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(54) METHOD AND DEVICE FOR VALIDATING AND CHARACTERIZING COINS

(57) Method and apparatus for coin validation and characterisation, comprising partial illumination of the edge of coin (1) by a collimated beam of light (6) with a rectangular cross-section, which reaches the edge of the coin along a band parallel to the axis of said coin, of a width equal to or smaller than the thickness of the alterations which are to be detected. A sensor (9) for analysing the reflected light is placed so that it receives only the diffuse reflection (11) caused by the relief or surface alterations of the coin edge, but does not receive specular reflection (12) caused by the smooth areas of said edge.

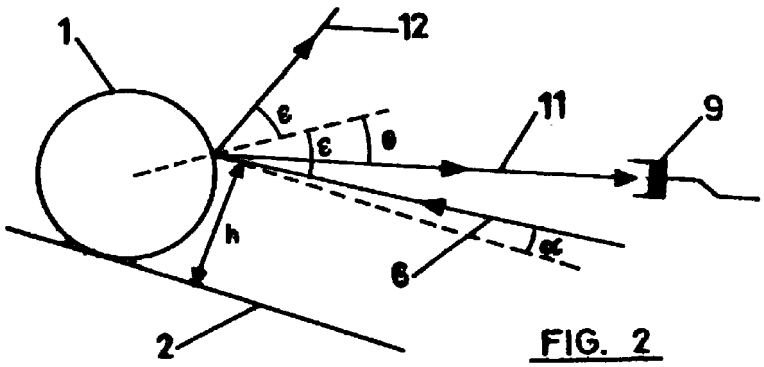

FIG. 2

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Description

[0001] The present invention relates to a method for validation and characterisation of coins by examining the relief on the coin edge. The invention also includes the apparatus used to carry out the validation and characterisation.

[0002] The method and apparatus of the invention obtain an electrical signal which is characteristic of the existence or absence of relief and also of the type of relief present in the coin edge, where by relief is meant both recesses and embossing present in the edge, in whichever configuration they are present, such as ribs, grooves, etc.

[0003] Systems are known for analysing the validity of coins by illuminating the edge of said coins and analysing the reflected signal.

[0004] At this time apparatuses are known which analyse coins by illuminating their edge and analysing the signal reflected by the coin.

[0005] Document WO 91/066072 (Datalab) discloses a apparatus which analyses the knurling of coin edges by illuminating an arc of the coin. The reflected light is focused on a sensor by a lens. On the detector is placed a grid-like mask with an image engraved similar to that of the valid coin. If the periodicity of the mask and the coin knurling coincide a modulated signal is produced which is used to recognise the coin. This procedure has the disadvantage that the analysis of the coin takes place in a small spatial area which matches the circular sector of the coin edge when it is placed opposite the optical axis of the lens. Additionally, only part of the image obtained is properly focused, since the focal plane will only lie on a relatively small area of the coin edge because of its curvature. A further inconvenient of the apparatus described is that it is only valid for detecting a knurl which matches that of the mask employed.

[0006] Document DE 3711941 (Standard Elektrik Lorenz) describes a apparatus for lateral verification of coins where the coin is illuminated from the bottom, from near the rolling track. Before reaching the coin the beam of light is focused, so that it is incident on a small area of the coin edge. The receptor is placed embedded in the bottom of the rolling track so that it receives the light reflected from the edge of the coin when it is near said sensor. This system, as the previous one, has the disadvantage that the coin can only be analysed over a small area of its path because of the location and geometry used for the emitter and receiver set. Additionally, the emitted beam can only be focused on a small range of distances.

[0007] Belgian Patent 861.396 (Mars) employs an optical procedure for discriminating coins having different edges. It can differentiate grooved coins from flat or polygonal coins. The apparatus relies on illuminating the coin edge with a photodiode and detecting the level of light reflected by the coin. For a flat coin the reflected light is different than for that obtained from a grooved coin. It is also different if the coin is polygonal, in which case more than one light impulse is produced. The device and procedure described does not allow a detailed analysis of the coin edge, since it can only measure the total amount of light reflected by a coin, so that coins with different grooves may produce similar reflection levels, or two different results may be obtained for identical coins in a different state of conservation (different shine).

[0008] The object of the present invention is a method and an apparatus which allow to obtain information on the edge of the coin which is independent of the shine or conservation state.

[0009] The invention provides a signal characteristic of the relief (hereunder grooves) of the coin edge, so that for example, the number of grooves of the coin in a certain segment can be found, the spacing between grooves, the type of grooves (continuous or staggered) or if the coin is smooth. Likewise, size characteristics of the grooves may be obtained, such as the size of the grooves, separation between grooves and uniformity of the grooves.

[0010] In accordance with the present invention, the light emitter which illuminates the coin edge and the receiver for the light reflected by said edge are arranged with respect to each other so that the receiver receives only the diffuse reflection caused by the grooves of the edge surface, but not the specular reflection caused by the smooth area of the edge which lack relief.

[0011] As described above, by relief is meant both recesses and embossing of the edge, and in general any geometrical alteration of its surface.

[0012] So that the measurement is characteristic of the coin grooves, the width of the illuminating beam must be equal to or smaller than the size of the grooves. For this purpose, the light arriving from the emitter is passed through a slit, producing a rectangular beam which reaches the coin edge along a band parallel to the edge of the coin which encompasses the entire extension of said edge and has a width equal to or smaller than the thickness of the groves or geometrical alterations of said coin edges.

[0013] In order to prolong the measurement for a distance sufficient to examine a significant area of the coin periphery, the light beam must maintain its properties constant along its entire path, so that a collimated beam should be preferably used.

[0014] Preferably, the beam which illuminates the edge of the coins must be substantially parallel to the rolling plane of the coin, or form a small angle with it and is incident on the edge of the coins at a certain height above the rolling track, higher than the radius of said coins.

[0015] The apparatus for performing the procedure of the invention comprises a collimated light emitter which generates a light beam parallel or at a small angle to the rolling track of the coin; a wall or screen which is placed between the light emitter and the coin and is pro-

vided with a slit which allows a rectangular beam to pass which illuminates the entire width of the coin edge; and a receiver of reflected light placed so that it can only receive diffuse light reflected from the coin edge and not light reflected specularly by said edge. This property allows the receiver to be placed near the emitter.

[0016] The characteristics of the method and apparatus of the invention as set forth in the claims are now described in greater detail with the aid of the attached drawings, in which is shown an example of a non-limiting embodiment.

[0017] In the drawings:

Figure 1 is an basic assembly diagram of the apparatus of the invention.

Figure 2 is a diagram of the incident light beam and the beam reflected by the coin edge, according to the method of the invention.

Figure 3 is a sectional enlarged view of the slit which forms the light beam incident on the coin edge according to the method of the invention.

Figure 4 shows the light beam obtained by the slit of figure 3 which is incident on the edge of the coin.

Figures 5 to 8 show the signals obtained with the apparatus and method of the invention from coins with different relief on their edges.

[0018] Figure 1 shows a coin (1) rolling along a rolling track (2). The edge of the coin is illuminated by an emitter (3), preferably consisting of a laser diode, which emits a light (4) which passes through a slit (5) producing a beam (6) of rectangular outline which will incide on the edge of coin (1).

[0019] Figure 3 shows in greater detail slit (5) through which passes light (4) produced by emitter (3), obtaining a rectangular shaped beam (6) which, as seen in figure 4, incides on the edge of the coin along a band parallel to the first axis of said coin, with the length of this band preferably greater than the thickness of the edge of coin (1) and its width equal to or smaller than the width of the geometrical alterations or grooves (8) of the edge of coin (1) which are to be measured.

[0020] The basic installation shown in figure 1 is completed with a receiver (9) for light (10) reflected by the edge of coin (1).

[0021] The method of the invention tries to avoid light reflected specularly by the edge of coin (1) from reaching receiver (1), which consists of a suitable receiver.

[0022] For this purpose, in accordance with the invention, the edge of coin (1) is illuminated at an angle substantially parallel to the rolling track (2) of coin (1), so that beam (6) incides on said edge above the centre of the coin. In these conditions, as shown in figure 2, detector (9) will only receive diffuse reflection (11)produced by the striations or geometrical alterations of the coin edge, while specular reflection (12) due to the smooth areas of the coin edge, does not reach detector (9). When illuminating beam (6) is strictly parallel to the rolling ramp (2), receiver (9) will provide a signal with an amplitude growing as coin (1) nears the receiver (inverse square law). This effect, which in principle is of no consequence unless the amplitude of the pulses is used to identify the coins, may be reduced by inclining beam (6) somewhat with respect to the rolling direction, by a small angle alpha, on the order of for example 3°when detector (9) is placed near emitter (3). By placing detector (9) in the same area as emitter (3), direct reflection (12) will not arrive at the receiver.

[0023] Emitter (3) shall be a semiconductor laser, visible or infrared, with a collimated light output. Generally, these type of devices provide an elliptical section beam, which is not a problem for this application since a rectangular beam is desired. In any case, this is achieved, as described above, by interposing between emitter (3) and coin (1) a slit (5) of dimensions suitable to form the desired beam (6), as already described, with the longer side coinciding with the major axis of the beam's elliptical section.

[0024] Thanks to the use of collimated light the slit (5) may be placed near emitter (3), thus allowing a compact and small assembly.

[0025] The optimal dimensions for slit (5) are set for its length by the maximum thickness of the coin to be measured, which may be estimated at around 3 mm. As regards the height of slit (5) this is set on one hand by the fineness of detail required or by the smallest grooves which need to be identified, and on the other hand by the diffraction effect which appears when the slit is excessively thin. It has been found that a slit height between 0.2 and 0.4 mm may be suitable for most commonly used coins with tolerable diffraction from red to near infrared bands.

[0026] As mentioned before, receiver (9) is mounted so that it does not sense light (12) specularly reflected by the coin, but so that it does receive diffuse light (11) reflected by the relief of said coin.

[0027] Figures 5 to 8 show the signals provided by receiver (9) for different types of relief on a con edge. When the coin has no relief the detector will provide a virtually null signal.

[0028] Figure 5 shows the signal obtained when inserting a coin with a 'Spanish flower' type edge, which consists of curved notches separated by a distance several times greater than the size of said notch. As seen, impulses separated by signal-free intervals appear, which correspond to the incisions and to the smooth areas of the coin edge respectively.

[0029] Figure 6 corresponds to the signal obtained by a sample coin similar to the future 1 Euro coin, which shows a fine striation interrupted by smooth areas. As in the previous case, impulses are seen clearly which cor-

respond to the striations of the coin edge, but the separation between impulses and their duration is clearly smaller as the grooves are much thinner.

[0030] Figure 7 shows a coin with a uniform striation, which shows impulses with duration and separation between them substantially constant. However, a 'compression' of the signal is appreciable from left to right, which is due to the acceleration of the coin as it rolls on an inclined plane, as shown in figure 1.

[0031] Lastly, figure 8 shows the signal which appears for a coin which in addition to a uniform striation presents uniformly distributed figures. In this case impulses representative of the striation also appear, but with their amplitude modulated by the signal produced by said motifs.

[0032] As can be inferred from the figures shown it is possible to obtain easily signal characteristics which are representative of coin parameters which identify these, as a function of the relief of their edge. For example, impulses in a certain spatial or time interval can be counted, duration of the impulses and their separation may be measured, or the amplitude and frequency of these impulses may be measured.

[0033] The device disclosed can be completed with known systems for measuring the coin diameter, such as that described in Patent ES 557 523 in the name of the present applicants, consisting of optical sensors (13) which in addition to its size (chord intercepted by the optical sensors) can provide the average speed of the entering and exiting coin sides and its acceleration. These data are particularly interesting when requiring the exact measurement of the pulse duration and separation. As mentioned previously, the duration of the pulses received by the detector depends on the relief of the coin and of the speed at which it travels along the rolling track. Therefore, if the speed and acceleration of the coin are known by applying the formulae for uniformly accelerated motion (which is the actual case of a coin rolling down an plane of constant inclination) it is possible to normalise and thereby obtain the pulse duration regardless of the fall conditions of the coin (speed and acceleration). It is thus possible to calculate precisely characteristic parameters of the coin such as type of grooving (uniform, staggered thick, fine or without inclusions, etc.), number of grooves between two fixed positions (such as between the two diameter measurement photodetectors, or between two instants), number of grooves for staggered grooving, space between grooves and space without grooves (for staggered grooving), uniformity of the grooving, ratio of grooved and smooth areas, etc., resulting in a substantial aid in identification of coins since as a rule, the etching characteristics of the edge of coins is constant between different mintings of the same coin. Additionally, the precision and fine resolution of the characteristics which the apparatus of the invention can provide makes it particularly applicable for fraud discrimination and interference between coins of different countries.

Claims

1. Method for coin validation and characterisation comprising the partial illumination of the edge of the coin and the analysis of the light reflected by said edge by means of a sensor or detector, characterised in that the edge of the coin is illuminated by a beam of collimated light, of a rectangular cross-section which reaches the edge of the coin along a band parallel to the axis of the coins, of a width equal to or smaller than the thickness of the alterations which are to be detected; and in that the sensor in charge of analysing the reflected light is placed, with respect to the light emitter, so that said sensor receives only diffuse reflections caused by the relief or surface alterations of the coin edge, but not by specular reflection caused by the smooth areas of said edge, devoid of any relief or alteration.

2. Method as in claim 1, characterised in that the edge of the coin is illuminated by means of a beam of light substantially parallel to the rolling plane of the coin, which incides on the coin edge at a height, with respect to the rolling track, greater than the radius of said coin.

3. Method as in claim 2, characterised in that the beam of light which illuminates the edge of the coins is slightly inclined downwards with respect to the rolling plane of the coin.

4. Method as in claims 2 or 3, characterised in that the light receiver is placed next to the light emitter.

5. Method as in claim 1, characterised in that the edge of the coin is illuminated by a beam which covers the entire width of the edge of said coin.

6. Method as in claim 1, characterised in that the light originating at the light emitter is made to pass through a slit which produces a beam with a rectangular cross-section, which reaches the edge of the coin along a band parallel to the axis of the coin.

7. Apparatus for coin validation and characterisation, characterised in that it comprises an emitter of collimated light, which generates a beam of light parallel or at a small angle to the rolling track of the coin; a wall or screen interposed between the light emitter and the coin which is provided with a slit which allows a rectangular cross-section beam to pass, which illuminates the entire width of the coin edge; and a reflected light receiver placed so that it only receives diffuse light reflected by the edge of the coin and not light reflected specularly from said coin edge.

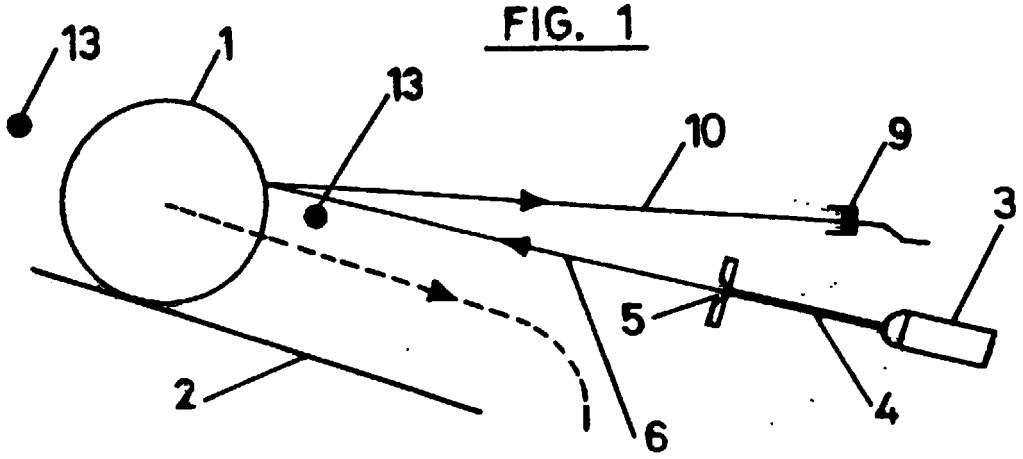
8. Apparatus as in claim 7, characterised in that the

light emitter is a semiconductor laser.

9. Apparatus as in claim 7, characterised in that the aforementioned slit allows a rectangular section beam to pass which, in the useful area of measurement of the coin edge, has a width equal to or smaller than the size of the smallest detail or geometrical alteration which is to be recognised in the coin edge, and a length preferably equal to or greater than the thickness of said edge.

10. Apparatus as in claim 7, characterised in that the detector is a photodiode or phototransistor and is placed in an area where there is no light reflected specularly by the coin, preferably next to the emitter or position of back-reflection.

FIG. 1



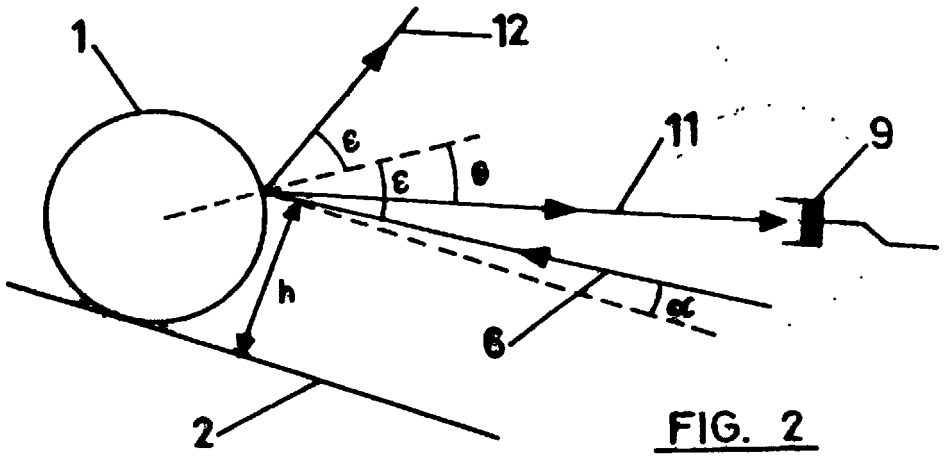


FIG. 2

FIG. 3

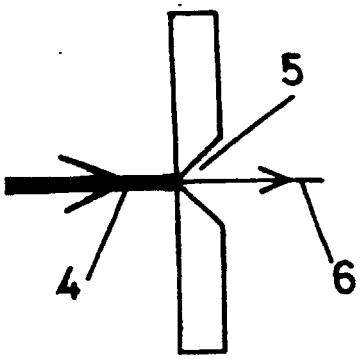
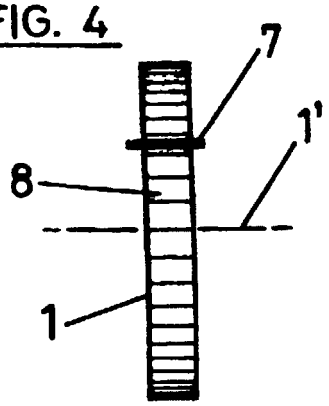


FIG. 4



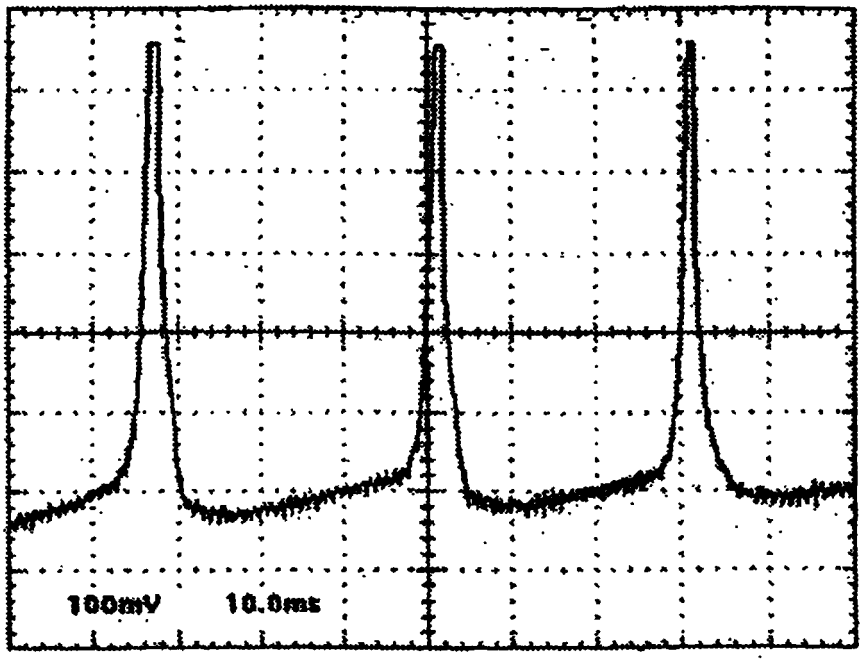
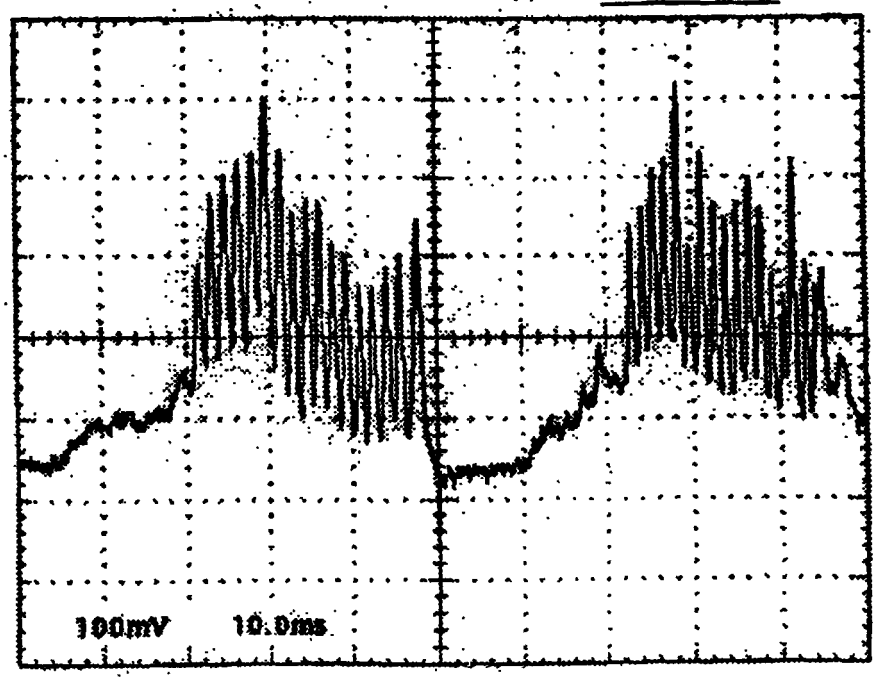


FIG. 5

FIG. 6



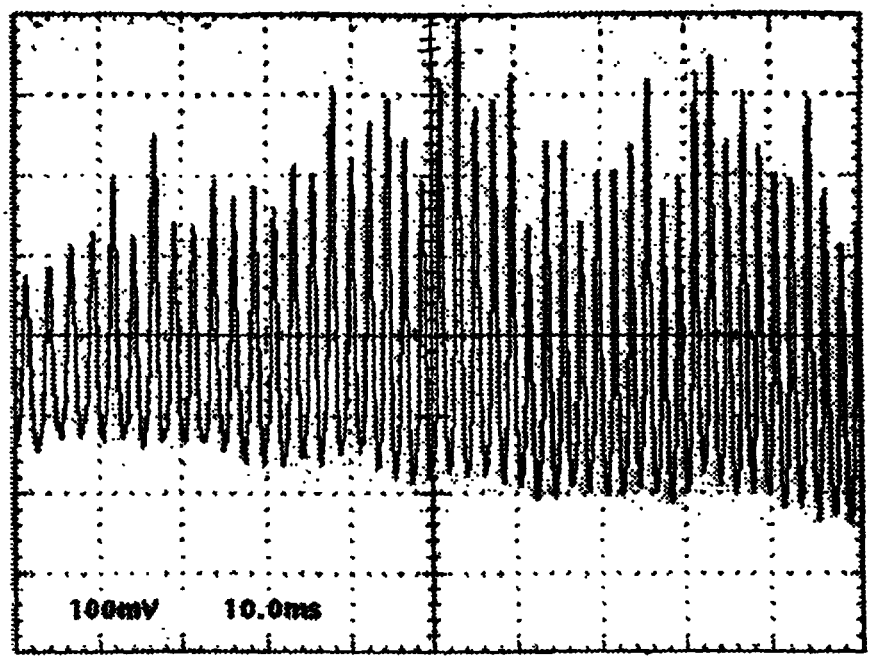
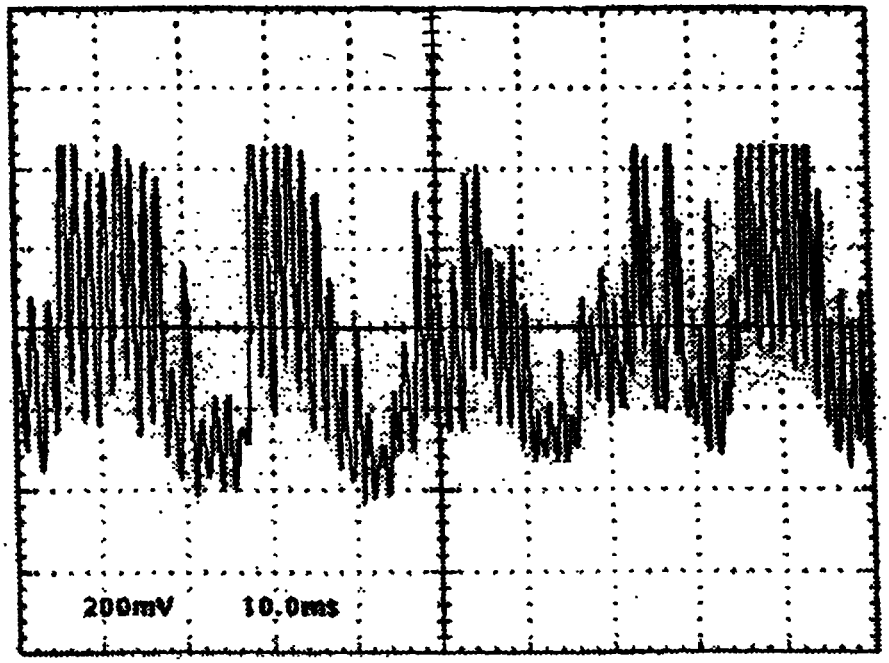


FIG. 7

FIG. 8



INTERNATIONAL SEARCH REPORT

Inter ›nal Application No
PCT/ES 99/00400

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G07D5/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G07D G07F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	EP 0 416 932 A (GLORY KOGYO KK) 13 March 1991 (1991-03-13) column 1, line 1 -column 7, line 31 abstract; figures ---	1,4,5,7, 10
A	DE 37 11 941 A (STANDARD ELEKTRIK LORENZ AG) 20 October 1988 (1988-10-20) the whole document ---	1-3,7,10
A	GB 2 071 381 A (MARS INC) 16 September 1981 (1981-09-16) page 1, line 1 -page 2, line 45; claim 1 abstract; figures ---	1-4
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
15 March 2000	19 04 2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Navarro Farell, a.

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INTERNATIONAL SEARCH REPORT

Inter .nal Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 91 06072 A (DATALAB OY) 2 May 1991 (1991-05-02) abstract; figure 1 -----	

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Information on patent family members

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