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Remarks:

Amended claims in accordance with Rule 86 (2) EPC.

(54) **Coin selection device and method**

(57) Coin selection device and method comprising a path (4) followed by a coin (5) between an inlet opening and one or more outlet openings, a first set of sensors (2, 2', 2''), a second set of sensors (3), with said first and second sets of sensors placed along said path.

For each instant in time the first set of sensors provides a first set of data relating to a position of the aforementioned coin with respect to the second set of sensors, while the second set of sensors provides a second set of data relating to one or more characteristic properties of the coin.

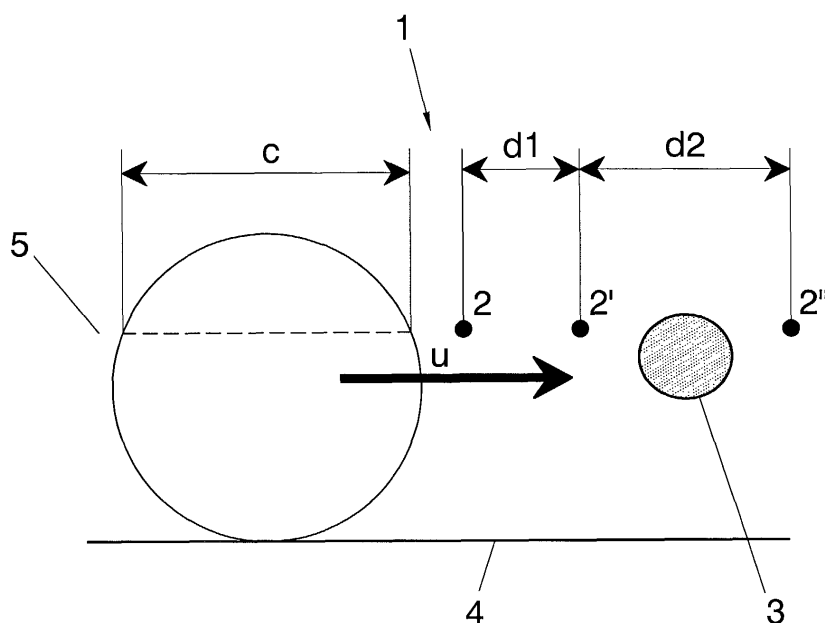


FIG.1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to coin selectors having an internal path or trajectory along which coins travel between an inlet opening and one or more outlet openings.

[0002] Selectors of this type are used in machines that operate by inserting one or more coins with sufficient value to obtain the required product or service.

[0003] Such selectors include sensors along the path of the coins that measure various characteristics of their dimensions (radius, thickness), alloy (weight, hardness) and electric and magnetic properties, thereby allowing to detect the denomination and validity of the coins.

BACKGROUND OF THE INVENTION

[0004] One of the most important demands facing coin selector manufacturers is a greater accuracy in coin characterisation. Two-colour coins made from different materials in their core and rim are increasingly used. For these coins it is not enough to make accurate measurements but it is also necessary to carry out independent measurements of the rim and the core, avoiding the union area.

[0005] It is possible to find two-colour slugs consisting of a single-colour legal tender coin to which has been added a rim of a material similar to that of the coin to be imitated. An accurate determination of the rim material would allow their discrimination. Likewise, it is possible to find slugs imitating single-colour coins consisting of a ring-shaped piece added to a legal tender coin of the same material, in order to change its diameter to resemble that of the coin to be imitated. In these cases an accurate measurement of the outer edge would detect said ring.

[0006] European Patent EP-710933-B1 discloses a device for determining predefined characteristics of an object (a coin or token) comprised of two materials with different electromagnetic properties. The device basically consists of a path along which travel the coins, an electromagnetic sensor, two optical walls placed at the sensor input and output and a third optical wall at the centre of the electromagnetic sensor. The rim is measured when the optical wall placed at the centre of the sensor is activated. As the measurement is made at a fixed position, depending on the width of the rim it may be impossible to obtain a measurement that corresponds exclusively to said rim. Furthermore, the centre of the coin is measured by measuring the time during which said coin is blocking the first wall. The measurement of the coin centre with the electromagnetic sensor is made after a time equal to half the aforementioned interval after the second wall is blocked. This method relies on the assumption that the speed of the coin is approximately constant, when it is in fact subjected to a

constant acceleration. In addition, the first and second walls must be separated by a distance greater than the diameter of the largest coin to be measured, thus reducing the flexibility in the positioning of the walls.

[0007] Another way to carry out measurements of specific areas of the coin is to place several electromagnetic sensors at different heights, so that each sensor measures a different area of the coin. Patent applications WO 99/12130 by Azkoyen and WO 99/23616 by Coin Controls describe sensor arrangements of this sort. This system also lacks flexibility, as the measurement areas are determined by the position of the sensors and the size of the coin. Using several sensors also implies a considerably higher cost.

[0008] Another alternative is disclosed in German Patent application DE-10003289-A1, which basically describes a method in which the measurements made by a sensor between two specific amplitudes as a coin passes are stored in a memory. Later, the width of the curve is determined to give an approximation of the speed of the coin. As the number of samples taken per unit time is known, a linear correspondence allows estimating which measurements correspond to each area of the coin. However, this method does not consider the fact that the coin motion is accelerated, so that the relationship between time and space is not linear. Thus, for example, measurements at the middle point of the measurement curve with respect to time do not correspond to the central area of the coin.

[0009] In addition, document DE-29720045-U describes the use of phototransistors in coin selectors, describing a configuration in which an equal current is applied to all photodiodes, but with the phototransistors having different operating points. The great manufacturing spread in optoelectronic devices can make it difficult to ensure that all phototransistors operate in the linear region when applying the same current to all photodiodes.

DESCRIPTION OF THE INVENTION

[0010] The invention relates to a device according to claim 1 and to a method according to claim 7. Preferred embodiments of the device and the method are defined in the dependant claims.

[0011] It is an object of the present invention to provide a method and device for coin selection that solve the aforementioned drawbacks of currently available selectors, providing a selector that not only performs accurate measurements of the coins but allows identifying to which part of the coin a given measurement corresponds and vice versa.

[0012] The present invention relates to a method that allows improving the quality of any sensor or sensors by allowing to relate the measurements of a coin obtained by said sensors with the relative position between said coin and the sensor with which each measurement was taken. In this way, the method allows identifying which

measurement corresponds to the coin-sensor relative positions that must be characterised. Thus, for example, in order to measure a two-colour coin with an electromagnetic sensor it is necessary to measure the centre of the coin and the rim; with the coin selector of the invention and according to the method of the invention it is possible to measure both the centre and the rim, determining the measurement corresponding to each position of the coin with respect to the sensor. It is also possible to use the inverse method, so that the measurements corresponding to each position of the coin can be identified by a specific property, such as exceeding a given threshold or corresponding to extreme values (minimum and maximum signal values).

[0013] One of the advantages of the method of the invention with respect to the prior art is that it allows performing measurements in the relative sensor-coin positions that are of greatest interest for characterisation, regardless of the acceleration and speed of the coin. Another advantage is that this is performed regardless of the relative position of the sensors and of the size of the coin.

[0014] The coin selection device of the present invention comprises a path along which a coin travels between an inlet opening and one or several outlet openings, a first set of sensors and a second set of sensors. For each instant in time the first set of sensors provides a first set of data from which the position of said coin is calculated with respect to the second set of sensors, while the second set of sensors provides data related to one or more characteristic properties of the coin.

[0015] Preferably, said first set of sensors is comprised of at least two optical sensors, and more preferably at least three optical sensors, thereby allowing to select measurements that correspond to the most stable part of the coin trajectory.

[0016] Preferably, said optical sensors are placed at the same height with respect to the path of the coin. Placing the optical sensors at the same height with respect to the path of the coin (and in the direction of motion of the coin) provides a greater accuracy of the selection device of the invention.

[0017] The optical sensors may consist, for example, of pairs of photodiodes and phototransistors. Preferably, for each pair a control loop is established between the receiver and the emitter that injects the required current to each photodiode so that all phototransistors are maintained at a common operating point.

[0018] Preferably, the second set of sensors can consist of electromagnetic sensors. These can also be magnetic, capacitance, optical or extensometric sensors, or sensors of any type providing one or more characteristic properties of the coin.

[0019] That is, the coin selection device of the present invention is based on at least two sets of sensors. The first set of sensors determines the position of the coin relative to the second set of sensors at each moment in time, and can also provide data regarding its speed and

acceleration. The second set of sensors determines one or several characteristic properties of the coin as the coin passes, also for each moment in time. Thus, as both signals are obtained with respect to time the measurements of the two sets can be related.

[0020] Depending on the relative position of the first and second set of sensors, it may necessary to store in a memory the measurements of the second set of sensors until the first set provides the position of the coin at each instant in time. This is the case when the two sets of sensors share the same position along the path of the coin. However, if the second set is placed after the first set along said path at a sufficiently large distance it is not necessary to store the measurements taken by the second set of sensors.

[0021] The invention also relates to a method for coin selection that comprises:

- Placing a first set of sensors along the path followed by a coin in a selector;
- Placing a second set of sensors in said path;
- Measuring with the first set of sensors, at each instant in time, a first set of data from which the position of the aforementioned coin is calculated with respect to the second set of sensors;
- Measuring with the second set of sensors, at each instant in time, a second set of data related to one or more characteristic properties of said coin;

such that said first set of data from which the position of the coin is calculated, and said second set of data related to one or more characteristic properties of the coin are related to each other.

[0022] Preferably, the first set of data is measured with at least two optical sensors. According to a preferred embodiment, the first set of data is measured with at least three pairs of photodiodes and phototransistors, establishing a control loop between each receiver and emitter that injects a current in each photodiode, such that all the phototransistors operate in the linear region, thereby increasing the stability of the selection method of the invention.

[0023] Preferably, the selection method of the invention measures at least one specific property of said second set of data related to one or more characteristic properties of the coin, and said specific property is related to the relative position of the coin and the second set of sensors. Said specific property can consist of exceeding a predefined threshold for said second set of data, or exceeding or matching an extreme, maximum or minimum value for said second set of data.

[0024] It is also possible to relate the first set of data, used to calculate the position of the coin, with one or more characteristic properties of said coin measured by the second set of sensors, thereby improving the quality of said second set of sensors.

[0025] In this way the method of the present invention allows improving the quality of any second set of sen-

sors by relating the measurements obtained by the second set of sensors with the relative position of the coin and the second set of sensors, at which each measurement was made. The method also allows the inverse process, so that it is possible to identify to which coin positions correspond certain measurements that are identifiable by a specific characteristic, such as exceeding a predefined threshold or matching extreme values (maximum or minimum).

[0026] This is, the method of the present invention can be used to improve the quality of discrimination of a sensor of any type, such as electromagnetic, magnetic, capacitive, optical, extensometric, etc. The quality of the measurement is determined not only by the quality of the sensor (of whichever type) *per se*, but also by the capability of characterising specific areas of the coin independently of the rest of the coin.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] In what follows a briefly description is provided of a set of drawings that help a better understanding of the invention, and that specifically relate to an embodiment of the invention that is given as a non-limiting example.

[0028] Figure 1 shows a possible embodiment of the selection device of the present invention.

[0029] Figure 2 shows several relative positions between the coin and the optical sensors used to calculate the chord and the position of the coin.

[0030] Figure 3 shows a diagram with two graphs of the relation of the coin position with time and measurements of the coin with time.

[0031] Figure 4 shows, for a preferred embodiment of the invention, a block diagram of the control loop for maintaining the phototransistors in the same operating point.

DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

[0032] As depicted in Figure 1, which shows a possible embodiment for the selection device 1 of the invention, the preferred embodiment comprises a first optical sensor 2, a second optical sensor 2', a third optical sensor 2" and an electromagnetic sensor 3, placed along the path 4 of a coin 5; the arrow u shows the direction of motion of the coin 5.

[0033] The set of optical sensors 2, 2', 2" provides an accurate and stable measurement of the coin position with respect to time. The electromagnetic sensor 3 provides one or more characteristic properties of the coin. This electromagnetic sensor can be as described in the documents EP-246993 or EP-936582.

[0034] The first and second optical sensors 2 and 2' are separated by a distance d1, and the second and third optical sensors 2' and 2" are separated by a distance d2. The coin 5 has a chord c at the height of the

optical sensors.

[0035] It is considered that the coin follows a uniformly accelerated motion, so that it is ruled by the equation [1]:

$$x = \frac{1}{2}at^2 + v_0t + x_0 \quad [1]$$

[0036] Where a is the acceleration of the coin 5, v_0 is its velocity at $t=0$ and x_0 is its position at $t=0$.

[0037] Figure 2 shows the first, second and third optical sensors 2, 2', 2" and the coin at five positions of its path. At position P1 the coin is entering the second optical sensor 2'. Said position P1 is fixed as the origin of time and space, so that at this position time t is equal to 0 and the displacement x is 0. Thus, the term x_0 of equation [1] is 0.

[0038] At position P2 the coin is exiting the first optical sensor 2. At this position P2 the distance travelled by the coin is c-d1 and the time is t_{SA} , so that the equation [1] at this position takes the form:

$$c - d1 = \frac{1}{2}at_{SA}^2 + v_0t_{SA} \quad [2]$$

[0039] At the position P3 the coin is entering the third optical sensor 2". At this position P3, the distance travelled by the coin is d2 and the time is t_{EC} .

$$d2 = \frac{1}{2}at_{EC}^2 + v_0t_{EC} \quad [3]$$

[0040] At the position P4 the coin is exiting the second optical sensor 2'. At this position P4 the distance travelled by the coin is c and the time is t_{SB} .

$$c = \frac{1}{2}at_{SB}^2 + v_0t_{SB} \quad [4]$$

[0041] Solving the set of equations [2], [3] and [4] allows calculating the chord c, the acceleration a and the initial velocity v_0 . Other position could have been used in these calculations instead of the ones employed here, such as the exit from the third optical sensor 2" or the entrance in the first optical sensor 2. The positions corresponding to the most stable part of the coin trajectory should be used.

[0042] Once the acceleration and velocity are known it is possible to obtain the position occupied by the coin at any instant, or vice versa, the time at which the coin will be at a specific position. In the former case equation [5] is used; in the latter equation [6] is used, obtained by solving for t in equation [5]. Thus, for example, it may be of interest to know the measurement made by the electromagnetic sensor [3] when the coin is at the position P5, which would correspond to a measurement of the rim by said sensor. In this case the equation [6] would be used, where x is the distance travelled by the

coin from the position of reference *P1* to the position of interest *P5*.

$$x = \frac{1}{2}at^2 + v_0t \quad [5] \quad 5$$

$$t = \frac{\sqrt{v_0^2 + 2 * a * x} - v_0}{a} \quad [6] \quad 10$$

[0043] Figure 3 shows a graphical representation of this procedure, relating an area *Z* of the coin 5 to be identified and the measurements made by the electromagnetic sensor 3. It is assumed that the same coin enters twice with different velocities and accelerations, so that, applying equation [5], two position vs. time graphs *E1* and *E2* are obtained. For these introductions two possible graphs *M1* and *M2* of the (electromagnetic) measurements vs. time corresponding to measurements made by the electromagnetic sensor 3 for the coin 5. The graph *M1* corresponds to the graph *E1* and the graph *M2* corresponds to the graph *E2*. 15

[0044] It can be seen that with the present invention the measurement made by the electromagnetic sensor is the same in the graph *M1* as in the graph *M2*, as they correspond to the same position and thus to the same area *Z* of the coin; thus, with the present invention it is possible to measure any area of the coin regardless of the size of said coin. 20

[0045] In order to increase the stability the preferred embodiment considers the use of the optical sensors 10, which consist of phototransistors 8, in the linear region, as shown schematically in the block diagram of figure 4. Said figure 4 shows a controlled current source 6, powered at a voltage V_{dc} that feeds a photodiode 7. The level received at the phototransistor 8 is used, by means of a control loop 9, to control the current source 6. In this way, the operating point of the receiver is set at the same point for all the optical sensors, regardless of the characteristics of the emitter and the receiver and the temperature and cleanliness conditions at which they operate. 25 30 35 40

Claims 45

1. Coin selection device (1) comprising:

- a path (4) along which runs a coin (5) between an inlet opening and one or more outlet openings; 50
- a first set of sensors (2, 2', 2''); 55
- a second set of sensors (3);
- with said first and second set of sensors placed along said path,

characterised in that for each instant in time:

- the first set of sensors provides a first set of data from which a position of said coin is calculated with respect to the second set of sensors;
- the second set of sensors provides a second set of data related to one or more characteristic properties of the coin.

2. Coin selection device according to claim 1, **characterised in that** the first set of sensors consists of at least two optical sensors.

3. Coin selection device according to claim 2, **characterised in that** said optical sensors are all placed at the same height with respect to the path (4) of the coin (5).

4. Coin selection device according to any of claims 2-3, **characterised in that** said optical sensors (10) are pairs of photodiodes (7) and phototransistors (8), with a control loop (9) established for each pair between the receiver and the emitter that injects a current in each photodiode so that all phototransistors are maintained at a common operating point.

5. Coin selection device according to any of the above claims, **characterised in that** the second set of sensors consists of electromagnetic sensors.

6. Coin selection device according to any of the claims 1-4, **characterised in that** the second set of sensors consists of magnetic, capacitive, optical or extensometric sensors.

7. Coin selection method, comprising:

- placing a first set of sensors (2, 2', 2'') along a path (4) followed by a coin (5) in a selector;
- placing a second set of sensors (3) along said path;
- using the first set of sensors to measure for each instant in time a first set of data from which the position of said coin with respect to the second set of sensors is calculated;
- using the second set of sensors to measure for each instant in time a second set of data relating to one or more characteristic properties of said coin;

so that said first set of data used to calculate the position of the coin and said second set of data relating to one or more characteristic properties of said coin are related to each other.

8. Method according to claim 7, **characterised in that** the first set of data is obtained by at least two optical sensors.

9. Method according to any of claims 7-8, **character-**

ised in that the aforementioned first set of data is obtained by pairs of photodiodes (7) and phototransistors (8), establishing for each pair a control loop (9) between the receiver and emitter that injects a current in each photodiode such that all phototransistors operate in the linear region. 5

10. Method according to any of claims 7-9, **characterised in that** at least one specific property is measured of said second set of data relating to one or more characteristic properties of the coin, and said specific property is related with the relative position between the coin and the aforementioned second set of sensors. 10

11. Method according to claim 10, **characterised in that** said specific property consists of exceeding a predefined threshold for the second set of data, or corresponding to an extreme value, maximum or minimum, of said second set of data. 15 20

12. Method according to any of claims 7-9, **characterised in that** said first set of data relating to a position of the coin are related with one or more characteristic properties of the coin measured by the second set of sensors, improving the quality of said second set of sensors. 25

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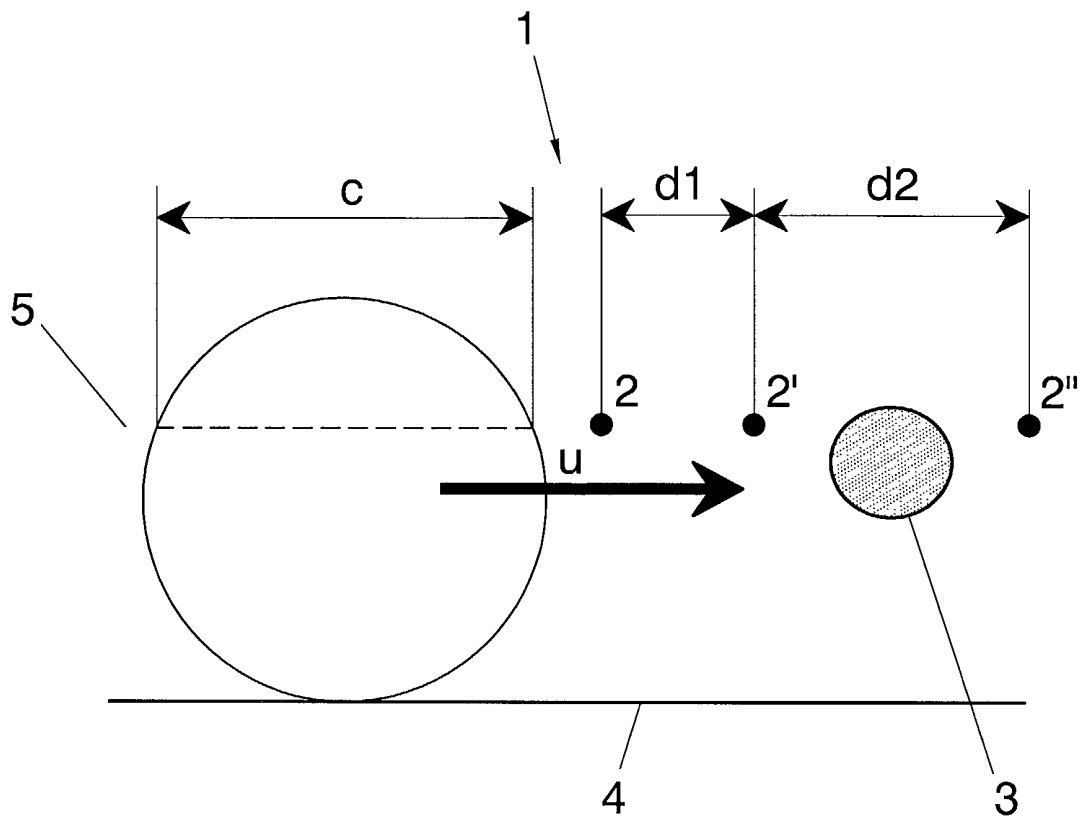


FIG.1

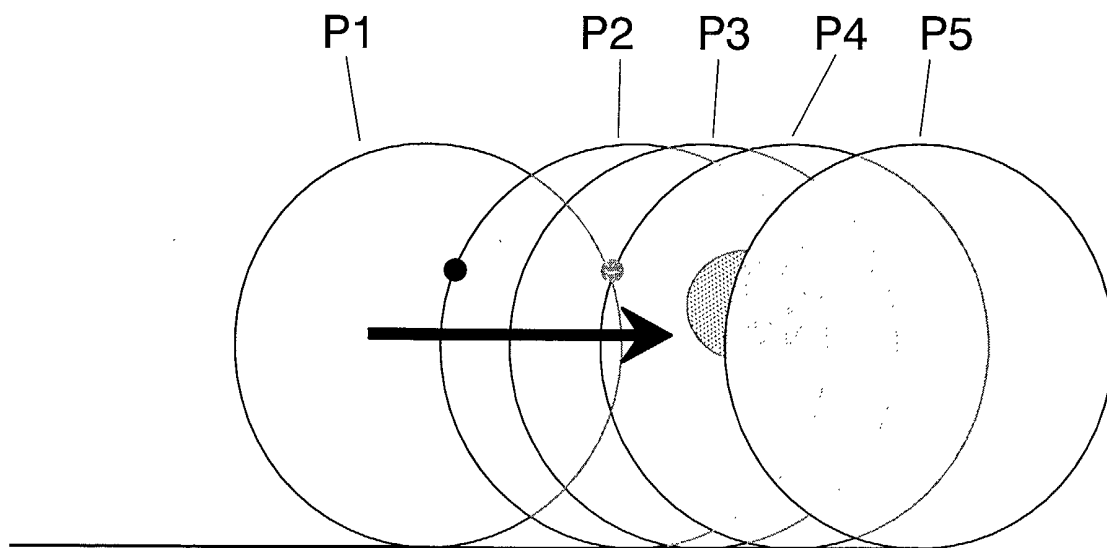


FIG.2

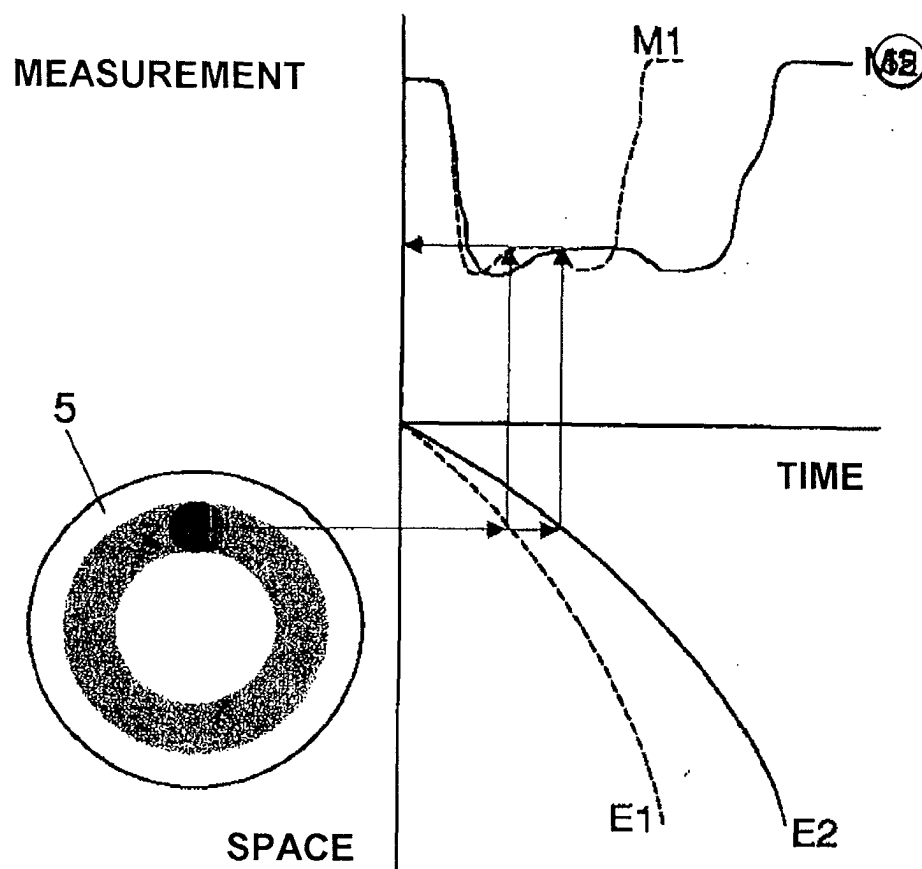


FIG. 3

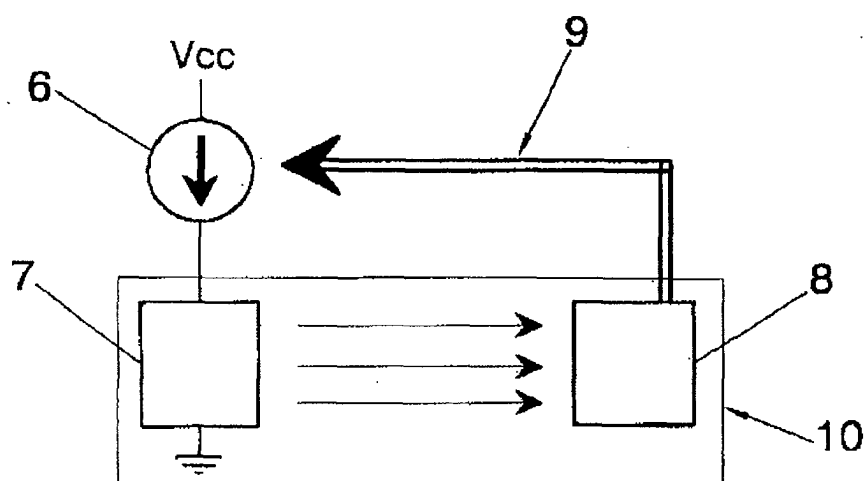


FIG. 4



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 38 0182

DOCUMENTS CONSIDERED TO BE RELEVANT			
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 22 January 2003	Examiner Neville, D
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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