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(54) Device and method for coin verification

(57) Device and method for coin verification, the device being mounted in a selector and comprising a sensor assembly; the selector comprises a casing and a zone of passage of the coin to be verified with a rolling track. The sensor assembly comprises an inertial mass and an accelerometer firmly mounted on said inertial mass, the accelerometer measuring the acceleration of the inertial mass according to a first direction in which an action-reaction force is produced between coin and sensor assembly; the sensor assembly has at least one degree of freedom according to a first axis, said first axis being directly related to the first direction of the accelerometer; the device is mounted on the selector casing at any point along the zone of passage of the coin.

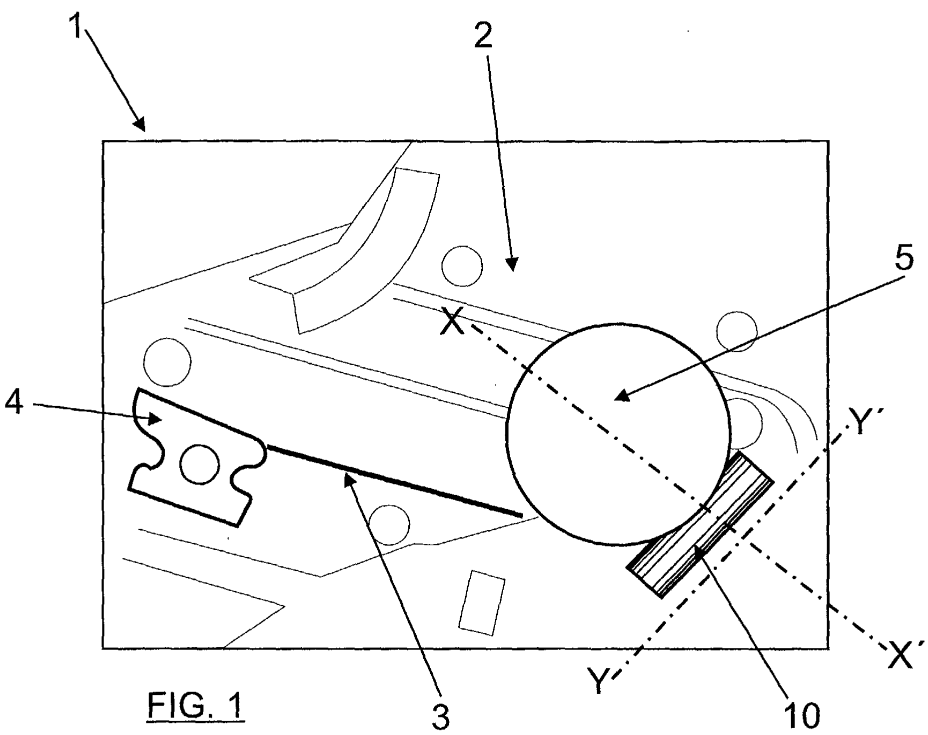

FIG. 1

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Description

Field of the invention

[0001] The present invention lies in the field of devices that check the validity of coins or metal tokens, or of disc-shaped elements in general. In order to differentiate legal tender coins or valid tokens from each other or from fraudulent ones, these devices determine distinct properties such as their dimensions, electrical properties, electromagnetic properties, minting matrices, weight, hardness, etc.

Background of the invention

[0002] Currently, in order to determine the different properties of the coins or metal tokens all types of sensor are employed (optical, electromagnetic, piezoresistive, etc.); the signals obtained from these sensors are processed by subsequent electronic methods.

[0003] Among these methods, the most widely used are those measuring the dimensions of the coin by optical methods and those determining the properties of the alloy in relation to electrical conductivity and magnetic permeability using one or more electromagnetic sensors.

[0004] A lesser number of inventions are known and described relating to measuring the mechanical properties of the coins, such as their elasticity or hardness, which are of interest for detecting frauds consisting of softer and less elastic materials like lead and tin, which some frauds are made of. Determination of hardness and/or elasticity properties are attempted indirectly by measuring, for example, the contact time when the coin strikes a harder element, the energy transmitted to a sensor in such an impact, the form and/or duration of the vibrations generated on the sensor element in the impact, and even the actual vibrations produced on the coin and which are manifested in form of sound. The sensors used in these inventions are generally piezoelectric elements, microphones, or even capacitive type sensors.

[0005] Thus, for example, EP-0318229-A2 describes a method for coin discrimination based on analysis of the sound emitted by coins after striking a hard surface or plate, using as the sensor a microphone placed in the vicinity of the impact surface.

[0006] GB-2339316-A describes a device incorporating a piezoelectric sensor that provides an electric signal representative of the vibrations transmitted through the selector casing from the impact surface, after the impact of the coin against said surface.

[0007] GB-2236609-A describes a coin selector incorporating a piezoelectric sensor that is mounted in the vicinity of a piece which the coin strikes and that acts as a damper or absorber of the kinetic energy of the coin; after the impact, the vibrations propagate through the casing and the piezoelectric sensor generates an electric signal.

[0008] Document WO 83/00400-A1 describes a device for discriminating coins as a function of their elasticity; to this end a piezoelectric sensor is employed which receives the vibrations, via an intermediate piece, generated in a first piece which receives the impact of the coin under analysis. For the device to be trustworthy, the coins must strike the impact surface from the same height.

[0009] In EP-0543212-B1 a piezoelectric sensor is described that is designed to discriminate between coins as a function of their hardness, an estimation of which is made by measuring the time of contact of the coin when striking the sensor during its rolling path. The sensor is constructed by mounting a piezoelectric sensor between a static block that acts as a rigid support and a hard impact surface, which may be spherical or linear. The pressure exerted by the coin while it is in contact with the impact surface is transmitted directly to the piezoelectric sensor as a compression force, being transformed into an electric signal. The duration of the signal from its start until it reaches its steady value is taken as a representation of the hardness of the coin.

[0010] Document ES-2114831-A2 relates to a piezoelectric sensor applicable to discriminating coins as a function of their material and dimensions. For this purpose, as the coin rolls it is made to strike against a solid body that is integrally embedded in one of the walls of the coin trajectory. In its vicinity and at a certain optimum distance, a piezoelectric transducer is mounted that transforms the vibrations produced by the impact of the coin against said body into an electrical signal.

[0011] Also, in EP-0500836-B1, a device is described for discriminating coins as a function of their elasticity. In this case a deformation sensor is used located in the area of impact of the coins, which detects the vibrations generated on impact.

[0012] WO 93/06569-A1 describes a device incorporating a metal plate on which a piezoelectric sensor is mounted; the impact of the coin against said plate produces an oscillating signal that depends on the mass and elasticity of the coin, and the analysis of which is carried out by recording the maximum and minimum values of said signal within a defined time interval. The acceptability of the coin is determined as a function of the peak values or of a combination thereof.

Description of the invention

[0013] The invention relates to a device according to claim 1 and to a method according to claim 19. Preferred embodiments of the device and the method are defined in the dependent claims.

[0014] One of the fundamental limitations of previously described procedures is that the impact characteristics are greatly dependent on the mechanical characteristics and dimensions of the selector, like, for example the materials used, the anchoring of the different components, its inclination, manufacturing tolerances, resulting in large dispersions in the coin measurements that substantially hinder discrimination of frauds. In addition to this problem, the sensors employed, particularly piezoelectric and piezoresistive ones generally have broad tolerances and drifts. Furthermore, procedures intended for measuring the time of contact of the coin and the element that it strikes are not very reliable in practice, as said time is very similar for most coins of legal tender. Thus, in practice it is only possible to detect frauds made from much softer materials than the coins, such as lead.

[0015] An objective of the present invention is a device and method for verification of coins and/or tokens that serve not only to determine and differentiate frauds of the soft material type, but also to identify and differentiate different coins of legal tender from each other by measuring their mechanical properties.

[0016] Another objective of the present invention is to obtain a device and method that do not depend on selector dispersions due to its manufacturing process or installation.

[0017] The invention relates to a device for obtaining the mechanical characteristics of a coin for its verification. The device is mounted in a selector comprising a casing and a zone of passage of the coin to be verified, the zone of passage including a rolling track.

[0018] The device of the invention comprises a sensor assembly, which in turn comprises an inertial mass and an accelerometer mounted integrally on said inertial mass. The accelerometer measures the acceleration of the inertial mass according to a first direction in which an action-reaction force is produced between coin and sensor assembly.

[0019] The sensor assembly has at least one degree of freedom according to a first axis, said first axis being directly related to the first direction of the accelerometer.

[0020] The device for obtaining the mechanical characteristics of a coin for its verification is mounted on the selector casing at any point of the zone of passage of the coin through the selector, so that an impact is produced between coin and sensor assembly. Better results are obtained from the sensor assembly when the latter is mounted in an area in which the movement of the coin takes place in a stable manner.

[0021] Preferably, the sensor assembly is arranged at the end of the coin rolling track. In some selectors it may also be convenient to locate the sensor assembly at the beginning of the rolling track, forming part of the striking plate or absorbent element of the coin prior to its rolling. It is also possible to locate the sensor assembly in a zone where the coin is in free fall, as may be a zone prior to the rolling track.

[0022] In any case, it is possible to use the impact of the coin on the rim of its edge or on the front part of said edge.

[0023] In order to obtain an improved sensor assembly, the accelerometer is mounted on an inertial mass comparable to that of the coin, that is, the inertial mass is of the same order of magnitude as the mass of the coin it is wished to verify. Thus, the inertial mass preferably has a mass between 1 and 50 grams, and more preferably the inertial mass has a mass between 1 and 10 grams.

[0024] The surface on which the impact takes place must have a hardness greater than that of the hardest coin. Thus, preferably, the inertial mass can be made of a first material with a hardness that is greater than that of the hardest coin.

[0025] As only the surface on which the impact takes place must be hard, a piece can be used made of two or more different materials, or else subject a material to a surface treatment. That is, the inertial mass can be made of any second material whatsoever, covered with a first material with a hardness greater than that of the hardest coin. Another possibility is that the inertial mass be made of different materials, the material of the surface on which impact takes place being a first material having a hardness greater than that of the hardest coin.

[0026] As a first material having a hardness greater than that of the hardest coin it is possible to use many steels available on the market. Another possibility is to use ceramic materials.

[0027] In addition, it is convenient that the surface on which the impact takes place has a surface that minimises the area of impact; in this manner, more repeatable or stable results are obtained. Thus, for example, it is possible to use a surface with a gentle curvature. A simple geometry can consist of a cylindrical steel or ceramic surface, which transmits the impact to the rest of the sensor assembly. In the case of a lateral impact it is possible to use a flat impact surface forming a certain angle with the direction of movement of the coin.

[0028] Unlike the devices known, the invention uses a sensor assembly with an accelerometer mounted on an inertial mass, the sensor assembly having at least one degree of freedom to move on the impact of the coin. The axis or direction of motion shall be related to that of the action-reaction force of the sensor assembly during the impact.

[0029] Preferably, the inertial mass is elastically joined to the selector casing. In this manner the returns of the inertial mass to the point of origin is ensured, for example, by two or more springs that subject said inertial mass to a restoration force of negligible magnitude with respect to the acceleration force produced by the impact, whereby for mechanical purposes, the mass of the sensor assembly can be considered to be free on said axis. In this manner the sensor which is mounted on the inertial mass will be subjected to an acceleration throughout the duration of the impact that will be related to the relative masses of the sensor and coin assembly, the speed of the coin and particularly the elasticity and hardness of the materials that come into contact. For the surface on which impact takes place, a material is chosen with a hardness greater than that of the hardest coins, the object being that permanent deformations occur only on the coins, while on said mass the deformation is always elastic.

[0030] That is, in order to make the response of the sensor assembly as independent as possible of the mechanics of the selector, this sensor assembly has been designed based on an accelerator mounted on an inertial mass, so that the sensor assembly behaves as an element independent of the selector casing. This is achieved by securing or suspending the sensor element by elastic components. Thus, the sensor assembly will behave as a free element and therefore is independent of the other characteristics of the selector that could affect its response unpredictably. In this assembly the development with time of the action-reaction force during the impact is translated into the development of the acceleration of the sensor assembly over the same time interval.

[0031] Another aspect of the present invention is to provide a method for obtaining the mechanical characteristics of a coin for its verification.

[0032] This method comprises the following steps:

- arranging an inertial mass elastically within a selector casing
- arranging an accelerometer integrally joined to the inertial mass,
- characterising the mechanical response of the selector as a whole, with regard to impacts on the sensor assembly
- subjecting the coin to an impact against the inertial mass, producing an acceleration in said inertial mass,
- using the accelerometer to measure data related to the acceleration that is produced in said impact,
- processing said data related to the acceleration together with said characterising of the mechanical response of the selector, and
- extracting a characteristic function of the development of the action/reaction force between coin and inertial mass,

such that said development is independent of the selector characteristics, and shall depend only on the hardness and elasticity of the coin material.

[0033] In addition, each sensor assembly will have certain individual characteristics associated to it that will not be identical for the different elements of a given production series, due to the inevitable tolerances in the mechanical element of the inertial mass, assembly of the sensor assembly and the tolerances of the sensor (accelerometer) itself. In order for the measurement of the contact force to be independent of the selector, that is, of the sensor assembly itself, it is first necessary to characterise the mechanical response of the selector as a whole.

[0034] This sensor characterisation is preferably performed by measuring its impulse response or its frequency response, in both magnitude and phase.

[0035] Preferably, the characterisation of the mechanical response of the selector as a whole is carried out by producing an impact with a duration substantially shorter than the typical duration of a coin impact.

[0036] By way of illustration, a typical impact duration for coins in legal tender is between 40 μs and 200 μs, depending on the characteristics of the coin and of the impact element. A considerably shorter impact duration can be obtained by employing a free-falling small spherical ball of diameter, for example, of 3mm or less, made of steel or any other material with a high Young's modulus and hardness. The duration of this impact is on the order of 10 μs.

[0037] The characterising of the sensor assembly can also be carried out by introducing a set of different discoid tokens made of materials with known mechanical properties, encompassing a range of values of hardness and elasticity.

[0038] This method is completely different to that suggested, for example, in the aforementioned document GB-2339316-A, wherein a calibration is proposed based on introducing a set of valid coins and frauds, whereby, by means of a training algorithm, selector-dependent parameters are calculated for each valid coin. The calibration method proposed herein does not require the use of coins, nor of frauds and is valid for coins of any value.

[0039] The information obtained from the mechanical response of the selector is stored in the selector memory and is used to calculate, based on the form provided by the sensor assembly of the impact acceleration of the coin, the true form and development of the action-reaction force between coin and sensor assembly, which will depend only on the properties of hardness and elasticity of the material of the coin.

[0040] The calculation or extraction of the action-reaction force can be performed in several ways, which can be distinguished in a first classification as time-based and frequency-based.

[0041] Regarding time-based calculations, if y(t) is the expression of the signal provided by the sensor assembly upon impact of a coin and h(t) is the expression of the calibration response of the selector, it is assumed that the expression relating them to the form of the impact acceleration, termed x(t), has the form:

$$y(nT_s)= h(nT_s)*x(nT_s),$$

where * is the linear convolution operation and T_s is the signal sampling period. From this relation $x(nT_s)$ can be obtained by a linear deconvolution operation.

[0042] Another possibility is to calculate the development of the action-reaction force by filtering the data relative to the acceleration with the inverse impulse response filter; that is, an alternative form of performing this calculation in the time domain is that of calculating the inverse filter $h_i[nT_s]$ from $h(nT_s)$ and then calculating $x(nT_s)$ as:

$$x(nT_s)= h_i(nT_s)*y(nT_s).$$

[0043] In any case, $x(nT_s)$ can be calculated using any known deconvolution technique, preferably by recursive calculations from samples in time of the impulse response of the sensor assembly and from the acceleration produced during the impact of the coin on the sensor assembly.

[0044] Regarding the frequency-based calculation, it is first necessary to obtain the spectra of the signals h (t) and y(t), which can be obtained by applying discrete techniques using a DFT (Discrete Fourier Transform) operation, giving rise to H[k] and Y[k] respectively. From this point the complex division will be performed:

$$Y[k]/H[K] = X[k],$$

where X[k] is the DFT of the desired signal $x(nT_s)$, which is finally calculated by an inverse DFT operation on X[k].

[0045] That is, the deconvolution is carried out by means of a complex division of the spectrum of the acceleration produced in the impact of the coin with the sensor assembly and the frequency response of the selector, and then performing the inverse discrete Fourier transform on the result of said division.

[0046] Another alternative to this calculation is to obtain the frequency response of the inverse filter proceeding as follows:

$$H_i[k] = 1/H[k]$$

[0047] And $h_i(nT_s)$ is then calculated by the inverse DFT of $H_i[k]$, and the following calculation is made:

$$x(nT_s)= h_i(nT_3)*y(nT_s).$$

[0048] The methods pointed out above are non-limiting embodiments of the technique described, it being possible to calculate $x(nT_s)$ by other methods, assuming the model defined by the expression:

$$y(nT_s)= h(nT_s)*x(nT_s).$$

[0049] Furthermore, as an alternative to the time- or frequency-based methods described above, the sequence x[n] can also be obtained using as a parameter for discriminating between coins and frauds, various functions that result from X[k] and even Y[k] on the assumption that selector calibration is not necessary. Thus, for example, spectral powers can be calculated by bands as follows:

$$\sum_{j=l}^{m} X^2[j] \quad \text{or} \quad \sum_{j=l}^{m} Y^2[j]$$

where l and m are, respectively, the first and last spectral components of the band of interest. Preferably, calculations involving recursive type operations, sums of products of samples or discrete Fourier transforms, are performed by digital signal processors (DSPs).

[0050] That is, the method of the present invention measures the form in time of the action-reaction force between coin and sensor assembly (inertial mass-accelerometer) on which the latter strikes during the entire contact time. Said form results from the interaction between the elasticity and plasticity of the coin whereby it provides specific information thereon. Alternatively, the method calculates the spectral power of the signals involved in the impact.

[0051] Another aspect of the invention consists in using the high reliability in determining the instant at which the coin strikes the sensor assembly, in order to use it as a reference for analysing coin characteristics with another type of sensor, like, for example, a microphone. When sensors are used to characterise coins by analysing the sound emitted by the coins after striking a hard surface, it is sometimes difficult to determine the precise instant at which the coin strikes said surface as, during its fall, before reaching the impact area, the coin collides against the walls of the selector producing sound signals that can be confused with the useful signal occurring after impact with the hard surface. The accelerometer provided as part of the sensor assembly produces a very clear signal, the start of which can be related to the precise instant at which the coin strikes the sensor assembly, and which can be used as a reference for analysing the sound emitted by the coin. In addition, as the impact element is mounted freely on the selector casing, the sound that appears after the impact is less influenced by other sounds foreign to the coin, as the impact is not transmitted to the casing. These two characteristics considerably improve the measurements that the acoustic sensor can make of the coins, obtaining improved results in the acoustic discrimination of coins. For purposes of acoustic discrimination, optimum results are obtained if the sensor assembly is mounted in the area in which the coin has attained good stability in its motion.

Brief description of the drawings

[0052] Below is provided a brief description of a set of drawings that will assist in a better understanding of the invention, and which are specifically related to an embodiment of the invention presented as a non-limiting example thereof.

Figure 1 shows an arrangement in a coin selector, of a coin verification device according to a first preferred embodiment of the invention.

Figure 2 is a section on the plane X-X' of the selector shown in figure 1.

Figure 3 is a section on the plane Y-Y' of the selector of figure 1.

Figure 4 is a second preferred embodiment of the verification device of the invention.

Figure 5 is a side view of figure 4 (with the walls of the selector casing removed).

Figure 6 shows the form of the signal produced by the accelerometer when characterising the selector.

Figure 7 shows the form of a coin impact (a double impact) as well as the calculated value of the action-reaction force.

Figure 8 shows the different forms of the acceleration for a coin of legal tender and for a fraud.

Description of a preferred embodiment of the invention

[0053] Figure 1 shows a part of a coin selector 1 in an open position, showing, as known selector components, a selector casing 2, a rolling track 3 for the coins and a striking plate 4. Inside the selector, at the end of the rolling track, is a coin 5. This coin 5 is in contact with an inertial mass 10 that in this embodiment is a steel cylinder.

[0054] Figures 2 and 3 show an embodiment of the coin verification device of the invention in which the sensor assembly comprises an inertial mass 10 and an accelerometer 11. In the position shown in figure 2 the coin 5 has not struck the sensor assembly yet. When the impact between the coin and sensor assembly takes place, in accordance with the preferred embodiment shown in figures 2 and 3, the impact will take place on the rim of the coin edge. In this case, the sensor assembly is placed at the end of the rolling track, the inertial mass being situated on one of the walls of the selector casing. The sensor assembly, comprising an inertial mass 10 and an accelerometer 11, is subjected by springs 12 to a restoration force that ensures the return of the sensor assembly to its point of origin after the impact. This restoration force is smaller in magnitude than the force exerted on the sensor assembly by the impact.

[0055] In figures 2 and 3 the arrow A indicates the sense and direction of the coin rolling motion, and the arrow B indicates the sense and direction of the action-reaction force of the sensor assembly after the impact (not shown) with the coin.

[0056] Figures 4 and 5 show another possible embodiment for the invention. In these figures the selector casing has been omitted for the sake of greater clarity. In this embodiment, the sensor assembly is placed at the start of the coin rolling track, forming part of the element (or striking plate) that absorbs the impact of the coin before it rolls. In this case, the coin 5 strikes with the front part of its edge on the inertial mass 10. The sensor assembly in this case is attached by an elastic, not rigid, support 13.

[0057] The accelerometer is connected by electrical connections 14 to electronic means (not shown) which, for example, digitally process the signal given by the accelerometer (on the sensor assembly), extract the function that characterises the development of the action-reaction force between coin and sensor assembly.

[0058] With any of the embodiments of the device of the invention shown in figures 1 to 5, the calibration or characterisation of the selector is carried out to obtain its mechanical characteristics upon impact of an object on the sensor assembly. The selector is calibrated by launching in free fall a spherical ball with a diameter that can be, for example, 3mm or less, made of steel or other material with a higher Young's modulus and hardness. Alternatively, the calibration can be carried out by introducing discoid tokens of different characteristics with regard to hardness and elasticity.

[0059] Figure 6 shows the form of the selector calibration signal, h(t).

[0060] After said calibration has been carried out, the development of the action-reaction force calculated between coin and sensor assembly is independent of the selector characteristics, and will only depend on the characteristics of the coin.

[0061] Figure 7 shows the form of the impact of a coin, more specifically a double impact, given by the sensor assembly y(t) together with the calculated value of the form of the acceleration x(t). In this figure it is appreciated how the signal x(t) is essentially non-zero for the time the impact lasts, and that by means of the described procedure the resonance of the sensor assembly, among other things, has been eliminated.

[0062] Figure 8 shows the different forms of the acceleration $x_m(t)$ and $x_f(t)$ for a coin of legal tender and a fraud, respectively.

[0063] One possible method for extracting the acceleration x(t) by time-based calculations is that the expression relating the signal given by the sensor y(t) and the calibration response obtained for the selector h(t) with said acceleration x(t) has the form:

$$y(nT_s) = h(nT_s)*x(nT_s),$$

where * is the linear convolution operation and T_s is the sampling period of the signal. With this relation $x(nT_s)$ is obtained by a linear deconvolution operation.

[0064] The method described is a non-limiting embodiment, it being possible to calculate $x(nT_s)$ by other methods.

Claims

1. Device for obtaining mechanical characteristics of a coin (5) for its verification, mounting the device in a selector (1) and comprising a sensor assembly, the selector (1) comprising a casing (2) and a zone of passage of the coin (5) to be verified with a rolling track (3), **characterised in that**:

- the sensor assembly comprises an inertial mass (10) and an accelerometer (11) mounted firmly on said inertial mass, the accelerometer measuring the acceleration of the inertial mass according to a first direction in which an action-reaction force is exerted between coin and sensor assembly, and **in that**
- the sensor assembly has at least one degree of freedom according to a first axis, said first axis being directly related to the first direction of the accelerometer, and **in that**
- the device is mounted on the selector casing at any point of the zone of passage of the coin.

2. Device according to claim 1, **characterised in that** the inertial mass (10) is of the same order of magnitude as the mass of the coin (5) to be verified.

3. Device according to claim 2, **characterised in that** the inertial mass (10) has a mass between 1 and 50 grams.

4. Device according to claim 3, **characterised in that** the inertial mass (10) has a mass between 1 and 10 grams.

5. Device according to any of the previous claims, **characterised in that** the inertial mass (10) is made of a first material with hardness greater than that of the hardest coin.

6. Device according to any of claims 1-4, **characterised in that** the inertial mass (10) is made of any second material whatsoever, coated with a first material with hardness greater than that of the hardest coin.

7. Device according to any of claims 1-4, **characterised in that** the inertial mass (10) is made of different materials, the material of the surface whereon the coin impacts being a first material with a hardness greater than that of the hardest coin.

8. Device according to any of claims 5-7, **characterised in that** the first material is steel.

9. Device according to any of claims 5-7, **characterised in that** the first material is a ceramic material.

10. Device according to any of the previous claims, **characterised in that** the inertial mass (10) has a surface on which the impact of the coin occurs that is gently curved.

11. Device according to claim 10, **characterised in that** the inertial mass is a cylinder.

12. Device according to any of claims 1-9, **characterised in that** the inertial mass has a surface on which the coin impact occurs which comprises a plane having a certain angle with respect to the trajectory of the coin.

13. Device according to any of the previous claims, **characterised in that** the inertial mass is connected elastically to the selector casing.

14. Device according to claim 13, **characterised in that** the inertial mass is attached to the casing by one or more springs (12).

15. Device according to any of the previous claims, **characterised in that** the sensor assembly is arranged at the start of the rolling track (3).

16. Device according to any of claims 1-14, **characterised in that** the sensor assembly is arranged at the end of the rolling track (3).

17. Device according to any of claims 1-14, **characterised in that** the sensor assembly is arranged at a point of the zone of passage of the coin in which the movement of the coin (5) is taking place in a stable manner.

18. Device according to any of claims 1-14, **characterised in that** the sensor assembly is arranged at an area of free fall of the coin (5).

19. Method for obtaining mechanical characteristics of a coin for its verification, that comprises:

- arranging an inertial mass (10) elastically on a casing (2) of a selector (1),
- arranging an accelerometer (11) firmly attached to the inertial mass (10), said inertial mass and said accelerometer forming a sensor assembly,
- carrying out a characterisation of the mechanical response of the selector upon an impact on the sensor assembly,
- subjecting the coin to an impact against the inertial mass, producing in said inertial mass an action-reaction force,
- measuring with the accelerometer some data related to the acceleration produced in said impact,

- processing said data related to the acceleration together with the characterisation of the mechanical response of the selector, and
- extracting a characteristic function for the development of said action-reaction force between coin and inertial mass,

such that said development is independent of the selector characteristics.

20. Method according to claim 19, **characterised in that** said characterisation is carried out by measuring the impulse response of the selector.

21. Method according to claim 20, **characterised in that** said characterisation is carried out by producing an impact with a duration substantially shorter than the typical duration of a coin impact.

22. Method according to claim 19, **characterised in that** said characterisation is carried out by measuring the frequency response of the selector in both magnitude and phase.

23. Method according to any of the previous claims, **characterised in that** the extraction of said development of the action-reaction force is carried out by deconvolution techniques.

24. Method according to any of claims 19-23, **characterised in that** the extraction of said development of the action-reaction force is carried out by filtering the data relative to the acceleration with the inverse filter of the selector response.

25. Method according to claim 23 when depending on claim 20, **characterised in that** the calculation is performed recursively from samples in time of the impulse response of the sensor assembly and of the acceleration produced by the coin impact on the sensor assembly.

26. Method according to claim 23 when depending on claim 22, **characterised in that** the deconvolution is carried out by the complex division of the spectrum of the acceleration produced in the coin impact on the sensor assembly and the frequency response of the selector, thereafter performing the inverse discrete Fourier transform of the result of said division.

27. Method according to claim 24, **characterised in that** the time coefficients of the inverse filter are obtained by a recursive calculation method using samples in time of the impulse response, and **in that** the form of the development of the action-reaction force is calculated by the convolution in time between said coefficients of the inverse filter and the sampled signal provided by the sensor assembly upon the impact of the coin.

28. Method according to claim 24, **characterised in that** the time coefficients of the inverse filter are obtained by the inverse discrete Fourier transform of the complex inverse of the function that results from calculating the discrete Fourier transform of the impulse response samples of the selector, and **in that** the form of the development of the action-reaction force is calculated by the convolution in time of said coefficients of the inverse filter and the sampled signal provided by the sensor assembly upon the impact of the coin.

29. Method according to any of claims 22-28, **characterised in that** the calculations involving recursive type operations, sums of products of samples or discrete Fourier transforms are performed by a digital signal processor (DSP).

30. Method according to claim 19, **characterised in that** a parameter for discriminating coins is obtained by calculating the spectral power by bands of the acceleration signal produced by the coin or of the action-reaction force calculated.

31. Method according to any of the previous claims, **characterised in that** the development of said action-reaction force between coin and inertial mass is used as a reliable reference for determining an instant after which the sound produced by the coin can be analysed.

32. Method according to claim 31, **characterised in that** for coin identification said instant is used together with an electrical signal corresponding to an acoustic signal produced by the impact of the coin on the inertial mass, without said acoustic signal being affected by vibrations produced in the casing of the selector by said impact.

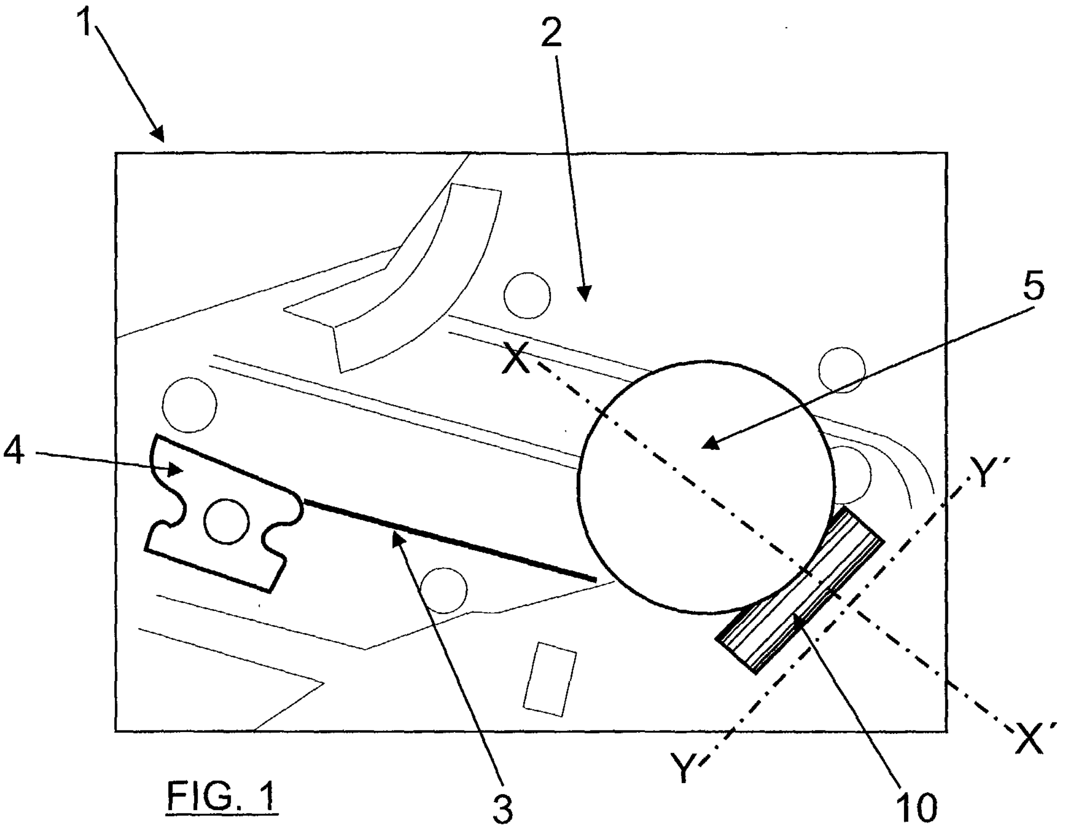

FIG. 1

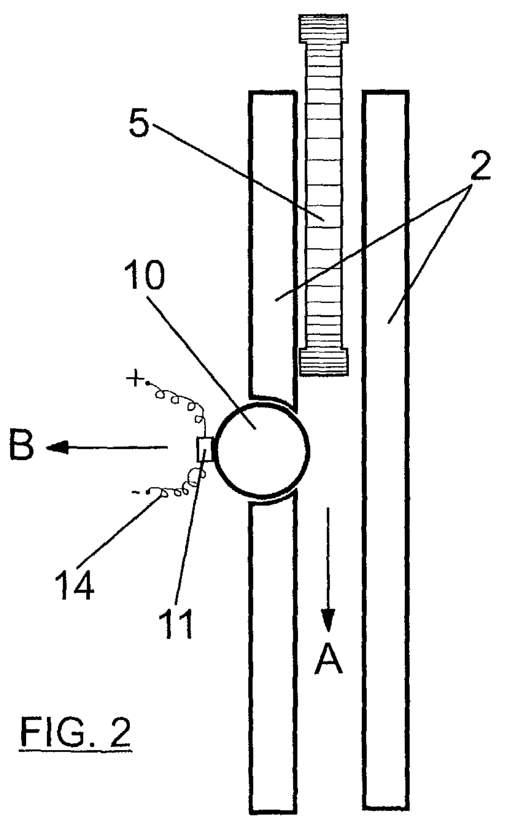

FIG. 2

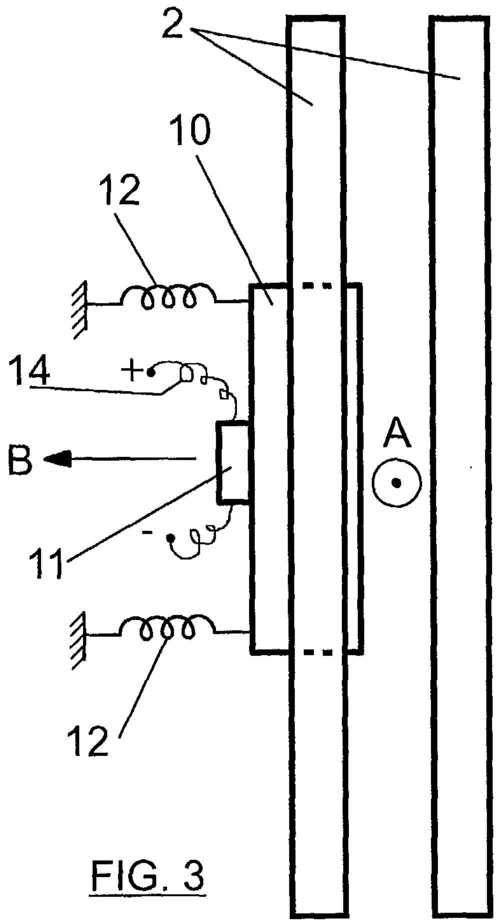

FIG. 3

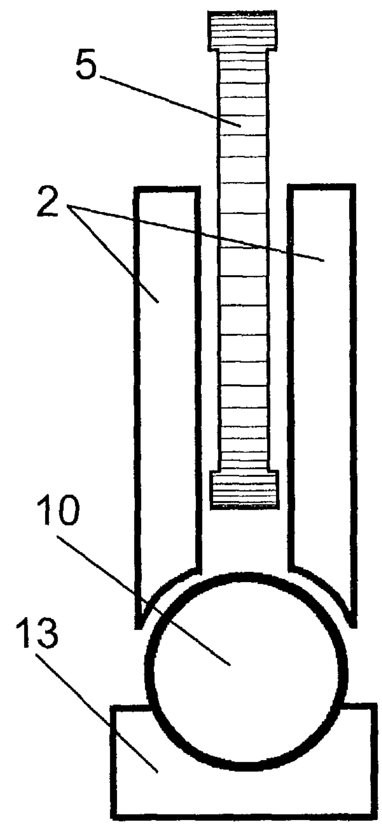

FIG. 4

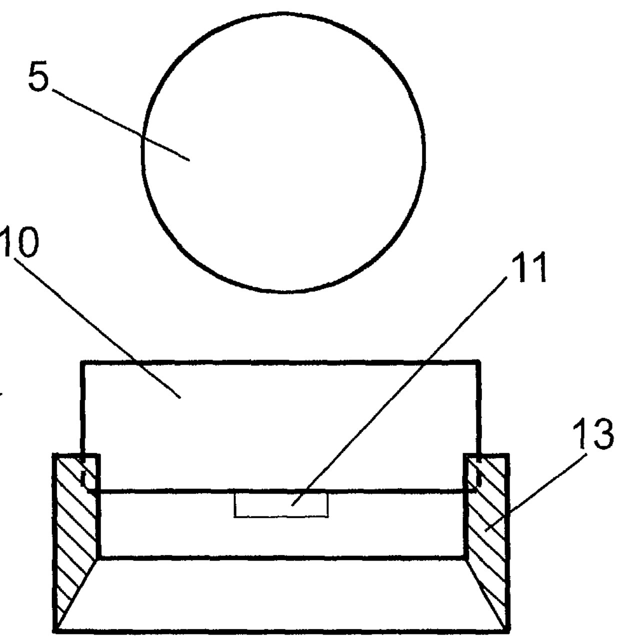

FIG. 5

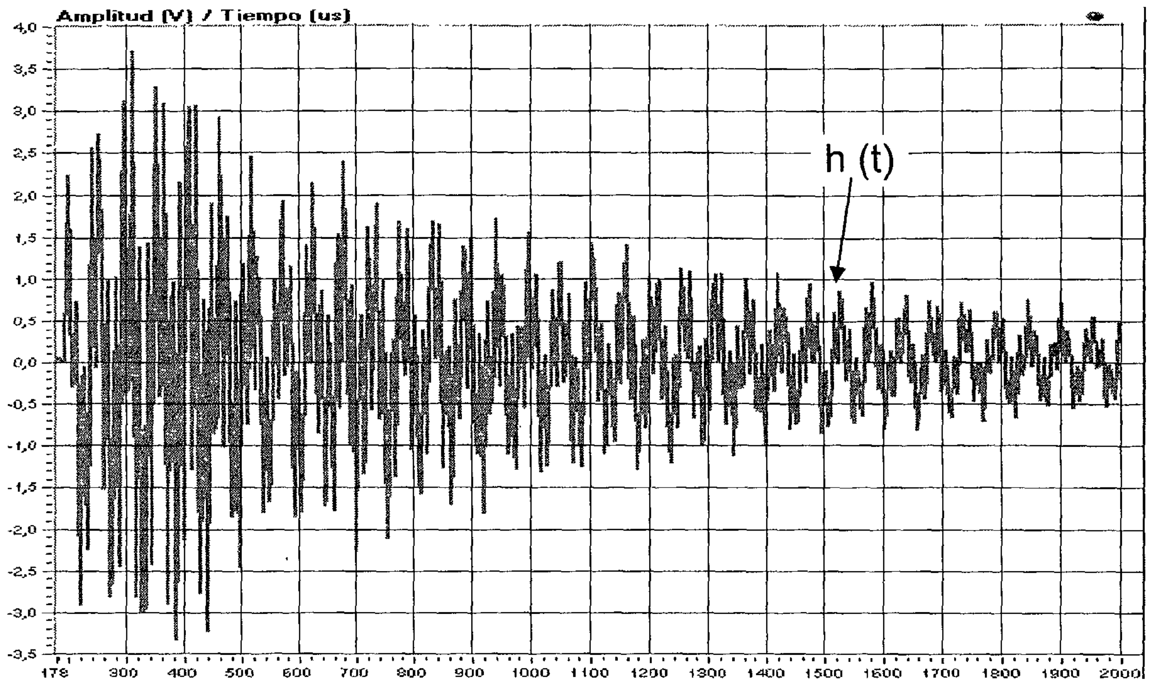
Amplitud (V) / Tiempo (us)
h (t)
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
-0,5
-1,0
-1,5
-2,0
-2,5
-3,0
-3,5
178 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000

FIG. 6

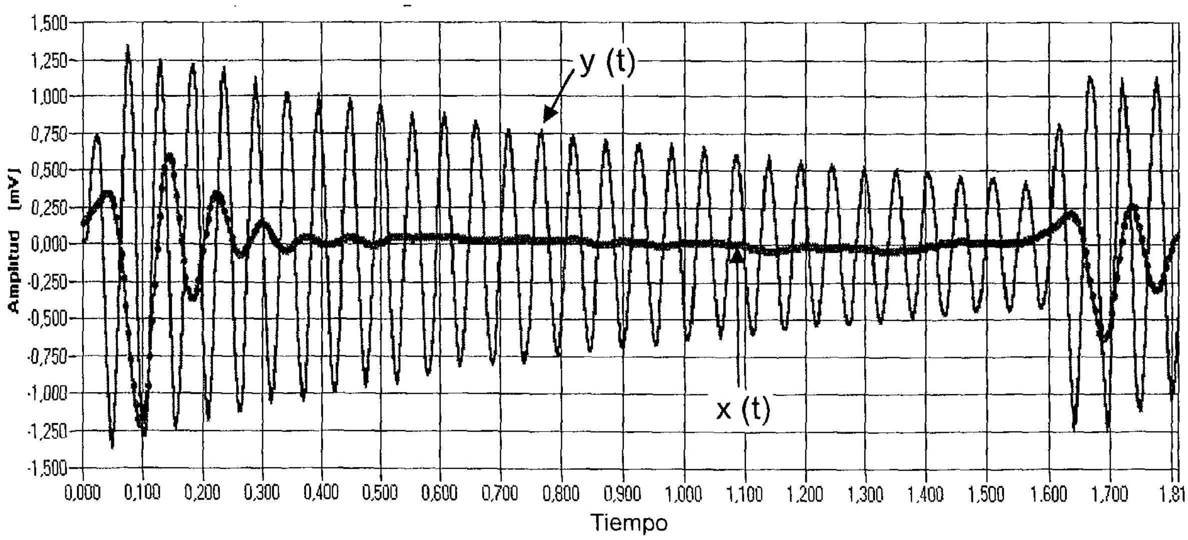
y (t)
x (t)
Amplitud [mV]
1,500
1,250
1,000
0,750
0,500
0,250
0,000
-0,250
-0,500
-0,750
-1,000
-1,250
-1,500
0,000 0,100 0,200 0,300 0,400 0,500 0,600 0,700 0,800 0,900 1,000 1,100 1,200 1,300 1,400 1,500 1,600 1,700 1,81
Tiempo

FIG. 7

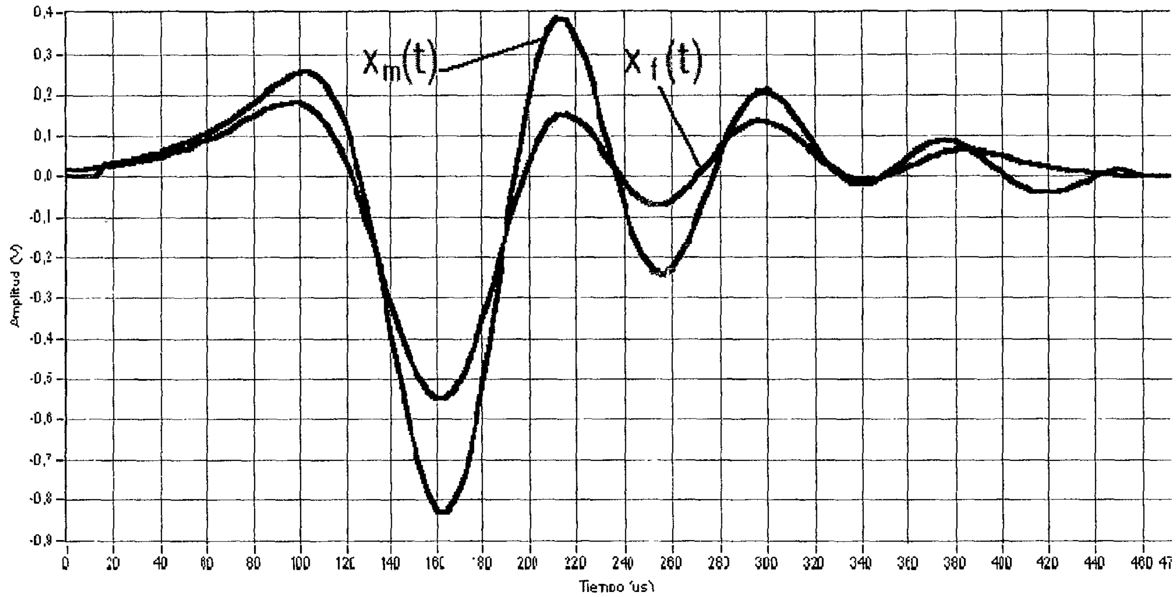
$x_m(t)$
$x_f(t)$
0,4
0,3
0,2
0,1
0,0
-0,1
-0,2
-0,3
-0,4
-0,5
-0,6
-0,7
-0,8
-0,9
Amplitud (V)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
Tiempo (us)

FIG. 8

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 38 0143

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A	US 5 226 520 A (PARKER) 13 July 1993 (1993-07-13) * column 8, line 57 - column 9, line 9; figure 7 *	1-32	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18 December 2002	Neville, D

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