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(54) **System and method of coin selection**

(57) Coin selector system which comprises, at least:
(i) a first light sender element (1);
(ii) a second receiver element (2) of the light transmitted by the first sender element (1); and
(iii) means to process the signal;
all of which is done in such a way that there is no significant coupling between the sender element (1) and the receiver element (2) without the presence of a coin (10), while there will exist a coupling at the interposition of the coin (10) edge.

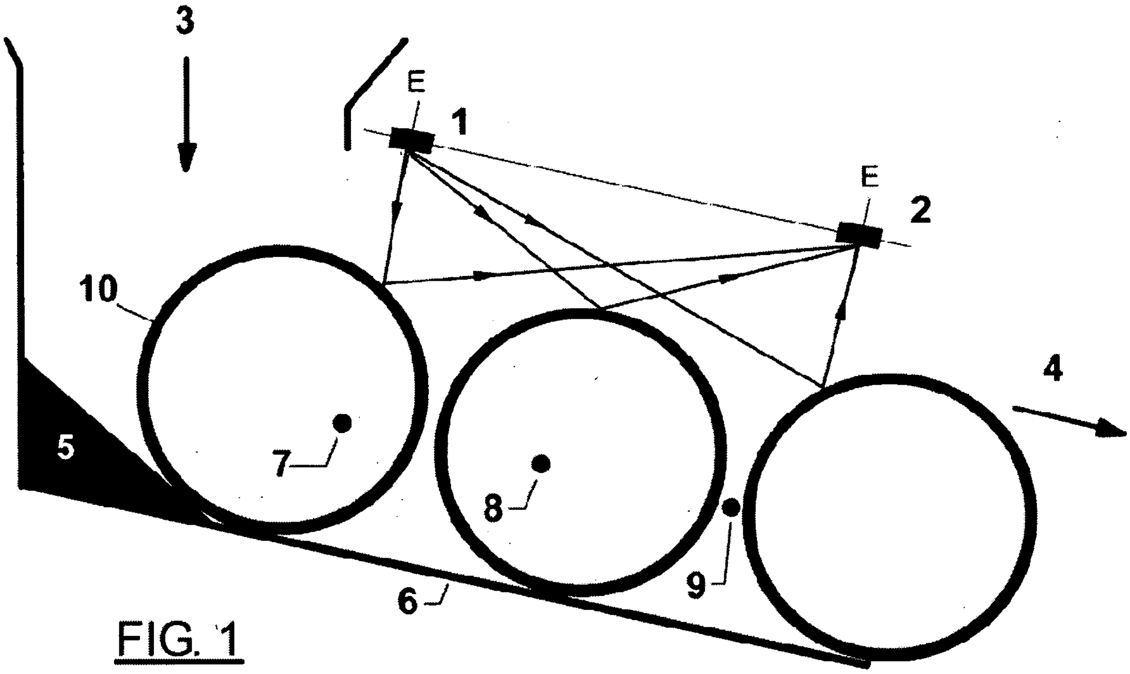


FIG. 1

EP 2 107 533 A2

Description

OBJECT OF THE INVENTION

[0001] The object of the present invention is a system which proves the validity of coins, tokens or in general, discoid elements through the analysis of the edge of said element. The present invention solves the analysis of the coin edge in a simple and economical way, and it can be incorporated in coin selectors as an additional sensor in combination with other sensors for the analysis of other characteristics, such as diameter and electric and mechanical characteristics of the alloy.

FIELD OF THE INVENTION

[0002] The present invention refers to the field of devices which prove the validity of coins, tokens or other discoid elements. In order to differentiate valid elements from those which are not, these devices determine different properties thereof such as, for example, their dimensions, electromagnetic properties, electric properties, weight, hardness, coining, among others.

BACKGROUND OF THE INVENTION

[0003] In the current state of the art, in order to determine the different properties of the coins, tokens or discoid elements, a wide variety of sensors are used, such as optical, magnetic, piezoelectric or acoustic sensors which are processed by electronic means prepared to that end.

[0004] Commonly used systems are the systems which measure the dimensions of coins with optical procedures, and the ones which determine the properties of the alloy related to the electric conductivity and magnetic permeability, using one or several electromagnetic sensors. Other optical procedures are related to the examination of the engraving or embossing of the coins, ones pointing to the analysis of the coin faces and others pointing to the analysis of the edge or rim thereof.

[0005] There are numerous examples of sensors which examine the engraving of the coin faces and which are normally based on CCD image sensors. These system<s present a problem in that there are multiple different engravings or images for the same coin, which complicates its identification to a very large extent. Moreover, the sensor and the electronics associated are very expensive, thus limiting the possibilities of their use.

[0006] By contrast, the examination or identification of the coin edge requires more simple and economical methods. For example, the following documents can be quoted as examples thereof in the current state of the art:

[0007] Thus, for example, GB2071381 describes an optical sensor for coin edges comprising a sender-receiver couple whose optical beams point towards the coin, coinciding in its edge. Part of the light transmitted is reflected by the coin and reaches the sensor. According to the intensity of the light received, the coin in question will be accepted or rejected. This system has the inconvenience of only analyzing a small arch of the complete edge of the coin.

[0008] A similar arrangement for the analysis of coin edges can be found in EP0416932 which has the same previously described problem.

[0009] Other examples can be seen in DE3335347, in which the coin edge is examined with an arrangement of sensors contained in a plane perpendicular to the one along which the coin passes, while in the aforementioned case it was parallel. Like in the previous case, only a small part of the complete coin edge will be examined.

[0010] WO09106072A1 describes a device for coin edge analysis consisting of the illumination of the edge by a parallel light beam, which laterally illuminates the coin edge. On the vertical of the rolling track, there is a detector which has a focus lens and a grid coinciding with the passing of the model of the edge of the valid coin to be detected. With this arrangement, the sensor will only give a valid signal when the valid diameter of the coin (through the focus lens) coincides and when the edge model also coincides. This sensor also has the same problem as the previous inventions, since the analysis of the edge is performed in a small arch. Another problem is that the sensor is only valid for a type of coin (with a concrete diameter and edge), and therefore, it would be necessary to include as many specific sensors as types of coins to validate.

[0011] Generally, the effect produced by the analysis of a small part of the 360 degrees of the coin edge is that in many cases it is not possible to distinguish a coin with interrupted knurling from a flat one or one with continuous knurling and polygonal coins from circular ones. It is not possible to distinguish coins with angularly spaced inscriptions either, such as the case of the "Spanish flower" (like the €0.20 coins) or embossed patterns with a significant size or angular separation.

[0012] In order to solve the problem described and angularly increase the analysis of the coin edge, the following solutions have been developed:

[0013] The device of WO09106072A1 uses several photoreceptors oriented to different angles of the coin increasing the area of analysis. Besides being expensive, this solution presents the problem of the space required for its implementation.

[0014] WO09744760A1 describes an optical system based on a laser light source and an optics which lightens the coin according to a vertical line perpendicular to the rolling track. In the opposite part, there is a linear sensor which is also vertical. The coin partially interrupts the beam and projects the shadow of the edge on the sensor. This enables to analyze a more important part of the coin edge, but presents the inconvenience of the high price of the sender, optics and sensor set, which makes it unfeasible in many applications.

[0015] WO00043961A1 describes another form of edge analysis. In this case the sender is a collimated laser light source to attain a beam with a rectangular section, stable with the distance. The result is a precise analysis of a wide area of the coin edge, but it has the inconvenience that the light source has to be located on a side of the rolling track, which is difficult to solve in small devices. Moreover, the light source is expensive and not very strong for uses demanding a wide range of temperatures or in adverse environmental conditions.

DESCRIPTION OF THE INVENTION

[0016] In order to solve the aforementioned problems, it is presented the system and method of coin selection object of the present invention. Said system comprises at least:

(i) a first light sender;
(ii) a first receiver of the light transmitted by the first sender; and
(iii) means to process the signal.

[0017] All of this is done in such a way that there is no significant direct coupling between the sender-receiver without the presence of a coin, while there will exist a coupling at the interposition of a coin edge.

[0018] In order for this coupling to materialize during an important path of the coin, said senders and receivers will be located on a line which is essentially parallel to the rolling track and at a minimum distance bigger than the diameter of the coin with the biggest admissible size.

[0019] The separation between the sender and receiver is an important characteristic since it will define the area of the rolling track in which the coin edge will be examined. It is assumed that, regardless of the coin size, the area of analysis of the coin edge is equivalent, at least, to the distance between both elements of the sender-receiver set. This characteristic enables the area of the coin edge examined to be much bigger than the ones described in the state of the art and the previously mentioned ones.

[0020] An important characteristic for the sender and receiver is that they must have an important beam width, since, if not, when they are moved away from each other, there would not be an optical coupling through the reflection of the coin edge. That is to say, the sender and receiver do not have to incorporate concentrating optics. Moreover, it is convenient for the senders and receivers to have a radiation diagram approximate to the cosine law, that is to say, with a maximum (100% of the radiation transmitted for the sender or sensitivity for the receiver) in the frontal axis (0°) and a radiation minimum (0%) on the side (90°). It is also very convenient for the sender to work in the infrared spectrum and for the receiver to be exclusively suitable for said infrared radiation, so as to minimize the effects of the room light which could penetrate through the openings inside the device.

[0021] Another important characteristic of the arrangement of the sender and receiver is that the maximum radiation axis and sensitivity respectively, are oriented towards the rolling track of the coins, that is to say, that they are both located parallel to each other and with the optical axes perpendicular to the rolling track. Under these conditions, there will be no significant coupling between them if there is no coin and the radiation diagram defined enables the coupling with a coin during the entire path of the area of analysis. If there is no coin, there can exist a small coupling due to the reflections of a rolling channel which do not significantly affect the quality of the signal received in the device of the invention, which can be considered a controlled parameter in the mounting (offset) and which can be discriminated from the signal provided by the sensor.

[0022] Adequately choosing the separation between the sensors and the height on the rolling track, it is possible to achieve for a wide range of coin diameters a low dependency of the signal level according to the relative position of the coin in relation to the sensor.

[0023] The system is completed with processing means of the signal comprising:

(i) a first amplifying stage in the sensor;
(ii) a second stage of controlling the intensity radiated for the sender; and
(iii) signal processing means.

[0024] Wherein, it has been established' that said processing means are based on a microcontroller and, more specifically, a microcontroller such as a digital signal processor or DSP. Moreover, said signal processing means include, at least:

(i) two filters, and
(ii) one diverter.

[0025] The sensor so described has the characteristic of offering safety to be able to distinguish authentic coins from fake ones, or intrusions from other coins valid in other countries.

[0026] The system object of the present invention solves the problem of analysis in a wide area of the coin edge. For example, in a typical selector we can multiply by a factor between two and three the edge arch analyzed by this system, compared to the one known so far, being possible to analyze more than 50% of the circumference of the coin edge.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The following is a brief description of a series of drawings which will help understand the invention better and relating clearly to an embodiment of said invention which is presented as a non-limiting example thereof.

[0028] Figure 1 schematically shows the arrangement of the sensors together with the path of the light beams in different coin positions.

[0029] Figure 2 shows the block diagram associated to the optical sensor.

[0030] Figure 3 shows the type of radiation diagram used for the sender and receiver of the optical sensor of the invention.

[0031] Figure 4 shows the signal obtained at the outlet of the sensor with a coin with the technology of the previous art.

[0032] Figure 5 shows the signal obtained with the solution proposed under the same conditions as in the previous case.

[0033] Figure 6 shows the outlet of the amplifier (12) for two coins with different reflectivity.

[0034] Figure 7 shows the outlet of the amplifier (12) for a coin with high relief details on its edge.

[0035] Figure 8 shows the outlet of the amplifier (12) for a coin similar to the one shown in figure 7 but with low relief details.

[0036] Figure 9 shows the outlet of the band-pass filter (13) for the coin shown in figure 7.

[0037] Figure 10 shows the outlet of a band-pass filter (13) for the coin shown in figure 8.

[0038] Figure 11 shows the outlet of the amplifier (12) for a coin with a polygonal edge.

[0039] Figure 12 shows the outlet of the amplifier (12) for a coin with a circular edge.

[0040] Figure 13 shows the outlet of the low-pass filter (14) for the coin shown in figure 11.

[0041] Figure 14 shows the outlet of the low-pass filter for the coin shown in figure 12.

[0042] Figure 15 shows the outlet of the diverter (15) for the coin shown in figure 11.

[0043] Figure 16 shows the outlet of the diverter (15) for the coin shown in figure 12.

PREFERRED EMBODIMENT OF THE INVENTION

[0044] As it can be seen in the attached drawings, and specially in **figure 1,** the system object of the present invention comprises, at least, a sender (1) which is preferably located next to the entrance (3) for the coins, while the receiver (2) is mounted next to the end (4) of the rolling ramp (6) and approximately at the same distance of said track than the sender (1). The distance of the optical couple to the rolling track (6) is bigger than the diameter of the biggest coin. On the other hand, the distance between the sender (1) and the receiver (2) is:

- always bigger than the diameter of the smallest admissible coin;
- preferably similar to the length of the rolling track (6);
- or else, close to the diameter of the biggest admissible coin;

[0045] The axes (E) of maximum radiation/sensitivity of the sender (1) and the receiver (2) have to be oriented towards the rolling ramp (6). In this way, the optical sensor of the coin edge explores the coin edge during the entire path along the measuring area.

[0046] As an example of the improvement of the area of coin analysis, we can see in **figure 4,** which represents the technology of the aforementioned art, that the form of the signal obtained has strong lateral slopes, while the useful duration of the signal is, at the most, 70ms, which at a typical speed of the coin corresponds to approximately 14mm of path. Moreover, the start and end areas of the signal mentioned are not very useful due to their low level. Comparing this signal to the one represented in **figure 5,** it can be seen the signal provided by the proposed sensor in the same conditions as the aforementioned case. As it can be seen in the signal, the level is much more constant and the useful signal has a duration of 180ms, which is equivalent to 36mm of path of the coin, that is to say, more than twice than in the previous case, with the advantage that the signal is useful from start to end.

[0047] Going back to **figure 1,** this figure shows a schematic view of the path of the light sent by the sender (1), which is reflected on the coin (10) edge, represented in three different positions and reaches the receiver (2). As it can be deduced from this mounting, both components, sender (1) and receiver (2), have to have such a beam width that the coupling between them is kept the same, when there is a coin on the rolling track (6). A typical convenient diagram for the embodiment proposed can be seen in **figure 3,** where the beam width, at 50%, is about ±65°. With this diagram, it is obtained a quite planar outcome for the coupling between the sender (1), coin (10) and receiver (2), for a range of diameters of normally used coins (10). This characteristic remarkably facilitates extracting the useful signal from the coin edge, consisting in the variations of the signal with respect to a medium level, that is to say, the alternate modulating component which is superimposed to the medium signal which is the value of the coin reflectivity. The alternate component shown is caused by the reflections produced by irregularities in the coin edge, which is the main characteristic which we intend to identify or detect.

[0048] To optimize the results, it is convenient to use a power source (11) controlled by a microcontroller (16) to feed the sender (1), which will be a photodiode, preferably with emission in the infrared. To compensate the thermal drift typical of photodiodes, optionally, it is possible to mount a temperature sensor, not indicated in the figures, and next to the sender (1) which can consist of a standard signal diode. According to the temperature, it is possible to control the power source of the sender (1) or else compensate the measure according to a law inverse to the thermal variation. As regards the receiver (2), it is convenient that it be a high sensitivity PIN photodiode with visible light filter (transparent to the infrared). The outcome of the sensor will, be connected to the inlet of the current to voltage amplifier (transimpedance amplifier (12)) which has the advantage of linearly using the receiver (2) and optimizing the thermal behavior, as it can be seen in **figure 2.**

[0049] Additionally, the device can include optical barriers (7), (8) and (9) which are normally used for measuring the diameter and position of the coin. This can be useful to analyze the signals and relate them to the position of said coin (10) on the rolling track (6).

[0050] It is convenient to incorporate band-pass filtration means. In this way, the continuous and low frequency components disappear, remaining only the useful signal associated with the fine details of the coin edge. Given the fact that the components to be filtered are not very important, the filter is simple and for example, a second order Butterworth pass-band filter is enough, and can be incorporated through analogical means, or digital means, preferably using a microcontroller such as a digital signal processor or DSP.

[0051] The system object of the present invention also comprises a second filter, namely a low-pass filter, so as to extract the low frequency components related for example to the presence of interrupted knurling, high reliefs, intrusions or polygonal coins. The outcome of the filter can be used directly or after passing through a diverter (15) which eliminates the direct current component and defines more precisely the flanks and slopes of the signal represented in the transitions of the different areas of the coin edge.

[0052] The four signals, that is to say, the original signal and the two filtered signals and the one derived from the second filter, are analyzed by a microcontroller (16) which calculates, for each one of them, parameters such as the medium value of the signal, the effective value (RMS), maximum and minimum peak values, peak to peak value, number of zero values (transitions), Fourier transform, separation between peaks and statistical parameters such as standard deviation and variance. The calculation of the parameters mentioned can be made for the entire path of the coin (10) along the rolling track (6) or for sections. In this case, optical barriers (7-9) are used to define an initial section, a central one and a final one.

[0053] In the system described in the present invention it is possible to relate the parameters calculated with the instantaneous position of the coin, for example, as it is described in EP1391851 of the same applicant, being possible to obtain in this way data related to the real separation of the details detected on the coin edge. Finally, the parameters obtained are compared with those established for valid coins, and, if they are acceptable, the microcontroller (16) will activate the inlet gate (17) together with other signals of communication with other devices, not indicated in the figures, and if not, the coin will be rejected.

[0054] Figures 6 to 16 show examples where there are shown some of the possibilities of the system as regards coin discrimination according to the shape or details of the edge and its reflectivity. **Figure 6** shows the outlets of two coins having the same shape and size but with different reflectivity on the edge. This signal (12) is analyzed directly by the microcontroller (16) and parameters such as the medium value of the signal or the minimum value can be enough to distinguish one from another.

[0055] Another example of two similar coins but with the difference of one of them featuring high relief and low relief details on the edge is shown in **figures 7 and 8** respectively. Even though it can also be used the direct signal from the amplifier (12), it is convenient to use the one from the band-pass filter (13), whose outlets are shown in **figures 9 and 10** respectively. The microcontroller will calculate for example parameters such as effective value of the signals (RMS), maximum peak value, minimum peak value, peak to peak value, number of peaks which are over a predetermined threshold, etc., being it possible to identify or discriminate coins thanks to this characteristic. The calculation of the parameters can be made globally for the whole signal or as it has been mentioned before, it can be made by sections, or calculating the size or separations of the details identified, since with the same sensors it is possible to associate the signal to the position of the coin at each instant.

[0056] A third example is shown in **figures 11 and 12,** where there are shown two coins, respectively, which have a similar size and material but the first one has a polygonal edge while the other one has a circular edge. In this case, the signals can also be used directly from the sensor (12), but it is more convenient to use those of the low-pass filter (14) outlet, which correspond to **figures 13 and 14,** and, even better, those of the diverter outlet (15), **figures 15 and 16,** which improves the conditions of signal analysis, eliminating the continuous component and indicating the transitions better. As in the previous cases, the microcontroller will calculate the parameters which will be used to discriminate the coins according to their edge characteristics.

[0057] Even though the preferred embodiment is made on a model of a typical coin selector in which the coins go rolling through the sensors, it is possible to incorporate it to other types such as free falling, disk or conveyor belt for coins, among others.

Claims

1. Coin selector system which has a coin rolling track (6) arranged to define a rolling path for a coin (10) between:

   (a) an entrance (3) to the rolling track (6) through which an inserted coin (10) starts a path along the rolling track (6);
   (b) an end (4) of the rolling track (6) through which a coin (10) exits the rolling path (6) once it has travelled along said rolling path;
   characterized in that it comprises, at least:
   (c) a first light signal sender (1) element, located next to the entrance (3), arranged to emit a light signal incident on an edge of the coin (10) and generate a reflected light signal;
   (d) a second light signal receiver (2) element,

located next to the end (4), arranged to receive a light signal reflected by the edge of the coin (10);
(e) means to process the reflected signal;
wherein the first sender (1) element and the second receiver (2) element:
(f) are located on a line which is substantially parallel to the rolling track (6) at a minimum distance from the rolling track (6) bigger than the diameter of the coin with the biggest admissible size;
are located and arranged so that:
(g) there is no significant direct coupling between the sender (1) and the receiver (2) if there is no coin;
(h) there is a coupling thanks to the light signal reflected by the coin (10) edge.

2. System according to claim 1, **characterized in that** the distance between the sender (1) and the receiver (2) is bigger than the diameter of the smallest admissible coin.

3. System according to claim 1 or 2, **characterized in that** the distance between the sender (1) and the receiver (2) is essentially equal to the length of the rolling track (6).

4. System according to claim 1 or 2, **characterized in that** the distance between the sender (1) and the receiver (2) is close to the diameter of the biggest admissible coin.

5. System according to the preceding claims, **characterized in that** the axes (E) of maximum radiation of the sender element (1) and of maximum sensitivity of the receiver element (2) are oriented towards the rolling ramp (6).

6. System according to the preceding claims, **characterized in that** the sender element (1) has a radiation diagram with a maximum of 100% of radiation in the frontal axis (E) and a minimum of 0% of radiation on the side.

7. System according to the preceding claims, **characterized in that** the receiver element (2) has a radiation diagram with a maximum of 100% of sensitivity in the frontal axis and a minimum of 0% of sensitivity on the side.

8. System according to the preceding claims, **characterized in that** the sender element (1) is a photodiode with emission in the infrared spectrum.

9. System according to the preceding claims, **characterized in that** the receiver element (2) is a PIN photodiode with a visible light filter transparent to the infrared.

10. System according to the preceding claims, **characterized in that** it comprises a plurality of optical barriers (7-9) to measure the diameter and position of the coin.

11. System according to the preceding claims, **characterized in that** the means to process the signal comprise, at least:

(i) logical signal processing means (16);
(ii) a power source (11) of the sender element (1);
(iii) signal amplifying means (12) of the receiver element (2);
(iv) band-pass (13) filtration means (13);
(v) low-pass (14) filtration means; and
(vi) signal diverting means (15);
so that the signal processing means (16) govern the power source (11) of the sender element (1) and also receive signals from the diverter (15) filters (13, 14) and the amplified signal (12) of the receiver element (2).

12. System according to the preceding claims, **characterized in that** it comprises a temperature sensor to detect the thermal drift of the sender element (1).

13. System according to claims 11-12, **characterized in that** the amplifying means (12) comprise a transimpedance amplifier.

14. System according to the preceding claims, **characterized in that** any of the band-pass filtration means, low-pass filtration means and diverter is implemented in any form selected from:

- analogical implementation with dedicated circuitry;
- digital implementation in the logical signal processing means (16).

15. System according to the preceding claims, **characterized in that** the signal processing means (16) comprise a digital signal processor or DSP.

16. Coin selection method, implemented in a system according to claims 1 to 13, **characterized in that** it analyzes, at least, the following signals:

- the amplified signal (12) of the receiver element (2);
- the band-pass filtered signal (13);
- the low-pass filtered signal (14);
- and the one derived (15) from the low-pass filtered signal (14);
so that for each one of them it is calculated the

medium signal value, the effective value, the maximum and minimum peak value, peak to peak value, number of zero values, Fourier transform, separation between peaks, typical deviation and variance for the entire path of the coin or for sections;
and wherein, besides, the parameters obtained are compared to the ones established for valid coins, and, if they are acceptable, the microcontroller (16) will activate the inlet gate (17) together with other signals of communication with other devices, not indicated in the figures, and if not, the coin will be rejected.

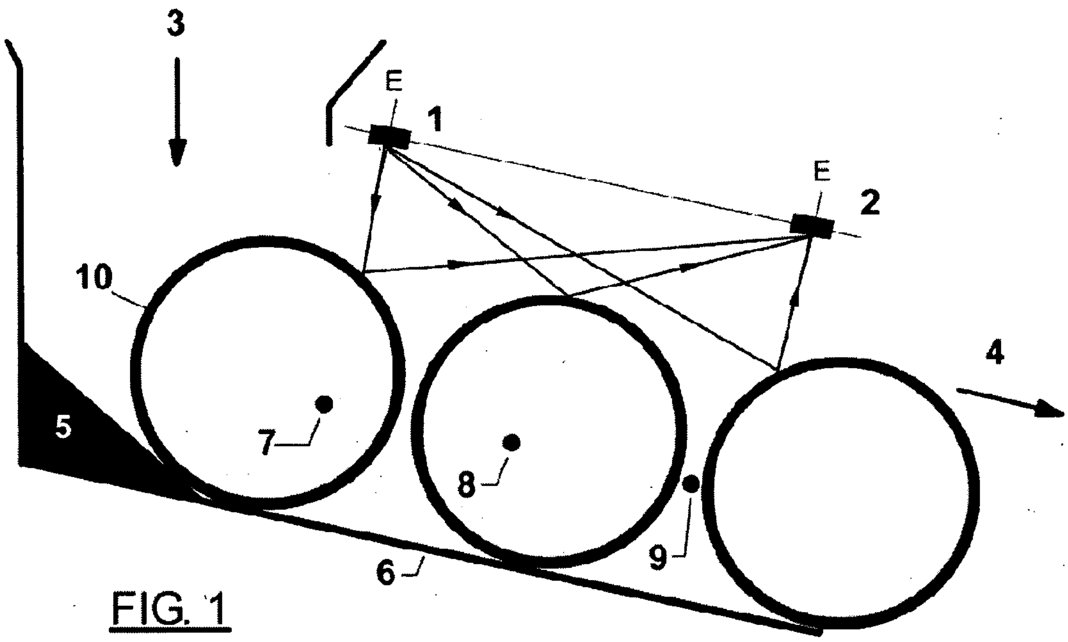


FIG. 1

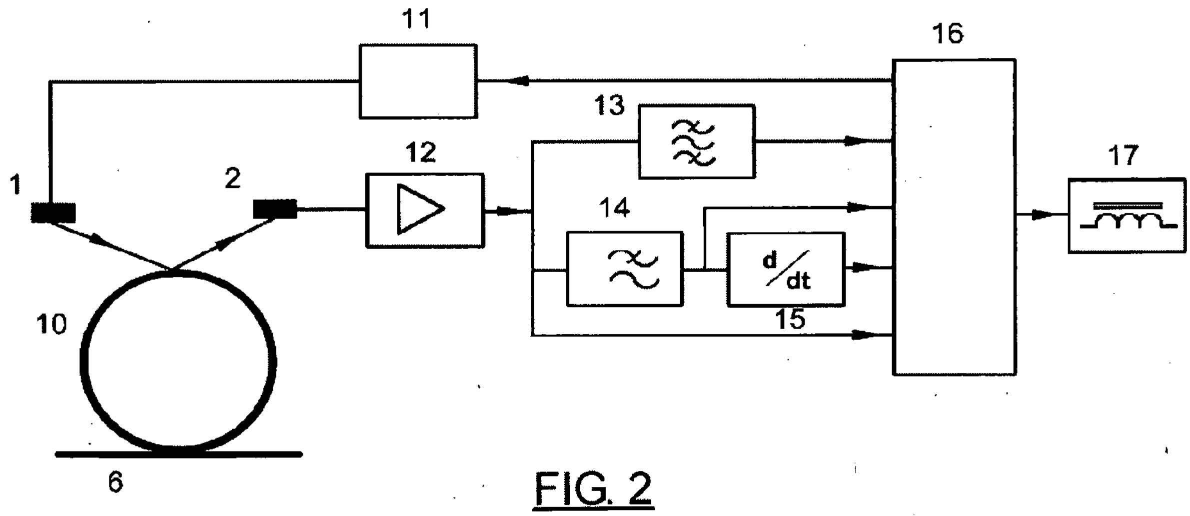
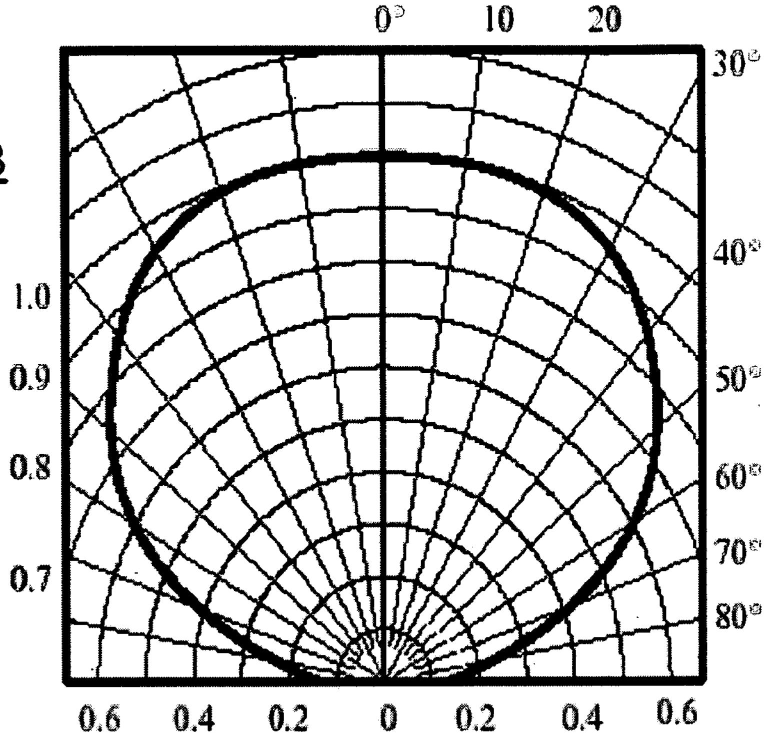


FIG. 2

FIG. 3



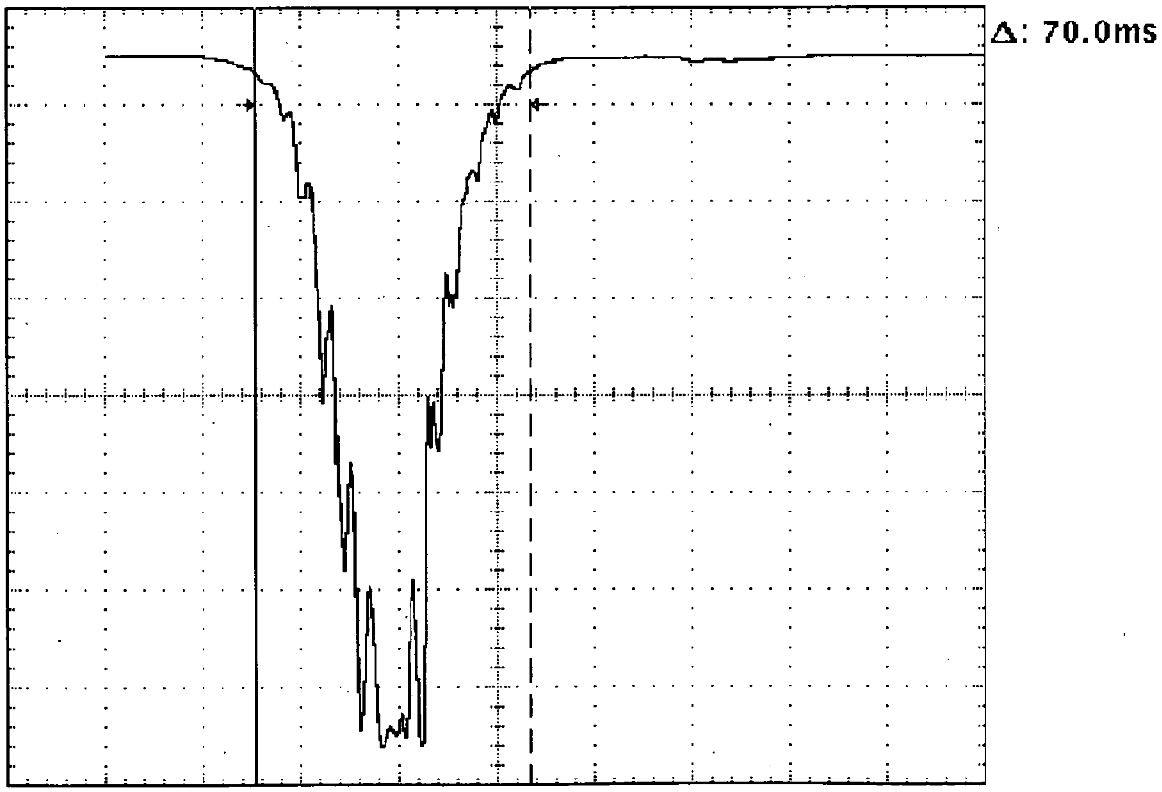


FIG. 4

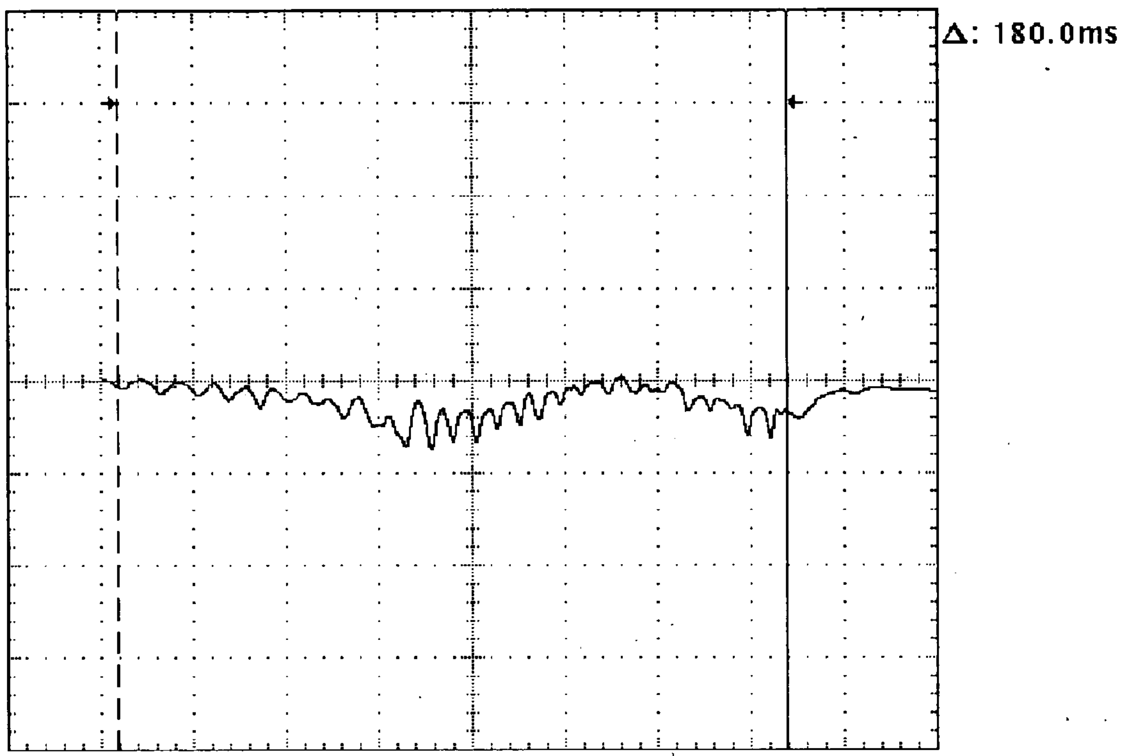

Δ: 180.0ms

FIG. 5


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FIG. 6

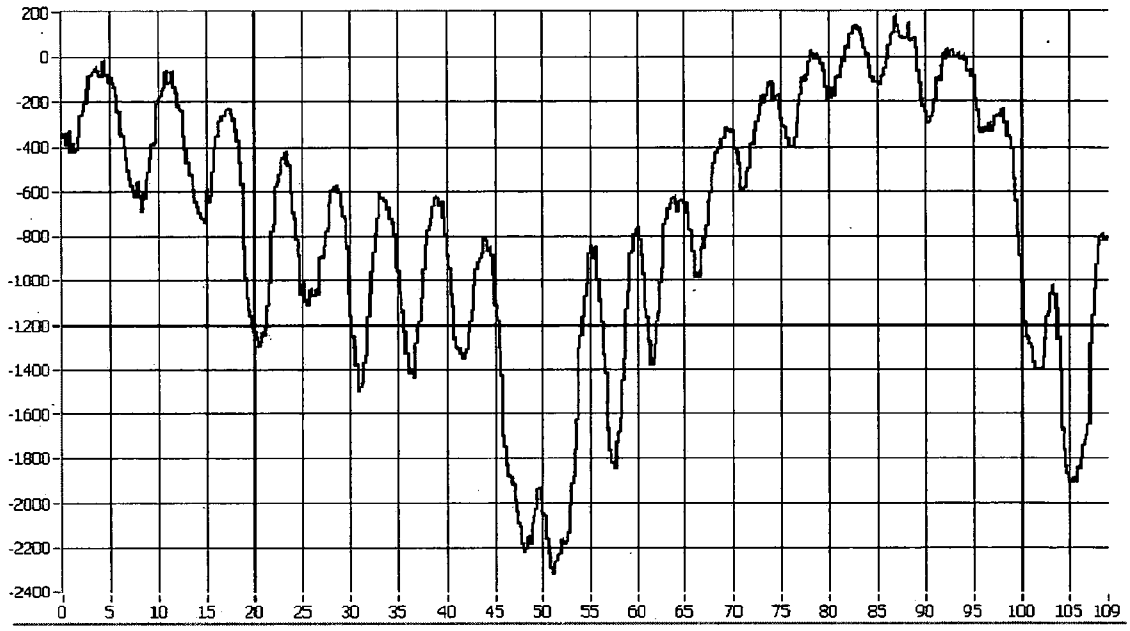
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FIG. 7

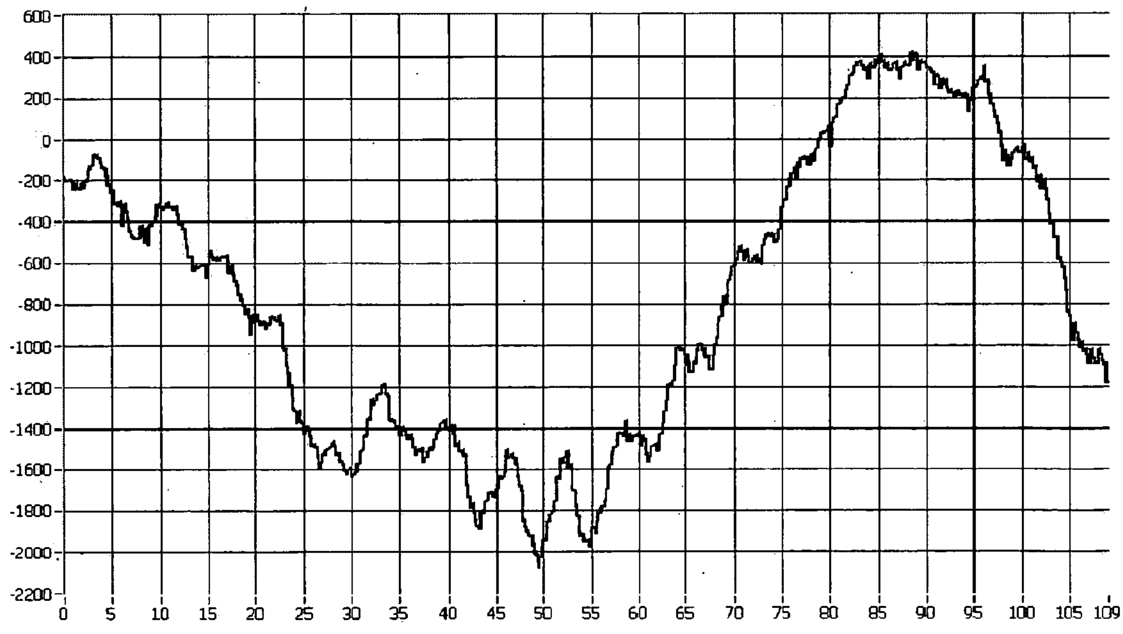
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FIG. 8

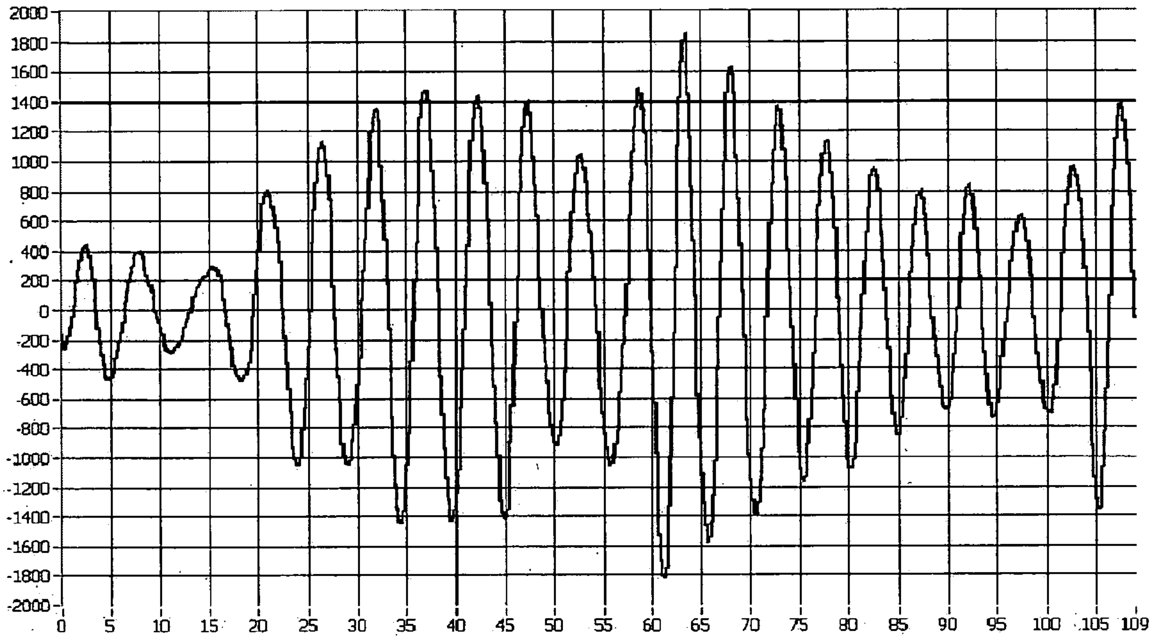
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FIG. 9

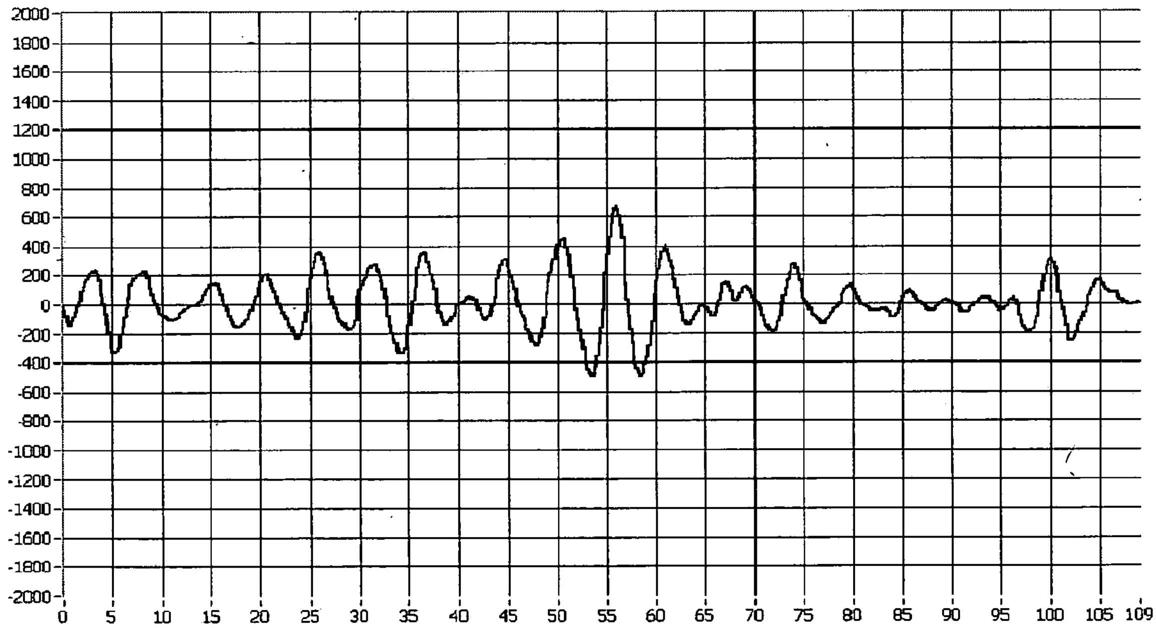
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FIG. 10

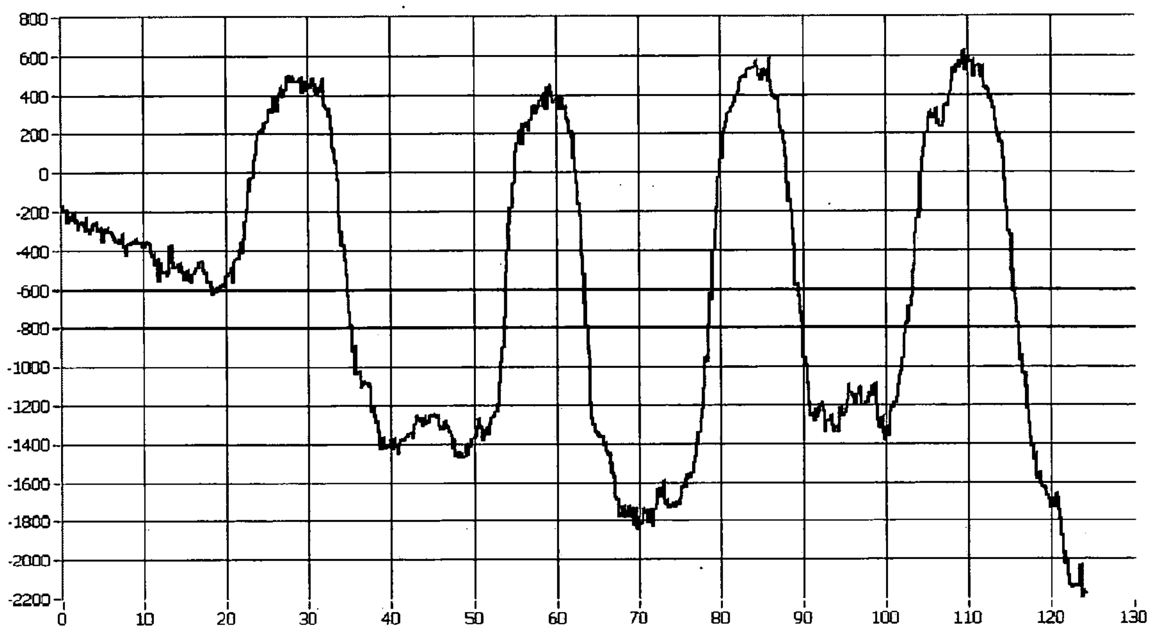
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FIG. 11

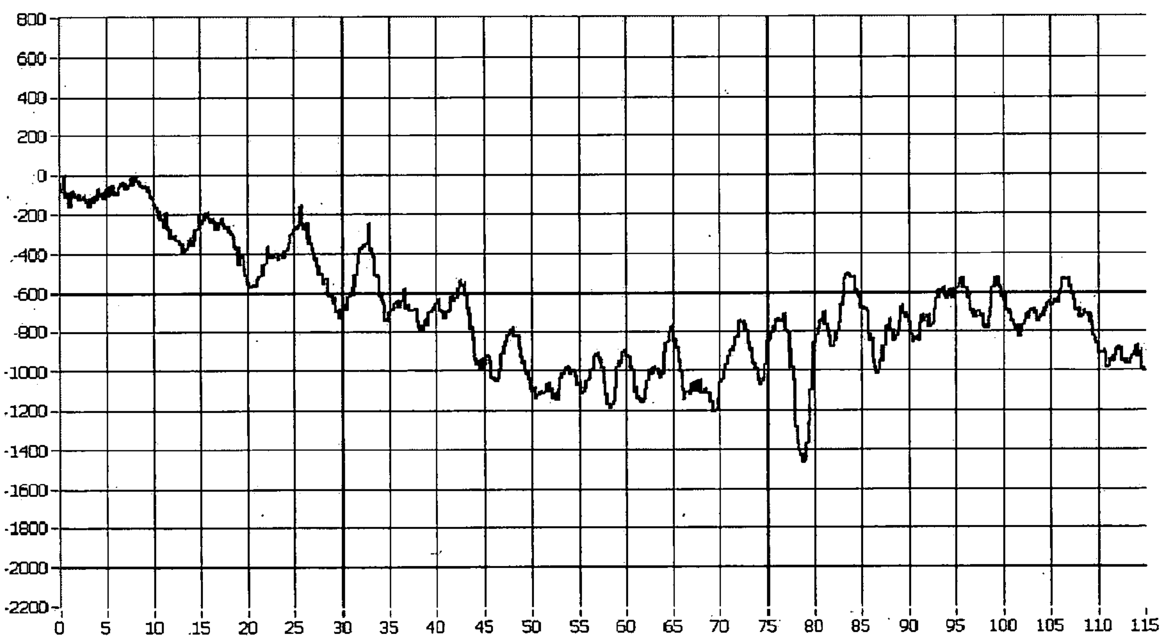
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FIG. 12

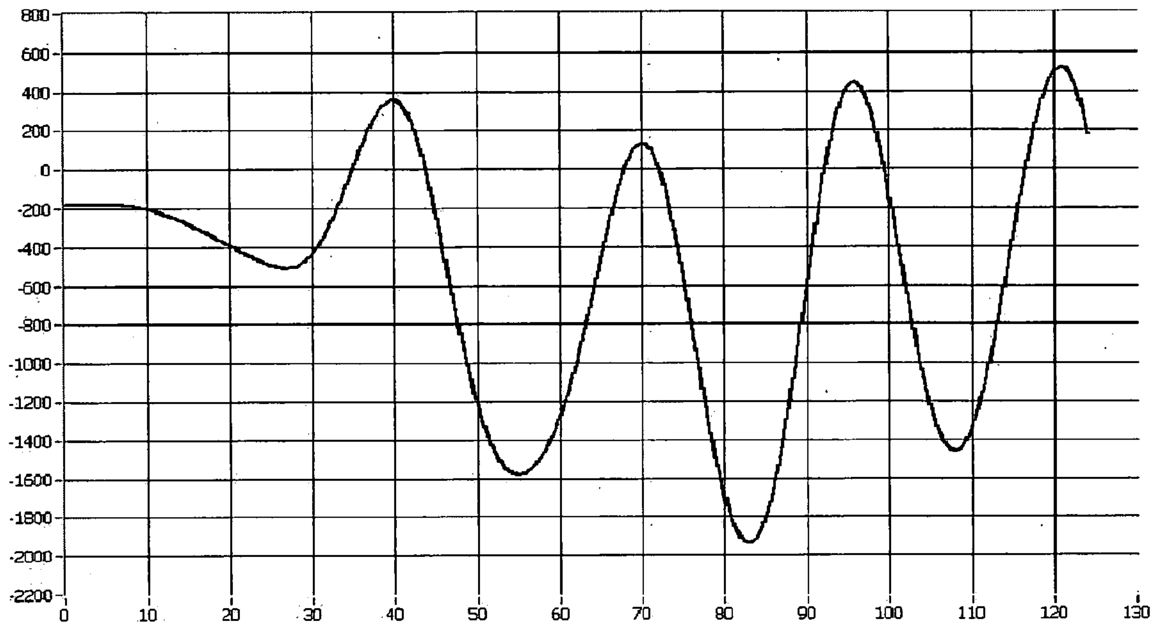
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FIG. 13

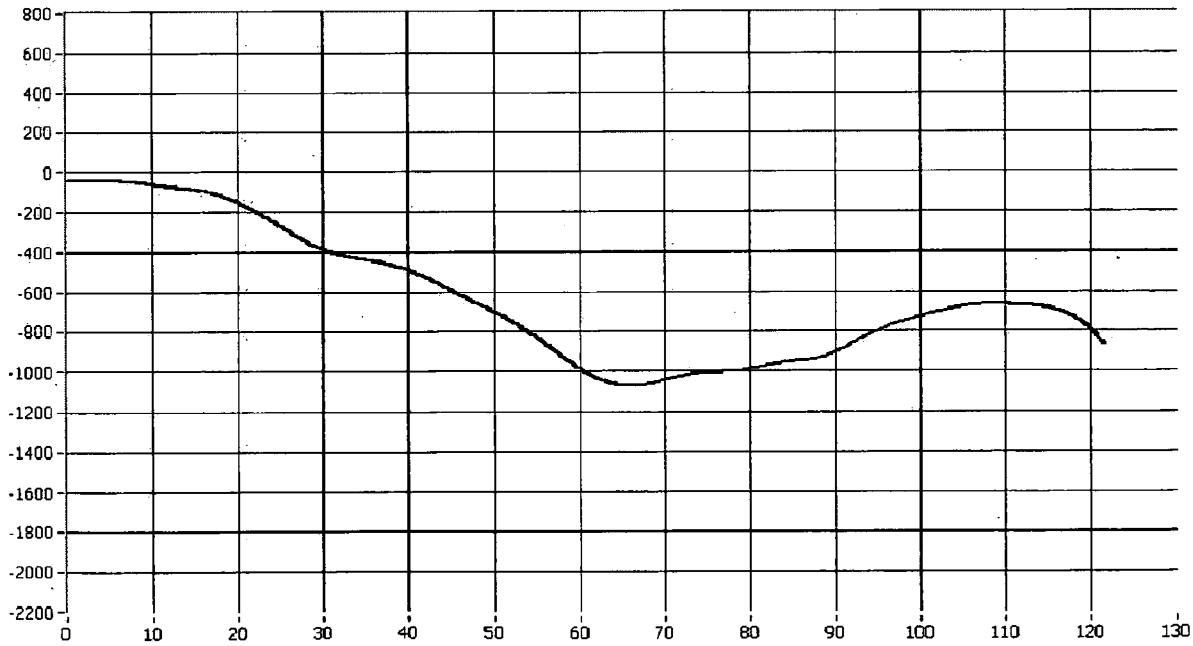
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FIG. 14

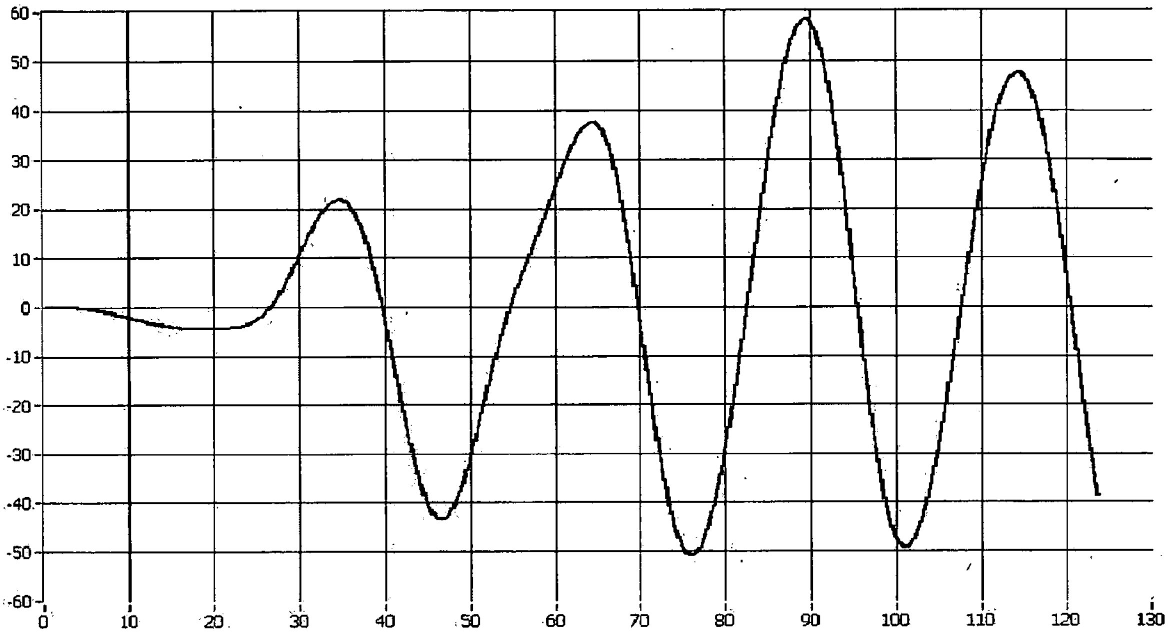
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FIG. 15

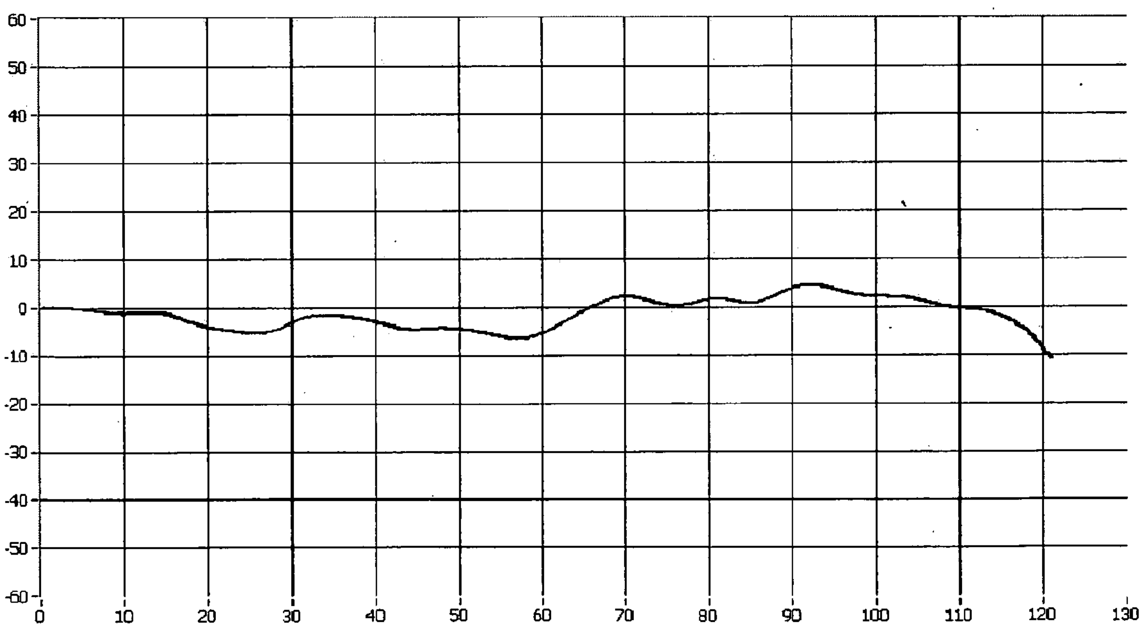
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FIG. 16

REFERENCES CITED IN THE DESCRIPTION

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