

(12) PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. **AU 199917521 B2**
(10) Patent No. **751886**

(54) Title
Method and apparatus for detecting a fluid and a temperature

(51)⁶ International Patent Classification(s)
G08B 021/00 A61F 013/42
A61F 005/48

(21) Application No: 199917521 (22) Application Date: 1998 .12 .22

(87) WIPO No: W099/33037

(30) Priority Data

(31) Number (32) Date (33) Country
1511/97 1997 .12 .22 DK

(43) Publication Date : 1999 .07 .12
(43) Publication Journal Date : 1999 .09 .16
(44) Accepted Journal Date : 2002 .08 .29

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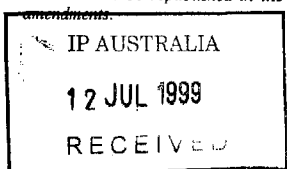
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(56) Related Art
GB 2113835
US 4792790
US 5291180

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

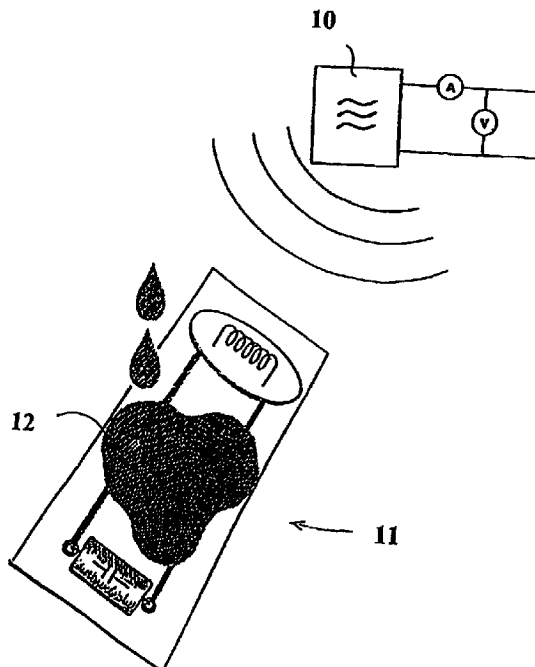
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : G08B 21/00, A61F 13/42, 5/48		(11) International Publication Number: WO 99/33037
A1		(43) International Publication Date: 1 July 1999 (01.07.99)
(21) International Application Number: PCT/DK98/00577 (22) International Filing Date: 22 December 1998 (22.12.98) (30) Priority Data: 1511/97 22 December 1997 (22.12.97) DK (71) Applicant (for all designated States except US): BENT THORNING BENSEN A/S [DK/DK]; ~~H.P. Christensen-Vej 6, DK-3000 Elsinore (DK). Stenfeldtsvej 7 DK-3000 Elsinore~~ (72) Inventor; and (73) Inventor/Applicant (for US only): BENSEN, Bent, Thorning [DK/DK]; Stenfeldtsvej 3, DK-3000 Elsinore (DK). (74) Agent: HOFMAN-BANG & BOUTARD, LEHMANN & REE A/S; Hans Bekkevolds Allé 7, DK-2900 Hellerup (DK).		
(81) Designated States: AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).		
Published With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.		
 		

(54) Title: METHOD AND APPARATUS FOR DETECTING A FLUID AND A TEMPERATURE

(57) Abstract

A method and apparatus for detecting a fluid; said method comprising providing one or more oscillators (10) transmitting electromagnetic energy; providing one or more resonant circuits (11) receiving electromagnetic energy from the oscillators; bringing the fluid and the one or more resonant circuits (11) into contact with each other so that the receptions of electromagnetic energy of the resonant circuits are changed; and detecting changes of the transmissions of the oscillators by changes in one or more characteristics thereof upon the changes in the receptions of the electromagnetic energy of the resonant circuits; and use thereof for the detection of fluid levels, empty containers, and leak of fluids from containers and bodies containing said fluids; e.g. for monitoring collection of drain fluid from a human or for monitoring leak of fluid from a human suffering from urinary and/or faecal incontinence. Further, a method and apparatus for detecting a temperature, and sensing devices for sensing an external parameter, in particular a fluid or a temperature.



METHOD AND APPARATUS FOR DETECTING A FLUID AND A
TEMPERATURE

5 DESCRIPTION

1. BACKGROUND OF THE INVENTION

10 The present invention relates to a method and apparatus
for detecting a fluid; use thereof for detecting the
level of fluid in a container; and use thereof for
monitoring a leak of fluid from a body containing said
fluid, in particular a leak of body fluid from a human or
an animal.

15 The present invention further relates to a method and
apparatus for detecting a temperature.

20 The present invention still further relates to a sensing
device for sensing an external parameter, in particular a
fluid or a temperature.

The Technical Field

25 Generally detection of a fluid, e.g. for detecting the
level of a fluid in a container or for detecting a leak
of fluid from a body such as a container or a human or
animal body containing said fluid comprises production of
a sensor signal of the fluid and detection of the
30 produced sensor signal by appropriate detection
electronics.

35 In applications of e.g. detecting levels or leaks of
stationary oil containers, or detecting leak of body
fluids from patients or elderly confined to a bed, the
sensor of the fluid and the detection electronics are

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typically interconnected by electrically conducting connectors e.g. wires or cables. However, such connections can be sensitive to damage and for patients or elderly confined to a bed they can be very
5 inconvenient and put severe constraints on their movability.

Particularly for patients or elderly who are able to walk around, such electrical connections cannot be used
10 without restricting their movability.

Since lack of movability of patients and elderly requires an increased level of monitoring of e.g. wounds and urinary and faecal incontinence by personnel, such a
15 monitoring often being considered inconvenient and cumbersome, electrical connections of monitoring devices implicitly contribute to bad sanitary conditions for patients and elderly and contaminated environments of wound healing sections, incontinence sections and the
20 like of hospitals and nursery homes.

A similar situation holds for monitoring the temperature of patients and elderly.

25 Wireless connection based on suitable receiver/-transmitter electronics at the sensor and detection electronics can be contemplated. However, in order to function, such electronics requires a portable power supply such as a voltage battery. This is impractical
30 because of the necessary exchange or recharge of discharged batteries.

Consequently there is a need for wireless connection of fluid sensor, or temperature sensor, respectively, and
35 detection electronics which do not require portable power supply; as well as sensors suited for sensing

exposure of an external parameter, in particular fluid or a temperature without requiring external power supply.

5 Prior Art Disclosures

- International Application No. PCT/NL/00083 discloses an assembly for detecting and signalling wetness of a diaper; said assembly comprising an electronic device
10 mounted in a housing to be applied on a diaper and directly connected to connectors on a sensor strip adhered to the inside or outside of said diaper for detecting presence of wetness near said conductors.
- 15 US Patent No. 4 646 066 discloses an indicator device and method of measuring incremental environmental exposure of an environmental parameter; said method comprising measuring responses of a target to an electromagnetic interrogation signal; said target including a tuned
20 circuit and an element that is sensitive to environmental exposure, especially exposure to specified fluids e.g. liquids and water vapour, influencing the electronic or ionic conductivity. There is no teaching of parameter influences including the capacitance of the tuned
25 circuit, nor of a measuring method based on changes of transmission of electromagnetic energy of oscillators transmitting electromagnetic energy to the tuned circuits.
- 30 EP 0 715 152 discloses a sensing device for sensing the presence or absence of an article, e.g. a material, a liquid, a powder, and the human body; said device comprising an oscillator for generating a high frequency signal; a sensor including a resonance circuit for
35 receiving the high frequency signal from the oscillator and a detector for producing a signal relating to a

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variation of an impedance change of the sensor; said sensor and detector being coupled through a cable.

GB 2 113 835 discloses a sensor for detecting quantities
 5 such as position, force, pressure, liquid level, flow, temperature, voltage, current, and magnetic field; said sensor comprising opto-electric means for converting optical energy into electric energy and vice versa and at least one electric resonant circuit and means arranged to influence a
 10 characteristic of the resonant circuit by the quantity to be detected.

US Patent No. 5 570 082 discloses a device for detecting wetness in diapers for the purpose of calling the attention
 15 of the caretaker. The device is a combination of an antenna, a non-linear element and two parallel electrodes, the two electrodes being embedded in the diaper in an area likely to experience wetness and being adapted to provide a strong coupling between the antenna and the non-linear
 20 device when subjected to wetness thereby reducing the resistance between the electrodes. This device does not include a resonant circuit.

US 4 792 790 discloses a tag-like construction affixable to
 25 an object. The construction incorporates a closed resonant circuit having conductor paths arranged in at least two superimposed surfaces by folding together.

2. DISCLOSURE OF THE INVENTION



30 In one aspect, the invention provides an article for containing a fluid; said article comprising a wireless fluid

sensing device for sensing taking up or delivery of the fluid by the article; said fluid sensing device including at least one resonant circuit having a resonant circuit parameter that will change by the fluid contacting the resonant circuit; and means, which can be wirelessly and inductively coupled to the resonance circuit and emit electromagnetic signals to excite the resonance circuit, and which wirelessly and inductively can detect a change in said parameter; and said sensing device being arranged in a position on the article suitable to sense taking up or delivery of fluid by the article.

The sensing device may be contained in or attached onto the article.

The sensing device may be embedded in a carrier with an adhesive.

The article for example, may be a container, an absorbent, a diaper or a bandage.

The fluid may, for example, be urine, faeces, or blood or an infusion liquid.

The invention also provides a wireless fluid sensing device for sensing taking up or delivery of a fluid by an article for containing a fluid; said sensing device including at least one resonant circuit having a resonant circuit parameter that will change by the fluid contacting the resonant circuit; and means permitting wireless detection of a change in said parameter; and said sensing device being arranged in a position suitable to monitor filling or emptying of the fluid; the sensing device comprising:

a substrate having a back side and a front side, and at least one electrical conducting means, comprising an



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inductance, positioned on or embedded in said back side, front side, or both, of the substrate, said substrate further having at least two parts in a mutual overlaying relationship, so that said conducting means together with at least a part of the substrate provide a capacitance, said inductance and capacitance being electrically interconnected to form said at least one resonant circuit; and means permitting wireless detection of a change in said parameter.

10

The resonant circuit may further have a resistance means.

The resistance means may be a thermally sensitive resistor.

15 The capacitance may be formed by a pair of electrodes and a spacer means, and a variable distance between said pair of electrodes. The spacer means may be an absorber.

20 The at least two parts of the substrate may be brought in a mutual overlaying relationship by folding.

The one or more resonant circuits may have coils having separated windings for receiving the fluid and short cutting the circuit. The windings may be made of an electrically conducting material selected from the group consisting of metals such as aluminium, copper, and tin; electrically conducting polymers such as polyaniline; or electrically conducting polymer blends such as blends of poly(p-phenylene vinylene), polyacrylamide, polyaniline and polyethylene.

30

The means permitting wireless detection of a change in said parameter may be an electromagnetic antenna.



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The invention further provides a system for monitoring a fluid flowing to or from a human or animal body, the system comprising:

5

(a) one or more articles for containing the fluid as above described, optionally comprising a wireless fluid sensing device as above described;

10

(b) one or more oscillators for transmitting electromagnetic energy to one or more resonant circuits of said one or more articles; and

15

(c) one or more detectors for detecting changes in one or more characteristics of the one or more oscillators upon changes in characteristics of the one or more resonant circuits.

20

The one or more oscillators may be one or more inductors for each different band of operation for each resonant circuit. The inductors may be interchangeable either manually or automatically.

25

The inductors may be external inductors in the form of coils.

The one or more oscillators may be connected to one or more antennas.

30

The antennas may have a radiator element, transmission lines, and optional transformers, coupled to the inductor, or constituting a part of the inductor.



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The one or more detectors may detect an increase of energy loss of one or more of the oscillators.

- 5 The one or more detectors may detect a decrease of energy loss of one or more of the oscillators.

The resonant circuit may further have a resistance means. The resistance means may be a thermally sensitive resistor.

- 10 The capacitance may be formed by a pair of electrodes and a spacer means.

There may be a variable distance between said pair of electrodes.

- 15 The spacer means may be an absorber.

- The one or more oscillators may operate at ranges of frequencies being the resonant frequencies of the resonant
20 circuits.

The invention also provides use of the above-described system for development and maintenance of health of a patient, an elderly, or a baby.

- 25 The patient may suffer from urinary and/or faecal incontinence.

More patients may be monitored and said at least one resonant circuit may differ from each other for each
30 patient.



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Embodiments of the present invention may avoid the need for an electrical connection between a sensor of the fluid and an electronic detection system therefore and without requiring a portable power supply for the fluid sensor.

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2025



By contact of the resonant circuit with the fluid, or by exposing the resonant circuit to different temperatures, one or more of the characteristics resistance R, capacitance C and inductance L, or any derivative thereof, e.g. the resonance frequency $\omega_0 = (LC)^{-1/2}$, or higher harmonics thereof, or the quality factor $Q = \omega L/R$, e.g. at resonance $\omega = \omega_0$, change.

When one or more of the characteristics change, the ability of the resonant circuit to receive electromagnetic energy changes. This can be detected by detecting changes in one or more characteristics of one or more oscillators transmitting electromagnetic energy to said resonant circuit.

Generally, sensing devices can be manufactured in any suitable way that allow the external parameters to affect the impedance of the respective resonant circuits.

In the particular aspect of the invention relating to detecting a fluid, resonant circuits can be prepared in any suitable way that ensures the penetration of fluid into the resonant circuit to such an extent that one or more of its characteristics are changed.

In the particular aspect of the method of detecting a fluid, the change of characteristics of the resonant circuit causes a detectable change in one or more of the characteristics of the one or more oscillators.

In a preferred embodiment, the resonant circuit consists of a coil having separated windings which can receive the fluid and short cut the circuit.



The windings can be of any suitable material. In a preferred embodiment, the windings are made of an electrically conducting material selected from the group consisting of metals such as aluminium, copper, tin; an
5 electrically conducting polymer such as polyaniline; and an electrically conducting polymer blend such as poly(p-phenylene vinylene), polyacrylamide, polyaniline and polyethylene, or combinations of these.

10 Specifically useful electric conducting polymers include a flexible, crease resistant, one component, carbon filled ink and coating sold by Emerson & Cuming Speciality Polymers under the trademark Amicon C 932-74. Another useful electric conducting polymer is a highly
15 flexible, crease resistant, one component, silver filled, ink and coating sold by Wacker Chemikemi under the trademark Elastosil N 189. Both products are environmentally acceptable.

20 In the particularly aspect of detecting temperature changes, the resonant circuits can be prepared in any suitable way that ensures the influence of different temperatures to affect the impedance of the resonant circuit to such an extent that one or more of its
25 characteristics are changed.

In the particular aspect of the method of detecting a temperature change, the change of the characteristics of the resonant circuit causes a detectable change in one or
30 more of the characteristics of the one or more oscillators.

In a preferred embodiment, the resonant circuit consists of a coil having separated windings of which the resistance, inductance, or both, are sensitive to temperature.



The windings can be of any suitable material. In a preferred embodiment, the windings are made of a temperature sensitive, electrically conducting material.

5

In another preferred embodiment, the coil has two parts serially connected through a temperature sensitive resistance.

10 The fluid sensing device can be placed in any suitable position to detect the desired fluid. In preferred embodiments, the fluid sensing device is contained in or attached onto a container; or it is embedded in a diaper; or it is embedded in a carrier with an adhesive, such as
15 a sticker, to be attached on a desired location, e.g. onto said container or diaper.

Several resonant circuits can be positioned in one location to encode for given patterns of frequencies,
20 e.g. several small resonant circuits of e.g. different frequencies placed in a diaper can provide a unique identification of e.g. individual patients or elderly being monitored in a hospital or a nursing home.

25

Oscillators

According to the invention an oscillator operates in functional proximity of a resonant circuit.

30

In the present context the expression "functional proximity of a resonant circuit" is intended to mean that an oscillator in one location radiates electromagnetic energy, e.g. in form of radiowaves or microwaves, which can be fully or partly transferred to a resonant circuit in another location.

35



Generally, any suitable oscillator can be used, i.e. an oscillator which is able to produce electromagnetic oscillations and to emit electromagnetic energy e.g. in form of radiowaves or microwaves which is fully or partly received by the resonant circuit.

It should be understood that more than one oscillator can operate in functional proximity of said resonant circuits e.g. if more oscillators operates at different frequency ranges, and if changes in different characteristics of the resonant circuit are to be detected.

Generally, an oscillator comprises an generator which generates a high frequency signal of radiant energy e.g. an ac current or voltage, or an impulse, of a frequency around that of the resonant circuit. Generators can be any suitable generator known in the art, e.g. radio frequency signal generators.

In a preferred embodiment, the oscillator comprises a generator generating a signal of electromagnetic energy of a frequency around that of the resonant circuit.

An oscillator comprises one or more inductors. The inductors can be internal or external to a cabinet housing the oscillator. Preferably there is one or more inductors for each different bands of operation for each resonant circuit. Preferably more inductors can be interchanged either manually or automatically. The inductors can be of any suitable form. In a preferred embodiment the inductors are external inductors in form coils.



Functional proximity between the oscillators and the resonant circuits can be achieved in any suitable way. In a preferred embodiment, the inductors are external inductors in form of coils which surrounds the resonant circuit. In a particularly preferred embodiment, the coils are embedded in a bed for monitoring leak of body fluids of a human.

In another preferred embodiment, the oscillators comprises one or more antennas whereby the direction of the electromagnetic radiation, e.g. radio waves, can be more accurately defined. An antenna can be any suitable antenna known in the art, e.g. a dipole. In a preferred embodiment, the antenna comprises a radiator element, transmission lines, and optional transformers, coupled to the inductor, or constituting a part of the inductor.

Detectors

The apparatus further comprises one or more detectors for detecting one or more changes in one or more characteristics of said oscillators upon changes in the characteristics of one or more resonant circuits.

The characteristics of the oscillators comprise any suitable characteristic.

In a preferred embodiment the characteristics of the oscillator comprise current, voltage, or a derivative thereof such as power, whereby one or more characteristics, or derivatives thereof, of the resonant circuit are detected, e.g. change in frequency, particularly the resonance frequency; change in quality factor; and wholly or partial suppression or restoration of any of these.



In a preferred embodiment one or more of the detectors detect an increase or a decrease of energy loss of one or more of the oscillators.

5

Further, preferred uses appear from the following detailed description.

10 3. BRIEF DESCRIPTION OF THE DRAWINGS

In the following, the invention is further disclosed with detailed description of preferred embodiments, reference being made to the drawings in which

15

Figure 1 shows a diagrammatic sketch of the principle of the invention;

20 Figures 2A-2J show preferred embodiments of a resonant circuit and its production;

Figures 3A-3E show other preferred embodiments of a resonant circuit;

25 Figures 4A-4D show different embodiments of the resonant circuit;

30 Figure 5 shows another preferred embodiment wherein the operation of the resonant circuit depends on the presence of an electric conducting fluid;

Figures 6, 7, and 8A and 8B show different embodiments of applications of the resonant circuit;



Figures 9A, 9B, 10A, 10B, 11, and 12A and 12B show typical applications of the method and apparatus according to the invention;

- 5 Figures 13, 14, and 15 show different configurations of the external inductor of the oscillator and an antenna; and

10 Figure 16 shows a typical application for remote monitoring of baby wetness in a baby carriage.

4. DETAILED DESCRIPTION

- 15 Figure 1 shows a diagrammatic sketch of the principle of the invention.

20 An oscillator 10, shown in a schematic diagram, emits electromagnetic radiation of a frequency close to that of a resonant circuit 11 located within a functional distance of the oscillator so that a part of the emitted electromagnetic radiation is received by the resonant circuit.

- 25 The oscillator provides an output power which ensures that a suitable amount of the radiation is absorbed by the resonant circuit.

30 A fluid 12 gets in contact with the resonant circuit 11 thereby destroying or disturbing the ability of the resonant circuit to receive electromagnetic energy of the oscillating frequency. Consequently, the oscillator output power changes which is detected by a suitable detection circuit e.g. as schematically shown in the right part of the circuit with measurement of current A



and voltage V. The circuit is further connected to power supply and further electronics (not shown).

5 Figures 2A-2D show preferred embodiments of a resonant circuit, in particular for a sensing device according to the invention.

10 Figure 2A shows a resonant circuit produced by providing an electrical conductor, i.e. electrical conducting means, e.g. a metallic conductor such as aluminium or an electrically conducting coating, in form of two serially connected coils 21, 22 terminating in plates 24,25 on a substrate 23, e.g. a textile, a paper, or a suitable plastic foil. The substrate is folded along the line A-A, as shown in Figure 2B, providing the back surfaces of the substrate against each other and the front surfaces of the substrate carrying the coil away from each other. Thereby the formation of short circuits between the coils is avoided as further shown in the folded substrate in 15 20 Figures 2C and 2D.

Depending on the degree of folding, the distance between the plates 24,25 is changed, thereby providing a variable capacitance.

25 It should be noted that the skilled person can select the number of windings and their directions with respect to each other, for either enhancing coupling or decoupling of the magnetic fields of the coils of the folded substrate. 30

Figure 2D shows a cross section view of the resonant circuit along the line B-B in Figure 2C together with an equivalence diagram of the resonant circuit. The two serially connected coils 21, 22 project from each side of the folded substrate 23. The two center areas 24, 25 of



the coils make up the plates of a capacitor which capacitatively connects the plates of the two coils, thereby providing a resonant L-C circuit, a so-called LC resonant tank circuit. In practice such a circuit will
5 include a resistance R, either in series or in parallel therewith.

This embodiment of the resonant circuit has the advantage of providing exposed coils which are very sensitive to
10 external affects. This is particularly important when the resonant circuit is built in a container or carrier which otherwise protects the coils from external damage.

Figures 2E and 2F are similar to Fig. 2A and 2B except
15 that a resistance, in particular a temperature sensitive resistance, 26 has been inserted between the coils 21,22.

Figure 2H shows a substrate 23 supplied from a drum 27 to three sets A, B, C of rotational impression drums.
20

Drum set A applies the coils 21,22 (see Figure 2G) to the substrate. Drum set B applies an insulating material exposing free coil terminations 28,29, and drum set C applies the resistance 26, e.g. a temperature sensitive
25 material, in parallel with the coils. To the left of Figure 2H there is shown a folding operation step.

Figure 2I shows a substrate 23 supplied from a drum 27 to two sets A and B of rotation impression drums. Drum set A
30 applies coils 21,22 to the substrate (see figure 2E). Drum set B applies the resistance 26 in series with the coils.

Figure 2J shows an embodiment of the folding process step.



Figure 3A is similar to Fig. 2A, except for the direction of folding and insertion of a spacer.

Figure 3B shows another resonant circuit in which the substrate is folded in the opposite direction of that shown in Figure 2A, and in which a spacer 26 of a suitable insulating material, e.g. a textile, a paper, or a suitable plastic, is provided in between the folded parts as shown in Fig. 3C. The center areas 24, 25 make up the plates of a capacitor which are capacitatively connected as shown in Figs. 3D and 3E.

The spacer may contain a coil correcting metallic conductor.

An advantage of this embodiment is that the coils are better protected against accidental damage, which is useful when the resonant circuit is carried by e.g. a sticker.

Further, the spacer can be designed to have specific fluid penetration properties, e.g. built-in fluid channels which allow an easy access of the fluid to affect the characteristics of the resonant circuit, e.g. the capacitance. Also, the spacer can be a carrier with suitable mechanical properties, e.g. to function as a construction material.

Figure 4A-4D show different embodiments of the resonant circuit.

Figure 4A shows an embodiment wherein a material 31 between two coils 21, 22, e.g. the substrate 23 shown in Figures 2A-2D or the spacer 26 shown in Fig. 3D-3E, is able to absorb the fluid 12 which especially affects the capacitance of the resonant circuit 11. This embodiment



is e.g. for uses wherein the fluid substantially changes the dielectric constant of the material between the coil windings 21, 22 and/or plates 24, 25, or the leakage resistance therebetween, e.g. when the fluid is a liquid
5 such as water or urine, or e.g. an organic solvent or oil; or when the fluid is a gas which differ from that which is present in the resonant circuit, e.g. air.

Figure 4B shows another embodiment wherein the material
10 32 between the two coils 21, 22 is not absorbing the fluid, whereby especially the conductance between the windings of the coil is affected. Figure 4C shows a top view thereof. This embodiment is e.g. for uses wherein the fluid is an electrically conducting fluid such as an
15 electrolyte.

Figure 4D shows another embodiment wherein the coil windings 21, 22 are embedded in a fluid absorbing environment 33.
20

Figure 5 shows another embodiment of the resonant circuit wherein the resonant circuit comprises two conductors located in a fluid absorbing material 53. Originally, the two conductors are not connected. When the fluid
25 absorbing material 53 absorbs sufficient electric conducting fluid 12, or a fluid which affects the leak current between the two conductors, the resonant circuit becomes able to resonate and receive electromagnetic energy from the oscillator.

30 Figures 6, 7, and 8A and 8B show different embodiments of applications of the resonant circuit, in particular for a sensing device according to the present invention.

35 Figure 6 shows a resonant circuit 11 embedded in a diaper or bandage 60 able to absorb the fluid, e.g. urine or a



body fluid, e.g. blood from a wound, by an absorbing material 61.

Figure 7 shows a laminated resonant circuit 11 having the resonant circuit 11 embedded between two materials 71, 72 of which one 71 is compatible with human skin and allows humidity and body fluid to penetrate. The laminated circuit can be applied directly on the skin wholly or partly covering a bleeding wound 73. It can be fixed to the skin either by means of a plaster or a tape 75.

Figure 8A shows an attachable resonant circuit 80 of the type shown in Figure 7 wherein the resonant circuit is embedded between a carrier material wholly or partly covered with adhesive, e.g. a skin compatible adhesive, material 81 for affixing the resonant circuit to e.g. the skin, or a diaper, and a releasable cover material 82 covering said adhesive and to be removed without destroying the adhesive properties thereof before use. It should be noted that the resonant circuit can be of the laminated type, or it can be directly adhered to or incorporated in the carrier material.

Fig. 8B shows several attachable resonant circuits 80 similar to that of Fig. 8A provided on an "endless" releasably cover material 81, particularly useful for fast and easy handling and application of many sensing devices, e.g. fluid or temperature, to a human body or an article, e.g. a diaper.

Figures 9A and 9B with cross sectional views show application of a fluid sensing device, i.e. a resonant circuit 91 e.g. of the type shown in Figure 4B or Figure 7, contained in a container 92, e.g. a collection bag, or drain bag, for monitoring the level of the collected fluid, e.g. drain fluid 12. The characteristics of the



resonant circuit is changed upon contact with the fluid, see Fig. 9B.

Figures 10A and 10B show another application of a resonant circuit 101, e.g. of the type shown in Figures 3A-3E, attached to the outside of a container 102, e.g. an infusion bag, at the fluid level A-A for monitoring the level of a fluid 12 contained therein, when the level of the fluid sinks below the level A-A, the ability of the resonant circuit to receive electromagnetic energy from an oscillator changes because the capacitor between the serially connected coils changes as the container sides collapse against each other. This embodiment can be used to monitor infusion liquids and indicate an alarm, when the infusion bag is empty.

Figure 11 shows typical applications of the method and apparatus according to the invention.

A human is positioned within an external inductor 111 of the oscillator 112 which is powered externally and electronically communicating with external electronics through electrical connections 113, e.g. power cables and/or communication lines.

A resonant circuit 114 e.g. of the type shown in Figure 7 is partly covering a wound which may leak body fluid.

A resonant circuit 115 e.g. of the type being embedded in a diaper shown in Figure 6 is placed to monitor a leak of body fluid such as incontinence urine or faeces.

Further, a resonant circuit 116 is applied in a fluid level detector of a collected body fluid from a drain.



Also, resonant circuits 117 and 118 are applied in two infusion containers for monitoring when they are empty.

Finally, resonant circuit 119, a temperature sensor, is applied to the body.

Figure 12A shows a similar arrangement of resonant circuits as in Figure 11 wherein the external inductor 111 is exchanged with an antenna 121.

In Figure 12B a walking patient who is being monitored for fluid and temperature according to the invention is illustrated.

If all four applications of the resonant circuits are being applied at the same location as shown in Figures 11 and 12, then the characteristics of the resonant circuits are chosen to provide different responses for the individual resonant circuits, e.g. different resonance frequencies, so that the risk of false interpretation of the oscillator characteristics is avoided or minimized.

Figures 13, 14, and 15 show different configurations of the external inductor of the oscillator for uses of the resonant circuits in several locations. For simplicity, the uses of resonant circuits as level detectors, empty infusion container detector, bleeding detectors, etc. are not shown.

In Figure 13 there is one oscillator/external inductor and one resonant circuit or optionally a set of more resonant circuits for each location, e.g. for each patient.

In Figure 14, there is one oscillator/external inductor, but several resonant circuits for several locations. This



application presumes e.g. different resonance frequencies or patterns of frequencies for the different resonant circuits.

- 5 In Figure 15, there is one oscillator, the inductor of which is connected to an antenna. This application presumes e.g. different resonance frequencies or patterns of frequencies for different circuits. It provides the possibility that patients can move around more freely as they are not bound to a certain confirmed area as that shown in Figure 14.

- 15 Combinations of these configurations are particularly preferred. In particular, consideration of radio frequencies available and allowed at the site of application may exclude application of an antenna in order to limit any undesired interference with radiowave sensitive equipment.

- 20 A particularly preferred combination consists in combining the configurations Figure 13 and Figure 14 which is particular useful in situations where typically elderly people are being monitored in hospitals or nursing homes. In these applications, some patients or elderly are lying in bed and some walk around in confined areas. However, both of these categories of patients or elderly can be supervised from a central monitoring facility.

- 30 Thus, e.g. elderly can be supervised for a leak of body fluid and taken care of by proper action, e.g. replacement of a diaper, which considerably improves their well-being and comfort.

- 35 Fig. 16 shows a particular application where the resonant circuit is typically embedded in a diaper for babies put



- 29 -

to sleep in a baby carriage. The oscillator 161 typically has an external inductor 162 arranged to a remote transmitter/receiver 164, 165.

5 Alternatively, if the baby carriage does not provide an electromagnetic shielding effect, and suitable radio frequencies are available, the oscillator can be remotely placed and wireless sensing the characteristics of the resonant circuit in the diaper and detecting whether the
10 diaper has reached its level of discomfort.

In particular embodiments of the invention it surprisingly turns out that electrically conducting connectors between the sensor of the fluid and the detection electronics, and
15 battery power supply of the sensor, and receiver circuits for receiving and detecting responses of resonant circuits of the sensors can be avoided.

This provides a number of advantages e.g. that the sensor of
20 the fluid can be separated from the detection electronics for detecting changes in the sensor. This is particularly advantageous when monitoring bodies containing fluid wherein the sensor and the detection electronics used cannot be connected permanently by electrically conduction
25 connectors, or when they can only be connected by such connectors with great difficulties or inconveniences. Also, the oscillators and detection electronics can be simplified.

Embodiments of the described invention may provide uses of
30 the described method or the described apparatus for detection of fluid level in one or more containers, in particular incontinence containers, specifically diapers;



- 30 -

and use for detecting whether a container containing a fluid has been emptied for the fluid in particular emptying of an infusion containing use for monitoring leak of fluid from a container, or a human or animal body, in particular from a human suffering from urinary and/or faecal incontinence; whereby the health care personnel can monitor the hygienic condition of e.g. a diaper. When a body leak has been detected proper care of e.g. changing the diaper can then be taken.

10

The described invention also involves a method and an apparatus for detection of a temperature, or a temperature difference, and use thereof.

15 These methods may involve method providing one or more oscillators transmitting electromagnetic energy; providing one or more resonant circuits receiving electromagnetic energy from the oscillators; exposing the one or more resonant circuits to the temperature to be detected so that
20 the receptions of the electromagnetic energy of the resonant circuits are changed; and detecting changes of the transmissions of electromagnetic energy of the oscillators by changes in one or more characteristics thereof upon the changes in the receptions of the electromagnetic energy of
25 the resonant circuits, whereby receiver circuits for receiving and detecting responses of the resonant circuits can be avoided.

The detection of temperature may be effected by the described apparatus comprising one or more oscillators for transmitting electromagnetic energy; one or more resonant circuits for receiving electromagnetic energy from said



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oscillators; and one or more detectors for detecting changes in one or more characteristics of the one or more oscillators upon changes in characteristics of the resonant circuits by exposure thereof to a temperature, whereby a
5 simplified apparatus is obtained which avoids receiver circuits for receiving and detecting responses of the resonant circuits.

It surprisingly turns out that electrically conducting
10 connectors between the sensor of the temperature and the detection electronics, and battery power supply of the sensor, and receiver circuits for receiving and detecting responses of resonant circuits of the sensors can be avoided.

15 This provides a number of advantages e.g. that the sensor of the temperature can be separated from the detection electronics for detecting changes in the sensor. This is particularly advantageous when monitoring bodies for a
20 temperature wherein the sensor and the detection electronics used cannot be connected permanently by electrically conduction connectors, or when they can only be connected by such connectors with great difficulties or inconveniences. Also, the oscillators and detection
25 electronics can be simplified.

In addition to the use of the fluid detection method and apparatus described above, the described invention additionally provides the use of the method and apparatus as
30 claimed for detection of a temperature.



Temperature sensors comprising temperature sensitive

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resonant circuits may be designed to change their impedances at predetermined temperatures, typically in the range 35-42°C, preferably 36-40°C, most preferred 36-38°C, particularly about 37°C.

5

In addition to monitor patients or elderly for leak of body fluid, or supply of fluid to the body, their temperature can be monitored.

10 Sensors usable for such methods and apparatus in sensing external parameters, have been described more specifically sensing devices comprising resonant circuits which are responsive to parameters that are able to influence the impedance thereof, e.g. responsive to a fluid or a
15 temperature.

20 The described sensing device may comprise a substrate having a back side and a front side, and at least one electrical conducting means, comprising an inductance positioned on or embedded in said back side, front side, or both, of the substrate; said substrate further having at least two parts in a mutual overlaying relationship, so that said conducting means together with at least a part of the substrate provide a capacitance; said inductance and capacitance being
25 electrically connected to form a resonant circuit; and said conducting means being exposed to the external parameter to affect a parameter of said resonant circuit, whereby there is provided a resonant circuit which is easy to manufacture, e.g. by mass manufacturing using continuous substrate coating techniques.
30



The two folded sides of the substrate may be rotatable

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around the folding axis, whereby it is obtained that the capacitance formed therebetween can be varied. This embodiment is particularly useful when the sensing device is tagged to two sides of a container which sides can get
5 closer or further apart depending on the container having a content, e.g. fluid or not. An example being a urine collection bag having a sensing device tagged to the edge thereof, the sides of the bag getting further apart as the bag is being filled.

10

The described sensing device may comprise accession means for a fluid to affect the impedance of the resonant circuit thereby making the sensor particularly suited for detecting a fluid.

15

In another described embodiment, the sensing device comprises a temperature sensitive means thereby allowing remote and wireless monitoring of the temperature of e.g. a patient or an elderly.

20

Another aspect of the described invention relates to an article comprising a sensing device, including a transmitter/receiver combination.

25 Preferred articles include, but are not limited to, articles for containing or for taking up fluid or for delivering fluid; and articles for measuring temperature; such container e.g. being monitored for being filled or being emptied.



30 a preferred embodiment, the article consists of an hygienic article for healthy development and maintenance of

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health.

In a particularly preferred embodiment, the article consists of an absorbent or a bandage in form of a wrap or a trapping
5 used to protect, cover or immobilise an injured or diseased part of a human or an animal, or used during surgery.

In a particularly preferred embodiment, the article consists of an absorbent for urine or faeces, in particular diaper.

10

Articles comprising a sensing device as described in the present invention are preferably used in a method of monitoring hygienic conditions of one or more patients. The method may comprise applying one or more hygienic articles
15 according to the invention to one or more patients, each article having a sensing device with a resonant circuit that differ from each other; and transmitting electromagnetic energy to said resonant circuits.

20 In an embodiment, the method further comprises monitoring at least one response of said resonant circuits, thereby allowing the prior art techniques of interrogating the resonant circuit to be used.

25 In a preferred embodiment, the method further comprises monitoring changes of the transmission of electromagnetic energy of one or more oscillators transmitting electromagnetic energy to said resonant circuits, thereby obtaining the advantages of the method according to the
30 present invention.



Sensing devices according to the present invention do not

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necessarily depend on the method of detecting changes of one or more characteristics of the resonant circuit, i.e. for example by detecting the change of the transmission of electromagnetic energy of the oscillators according to the invention, or by detecting a response of the resonant circuit according to prior art methods. However, the specific resonant circuit used typically depends on the parameter to be detected, e.g. fluid or temperature.

10 Known methods include those referenced in US 4 646 066, e.g. US 4 321 586.

Generally, in the described method and apparatus for detecting a fluid, a resonant circuit has one or more characteristics which change by contact between the resonant circuit and a fluid.

In embodiments of the invention relating to detecting a temperature or a temperature difference, a resonant circuit may have one or more characteristics which change by exposing the resonant circuit to different temperatures.

In a preferred embodiment of both aspects, the characteristics comprises resistance, capacity, inductance, or any derivative thereof.

By contact of the resonant circuit with the fluid, or by exposing the resonant circuit to different temperatures, one or more of the characteristics resistance R, capacitance C and inductance L, or any derivative thereof, e.g. the resonance frequency $\omega_0 = (LC)^{-1/2}$, or higher harmonics thereof, or the quality factor $Q = \omega L/R$, e.g. at resonance $\omega = \omega_0$, change.



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When one or more of the characteristics change, the ability of the resonant circuit to receive electromagnetic energy changes. This can be detected by detecting changes in one or more characteristics of one or more oscillators transmitting electromagnetic energy to said resonant circuit.

Generally, sensing devices can be manufactured in any suitable way that allow the external parameters to affect the impedance of the respective resonant circuits.

In the particular aspect of the invention relating to detecting a fluid, resonant circuits can be prepared in any suitable way that ensures the penetration of fluid into the resonant circuit to such an extent that one or more of its characteristics are changed.

In the particular aspect of the method of detecting a fluid, the change of characteristics of the resonant circuit causes a detectable change in one or more of the characteristics of the one or more oscillators.

In a preferred embodiment, the resonant circuit consists of a coil having separated windings which can receive the fluid and short cut the circuit.

The windings can be of any suitable material. In a preferred embodiment, the windings are made of an electrically conducting material selected from the group consisting of metals such as aluminium, copper, tin; an electrically conducting polymer such as polyaniline; and an



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electrically conducting polymer blend such as poly(p-phenylene vinylene), polyacrylamide, polyaniline and polyethylene, or combinations of these.

- 5 Specifically useful electric conducting polymers include a flexible, crease resistant, one component, carbon filled ink and coating sold by Emerson & Cuming Specialty Polymers under the trademark Amicon C 932-74. Another useful electric conducting polymer is a highly flexible, crease
10 resistant, one component, silver filled, ink and coating sold by Wacker Chemikemi under the trademark Elastosil N 189. Both products are environmentally acceptable.

- 15 In the particular aspect of detecting temperature changes, the resonant circuits can be prepared in any suitable way that ensures the influence of different temperatures to affect the impedance of the resonant circuit to such an extent that one or more of its characteristics are changed.

- 20 In the particular aspect of the method of detecting a temperature change, the change of the characteristics of the resonant circuit causes a detectable change in one or more of the characteristics of the one or more oscillators.

- 25 In a preferred embodiment, the resonant circuit consists of a coil having separated windings of which the resistance, inductance, or both, are sensitive to temperature.

- 30 The windings can be of any suitable material. In a preferred embodiment, the windings are made of a temperature sensitive, electrically conducting material.



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In another preferred embodiment, the coil has two parts serially connected through a temperature sensitive resistance.

- 5 The fluid sensing device can be placed in any suitable position to detect the desired fluid. In preferred embodiments, the fluid sensing device is contained in or attached onto a container; or it is embedded in a diaper; or it is embedded in a carrier with an adhesive, such as a
10 sticker, to be attached on a desired location, e.g. onto said container or diaper.

- Several resonant circuits can be positioned in one location to encode for given patterns of frequencies, e.g. several
15 small resonant circuits of e.g. different frequencies placed in a diaper can provide a unique identification of e.g. individual patients or elderly being monitored in a hospital or a nursing home.

- 20 In embodiments of the invention an oscillator operates in functional proximity of a resonant circuit.

- By "functional proximity of a resonant circuit" is intended to mean that an oscillator in one location radiates
25 electromagnetic energy, e.g. in form of radiowaves or microwaves, which can be fully or partly transferred to a resonant circuit in another location.

- Generally, any suitable oscillator can be used, i.e. an
30 oscillator which is able to produce electromagnetic oscillations and to emit electromagnetic energy e.g. in form of radiowaves or microwaves which is fully or partly



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received by the resonant circuit.

It should be understood that more than one oscillator can operate in functional proximity of said resonant circuits
5 e.g. if more oscillators operates at different frequency ranges, and if changes in different characteristics of the resonant circuit are to be detected.

Generally, an oscillator comprises an generator which
10 generates a high frequency signal of radiant energy e.g. an ac current or voltage, or an impulse, of a frequency around that of the resonant circuit. Generators can be any suitable generator known in the art, e.g. radio frequency signal generators.

15 In a preferred embodiment, the oscillator comprises a generator generating a signal of electromagnetic energy of a frequency around that of the resonant circuit.

20 An oscillator may comprise one or more inductors. The inductors can be internal or external to a cabinet housing the oscillator. Preferably there is one or more inductors for each different bands of operation for each resonant circuit. Preferably more inductors can be interchanged
25 either manually or automatically. The inductors can be of any suitable form. In a preferred embodiment the inductors are external inductors in form coils.

Functional proximity between the oscillators and the
30 resonant circuits can be achieved in any suitable way. In a preferred embodiment, the inductors are external inductors in form of coils which surrounds the resonant circuit. In a



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particularly preferred embodiment, the coils are embedded in a bed for monitoring leak of body fluids of a human.

In another described embodiment, the oscillators comprise
5 one or more antennas whereby the direction of the
electromagnetic radiation, e.g. radiowaves, can be more
accurately defined. An antenna can be any suitable antenna
known in the art, e.g. a dipole. In a preferred embodiment,
the antenna comprises a radiator element, transmission
10 lines, and optional transformers, coupled to the inductor,
or constituting a part of the inductor.

The described apparatus may be in the form of detectors for
detecting one or more changes in one or more characteristics
15 of said oscillators upon changes in the characteristics of
one or more resonant circuits.

The characteristics of the oscillators comprise any suitable
characteristic.

20 In a preferred embodiment the characteristics of the
oscillator comprise current, voltage, or a derivative
thereof such as power, whereby one or more characteristics,
or derivatives thereof, of the resonant circuit are
25 detected, e.g. change in frequency, particularly the
resonance frequency; change in quality factor; and wholly or
partial suppression or restoration of any of these.

In a preferred embodiment one or more of the detectors
30 detect an increase or a decrease of energy loss of one or
more of the oscillators.



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The reference to any prior art in this specification is not, and should not be taken as, an acknowledgment or any form of suggestion that that prior art forms part of the common general knowledge in Australia.

5

Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" and "comprising", will be understood to imply the inclusion of a stated integer or

10 step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.



THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. An article for containing a fluid; said article comprising a wireless fluid sensing device for sensing taking up or delivery of the fluid by the article; said fluid sensing device including at least one resonant circuit having a resonant circuit parameter that will change by the fluid contacting the resonant circuit; and means which can be wirelessly and inductively coupled to the resonance circuit and emit electromagnetic signals to excite the resonance circuit, and which wirelessly and inductively can detect a change in said parameter; and said sensing device being arranged in a position on the article suitable to sense taking up or delivery of fluid by the article.
2. An article as claimed in claim 1 wherein the sensing device is contained in or attached thereon.
3. An article as claimed in any one of claims 1 or 2 wherein the sensing device is embedded in a carrier with an adhesive.
4. An article as claimed in any one of claims 1 to 3 consisting of a container.
5. An article as claimed in any one of claims 1 to 3 consisting of an absorbent.
6. An article as claimed in claim 5 consisting of a diaper or a bandage.
7. An article as claimed in any one of claims 1 to 6 wherein the fluid is urine, facea, or blood.
8. An article as claimed in any one of claims 1 to 4



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wherein the fluid is an infusion liquid.

9. A wireless fluid sensing device for sensing taking up
or delivery of a fluid by an article for containing a fluid;
5 said sensing device including at least one resonant circuit
having a resonant circuit parameter that will change by the
fluid contacting the resonant circuit; and means permitting
wireless detection of a change in said parameter; and said
sensing device being arranged in a position suitable to
10 monitor filling or emptying of the fluid; the sensing device
comprising:

a substrate having a back side and a front side, and at
least one electrical conducting means, comprising an
inductance, positioned on or embedded in said back side,
15 front side, or both, of the substrate,

said substrate further having at least two parts in a
mutual overlaying relationship, so that said conducting
means together with at least a part of the substrate provide
a capacitance, said inductance and capacitance being
20 electrically interconnected to form said at least one
resonant circuit; and means permitting wireless detection of
a change in said parameter.

10. A sensing device according to claim 9 wherein said
25 resonant circuit further comprises a resistance means.

11. A sensing device according to claim 10 wherein said
resistance means consists of a thermally sensitive resistor.

30 12. A sensing device according to claims 9 to 11 wherein
said capacitance is constituted by a pair of electrodes and
spacer means.



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13. A sensing device according to claim 12 wherein there is a variable distance between said pair of electrodes.

14. A sensing device according to claim 12 wherein said
5 spacer means is an absorber.

15. A sensing device according to claims 9 to 14 wherein said at least two parts of the substrate are brought in a mutual overlaying relationship by folding.

10

16. A sensing device according to claims 9 to 15 wherein the one or more resonant circuits consist of coils having separated windings for receiving the fluid and short cutting the circuit.

15

17. A sensing device according to claim 16 wherein the windings are made of an electrically conducting material selected from the group consisting of metals such as aluminium, copper, and tin; electrically conducting polymers
20 such as polyaniline; or electrically conducting polymer blends such as blends of poly(p-phenylene vinylene), polyacrylamide, polyaniline and polyethylene.

25

18. A sensing device according to claims 9 to 17 wherein said means permitting wireless detection of a change in said parameter comprises an electromagnetic antenna.

19. A system for monitoring a fluid flowing to or from a human or animal body, the system comprising:

(a) one or more articles for containing the fluid as claimed in claims 1 to 8, each comprising a wireless



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fluid sensing device as claimed in claims 9 to 16;

(b) one or more oscillators for transmitting electromagnetic energy to one or more resonant circuits of said one or more articles; and

5 (c) one or more detectors for detecting changes in one or more characteristics of the one or more oscillators upon changes in characteristics of the one or more resonant circuits.

10 20. A system according to claim 19 wherein the one or more oscillators comprise one or more inductors for each different band of operation for each resonant circuit.

15 21. A system according to claim 20 wherein the inductors can be interchanged either manually or automatically.

22. A system according to claims 20 and 21 wherein the inductors are external inductors in the form of coils.

20 23. A system according to claims 19 to 22 wherein the one or more oscillators are connected to one or more antennas.

24. A system according to claim 23 wherein the antennas comprise a radiator element, transmission lines, and
25 optional transformers, coupled to the inductor, or constituting a part of the inductor.

25. A system according to claims 19 to 24 wherein the one or more detectors detect an increase of energy loss of one
30 or more of the oscillators.



26. A system according to claims 19 to 24 wherein the one

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or more detectors detect a decrease of energy loss of one or more of the oscillators.

27. A system according to claims 19 to 26 wherein said
5 resonant circuit further comprises a resistance means.

28. A system according to claim 27 wherein said resistance means consists of a thermally sensitive resistor.

10 29. A system according to claims 19 to 28 wherein said capacitance is constituted by a pair of electrodes and a spacer means.

30. A system according to claim 29 wherein there is a
15 variable distance between said pair of electrodes.

31. A system according to claim 29 wherein said spacer means is an absorber.

20 32. A system according to claims 19 to 31 wherein the one or more oscillators operate at ranges of frequencies comprising the resonant frequencies of the resonant circuits.

25 33. Use of a system according to claims 19 to 32 for development and maintenance of health of a patient, an elderly, or a baby.

34. Use according to claim 33 wherein the patient suffers from urinary and/or faecal incontinence.

35. Use according to claim 33 or 34 wherein more patients



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are monitored and said at least one resonant circuit differs from each other for each patient.

5 DATED this 20th day of March, 2002
BENT THORNING BENSEN A/S
By its patent attorneys
Davies Collison Cave

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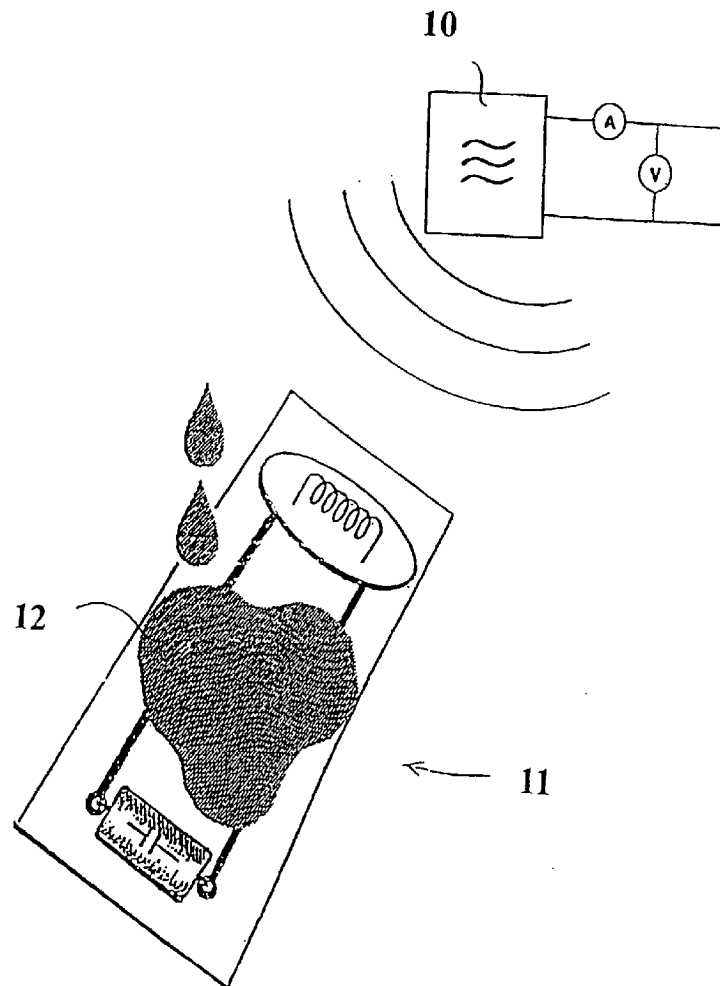


FIG.1

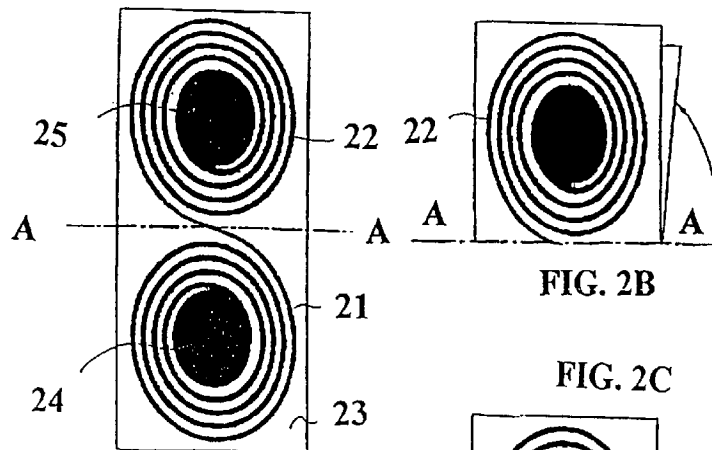


FIG. 2A

FIG. 2B

FIG. 2C

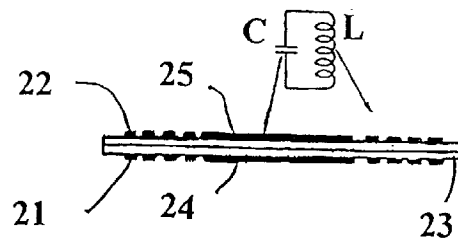
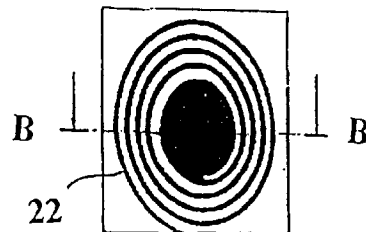
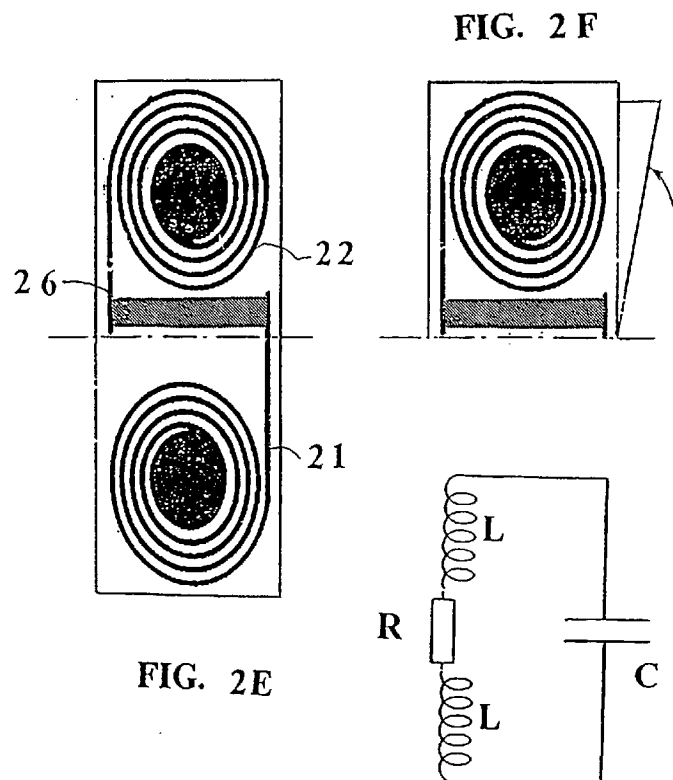


FIG. 2D



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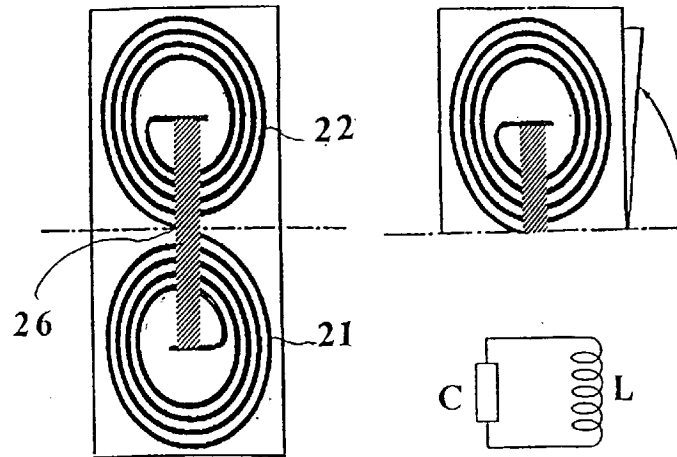


FIG. 2 G

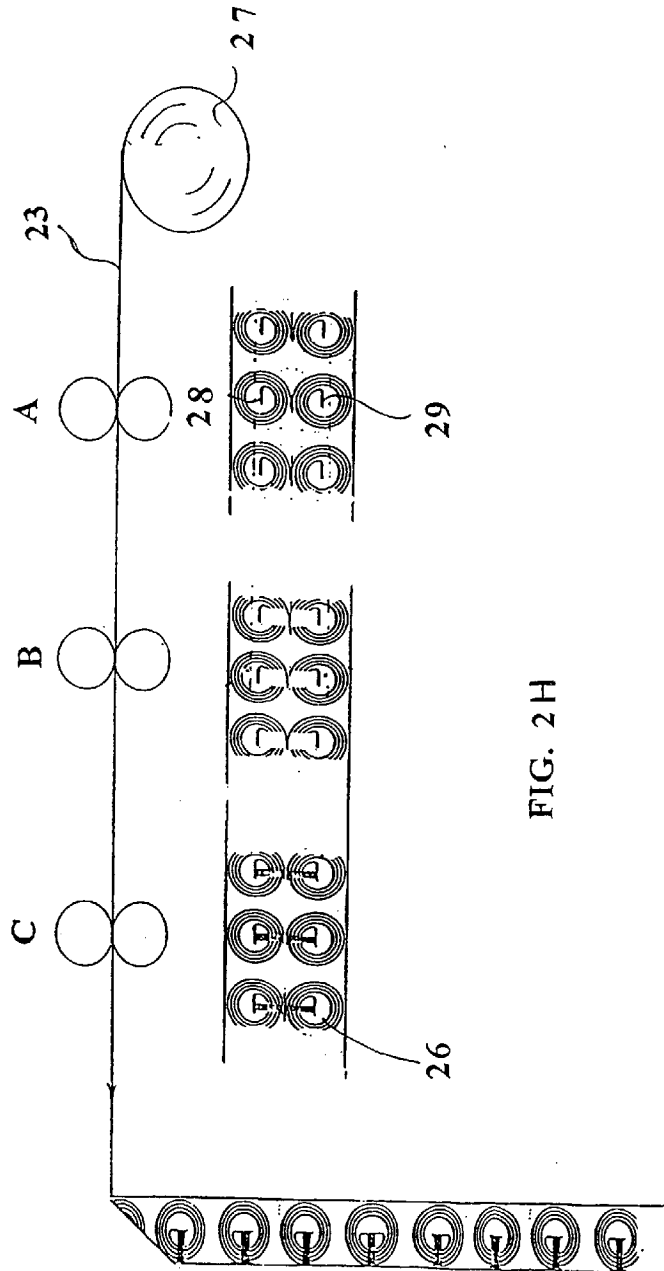


FIG. 2H

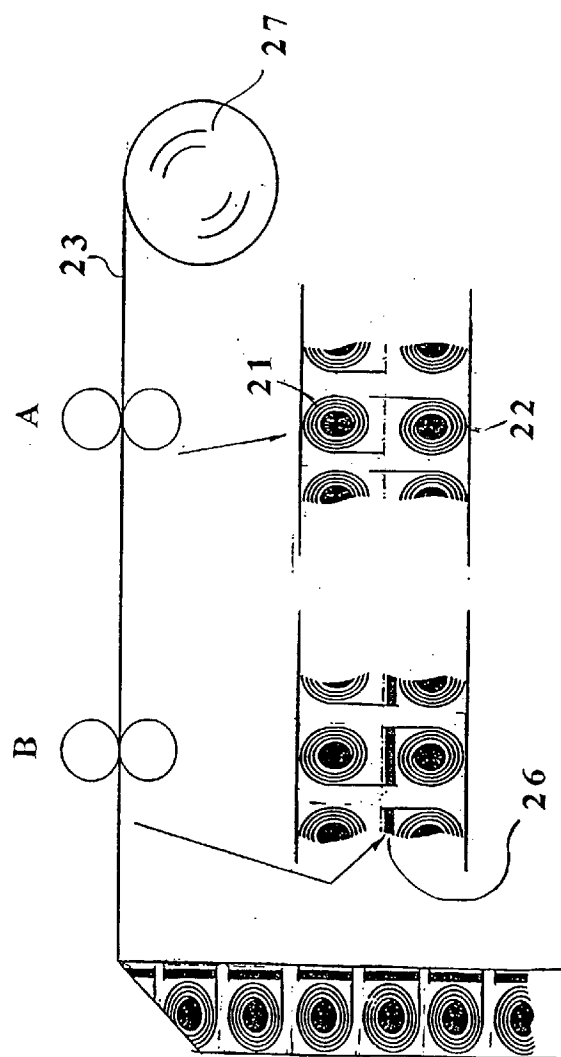


FIG. 2I

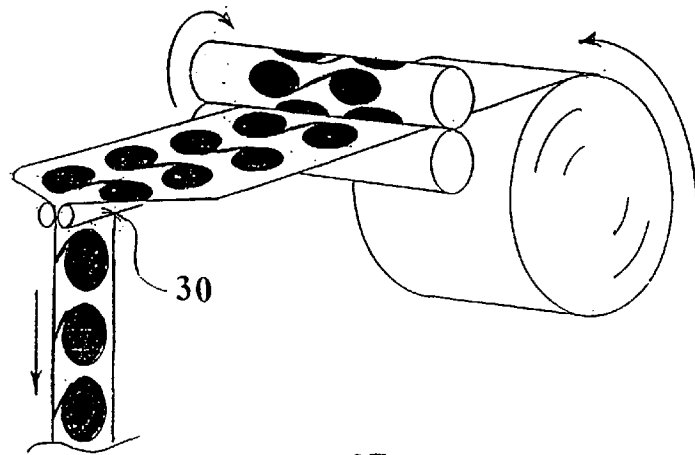
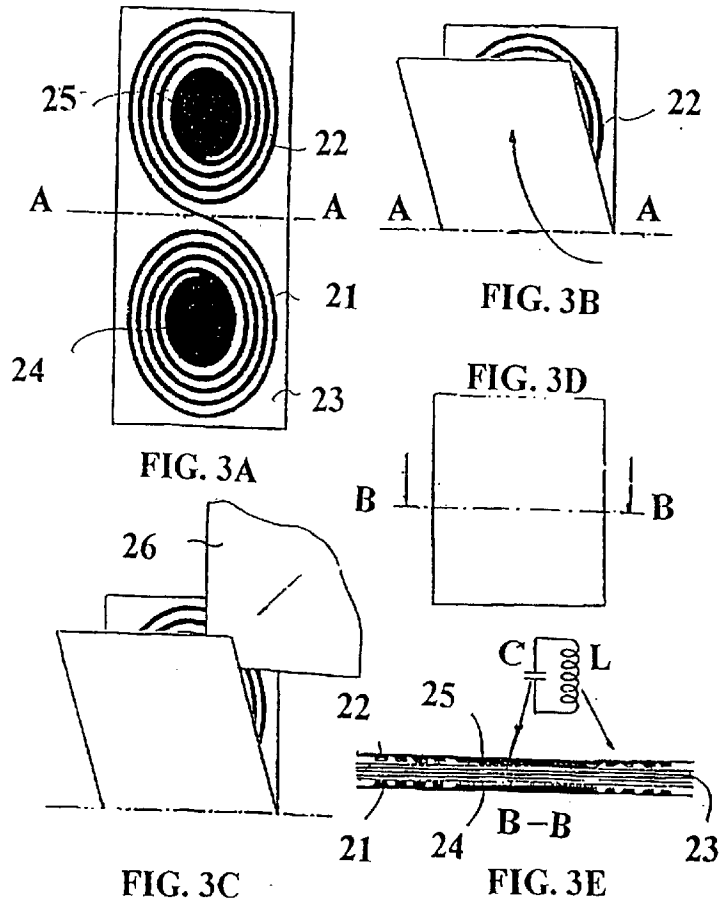
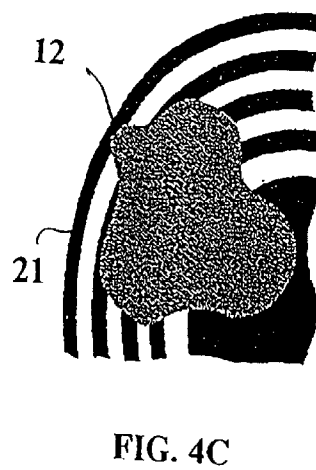
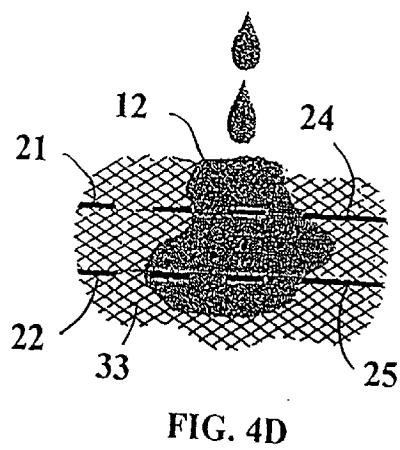
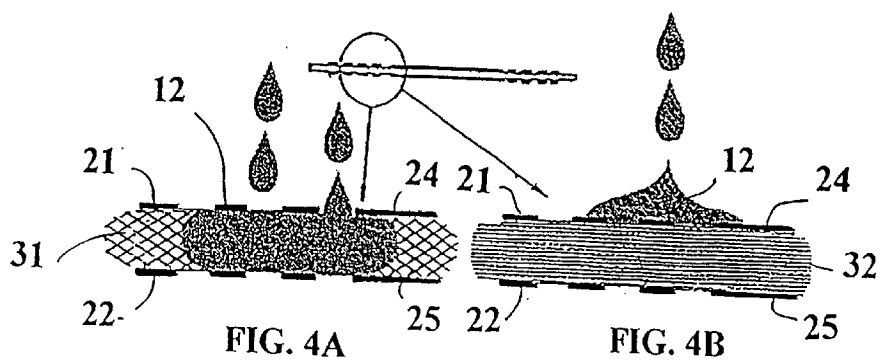


FIG. 2J





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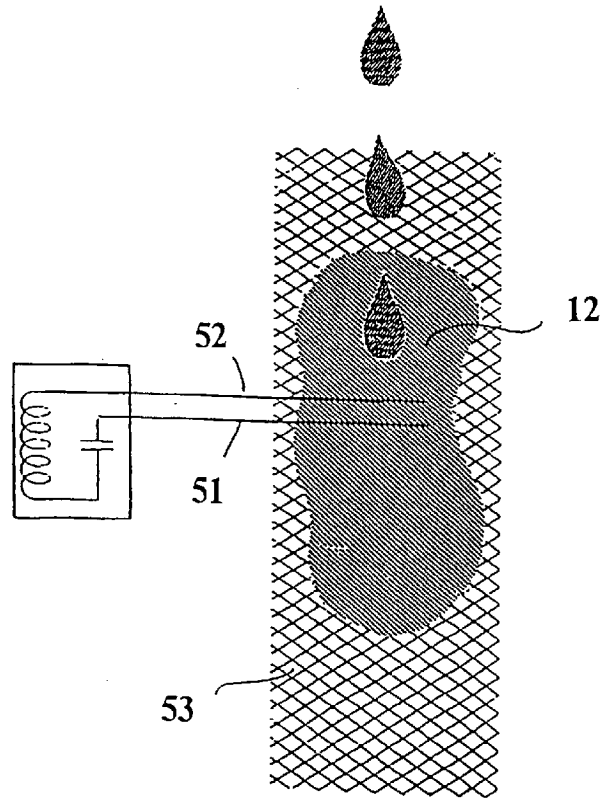


FIG. 5

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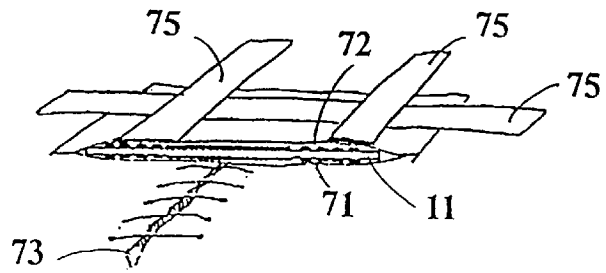
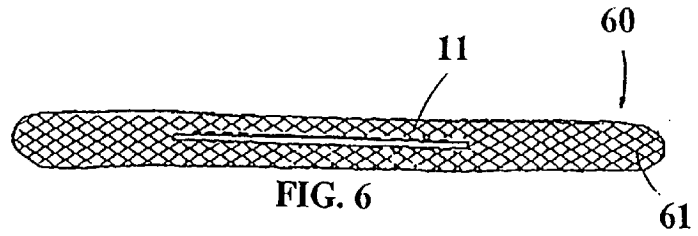


FIG. 7

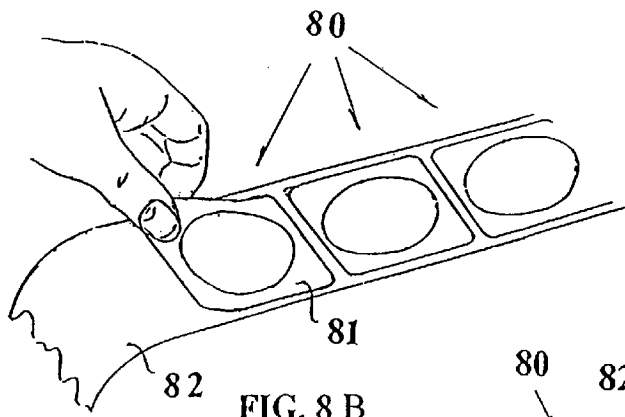


FIG. 8 B

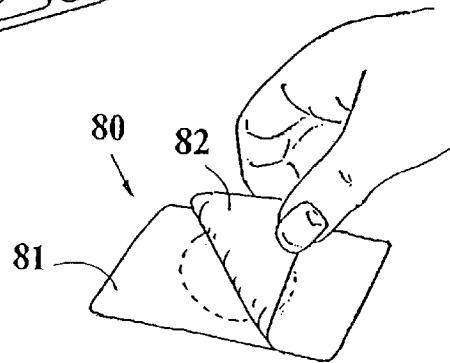


FIG. 8 A

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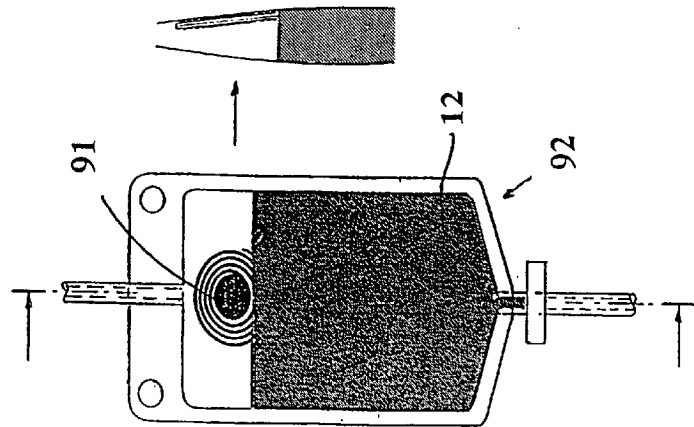


FIG. 9B

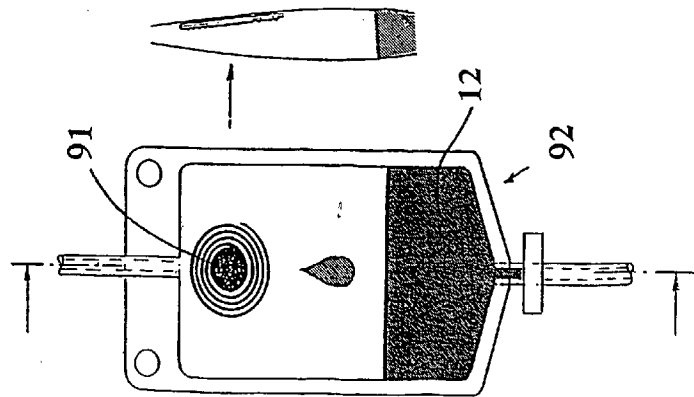


FIG. 9A

SUBSTITUTE SHEET (RULE 26)

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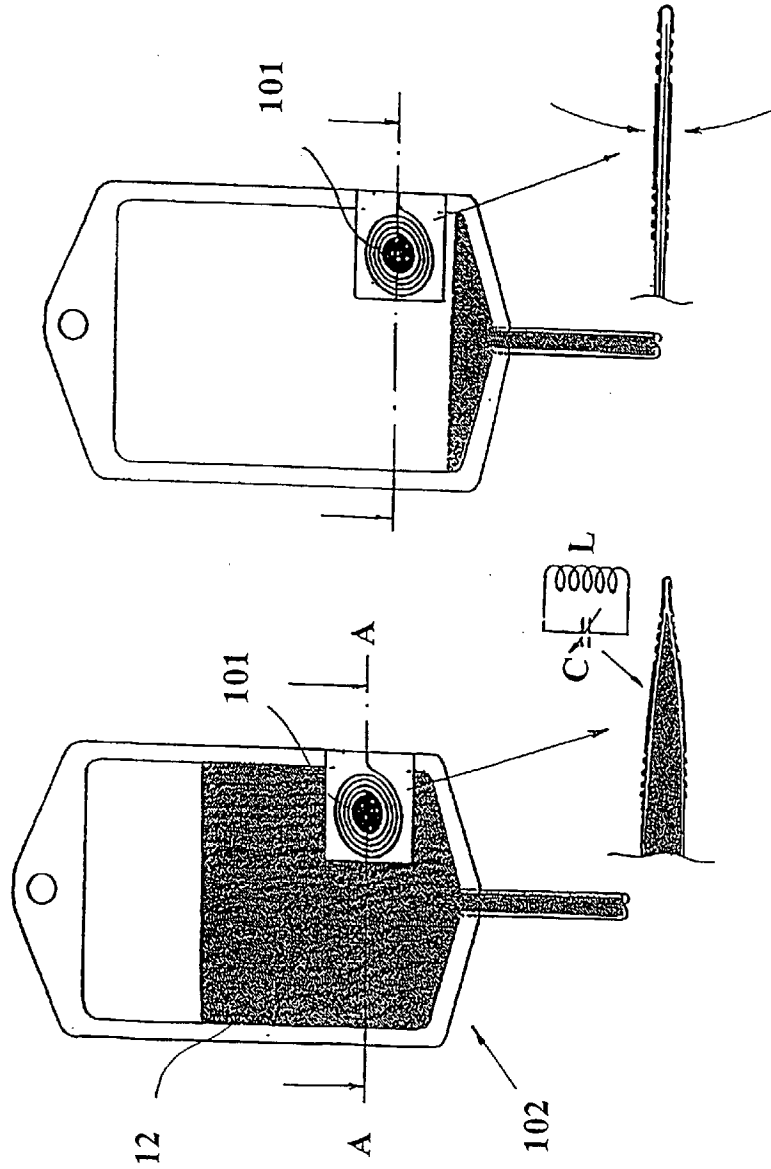


FIG. 10B

FIG. 10A

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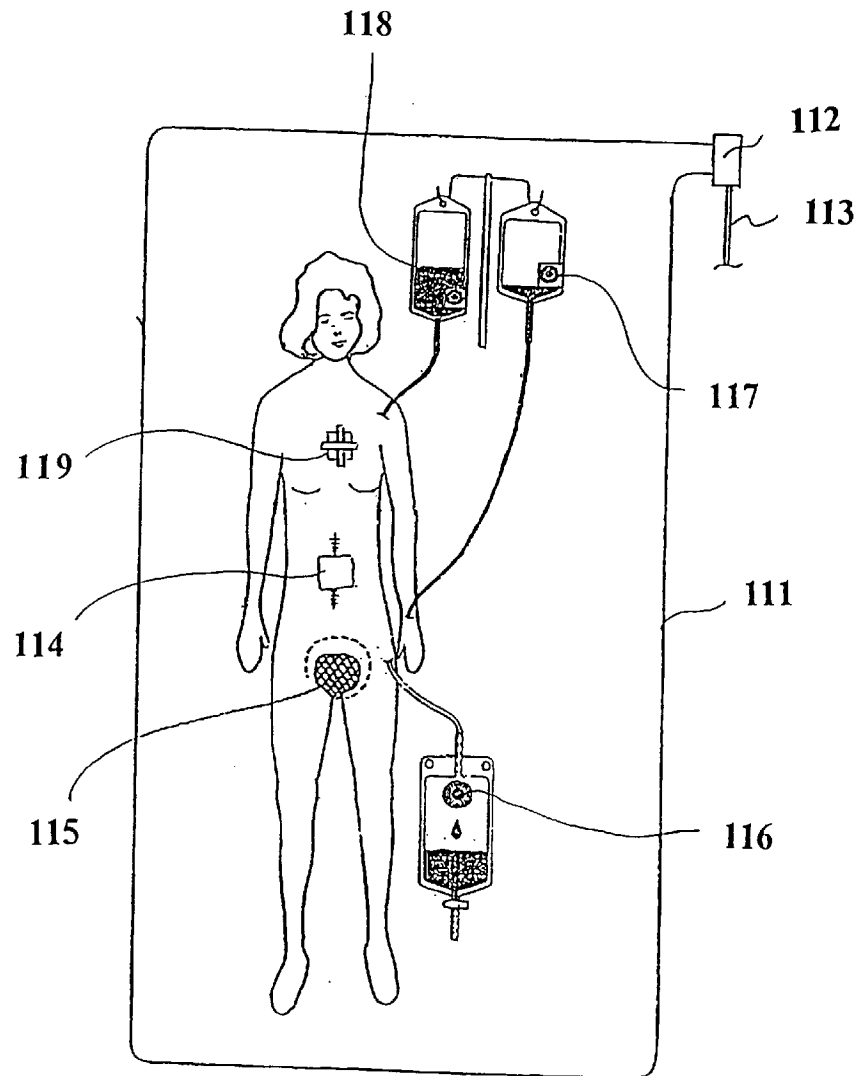


FIG. 11

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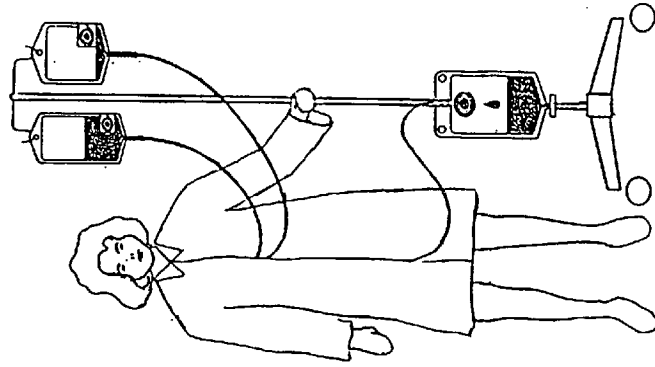


FIG. 12 B

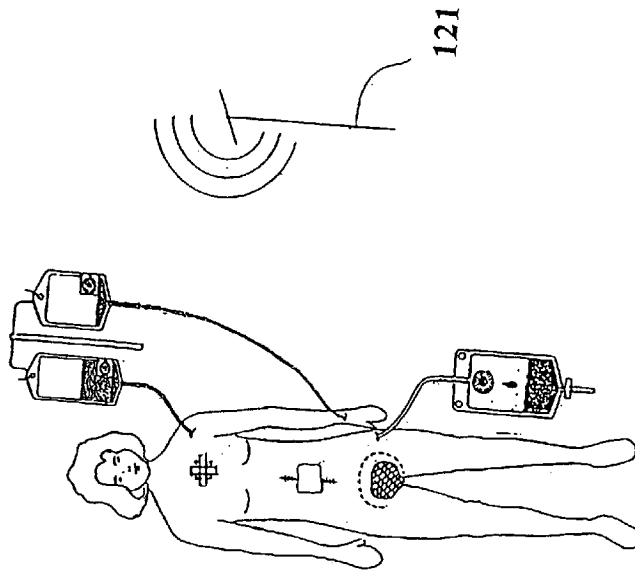


FIG. 12 A

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FIG. 13

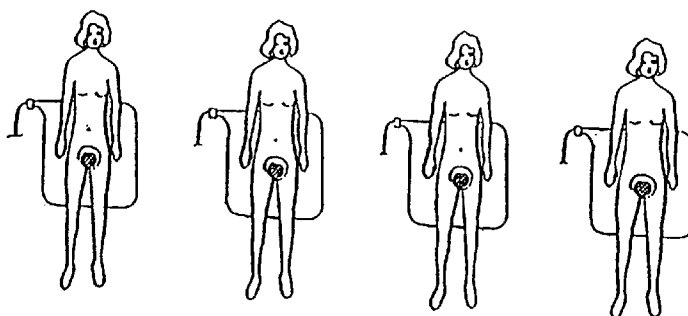


FIG. 14

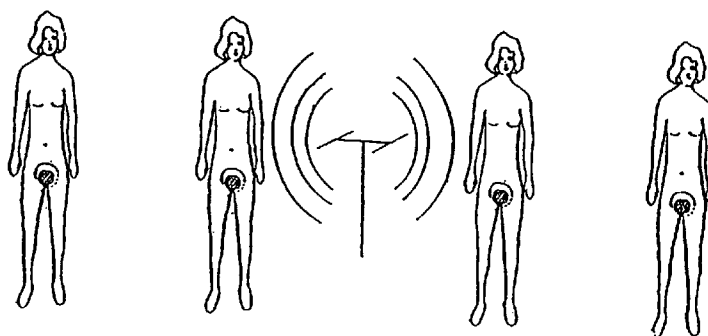
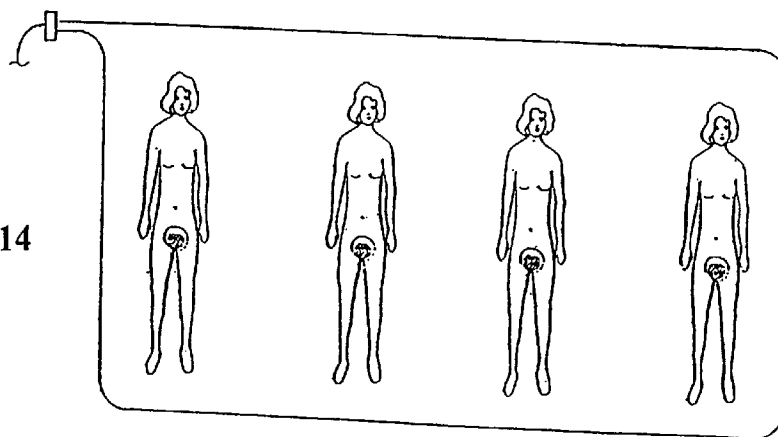


FIG. 15

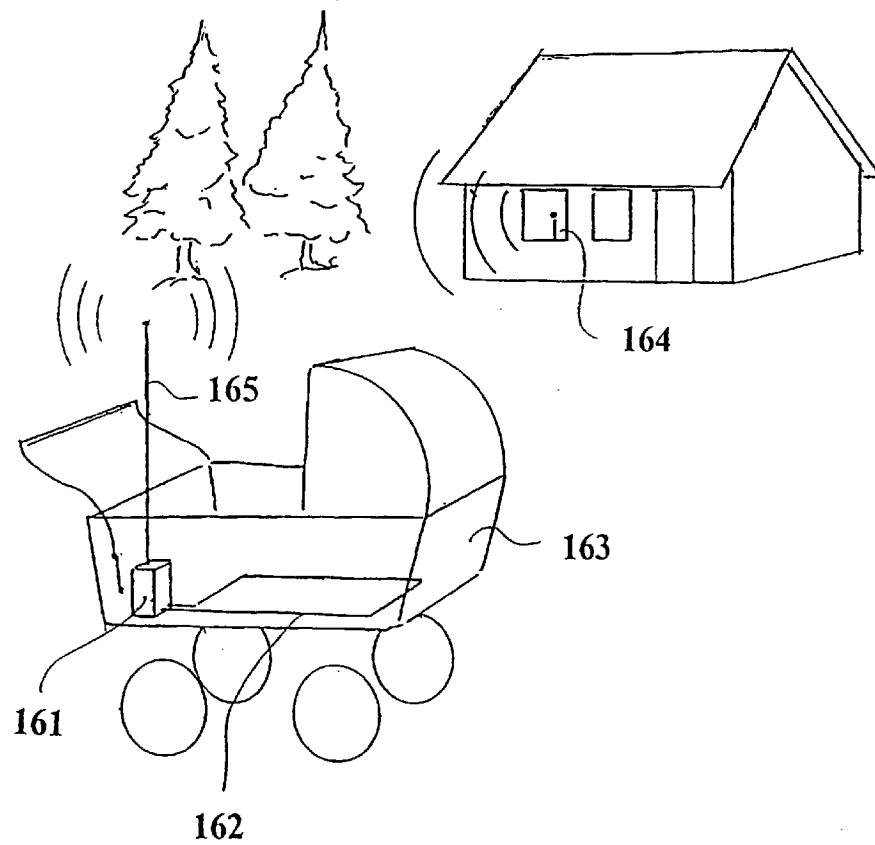


FIG. 16