used in the circuit model of figure 7;
- figure 9 is a simplified circuit model for an inductive pan detection method; and
- figure 10 is a diagram showing a pan-detection example comparing the signal of a known system with the signal obtained through the system according to the invention.

[0015] It is well known from the basic physical model of ferromagnetic materials, that by inducing in the material a sufficiently high magnetic field H, the flux density B in the material reaches the saturation state, i.e. the flux does not increase upon field increase. This general behavior of a typical heating element alloy (flux density B vs. applied field H) is shown in figure 3, where curves 1 and 2 relates to the same material at two different temperatures, 20°C and 450°C respectively.

[0016] Once the metal/alloy is saturated, its relative incremental permeability, defined as $\mu_r = \delta B/\delta H$, approaches unity; this means that the material looses its magnetic properties, then behaving like a non-magnetic material. This is shown in figure 4.

[0017] Obviously also the variation of the relative permeability μ_r versus temperature disappears because there is no longer a magnetic behavior (μ_r approaches unity).

[0018] The applicant started from the aforementioned physical behavior, in order to minimize or even cancel the thermal induced variations.

[0019] The method according to the invention consists in inducing magnetic saturation in the heater alloy by feeding it with a strong polarising current. According to another features of the invention, a suitable coupling network decouples the saturating current from the signal injected for pan detection purposes. The saturation grants that both at low and high temperature, the magnetic properties of the alloy are almost equal and the temperature-induced variation are limited to a negligible level.

[0020] The above phenomena can be better understood by considering figures 2, 3 and 4, where an example of material characteristics is reported. As can be easily understood looking at figure 4, when the applied injection field has no bias, the magnetic permeability, and so the recorded voltage, suffers from large variation over temperature. When a strong enough bias is given to the material, the differences collapse to a negligible level, thus making the recorded voltage unaffected from thermal effects.

[0021] A magnetic pan detection system according to the invention can be arranged in at least three embodiments.

[0022] With reference to figure 5, which represents a simplified model for mutual inductive method, in which the injection coil is different from the heating element, the reference RF current 8 is fed into the injection coil 9, that is physically separated by both the heating element 17 and the receiving coil 10. The loop 10 made by conductive material is placed above the injection coil 9 in order to pick up part of the generated magnetic field. The induced voltage 11 is fed to the signal conditioning unit shown in figure 6. Said induced voltage is typically lower in presence of any metallic object 15 onto the cooking surface.

[0023] Referring to figure 7, which represents a simplified model for a mutual inductive method, in which the injection coil is also the heating element, the reference AC current 8 is fed to the heating element 17 through a coupling filter 18. In figure 7, as in figure 9, the identical or similar components are indicated with the same reference numerals of figure 5. Said heating element 17 is used also as injection coil 9, its structure having a suitable geometry that allows the generation of a magnetic field directed towards the cooking surface. The aforementioned coupling filter (see figure 8) provides the necessary insulation between the high frequency reference signal and the biasing current. A loop 10, similar to the loop of figure 5, made by conductive material is placed above the injection coil 9 in order to pick up part of the generated magnetic field. The induced voltage 11 is fed to the signal conditioning unit (figure 6). Said induced voltage is lower in presence of any metallic object 15 onto the cooking surface.

[0024] Referring now to figure 9, which represents a simplified model for an inductive method, the reference RF current 8 is fed into a loop 10 made by conductive material that is placed above the heating element 17.

[0025] When a pan detection measurement is needed, a current is fed into the heating element 17 in order to saturate its alloy. Said action is straightforward when the heating element 17 is switched on, since the heating current flows through the heating element 17 saturating its alloy. When the heater is off, the saturating current must be supplied to the heating element just for the time needed for the measurement, being said power not used for cooking purposes but for saturation purpose only. In both cases, the pan detection signal must be sampled when the heater alloy is saturated enough.

[0026] The above embodiments can be applied to a single hob as well as to a cooktop made by a matrix of multiple heating elements.

[0027] In figure 10 it is shown the result of experimental results of a pan detection system according to the invention compared with a traditional system. With the reference 26 it is indicated how the pan detection signal of a known system changes by changing the power of a heating element, i.e. by changing its temperature, without any cooking utensil on the cooking hob. With the reference 25 it is shown the variation of the pan detection signal of the system according to the invention. It is evident how this last signal is surprisingly more stable than the signal of the known system.

Claims

1. A system for detecting the presence of a cooking utensil on a cooking hob, comprising at least an electrical heating element and detection means whose impedance changes due to the presence of said cooking utensil on the hob, **characterized in that** it comprises an electronic circuit adapted to drive the heating element towards magnetic saturation.

2. A system according to claim 1, in which the detection means detects the impedance of a probing coil (9, 10) placed below the cooking surface or the complex cross-impedance between an emitting coil (9) and a pick-up coil (10), **characterized in that** said impedance is measured when the heating element alloy, or any ferromagnetic object affecting such measurement, is driven into magnetic saturation by means of a strong enough polarizing current.

3. A system according to claim 2, **characterized in that** the sampling of the voltage/current induced into the probing coil (9, 10) is performed synchronously with the injection of a saturating current.

4. A system according to claim 3, **characterized in that** the saturating current is obtained by direct application of the mains voltage to the heating element (17).

5. A system according to claim 4, **characterized in that** the pan detection is carried out only when the current flowing into the heating element (17) is high enough to saturate it.

6. A system according to any of the preceding claims, **characterized in that** the electrical heating element is part of the detection means.

7. Method for detecting the presence of a cooking utensil on a cooking hob on the basis of a change of impedance in a conductive element placed in the proximity of the heating element, **characterized in that** said heating element is substantially magnetically saturated

8. Method according to claim 7, in which the impedance of a probing coil (9, 10) placed below the cooking surface or the complex cross-impedance between an emitting coil (9) and a pick-up coil (10) is detected, **characterized in that** said impedance is measured when a heating element alloy, or any ferromagnetic object affecting such measurement, is driven into magnetic saturation by means of a strong enough current injection.

9. Method according to claim 8, **characterized in that** the sampling of the voltage/current induced into the probing coil is performed synchronously with the injection of a saturating current.

10. Method according to claim 9, **characterized in that** the saturating current is obtained by direct application of the mains voltage to the heating element (17).

11. Method according to claim 10, **characterized in that** the pan detection is carried out when the current flowing into the heating element (17) is high enough to saturate it.

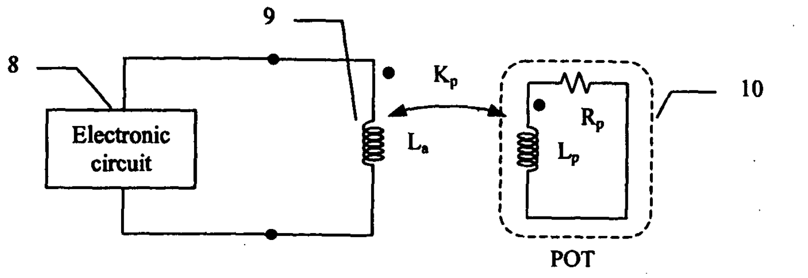

Fig. 1 (PRIOR ART)

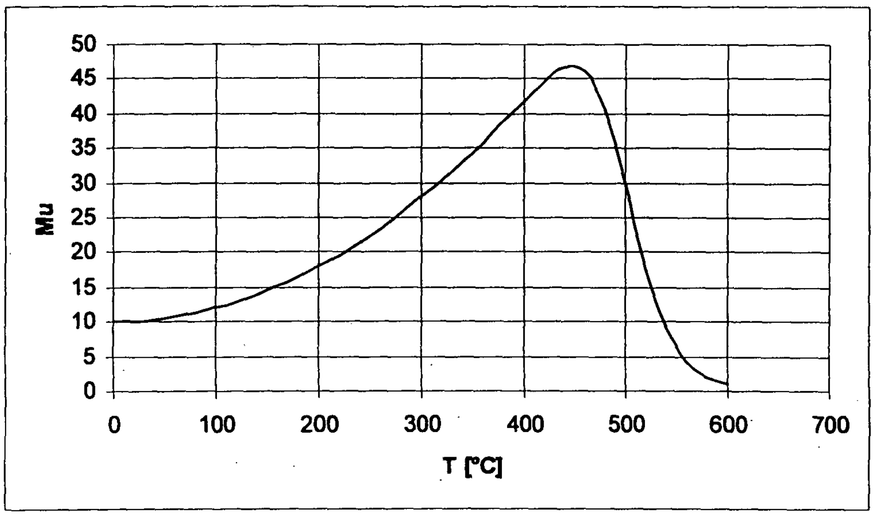

Fig. 2

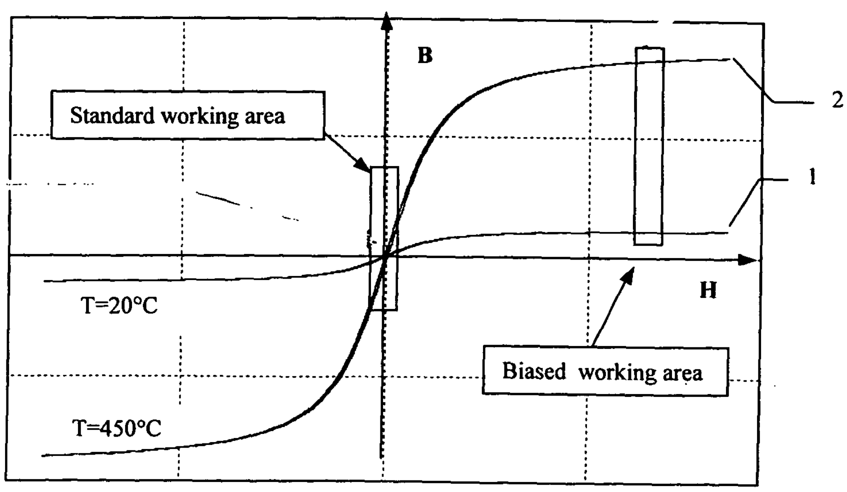

Fig. 3

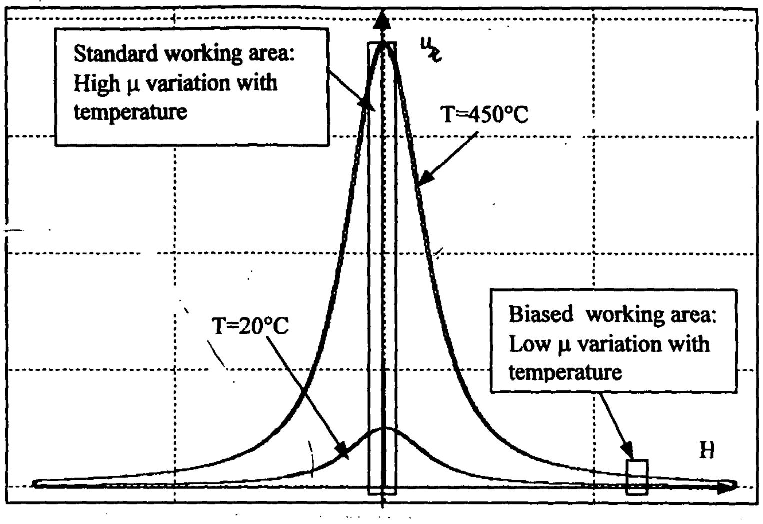

Fig.4

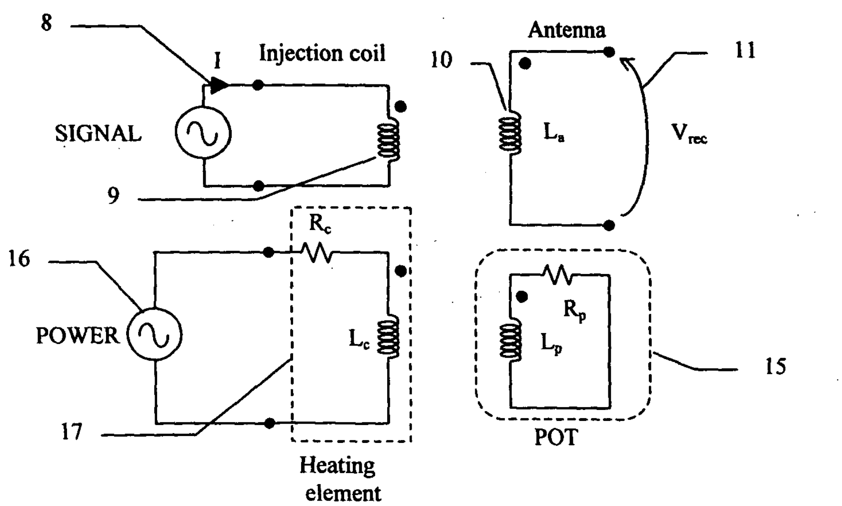

Fig.5

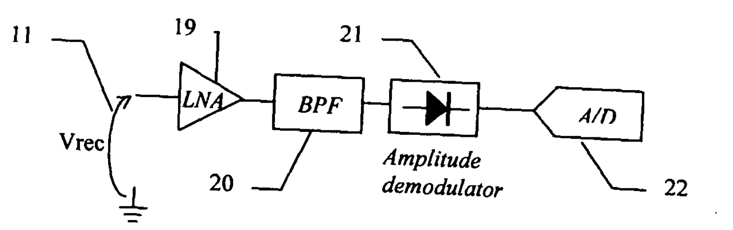

Fig.6

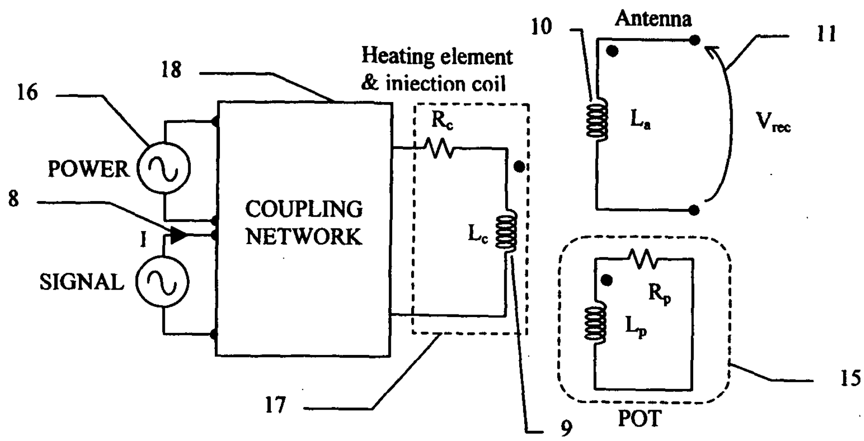

Fig.7

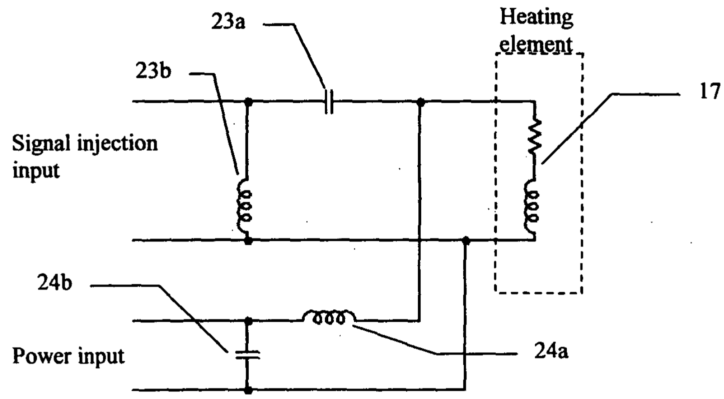

Fig.8

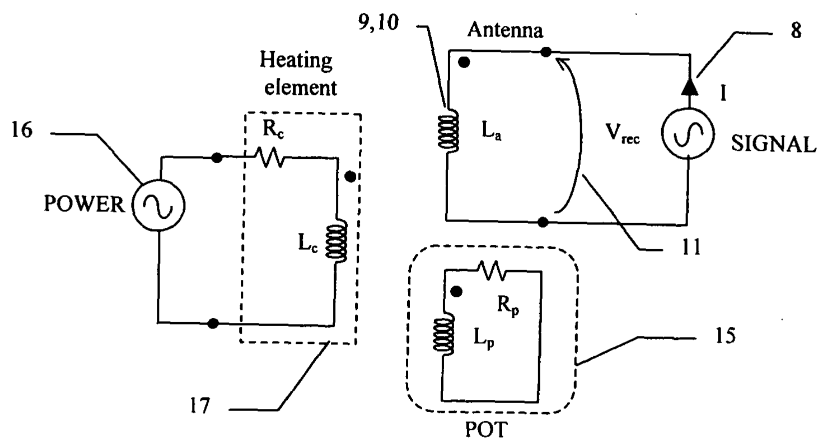

Fig.9

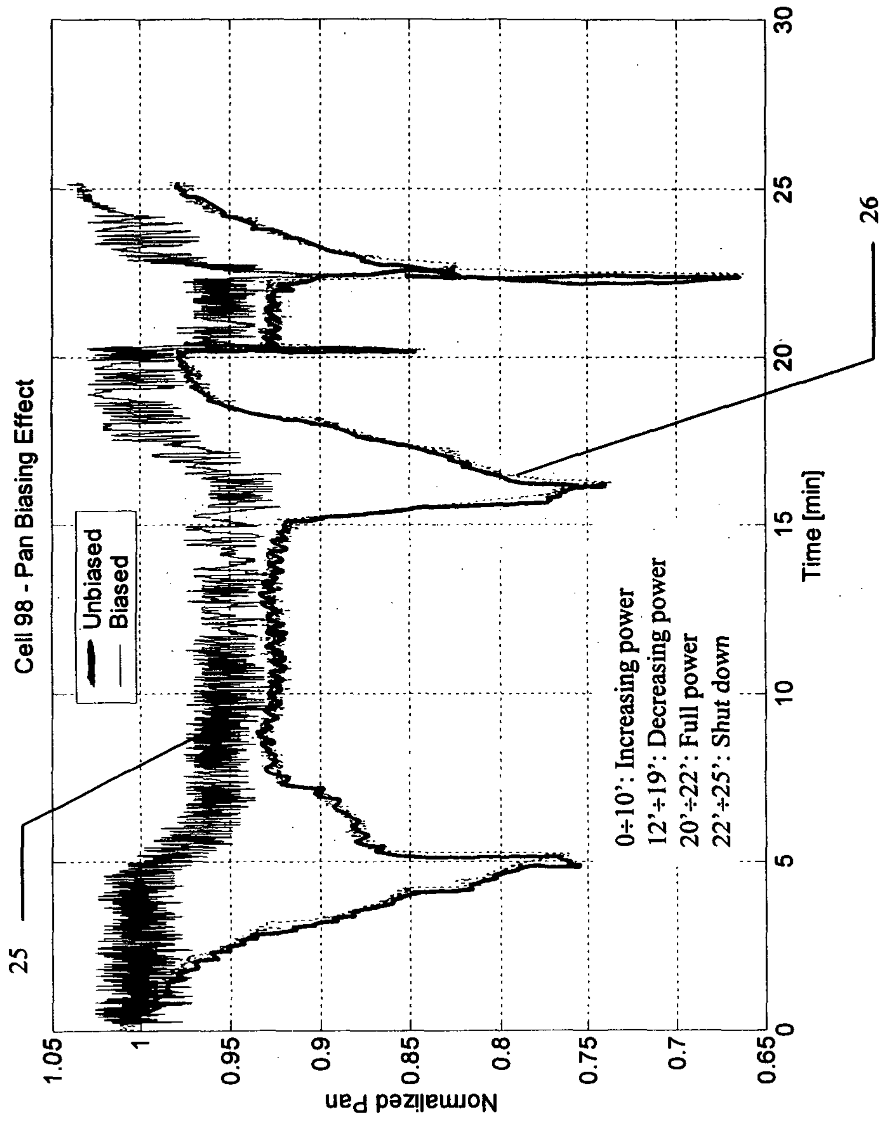
Cell 98 - Pan Biasing Effect
Unbiased
Biased
Normalized Pan
Time [min]
0÷10': Increasing power
12'÷19': Decreasing power
20'÷22': Full power
22'÷25': Shut down
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0
5
10
15
20
25
30
25
26

Fig. 10

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EUROPEAN SEARCH REPORT

Application Number
EP 03 02 8039

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	10 May 2004	Gea Haupt, M

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