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(54) **COIN ACCEPTOR**

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(56) References cited:
DE-A- 4 339 543 **GB-A- 2 266 400**

- **PATENT ABSTRACTS OF JAPAN vol. 018, no. 618 (P-1831), 24 November 1994 & JP 06 231333 A (TOSHIBA CORP), 19 August 1994**

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Description

Background

[0001] This invention relates to a coin acceptor and has particular but not exclusive application to a multi-coin acceptor for validating coins of different denominations.

Field of the invention

[0002] Coin acceptors which discriminate between coins of different denominations are well known and one example is described in our GB-A-2 169 429. The acceptor includes a coin rundown path along which coins pass through a sensing station at which coils perform a series of inductive tests on the coins in order to develop coin parameter signals which are indicative of the material and metallic content of the coin under test. The coin parameter signals are digitised so as to provide digital coin parameter data, which are then compared with stored coin data by means of a microcontroller to determine the acceptability or otherwise of the tested coin. If the coin is found to be acceptable, the microcontroller operates an accept gate so that the coin is directed to an accept path otherwise, the accept gate remains inoperative and the coin is directed to a reject path.

[0003] The coin sensing station includes a number of different coils which may be energised at different frequencies and may be of different sizes so as to form individual inductive couplings of with the coin under test as it passes through the coin sensing station, on one side only or on both sides of the coin. The coils used hitherto have had a cross-sectional area which is sufficiently large relative to the coin that the inductive coupling produces eddy currents over at least a major part of the surface of the coin, with the result that the sensed parameters constitute an average of a number of different parameters of the coin, for example its metallic content, its thickness and its surface pattern.

[0004] The averaging effect produced by the relatively large sensor coils gives rise to disadvantages in certain circumstances. For example, there is an increasing popularity for coins to be minted to include regions of different materials, for example, from more than one metal or metal alloy, and certain denominations of coins are formed of a central region of a first alloy, which is surrounded by an annular region of a second different alloy (referred to hereinafter as a "bimet" coin). The different regions present different inductive characteristics to the sensor coils of the acceptor but the relatively large area coils tend to average the effect of the two metallic regions, with the result that certain bimet coins cannot satisfactorily be distinguished from coins of other denominations and frauds, for example washers with a central hole.

[0005] Another example is described in US-A-4 995 497 (Tamura Electric Works Ltd) in which the coils are aligned along the path are energised to detect different characteristics of a coin under test. Two different characteristics of the material of the coin and the coin thickness are detected by detecting peaks in the values of signals induced in the coils, and the coin diameter is detected by detecting the crossover in the outputs of two of the coils spaced along the coin path. The peaks and the crossover are compared with data for true coins in a memory. The aligned nature of the coils needed for the diameter measurement restricts the sensing of the coin and gives rise to difficulties with bimetallic coins.

[0006] W0-A-93/22747 (Mars Inc) discloses a coin acceptor for use with multi-metallic coins that uses two magnetic sensors each substantially smaller in width than the diameter of the multi-metallic coin, arranged essentially parallel to the coin path. The sensors are connected in an electrical bridge circuit and the difference between the outputs of the sensors is used to discriminate between multi-metallic coins and frauds.

[0007] Further examples of coin sorting devices with multiple sensing coils are disclosed in GB2 266 400 A (Anritsu Corporation). In these arrangements a number of coils are provided that monitor a small region of the face of a coin.

[0008] The coils are arranged so that an output signal corresponding to an equivalent portion of the coin may be obtained, for coins of a number of different diameters. The output from one of the sensing coils is selected in accordance with a predetermined criterion, such as a signal peak within a given amplitude range. The selected output is then used to derive the coin thickness and conductivity which, together with an estimated diameter, may be compared with stored reference values. This arrangement depends heavily on the out put of one sensing coil, i.e. from one region of the coin, and may not fully overcome the previous problems distinguishing bi-metallic coins from other coins or objects.

Summary of the invention

[0009] In accordance with the present invention, it has been appreciated that by using small coils arrayed transversely of the coin path, and monitoring their outputs, it is possible to extract much more fine detail about the characteristics of the coin by seeking at least one predetermined criterion in the characteristics of sample values of at least one of the sensor outputs, and then comparing data from the sensor outputs with corresponding stored data in order to determine acceptability of the coin

[0010] More particularly, the invention provides a coin acceptor comprising a coin acceptor comprising a path for

coins, a plurality of sensor coils to sense a coin as it moves along the path, drive circuitry coupled to the sensor coils, the sensor coils being arranged in an array extending transversely of the coin path so as to be energised by the drive circuitry to inductively couple with different regions of the face of a coin as it moves past them, so that the sensor coils produce time varying sensor outputs as a function of the different regions respectively, sampling means to sample repetitively values of the individual sensor outputs produced during the passage of the coin past the sensors to provide corresponding sample values and control means to monitor the sample values and determine when a sampled value of at least one of the sensor outputs accords with a predetermined criterion and to compare the sample values with stored reference data values, wherein, the stored reference data comprises sets of coin parameter data values for coins of different denominations and the control means is arranged to compare the sample values relating to each of the plurality of regions sensed by the sensor coils with the stored data sets in response to the criterion being met, to determine the acceptability of the coin.

[0011] The array of sensor coils may include coil assemblies that are arranged in one or more lines extending transversely of the coin path. They may be on opposite sides or on one side only of the coin path.

[0012] The coil assemblies preferably have an area to face the coin of less than 72mm^2.

[0013] The sensor coil units may each be coupled in an oscillator circuit and the sampling means may be operative to sample an oscillatory characteristic of the circuit as the coin passes the unit such as frequency or amplitude or both.

[0014] The control means-may-be configured to select an ensemble of sample values of the sensor outputs that occur when one of the outputs accords with the predetermined criterion, and to compare the selected sample values with the stored data.

[0015] Alternatively, the control means may be configured to determine when the sensor outputs individually accord with a respective predetermined criterion and to compare the values thereof with the stored data.

[0016] The predetermined criterion may comprise a discontinuity in the value of sensor output such as a main or a localised maximum or minimum in the value of the sensor output that occurs during the passage of the coin. The predetermined criterion may also occur when at least one sample value from one of the sensors forms a predetermined value relationship with at least one sample value from another of the sensors. The value relationship may comprise a crossover of the values of the successive samples from one of the sensors with corresponding sample values from another of the sensors, or may be a function of the relative rate of change of the sample values from the sensors.

[0017] The invention also includes a coin discrimination method comprising sensing the passage of a coin along a path with a plurality of sensor coils that are spaced apart in an array extending transversely of the coin path and energised to inductively couple with different regions of the face of the coin as it moves past them, sampling values of the sensor outputs repetitively during the passage of the coin past the sensor coils to provide corresponding sample values, monitoring the sample values, determining when a sampled value of at least one of the sensor outputs accords with a predetermined criterion and comparing the sample values with stored reference data values, characterised in that, the comparison is made in response to the criterion being met, where said comparison is between stored reference data comprising sets of individual coin parameter values for coins of different denomination and sample values relating to each of the plurality of regions sensed by the sensor coils with the stored data sets to determine the acceptability of the coin.

Brief description of the drawings

[0018] In order that the invention may be more fully understood, an embodiment thereof will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a schematic elevational view of a first embodiment of a coin acceptor in accordance with the invention;
Figure 2 illustrates schematically the electrical circuits of the acceptor shown in Figure 1;
Figure 3 is a schematic partial cross sectional view of the acceptor taken along the line A - A' in Figure 1;
Figure 4a is an enlarged cross sectional view of one of the coils shown in Figure 3;
Figure 4b illustrates the front face of the coil shown in Figure 4a;
Figure 5 is a schematic illustration of the coils and the coil drive and interface circuits shown in Figure 1;
Figure 6 is a graph illustrating how the coin parameter signals vary with time as a coin moves past the sensor coils;
Figure 7 is a schematic block diagram that illustrates processing steps carried out by the microcontroller on successive ensembles of samples of the coin parameter signals taken as the coin passes the coils;
Figure 8 illustrates a routine carried out by the microcontroller for determining the occurrence of a peak in the coin parameter signal x1(a);
Figure 9 illustrates a routine carried out by the microcontroller for determining the occurrence of a crossover in the values of the coin parameter signals x1(a) and x2(a);
Figure 10 is a schematic elevational view of a second embodiment of coin acceptor in accordance with the invention;
Figure 11 illustrates schematically the electrical circuits of the acceptor shown in Figure 10;

Figure 12 is a schematic illustration of the coils and the coil drive and interface circuits shown in Figure 10,
Figure 13 is a graph illustrating how the coin parameter signals vary with time as a coin moves past the sensor coils shown in Figure 10;
Figure 14 is an enlarged portion of the graphs shown in Figure 13, and
Figure 15 is a schematic block diagram illustrating processing steps carried out by the microcontroller as the coin moves through the sensing station in Figure 10.

Detailed description

First embodiment

[0019] A first embodiment of coin acceptor according to the invention will be described which comprises a multi-coin acceptor capable of validating a number of coins of different denominations, including bimet coins, for example the new euro coin set and the new UK coin set including the new bimet £2.00 coin.

[0020] The physical layout of the coin acceptor is shown schematically in Figure 1. The acceptor includes a body 1 with a coin run-down path 2 along which coins under test pass edgewise from an inlet 3 through a coin sensing station 4 and then fall towards a gate 5. A test is performed on each coin as it passes through the sensing station 4. If the outcome of the test indicates the presence of a true coin, the gate 5 is opened so that the coin can pass to an accept path 6, but otherwise the gate remains closed and the coin is deflected to a reject path 7. The coin path through the acceptor for a coin 8 is shown schematically by dotted line 9.

[0021] The coin sensing station 4 includes four coin sensing coil units C1a,b, C2, C3a,b and C4 shown in dotted outline, which are energised in order to produce an inductive coupling with the coin. Also, a coil unit CC is provided in the accept path 6, downstream of the gate 5, to act as a credit sensor in order to detect whether a coin that was determined to be acceptable, has in fact passed into the accept path 6.

[0022] The coils are energised at different frequencies by a drive and interface circuit 10 shown in Figure 2. Eddy currents are induced in the coin under test by the coil units. The different inductive couplings between the three coils and the coin characterise the coin substantially uniquely. The drive and interface circuit 10 produces four corresponding coin parameter data signals x_1, x_2, x_3, x_4, as a function of the different inductive couplings between the coin and the coil units C1, C2, C3 and C4. A corresponding signal x_C is produced for the coil unit CC.

[0023] In order to determine coin authenticity, the four parameter signals x_1, x_2, x_3 and x_4 produced by a coin under test are fed to a microcontroller 11 which is coupled to a memory in the form of an EEPROM 12. The microcontroller 11 processes the coin parameter signals derived from the coin under test in a manner that will be described in more detail hereinafter and compares the outcome with corresponding stored values held in the EEPROM 12. The stored values are held in terms of windows having upper and lower value limits. Thus, if the processed data falls within the corresponding windows associated with a true coin of a particular denomination, the coin is indicated to be acceptable, but otherwise is rejected. If acceptable, a signal is provided on line 13 to a drive circuit 14 which operates the gate 5 shown in Figure 1 so as to allow the coin to pass to the accept path 6. Otherwise, the gate 5 is not opened and the coin passes to reject path 7.

[0024] The microcontroller 11 compares the processed data with a number of different sets of operating window data appropriate for coins of different denominations so that the coin acceptor can accept or reject more than one coin of a particular currency set. If the coin is accepted, its passage along the accept path 6 is detected by a post acceptance credit sensor coil unit CC, and the unit 10 passes corresponding data x_C to the microcontroller 11, which in turn provides an output on line 15 that indicates the amount of monetary credit attributed to the accepted coin.

[0025] The configuration of the sensor coils will now be described in more detail. Referring again to Figure 1, the acceptor has a coin door 16 that is hinged on a shaft 17 on the acceptor body 1, in a conventional manner. The coin run-down path 2 is provided between an interior wall 18 of the door 16 and a wall 19 of the acceptor body 1, as shown in more detail in Figure 3. The run-down path 2 comprises an inclined lip 20 on the door 16, down which the coin runs edgewise past the sensor coil units C1, C2, C3 and C4. The coin 8 is shown on the lip 20 of the run-down path 2 in Figure 3 The coin is shown schematically in an upright position although in practice, it will lean against one of the walls 18, 19. As known in the art, the door 16 is spring biased to the closed position shown in Figures 1 and 3 but can be hinged outwardly from the body 1 in the event of a coin jam so as to release the jammed coin and allow it to fall to the reject path 7.

[0026] In order to describe the improved operating characteristics of the acceptor, the coin 8 shown in Figure 1, is illustrated as a bimet coin and in this example comprises the new £2.00 coin. This comprises a first, central cupro-nickel core region 21 surrounded by a second, circular region or ring 22 of an alloy referred to herein as bronze, comprising 76% Cu, 4% Ni and 20% Zn. However, the invention is not restricted to the detection of bimet coins, as will be evident hereinafter.

[0027] Referring to Figure 3, the coil unit C1a,b comprises a pair of coil assemblies C1a, C1b mounted on the inside

of the wall 19 of the acceptor body 1 and on the wall 18 of the door 16. The coil assemblies C1a, C1b are configured to form an inductive coupling selectively with the bronze ring 22 of the bimet coin 8 under test i.e. with no significant inductive coupling to the central cupro-nickel region 21 of the coin.

[0028] As shown in more detail in Figure 4, each of the coil assemblies C1a, C1b comprises a generally cylindrical bobbin 23 of plastics material, on which windings of a coil 24 are formed. The bobbin 23 is push-fitted into a so-called half pot core 25 made of sintered ferrite material. The core 25 includes a central, cylindrical yoke 26 formed with a through hole to reduce the amount of ferrite material used, and a surrounding, concentric, cylindrical support flange 27.

[0029] As an alternative to using a bobbin, the windings of the coil 24 may be wound around a former, not shown, and the windings heated to melt their insulation, so that on cooling, a self supporting coil is formed, which is then removed from the former and push-fitted into the half pot core 25.

[0030] The support flange 27 of the half pot core 25 is push-fitted in a corresponding recess in the wall; thus the flange 27 of assembly C1a is push fitted into a cylindrical recess 28 in wall 19 and the flange 27 of assembly C1b is push fitted into a corresponding recess 29 in the wall 18. In this example, the outer diameter d_1 of the windings of the coil 24 is 7.3 mm. The inner diameter d_2 of the coil 24 with its bobbin 23 is 2.78 mm and the diameter of the hole through the yoke 26 is 2mm. The faces 30 of the coil assemblies C1a,b in this example, are spaced apart by 6.24 mm. The coils 24 have an axial length of 2.78 mm. The outer diameter d_3 of the half pot cores 25 is 9 mm and thus the area A of the end face 30 of each coil unit i.e. the end which faces the coin under test, is in this example 63.62 mm^2. The windings 24 of the assemblies C1a,b are electrically connected in series. As can be seen in Figure 3, the coil assemblies C1a,b are arranged with the coils 24 arranged on a common axis, on opposite sides of the coin 8 under test.

[0031] As well known in the art of solenoid coil design, the magnetic field of a generally cylindrical coil is concentrated along the coil axis; thus, for each of the coil assemblies C1a,b, the field is concentrated mainly in the ferrite yoke 26 of the half pot core 25 and the flux around the coil is mainly channelled in a loop around the coil by the surrounding ferrite flange 27, except in the region of face 30 where the flux passes through the surrounding material back to the yoke 26. Accordingly, the sensitivity of the assemblies C1a,b to passing coins is for the most part, restricted to the region of the coin which passes between the yokes 26. The assemblies C1a,b are positioned closely adjacent the coin rundown path 2 and the dimension d_3 of the coils is such that the inductive coupling between the coin and the coils is restricted substantially only to the second, outer region 22 of the coin 8, with no significant coupling occurring with the first inner region 21. As can be seen from Figure 3, the half pot cores 25 extend below the coin run-down path 20 in order that the cores 26 be configured in alignment with the outer ring 22 of the coin 8.

[0032] Considering the now the coil units C2, C3 and C4, these are made up of coil assemblies identical to the assembly C1a shown in Figure 4. The coil units C1-C4 are mounted in an array extending transversely to the coin path 2, along line 31 as shown in Figure 1. In this example, the line 31 extends orthogonally of the path 2, although other configurations transverse to the coin path can be used and more generally, it is not essential for the coil units to be arranged in a line. It has been found in accordance with the invention that improved discrimination can be achieved by making the area A of the coil assembly which faces the coin, such as the coil C1a,b, smaller than 72 mm^2, which permits coin regions with individual inductive characteristics to be sensed. The or each coil C need not be circular. In fact, advantages can be obtained from square or rectangular wound coils. The transverse array of sensors preferably includes at least three of the coil units.

[0033] Referring to Figure 3, the coil unit C2 is mounted above the unit C1a, b so as to intersect a chord of the coin as it passes through the coin sensing station 4. It will be understood that as the coin rolls past the coil unit C2, an inductive coupling will first be formed with the outer ring 22 of the coin, then the inner region 21 and then the outer region 22 again. The coil unit C2 comprises a single coil assembly and thus the coil unit 22 detects the characteristics of the coin from one side only.

[0034] The coil unit C3a, b comprises a pair of the coil assemblies C3a, C3b, mounted on opposite sides of the coin path in a similar way to the coil assemblies C1a, b. The coil unit C3a, b is mounted above the unit C2 and thus is sensitive to the coin at a different chordal position thereof.

[0035] The coil unit C4 comprises a single one of the coil assemblies as shown in Figure 4, mounted at a location above the coil unit C3a, b.

[0036] It will thus be understood that the outputs from the coil units C1-C4 will depend upon the characteristics of the coin, including its diameter, its material characteristics, its thickness, whether it is a bimet coin and a number of other factors, with the coil units being responsive to the characteristics of respective individual regions of the coin under test as it passes the coils.

[0037] Figure 5 illustrates how the coil units are connected to the coil drive and interface circuits 10 shown in Figure 1. Considering the coil unit C1, the coil assemblies C1a, C1b, are connected in series, in the feedback loop of an inverting amplifier A1, together with a capacitor C. The circuit thus acts as an oscillator, the output of which has an amplitude and frequency dependent on the inductance presented by the coil assembly C1a, C1b. As the coin passes between the coil assemblies C1a, C1b, an inductive coupling occurs between the coin and the coil assemblies with the result that the inductance in the feedback path of the amplifier changes, which in turn changes both the amplitude

and frequency of the oscillator, on a transitory basis.

[0038] The amplitude is detected by an envelope detector E1 for the coil unit C1, and the amplitude of the envelope is successively sampled as the coin passes between the coil assembly C1a, C1b by means of an analog to digital converter D1, so as to provide a series of successive digital sample values x1(a) as the coin passes the coil unit C1.

[0039] The coil unit C2 is connected in the feedback loop of an inverting amplifier A2 and a corresponding digital coin parameter signal x2(a) is produced by means of envelope detector E2 and analog to digital converter D2.

[0040] Additionally, the frequency deviation of the oscillator A2 is detected as the coin passes the coil unit C2. A frequency detector F detects the instantaneous frequency of the oscillator A2 and the output is successively sampled and digitised by analog to digital converter D2', so as to provide coin parameter output signal x2(f).

[0041] The coil unit C3a, b is connected in the feedback loop of inverting amplifier A3, with the coil assemblies C3a, C3b being connected in series. An envelope detector E3 and an analog to digital converter D3 produce an output digital parameter signal x3(a) which comprises a series of digital samples of the amplitude deviation produced as the coin passes between the coil assemblies C3a, C3b.

[0042] The coil unit C4 is connected in the feedback of amplifier A4 and envelope detector E4 together with analog to digital converter D4 produces an amplitude deviation signal x4(a).

[0043] Whilst for the purposes of illustration, individual A/D converters D1-D4 are shown, it will be appreciated that the outputs of the oscillator circuits could be multiplexed into a single A/D converter in order to reduce the expense of the circuitry.

[0044] Figure 6 illustrates the way in which the coin parameter signals x vary with time as the coin passes through the coin sensing station 4. It will be appreciated that the shape of the individual curves shown in Figure 6 are dependent upon the characteristics of the coin under test and the curves represent individual "signatures" for the coin denomination. The passage of the coin past the sensor coils C1-4 causes a general reduction in amplitude, but the A/D converters D1-D4 produce a signal inversion so as to product the graphs shown in Figure 6.

[0045] The analog to digital converters D1-D4 shown in Figure 5 produce an ensemble A_t of sample values with successive ensembles being produced for successive sample periods, spaced apart by a time D_t. Thus, an ensemble A_t is taken at time t where

$$A_t = \{ x_t1(a), x_t2(a), x_t2(f), x_t3(a), x_t4(a) \} \quad (1)$$

[0046] Although Figure 6 illustrates the individual ensemble values all occurring simultaneously at time t, in practice, the individual sample values x which make up the ensemble may be taken over a finite period, which is significantly shorter than D_t.

[0047] As shown in Figure 2, the microcontroller 11 receives the successive values of the coin parameter signals x that make up the successive ensembles A_t. As shown in Figure 7 the microcontroller 11 assembles the successive ensembles $A_k \rightarrow A_{k+n}$ into a running stack of n successive ensemble values 32.

[0048] The resulting ensemble data in the stack is processed in a step S1 in order to determine when the value of at least one of the coin parameter signals x adopts a predetermined criterion, such as the occurrence of a peak value in the sample values or when the sample value from one of the sensors forms a predetermined value relationship with the corresponding sample value from another of the sensors. This value relationship may be constituted by a crossover in the graphs, or the reaching or overpassing of a threshold, as will be explained in more detail hereinafter. The ensemble A of data which includes the predetermined criterion is stored at step S2.

[0049] Then at step S3, the individual coin parameter data values x1(a), x2(a), x2(f), x3(a) and x4(a) are compared with corresponding stored values held in the EEPROM 12 (Figure 1). The stored values are held in terms of windows W = w1a, w2a, w2f, w3a, w4a each with upper and lower limits, to accommodate minor variations from coin to coin. In fact, a series of different sets of coin windows W are stored in the EEPROM 12, corresponding to different coin denominations, and the results from step S2 are compared in step S3 with all of the stored sets in order to determine whether the coin is of an acceptable denomination.

[0050] If the coin is determined to be acceptable, an output is provided at step S4 indicating the denomination of the coin and its acceptability, so as to provide the outputs 13, 15 shown in Figure 2 or, indicating that the coin should be rejected.

[0051] The manner in which a peak in the coin parameter signal x1(a) can be detected during step S1, will be described in more detail with reference to Figure 8. The process starts at step S1.10. At step S1.11, a parameter p is set to equal zero. At step S1.12, successive coin parameter samples x1(a) are selected from three successive data ensembles A_k, for k = p - 1, p and p + 1.

[0052] At step S1.13, the three successive values of x1(a) are compared with one another. If the intermediate value is greater than the preceding and exceeding values, this indicates that a peak has occurred. Thus, the following ine-

quality is checked

$$x1(a)_{p-1} < x1(a)_{p.} > x1(a)_{p+1} \quad ? \tag{2}$$

[0053] If the test is true, the particular value of $x1(a)_p$ indicates a peak value. If the inequalities of test (2) are not true, the parameter p is incremented at step S1.14 and the process is repeated so as to sweep through successive ones of the data ensembles in an attempt to find a peak in x1(a).

[0054] When a peak is found, the entire data ensemble A_k is fetched from the stack, for the particular value of k = p. This is the data ensemble of coin parameter signals, occurring at the peak in x1(a).

[0055] At step S2.10, the fetched data ensemble is temporarily stored and, at step S3.10, the individual coin parameter signals from the stored data ensemble, namely x1(a), x2(a), x2(f), x3(a) and x4(a) are individually compared with corresponding windows stored in the EEPROM 12 to determine if the coin is of a particular denomination to be accepted by the acceptor. As previously explained, the process may be repeated for a number of different coin denominations which have associated stored windows in the EEPROM.

[0056] Figure 9 illustrates the routine for determining when a crossover occurs in the graphs of x1(a) and x2(a) shown in Figure 6. When the crossover occurs, the data ensemble associated with the occurrence of the crossover is used for comparison purposes with stored window data in the EEPROM 12.

[0057] At step S1.20, the routine starts and a parameter p is set to zero at step S1.21. Then the values of x1(a) and x2(a) are fetched from the stack 31 for two successive data ensembles A_k, the ensembles being selected by means of the parameter p, namely for k = p & p + 1.

[0058] Then, at step S1.23, the fetched data values are compared according to the following inequality in order to determine whether a crossover has occurred for the fetched data.

$$x1(a)_p < x2(a)_p \text{ AND } x1(a)_{p+1} > x2(a)_{p+1} \ ?$$

OR

$$x1(a)_p > x2(a)_p \text{ AND } x1(a)_{p+1} < x2(a)_{p+1} \ ? \tag{3}$$

[0059] It will be seen that these tests determine if the graphs for x1(a) and x2(a) shown in Figure 6 crossover one another.

[0060] In the event that no crossover is found, the parameter p is incremented at step S1.24 and the process is repeated for the next successive set of values in the stack 31 of data ensembles A_k shown in Figure 7.

[0061] If, however, a crossover is detected, the ensemble A_k with a particular value of k = p at which the crossover occurred, is fetched from the stack 31 and is stored at step S2.20.

[0062] Then, at step S3.20, the individual values stored at step S2.20 are compared with corresponding windows held in the EEPROM 12, as previously described, in order to determine coin authenticity and denomination.

[0063] The described example of the invention has the advantage that much more fine detail about the characteristics of the coin can be determined using the transverse array of coil units C1-C4. The small size of the coil assemblies relative to the coin allow the characteristics of individual chordal regions of the coin to be determined individually as shown by the individual graphs in Figure 6. As previously mentioned, the graphs of Figure 6 show the outputs derived from a bimet coin. Hitherto, when larger diameter sensing coils were used, which produced an averaging effect over at least a major portion of the surface area of the coin, it was difficult to distinguish between a bimet coin and a corresponding washer with a central hole. In contrast, the described embodiment of acceptor according to the invention, can readily distinguish between such a bimet coin and a corresponding washer. Referring to Figure 6, the output for x2(a) adopts the generally dome shaped configuration in response to a genuine bimet coin of a particular denomination. However, if a fraudulent washer with a central hole is passed through the acceptor, a trace 33 with a central "dip" is produced. With a prior art acceptor, which averaged the effect of the entire face of the coin, it was difficult to distinguish between the genuine coin and the washer, due to the averaging effect. However, in accordance with the invention, if the peak amplitude x1(a) is determined, so as to determine the ensemble A_X the corresponding value of the parameter x2(a) in the ensemble A_X adopts substantially different values for the true bimet coin and a corresponding washer with a central hole, namely values 34 and 35 respectively. Thus, the stored window data in the EEPROM 12 for the true bimet coil differs substantially from the data produced for a fraudulent washer, permitting such frauds readily to be detected. Thus, in accordance with the invention, by selecting the ensemble A_X, much more fine detail can be resolved

than hitherto.

[0064] Different criteria in the data can be determined on initial testing to find ensembles which uniquely characterise a particular coin denomination. For certain coins, the criterion used to select the ensemble A_X may be when one of the coin parameter signals x equals or crosses a predetermined threshold value stored in the EEPROM 12.

[0065] For some denominations, the crossover between certain graphs in the output shown in Figure 6 is a suitable criterion. For other coin denominations, there may be local minima in the graphs of Figure 6 which may be utilised. Certain bimet coins may produce a trough in one of the graphs, which can be used as the criterion.

[0066] Also, a more complicated relationship between points on the graphs of Figure 6 may be used and the relative shapes of the, curves may be considered. For example, values of two of the coin parameter signals x may be taken from an ensemble A_1 produced at a first time and then again from an ensemble A_2 produced at a later time, and the values may be processed to obtain an indication of the gradient of each of the graphs. When the gradients adopt a predetermined relationship, the corresponding data ensemble A is selected and compared with stored data in the EEPROM 12.

Second embodiment

[0067] A second embodiment of the invention will now be described with reference to Figures 10 to 15. The second embodiment is similar to the first embodiment and corresponding parts are marked with the same reference numbers. The second embodiment differs in the manner in which the coil units are disposed at the sensing station 4, and also the way in which the coin data are processed.

[0068] Referring to Figure 10, five of the previously described coil units C1-C5 are disposed in an array extending transversely of the coin path 9. Instead of being arranged in a straight line 31 as shown in Figure 1, the coil units are arrayed in a staggered arrangement, with the axes of the coil units being disposed to be generally orthogonal of the major faces of the coin as its passes through the axes, along the coin rundown path. As previously explained, the interaction between the coil units and the coin occurs primarily in the region of the core of each coil unit and the staggered coil arrangement shown in Figure 10 permits an additional coil unit C5 to be included within the circumference of the coin 8 as it passes along the path 9. The configuration of coil units can be used to sense coins with a diameter range of 15-33 mm. Thus, the arrangement of Figure 10 allows an additional region of the coin face to be analysed by the fifth coil unit. The connection of the coil units to the microcontroller 11 is shown schematically in Figure 11 and generally corresponds to the arrangement previously described with reference to Figures 1 and 5, with the provision of additional circuits for the coil unit C5, which produces a coin parameter signal $x_5(a)$.

[0069] In this example, each of the coil units C1-C5 includes a pair of coil assemblies mounted on opposite sides of the coin path, on the coin door 16 and the wall 19 of the validator, in the same way as coil assemblies C1a, b shown in Figure 1.

[0070] Referring to Figure 11, the coin units C1-C5 together with the post acceptance coil unit CC are connected through coil drive and interface circuits 10 to microcontroller 11. The operation of the circuit is similar to that described with reference to Figure 2. A random access memory RAM 31 is shown connected to the microcontroller 11.

[0071] The connection of the coil units C1-C5 is shown in more detail in Figure 12. The coil assemblies of each coil unit are connected in series. The coil assemblies of coil unit C2 are connected in an anti-phase such that the polarities of the assemblies mutually repel. The other coin units have their assemblies connected in phase such that the coil polarities attract. Each coil pair is connected in an oscillator circuit in the manner previously described with reference to Figure 5. The natural resonant frequency of each oscillator circuit is different in order to reduce crosstalk. The frequencies are, but not restricted to, between 60 and 100 KHz, and are high enough so as not to completely penetrate coins under test. Instead of using individual A/D converters for each coil unit, a multiplexer 32 is provided, which successively scans the outputs of the coil units and feeds them to a common envelope detector E1 and to A/D converter D1 such that samples of x1(a), x2(a), x3(a), x4(a) and x5(a) are sequentially produced on output line 33.

[0072] Also, frequency detector F is provided to detect frequency changes in the output of coil units C2. The output of detector F is fed to an A/D converter D2' in order to provide successive samples of coin signal x2(f). It will be understood that the multiplexer 32 can also provide samples for the post acceptance sensor CC, although this is not shown in Figure 12 in order to simplify the description.

[0073] Figure 13 illustrates the outputs from the various coil units C1-C5 during passage of the coin through the coin sensing station 4 of Figure 10.

[0074] Figure 14 illustrates an enlarged view of three successive groups of samples taken during passage of the coin through the coin sensing station. It will be seen that the multiplexer 32 shown in Figure 12 strobes between successive ones of the outputs of the coil units C1-C5 to produce successive groups of samples x1(a) - x5(a), that are fed to the microcontroller 11 shown in Figure 11. Also, the frequency modulation detected by frequency detector F of Figure 12 gives rise to corresponding sample values of x2(f).

[0075] The microcontroller 11 is configured to operate as shown in Figure 15. The successive groups of coin data

samples are fed at step S5 to the microcontroller 11 where a number of different criteria in the sensor outputs are detected. In this example, twelve different criteria are monitored as follows:

Criterion	Details
1	Maximum increase in x1(a) as coin passes
2	Maximum increase in x2(a) as coin passes
3	Maximum increase in x3(a) as coin passes
4	Maximum increase in x4(a) as coin passes
5	Maximum increase in x5(a) as coin passes
6	Maximum increase in frequency x2(f) as coin passes
7	Maximum reduction in frequency of x2(f) as coin passes
8	Maximum decrease in amplitude between two local maxima of amplitude x2(a) as coin passes
9	Maximum decrease in amplitude between two local maxima of amplitude x3(a) as coin passes
10	The value of amplitude x5(a) when the amplitude of x1(a) reaches a preset offset from its normal no-coin amplitude
11	The value of amplitude x4(a) when the amplitude of x2(a) reaches a preset offset from its normal no-coin amplitude
12	The value derived from one or more of the results of criteria 1 to 7 listed above. The derivation method may be preselected dependent upon the particular application or currency to be detected.

[0076] As used herein, "increase" and "decrease" relate to the inverted graphs shown in Figure 13. For criteria 1-6, the maximum increase in x(a) is relative to the value which occurs when no coin is present.

[0077] Referring again to Figure 15, these 12 criteria are detected at step S6. It will be understood that as the coin passes through the coin sensing station, successive groups of the coin data samples produced at step S5 are be fed to the microcontroller 11. Individual maxima and minima according to the criteria listed above, will be detected and temporarily stored in the RAM 31 connected to the microcontroller 11 shown in Figure 11. This temporary storage is shown at step S7 in Figure 15. As the coin passes, the individual maxima and minima will be updated as successive local maxima and minima are detected. As this occurs, the previously stored values thereof are compared with the newly produced values and an appropriate one of them is stored, depending on whether it should be the maximum or minimum. When the coin has passed, the resulting stored values of the 12 criteria are then compared with window data held in EEPROM 12 shown in Figure 11, in the manner previously described with reference to step S3 for the first embodiment. The window data stored in the EEPROM thus corresponds to values of the twelve criteria for true coins of different denominations, against which the criteria data from the coin under test can be checked for authenticity. This is carried out at step S8 in Figure 15. The coin is then accepted or rejected according to the outcome of the comparison, at step S9, in the manner previously described.

[0078] It will be appreciated that a feature of this algorithm is that local peaks and troughs in the various graphs of Figure 12 may be located and then rejected if a larger peak or trough occurs subsequently during the detection process. It will also be understood that the invention is not restricted to the particular criteria sought by the algorithm. Instead other criteria may be detected such as cross-overs, gradients and the like, as previously described.

[0079] As used herein, the term "coin" includes tokens and other coin-like items of value.

Claims

1. A coin acceptor (1) comprising a path for coins (2), a plurality of sensor coils (C1a,b, C2, C3a,b, C4) to sense a coin (8) as it moves along the path, drive circuitry (10) coupled to the sensor coils, the sensor coils being arranged in an array extending transversely of the coin path so as to be energised by the drive circuitry (10) to inductively couple with different regions (21, 22) of the face of a coin as it moves past them, so that the sensor coils produce time varying sensor outputs as a function of the different regions respectively, sampling means (D1-D4) to sample repetitively values of the individual sensor outputs produced during the passage of the coin past the sensors to provide corresponding sample values and control means (11) to monitor the sample values and determine when a sampled value of at least one of the sensor outputs accords with a predetermined criterion and to compare the

sample values with stored reference data values,
characterised in that the stored reference data comprises sets of coin parameter data values for coins of different denominations and the control means (11) is arranged to compare the sample values relating to each of the plurality of regions sensed by the sensor coils (11) with the stored data sets in response to the criterion being met, to determine the acceptability of the coin.

2. A coin acceptor (1) as in claim 1, wherein the sensor coils (C1-C4) are energised at different frequencies.

3. A coin acceptor (1) as in claim 1, wherein the control means (11) is a processor.

4. A coin acceptor (1) according to any one of claims 1 to 3 wherein the sensor coils (C1-C4) include an array of sensor coil units configured to form an inductive coupling selectively with respective regions of the coin.

5. A coin acceptor (1) according to claim 4 wherein the array of sensor coil (C1-C4) units includes coil assemblies that are arranged in a line extending transversely of the coin path.

6. A coin acceptor (1) according to claim 4 or 5 wherein one or more of the sensor coil units (C1-C4) include coil assemblies (C1a, b) on opposite sides of the coin path (2).

7. A coin acceptor according to claim 6 wherein one of the coil assemblies (C1a) is coupled to the drive circuitry (10) and the other (C1b) is coupled to the sampling means (D1-D4).

8. A coin acceptor (1) according to claim 4 or 5 wherein one or more of the sensor coil units (C1-C4) include coil assemblies (C2, C4) on one side only of the coin path.

9. A coin acceptor (1) according to claim 8 wherein each of the coil assemblies (C2, C4) of said sensor coil units is coupled to both the drive circuitry (10) and the sampling means (D1-D4).

10. A coin acceptor (1) according to any one of claims 2 to 9 wherein the coil units (C1-C4) include coil assemblies with an area to face the coin of less than $72mm^2$.

11. A coin acceptor (1) according to any one of claims 2 to 10 wherein the coil units (C1-C4) include coils configured around a magnetically permeable core (26) facing the coin path.

12. A coin acceptor (1) according to any one of claims 2 to 11 wherein the sensor coil units (C1-C4) are each coupled in an oscillator circuit and the sampling means (D1-D4) is operative to sample a parameter of the oscillatory characteristic of the circuit as the coin (8) passes the unit.

13. A coin acceptor (1) according to claim 12 wherein said characteristic comprises frequency or amplitude or both.

14. A coin acceptor (1) according to any preceding claim wherein the control means (11) is configured to select an ensemble (A) of sample values of the sensor outputs that occur when one of the outputs accords with said predetermined criterion, and to compare the selected sample values with said stored data (53).

15. A coin acceptor (1) according to any one of claims 1 to 13 wherein the control means (11) is configured to determine when the sampled sensor outputs individually accord with a respective predetermined criterion and to compare the values thereof with the stored data (58).

16. A coin acceptor (1) according to any preceding claim wherein the predetermined criterion comprises a discontinuity in the value of sampled sensor output.

17. A coin acceptor (1) according to claim 16 wherein the discontinuity comprises a main or a localised maximum or minimum in the sampled value of the sensor output that occurs during the passage of the coin (8).

18. A coin acceptor (1) according to any preceding claim wherein the predetermined criterion comprises the occurrence of at least one sample value from one of the sensors (C1-C4) forming a predetermined value relationship with at least one sample value from another of the sensors.

19. A coin acceptor (1) according to claim 18 wherein the value relationship comprises a crossover of the values of the successive samples from one of the sensors with corresponding sample values from another of the sensors, or may be a function of the relative rate of change of the sample values from the sensors (C1-C4).

20. A coin acceptor (1) according to claim 18 wherein the value relationship comprises a predetermined function of the relative rate of change of the sample values from the sensors.

21. A coin discrimination method comprising sensing the passage of a coin (8) along a path (2) with a plurality of sensor coils (C1a,b, C2, C3a,b, C4) that are spaced apart in an array extending transversely of the coin path (2) and energised to inductively.couple with different regions (21, 22) of the face of the coin (8) as it moves past them, sampling values of the sensor outputs repetitively during the passage of the coin (8) past the sensor coils (C1-C4) to provide corresponding sample values, monitoring the sample values, determining when a sampled value of at least one of the sensor outputs accords with a predetermined criterion and comparing the sample values with stored reference data values, **characterised in that,** the comparison is made in response to the criterion being met, where said comparison is between stored reference data comprising sets of individual coin parameter values for coins of different denomination and sample values relating to each of the plurality of regions sensed by the sensor coils (11) with the stored data sets to determine the acceptability of the coin.

22. A coin discrimination method as in claim 21, wherein the sensor coils (C1-C4) are energised at different frequencies.

23. A method according to claim 21 or 22 including continually seeking to determine when the sampled value of at least one of the sensor outputs accords with the criterion whilst the coin passes the sensor coils; and selecting the sample value which best meets the criterion if the criterion is not met more than once.

Patentansprüche

1. Münzenannahmevorrichtung (1) mit einem Pfad für Münzen (2), einer Vielzahl von Sensorspulen (C1a,b, C2, C3a, b, C4) zum Erfassen einer Münze (8), wenn sie sich entlang dem Pfad bewegt, einer Treiberschaltung (10), die mit den Sensorspulen gekoppelt ist, wobei die Sensorspulen in einem Feld angeordnet sind, das sich transversal vom Münzpfad erstreckt, um durch die Treiberschaltung (10) erregt zu werden, um mit unterschiedlichen Bereichen (21, 22) der Oberfläche einer Münze induktiv zu koppeln, wenn sie sich an ihnen vorbeibewegt, so dass die Sensorspulen sich mit der Zeit ändernde Sensorausgaben als Funktion der jeweiligen unterschiedlichen Bereiche erzeugen, Abtasteinrichtungen (D1-D4) zum jeweiligen Abtasten von Werten der einzelnen Sensorausgaben, die während des Laufens der Münze an den Sensoren vorbei erzeugt werden, um entsprechende Abtastwerte zu liefern, und einer Steuereinrichtung (11) zum Überwachen der Abtastwerte und zum Bestimmen, wenn ein abgetasteter Wert von wenigstens einer der Sensorausgaben mit einem vorbestimmten Kriterium übereinstimmt, und zum Vergleichen der Abtastwerte mit gespeicherten Referenzdatenwerten,
dadurch gekennzeichnet, dass die gespeicherten Referenzdaten Gruppen von Münzenparameterdatenwerten für Münzen unterschiedlicher Wertigkeiten aufweisen und die Steuereinrichtung (11) angeordnet ist, um die Abtastwerte in Bezug auf jeden der Vielzahl von durch die Sensorspulen (11) erfassten Bereichen mit den gespeicherten Datengruppen in Reaktion auf das Kriterium, das gerade erfüllt wird, zu vergleichen, um die Annehmbarkeit der Münze zu bestimmen.

2. Münzenannahmevorrichtung (1) nach Anspruch 1, wobei die Sensorspulen (C1-C4) bei unterschiedlichen Frequenzen erregt werden.

3. Münzenannahmevorrichtung (1) nach Anspruch 1, wobei die Steuereinrichtung (11) ein Prozessor ist.

4. Münzenannahmevorrichtung (1) nach einem der Ansprüche 1 bis 3, wobei die Sensorspulen (C1-C4) ein Feld von Sensorspuleneinheiten enthalten, die konfiguriert sind, um selektiv eine induktive Kopplung mit jeweiligen Bereichen der Münze zu bilden.

5. Münzenannahmevorrichtung (1) nach Anspruch 4, wobei das Feld von Sensorspuleneinheiten (C1-C4) Spulenanordnungen enthält, die in einer Linie angeordnet sind, die sich transversal vom Münzpfad erstreckt.

6. Münzenannahmevorrichtung (1) nach Anspruch 4 oder 5, wobei eine oder mehrere der Sensorspuleneinheiten (C1-C4) Spulenanordnungen (C1a,b) auf gegenüberliegenden Seiten des Münzpfads (2) enthalten.

7. Münzenannahmevorrichtung (1) nach Anspruch 6, wobei eine der Spulenanordnungen (C1a) mit der Treiberschaltung (10) gekoppelt ist und die andere (C1b) mit der Abtasteinrichtung (D1-D4) gekoppelt ist.

8. Münzenannahmevorrichtung (1) nach Anspruch 4 oder 5, wobei eine oder mehrere Sensorspuleneinheiten (C1-C4) Spulenanordnungen (C2, C4) nur auf einer Seite des Spulenpfads enthalten.

9. Münzenannahmevorrichtung (1) nach Anspruch 8, wobei jede der Spulenanordnungen (C2, C4) der Sensorspuleneinheiten mit sowohl der Treiberschaltung (10) als auch den Abtasteinrichtungen (D1-D4) gekoppelt ist.

10. Münzenannahmevorrichtung (1) nach einem der Ansprüche 2 bis 9, wobei die Spuleneinheiten (C1-C4) Spulenanordnungen mit einem Bereich, um der Münze gegenüberzuliegen, von kleiner als 72 mm^2 enthalten.

11. Münzenannahmevorrichtung (1) nach einem der Ansprüche 2 bis 10, wobei die Spuleneinheiten (C1-C4) Spulen enthalten, die um einen magnetisch permeablen Kern (26) konfiguriert sind, der dem Münzpfad gegenüberliegt.

12. Münzenannahmevorrichtung (1) nach einem der Ansprüche 2 bis 11, wobei die Sensorsputeneinheiten (C1-C4) jeweils in einer Oszillatorschaltung gekoppelt sind und die Abtasteinrichtung (D1-D4) arbeitet, um einen Parameter der Oszillationseigenschaft der Schaltung abzutasten, wenn die Münze (8) die Einheit durchläuft.

13. Münzenannahmevorrichtung (1) nach Anspruch 12, wobei die Eigenschaft eine Frequenz oder eine Amplitude oder beides umfaßt.

14. Münzenannahmevorrichtung (1) nach einem der vorangehenden Ansprüche, wobei die Steuereinrichtung (11) konfiguriert ist, um ein Ensemble (A) von Abtastwerten der Sensorausgaben auszuwählen, die dann auftreten, wenn eine der Ausgaben mit dem vorbestimmten Kriterium übereinstimmt, und um die ausgewählten Abtastwerte mit den gespeicherten Daten (53) zu vergleichen.

15. Münzenannahmevorrichtung (1) nach einem der Ansprüche 1 bis 13, wobei die Steuereinrichtung (11) konfiguriert ist, um zu bestimmen, wenn die abgetasteten Sensorausgaben einzeln mit einem jeweiligen vorbestimmten Kriterium übereinstimmen, und um ihre Werte mit den gespeicherten Daten (58) zu vergleichen.

16. Münzenannahmevorrichtung (1) nach einem der vorangehenden Ansprüche, wobei das vorbestimmte Kriterium eine Diskontinuität bezüglich des Werts einer abgetasteten Sensorausgabe umfaßt.

17. Münzenannahmevorrichtung (1) nach Anspruch 16, wobei die Diskontinuität ein Haupt- oder ein Lokalmaximum oder -minimum bezüglich des abgetasteten Werts der Sensorausgabe umfaßt, die während des Durchlaufens der Münze (8) auftritt.

18. Münzenannahmevorrichtung (1) nach einem der vorangehenden Ansprüche, wobei das vorbestimmte Kriterium das Auftreten von wenigstens einem Abtastwert von einem der Sensoren (C1-C4) umfaßt, der eine vorbestimmte Wertebeziehung zu wenigstens einem Abtastwert von einem anderen der Sensoren bildet.

19. Münzenannahmevorrichtung (1) nach Anspruch 18, wobei die Wertebeziehung eine Kreuzung der Werte der aufeinander folgenden Abtastungen von einem der Sensoren mit entsprechenden Abtastwerten von einem anderen der Sensoren umfaßt oder eine Funktion einer relativen Änderungsrate der Abtastwerte von den Sensoren (C1-C4) sein kann.

20. Münzenannahmevorrichtung (1) nach Anspruch 18, wobei die Wertebeziehung eine vorbestimmte Funktion der relativen Änderungsrate der Abtastwerte von den Sensoren umfaßt.

21. Münzenuntersuchungsverfahren mit einem Erfassen des Laufens einer Münze (8) entlang einem Pfad (2) mit einer Vielzahl von Sensorspulen (C1a,b, C2, C3a,b, C4), die in einem Feld voneinander beabstandet sind, das sich transversal vom Münzpfad (2) erstreckt, und die erregt werden, um mit unterschiedlichen Bereichen (21, 22) der Oberfläche der Münze (8) induktiv zu koppeln, wenn sie sich an ihnen vorbeibewegt, einem wiederholten Abtasten von Werten der Sensorausgaben während des Laufens der Münze (8) an den Sensorspulen (C1 - C4) vorbei, um entsprechende Abtastwerte zu liefern, einem Überwachen der Abtastwerte, einem Bestimmen, wenn ein abgetasteter Wert von wenigstens einer der Sensorausgaben mit einem vorbestimmten Kriterium übereinstimmt, und einem Vergleichen der Abtastwerte mit gespeicherten Referenzdatenwerten, **dadurch gekennzeichnet, dass** der

Vergleich in Reaktion auf das Kriterium durchgeführt wird, das gerade erfüllt wird, wobei der Vergleich zwischen gespeicherten Referenzdaten mit Gruppen von individuellen Münzenparameterwerten für Münzen unterschiedlicher Wertigkeit und Abtastwerten in Bezug auf jeden der Vielzahl von durch die Sensorspulen (11) erfassten Bereichen mit den gespeicherten Datengruppen erfolgt, um die Annehmbarkeit der Münze zu bestimmen.

22. Münzenuntersuchungsverfahren nach Anspruch 21, wobei die Sensorspulen (C1-C4) bei unterschiedlichen Frequenzen erregt werden.

23. Verfahren nach Anspruch 21 oder 22, das ein kontinuierliches Suchen enthält, um zu bestimmen, wenn der abgetastete Werte von wenigstens einer der Sensorausgaben mit dem Kriterium übereinstimmt, während die Münze an den Sensorspulen vorbeiläuft, und ein Auswählen des Abtastwerts, der das Kriterium am besten erfüllt, wenn das Kriterium nicht mehr als einmal erfüllt wird.

Revendications

1. Appareil accepteur de monnaie (1) comportant un chemin pour des pièces (2) de monnaie, plusieurs bobines (C1a,b, C2, C3a,b, C4) de capteur destinées à capter une pièce (8) pendant qu'elle se déplace le long dudit chemin, un circuit d'attaque (10) couplé aux bobines de capteur, les bobines de capteur étant agencées en une rangée s'étendant transversalement au chemin des pièces afin d'être alimentées en énergie par le circuit d'attaque (10) pour réaliser un couplage inductif avec différentes régions (21, 22) de la face d'une pièce pendant qu'elle les franchit, de façon que les bobines de capteur produisent des signaux de sortie de capteur variant dans le temps en fonction des différentes régions, respectivement, des moyens d'échantillonnage (D1-D4) destinés à échantillonner de façon répétitive des valeurs des signaux de sortie de capteur individuel produits pendant le passage de la pièce devant les capteurs pour produire des valeurs d'échantillon correspondantes et des moyens de commande (11) destinés à contrôler les valeurs d'échantillon et à déterminer lorsqu'une valeur échantillonnée d'au moins l'un des signaux de sortie de capteur est en accord avec un critère prédéterminé et à comparer les valeurs d'échantillon à des valeurs de données de référence mémorisées,

caractérisé en ce que les données de référence mémorisées comprennent des ensembles de valeurs de données de paramètre de pièce pour des pièces de différentes valeurs et les moyens de commande (11) sont agencés de façon à comparer les valeurs d'échantillon associées à chacune des multiples régions captées par les bobines (11) de capteur aux ensembles de données mémorisées en réponse au critère qui est satisfait, afin de déterminer l'acceptabilité de la pièce.

2. Appareil accepteur de pièce (1) selon la revendication 1, dans lequel les bobines (C1-C4) de capteur sont alimentées en énergie à des fréquences différentes.

3. Appareil accepteur de pièce (1) selon la revendication 1, dans lequel les moyens de commande (11) comprennent un processeur.

4. Appareil accepteur de pièce (1) selon l'une quelconque des revendications 1 à 3, dans lequel les bobines (C1-C4) de capteur comprennent une rangée d'unités de bobines de capteur configurées de façon à former un couplage inductif sélectivement avec des régions respectives de la pièce.

5. Appareil accepteur de pièce (1) selon la revendication 4, dans lequel la rangée d'unités de bobines de capteur (C1-C4) comprend des ensembles à bobines qui sont agencés suivant une ligne s'étendant transversalement au chemin des pièces.

6. Appareil accepteur de pièce (1) selon la revendication 4 ou 5, dans lequel une ou plusieurs des unités de bobines de capteur (C1-C4) comprennent des ensembles à bobines (C1a,b) sur des côtés opposés du chemin (2) de pièce.

7. Appareil accepteur de pièce selon la revendication 6, dans lequel l'un des ensembles à bobines (C1a) est couplé au circuit d'attaque (10) et l'autre (C1b) est couplé aux moyens d'échantillon (D1-D4).

8. Appareil accepteur de pièce (1) selon la revendication 4 ou 5, dans lequel une ou plusieurs des unités à bobines de capteur (C1-C4) comprend des ensembles à bobines (C2, C4) sur un côté seulement du chemin de pièces.

9. Appareil accepteur de pièce (1) selon la revendication 8, dans lequel chacun des ensembles à bobines (C2, C4)

desdites unités à bobines de capteur est couplé à la fois au circuit d'attaque (10) et aux moyens d'échantillonnage (D1-D4).

10. Appareil accepteur de pièce (1) selon l'une quelconque des revendications 2 à 9, dans lequel les unités à bobines (C1-C4) comprennent des ensembles à bobines présentant une aire qui fait face à la pièce inférieure à 72 mm^2.

11. Appareil accepteur de pièce (1) selon l'une quelconque, des revendications 2 à 10, dans lequel les unités de bobines (C1-C4) comprennent des bobines configurées autour d'un noyau magnétiquement perméable (26) faisant face au chemin de pièce.

12. Appareil accepteur de pièce (1) selon l'une quelconque des revendications 2 à 11, dans lequel les unités de bobines de capteur (C1-C4) sont couplées chacune dans un circuit oscillateur et les moyens d'échantillonnage (D1-D4) fonctionnent de façon à échantillonner un paramètre de la caractéristique oscillatoire du circuit lorsque la pièce (8) franchit l'unité.

13. Appareil accepteur de pièce (1) selon la revendication 12, dans lequel ladite caractéristique comprend une fréquence ou une amplitude ou les deux.

14. Appareil accepteur de pièce (1) selon l'une quelconque des revendications précédentes, dans lequel les moyens de commande (11) sont configurés de façon à sélectionner un ensemble (A) de valeurs d'échantillons des signaux de sortie du capteur qui apparaissent lorsque l'un des signaux de sortie est en accord avec ledit critère prédéterminé, et à comparer les valeurs d'échantillon sélectionnées auxdites données mémorisées (53).

15. Appareil accepteur de pièce (1) selon l'une quelconque des revendications 1 à 13, dans lequel les moyens de commande (11) sont configurés de façon à déterminer lorsque les signaux de sortie de capteur échantillonné sont individuellement en accord avec un critère prédéterminé respectif, et à comparer leurs valeurs aux données mémorisées (58).

16. Appareil accepteur de pièce (1) selon l'une quelconque des revendications précédentes, dans lequel le critère prédéterminé comprend une discontinuité dans la valeur du signal de sortie de capteur échantillonné.

17. Appareil accepteur de pièce (1) selon la revendication 16, dans lequel la discontinuité comprend un maximal ou minimal principal ou localisé dans la valeur échantillonnée du signal de sortie du capteur qui apparaît lors du passage de la pièce (8).

18. Appareil accepteur de pièce (1) selon l'une quelconque des revendications précédentes, dans lequel le critère prédéterminé comprend l'apparition d'au moins une valeur d'échantillon provenant de l'un des capteurs (C1-C4) établissant une relation de valeur prédéterminée avec au moins une valeur d'échantillon provenant d'un autre des capteurs.

19. Appareil accepteur de pièce (1) selon la revendication 18, dans lequel la relation des valeurs comprend un croisement des valeurs des échantillons successifs provenant de l'un des capteurs avec des valeurs d'échantillon correspondant provenant d'un autre des capteurs, ou peut être une fonction du rythme relatif de variation des valeurs d'échantillon provenant des capteurs (C1-C4).

20. Appareil accepteur de pièce (1) selon la revendication 8, dans lequel la relation de valeur comprend une fonction prédéterminée du rythme relatif de variation des valeurs d'échantillon provenant des capteurs.

21. Procédé de discrimination de pièce comprenant la détection du passage d'une pièce (8) suivant un chemin (2) à l'aide de plusieurs bobines (C1a,b, C2, C3a,b, C4) de capteurs qui sont espacées suivant une rangée s'étendant transversalement au chemin (2) de pièce et qui sont alimentées en énergie pour réaliser un couplage inductif avec différentes régions (21, 22) de la face de la pièce (8) lorsqu'elle les franchit, l'échantillonnage de valeurs des signaux de sortie des capteurs de façon répétitive pendant le passage de la pièce (8) devant les bobines (C1-C4) des capteurs afin de produire des valeurs d'échantillon correspondantes, le contrôle des valeurs d'échantillon, la détermination de l'instant où une valeur échantillonnée d'au moins l'un des signaux de sortie des capteurs est en accord avec un critère prédéterminé et la comparaison des valeurs d'échantillon à des valeurs de données de référence mémorisées, **caractérisé en ce que** la comparaison est réalisée en réponse au fait que le critère est satisfait, ladite comparaison étant réalisée entre des données de référence mémorisées comprenant des ensem-

bles de valeurs de paramètres de pièces individuelles pour des pièces de différentes valeurs et des valeurs d'échantillon associées à chacune des multiples régions captées par les bobines (11) de capteur avec les ensembles de données mémorisées pour déterminer l'acceptabilité de la pièce.

22. Procédé de discrimination de pièce selon la revendication 21, dans lequel les bobines (C1-C4) des capteurs sont alimentées en énergie à des fréquences différentes.

23. Procédé selon la revendication 21 ou 22, comprenant le fait de chercher en continu à déterminer lorsque la valeur échantillonnée d'au moins l'un des signaux de sortie des capteurs est en accord avec le critère pendant que la pièce passe par les bobines des capteurs, et de sélectionner la valeur d'échantillon qui satisfait le mieux au critère si le critère n'est pas satisfait plus d'une fois.

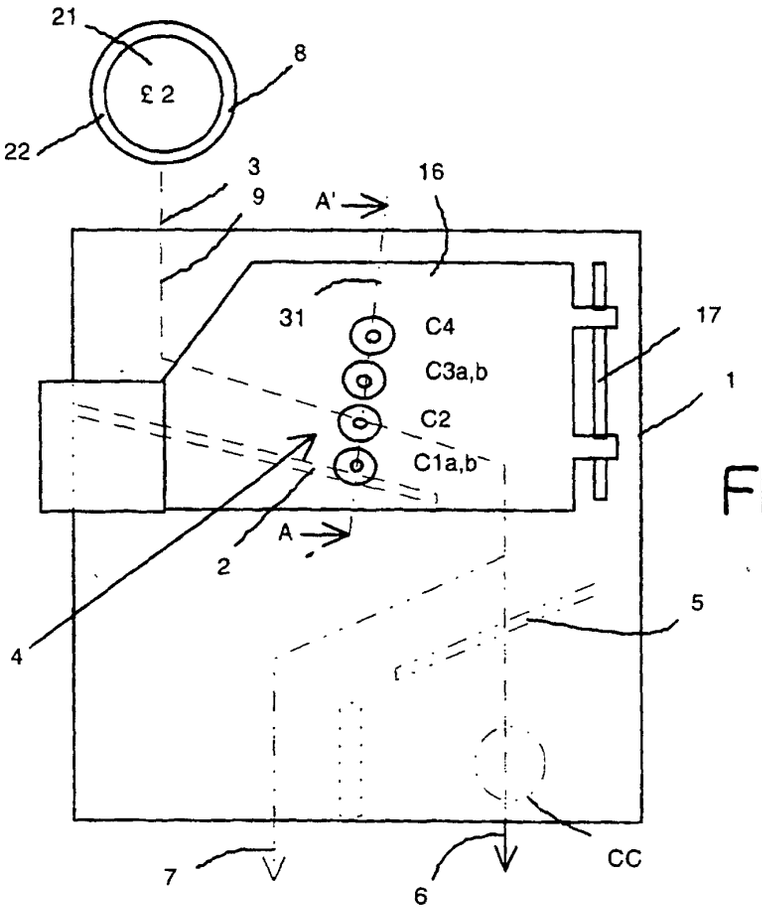

21
£ 2
8
22
3
9
A'
16
31
C4
C3a,b
C2
C1a,b
17
1
A
2
4
5
7
6
CC

FIG.1

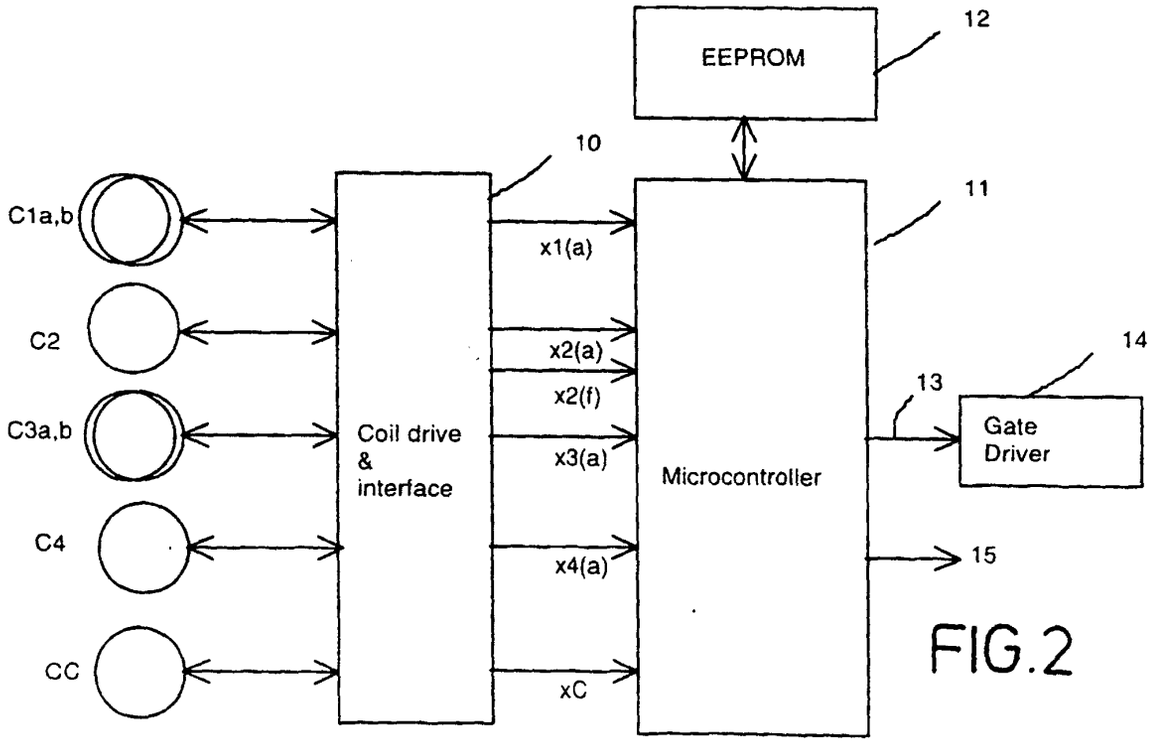

EEPROM
12
10
11
C1a,b
C2
C3a,b
C4
CC
Coil drive
&
interface
x1(a)
x2(a)
x2(f)
x3(a)
x4(a)
xC
Microcontroller
13
14
Gate
Driver
15

FIG.2

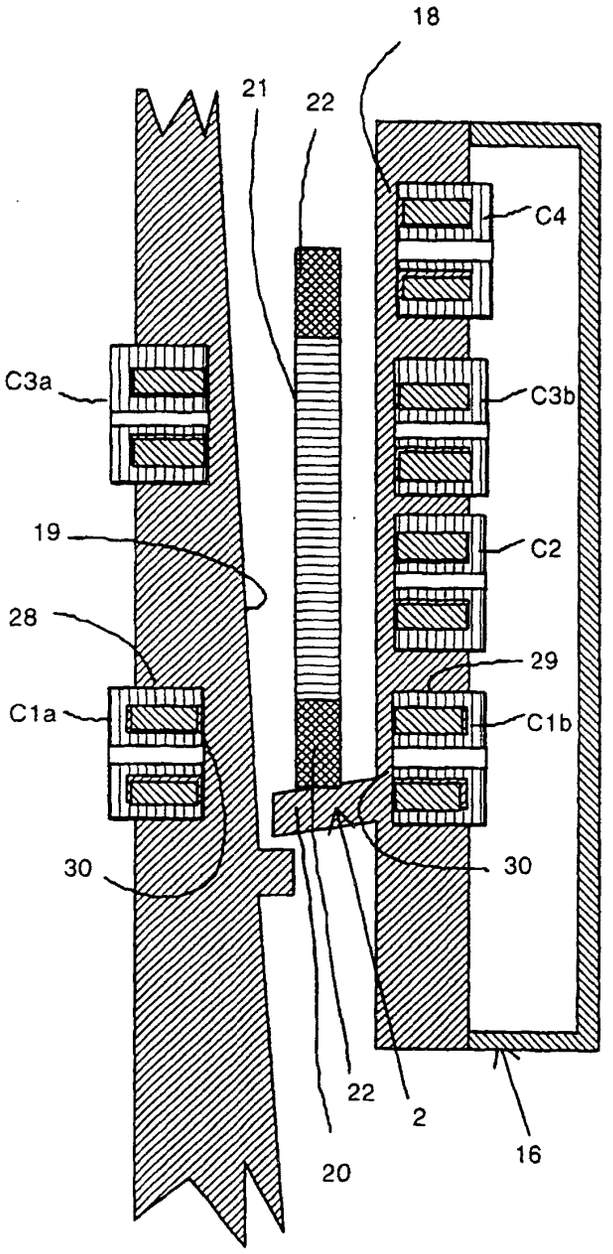


FIG.3

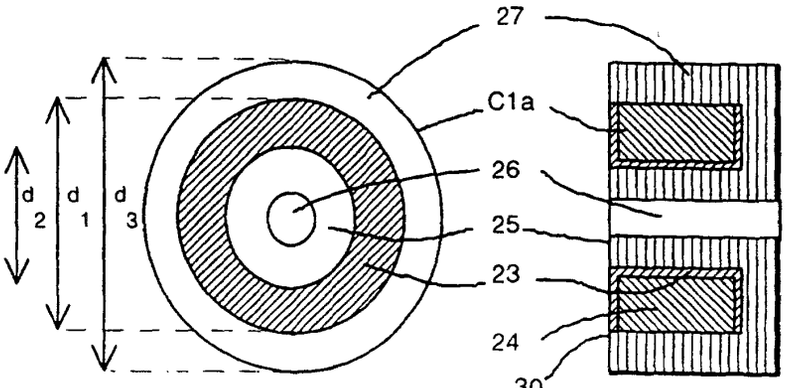


FIG.4b

FIG.4a

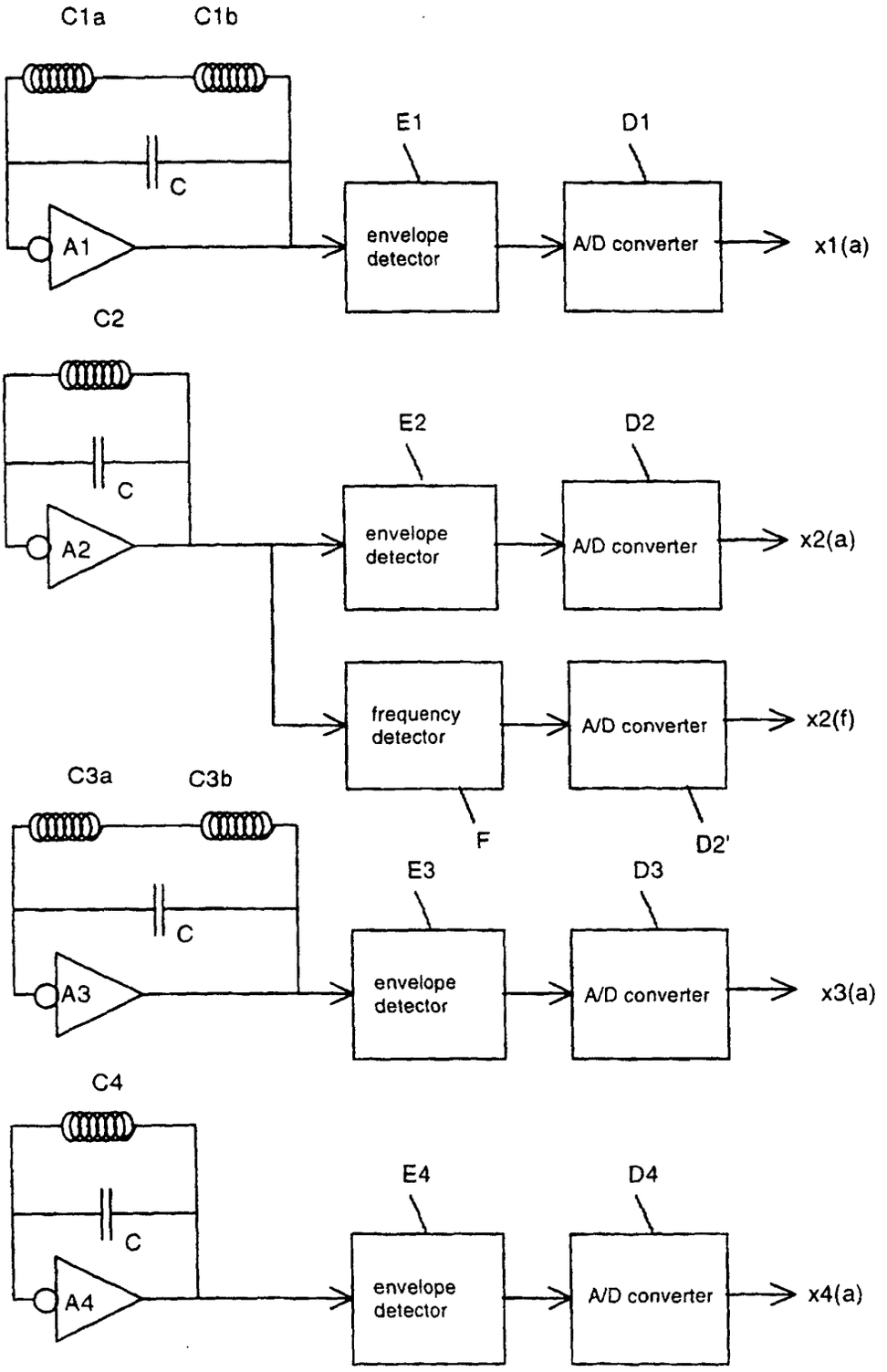

C1a
C1b
C
A1
E1
D1
envelope detector
A/D converter
x1(a)
C2
C
A2
E2
D2
envelope detector
A/D converter
x2(a)
frequency detector
A/D converter
x2(f)
F
D2'
C3a
C3b
C
A3
E3
D3
envelope detector
A/D converter
x3(a)
C4
C
A4
E4
D4
envelope detector
A/D converter
x4(a)

FIG.5

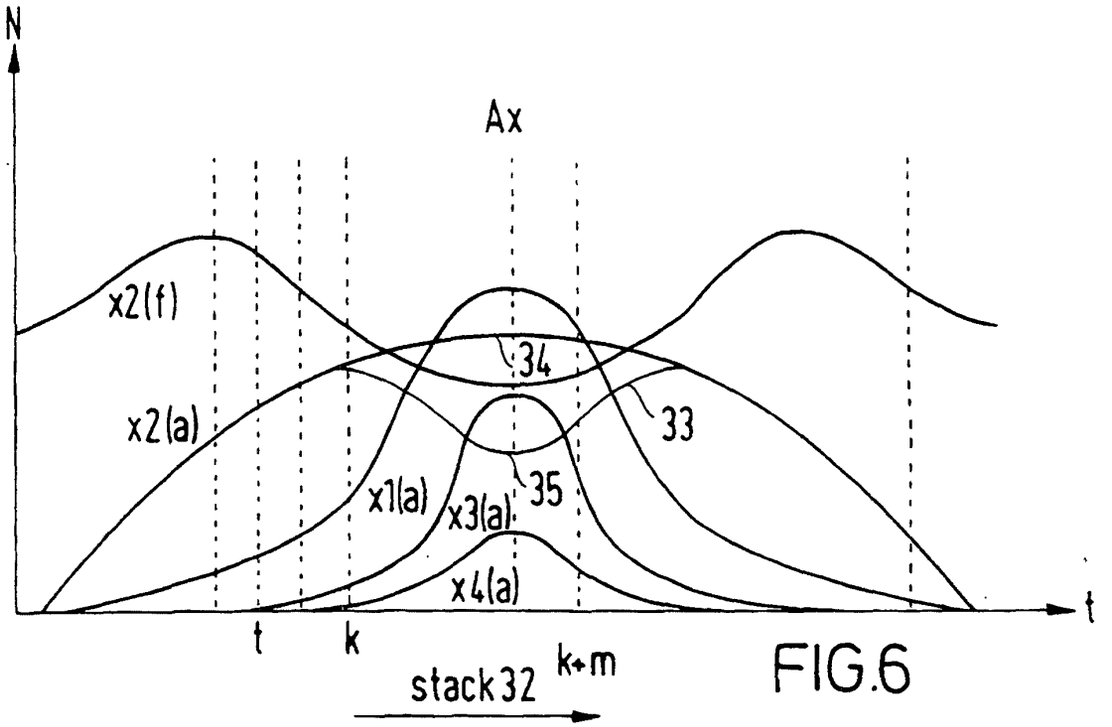

N
Ax
x2(f)
34
x2(a)
33
x1(a)
35
x3(a)
x4(a)
t
t
k
stack 32
k+m

FIG.6

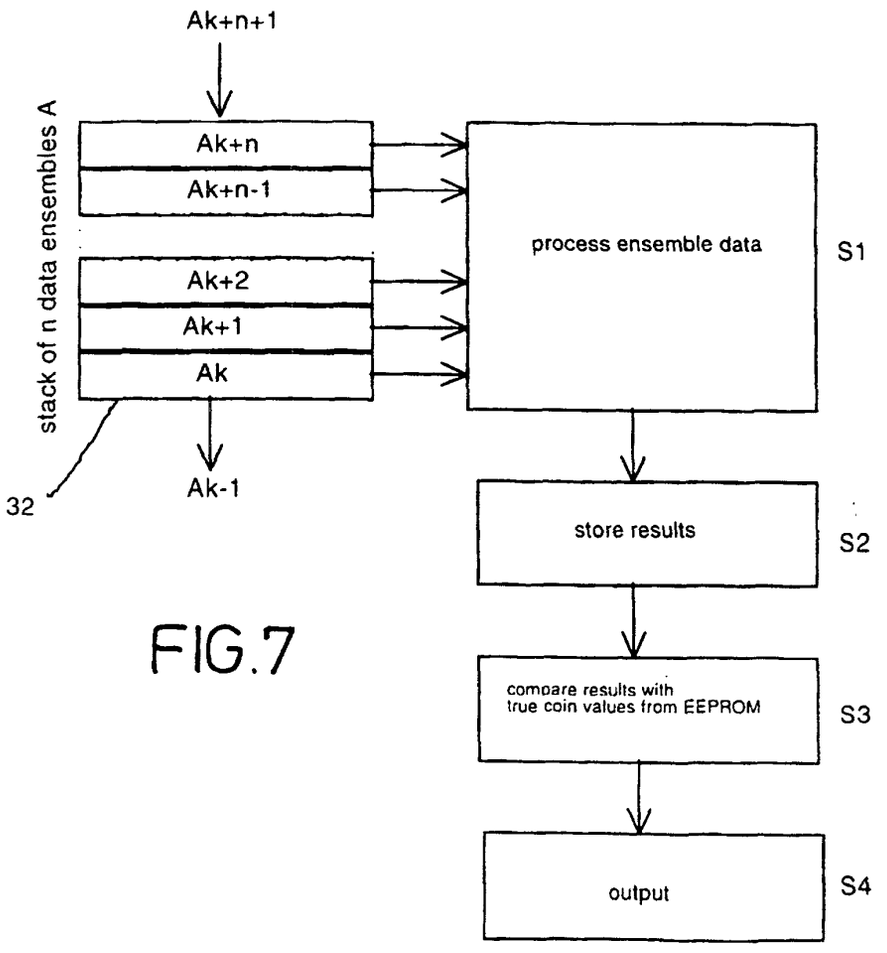

Ak+n+1
Ak+n
Ak+n-1
Ak+2
Ak+1
Ak
Ak-1
stack of n data ensembles A
32
process ensemble data
S1
store results
S2
compare results with
true coin values from EEPROM
S3
output
S4

FIG.7

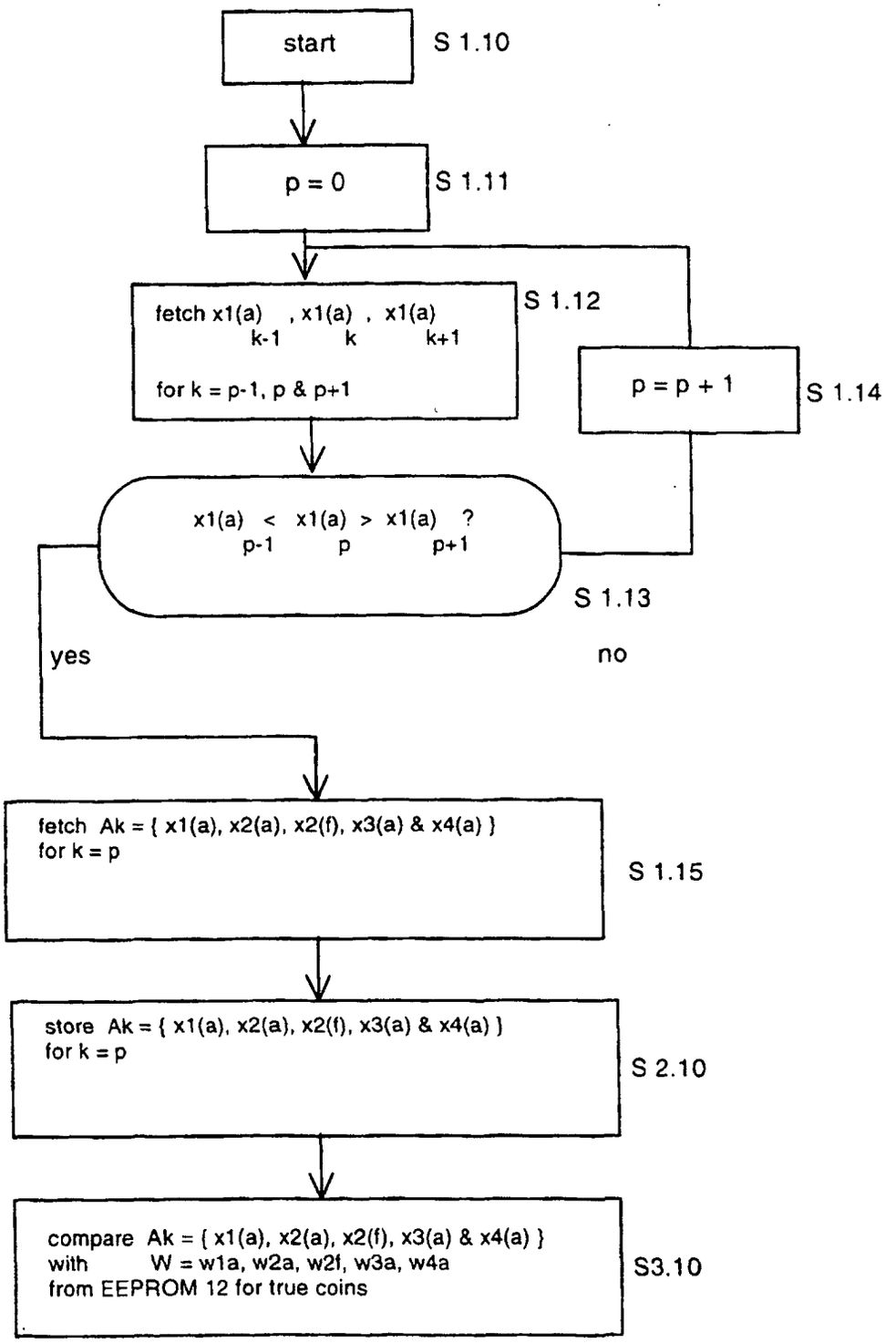

start
S 1.10
p = 0
S 1.11
fetch x1(a) , x1(a) , x1(a)
k-1 k k+1
for k = p-1, p & p+1
S 1.12
p = p + 1
S 1.14
x1(a) < x1(a) > x1(a) ?
p-1 p p+1
S 1.13
yes
no
fetch Ak = { x1(a), x2(a), x2(f), x3(a) & x4(a) }
for k = p
S 1.15
store Ak = { x1(a), x2(a), x2(f), x3(a) & x4(a) }
for k = p
S 2.10
compare Ak = { x1(a), x2(a), x2(f), x3(a) & x4(a) }
with W = w1a, w2a, w2f, w3a, w4a
from EEPROM 12 for true coins
S3.10

FIG.8

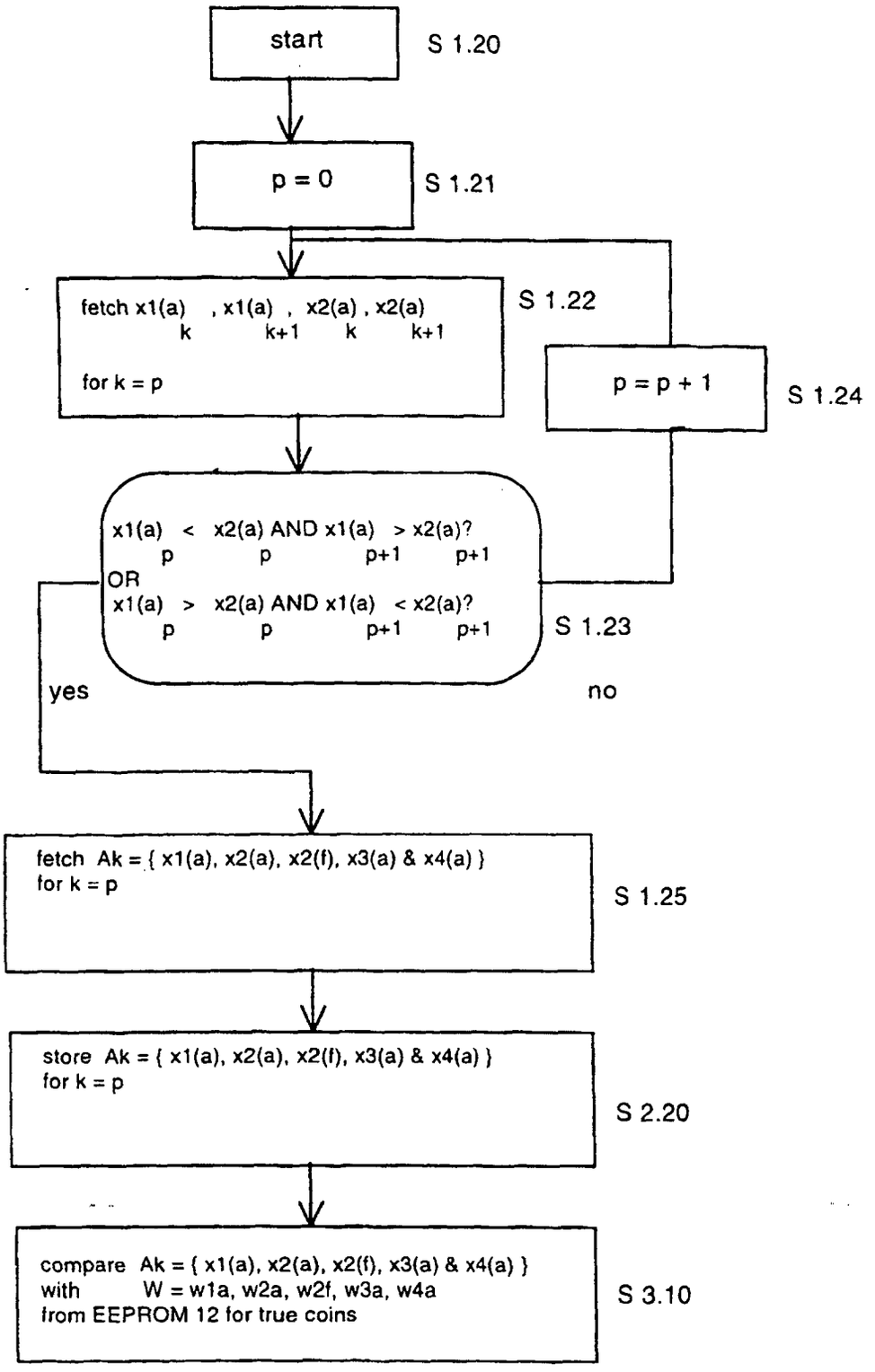

start
S 1.20
p = 0
S 1.21
fetch x1(a) , x1(a) , x2(a) , x2(a)
k k+1 k k+1
for k = p
S 1.22
p = p + 1
S 1.24
x1(a) < x2(a) AND x1(a) > x2(a)?
p p p+1 p+1
OR
x1(a) > x2(a) AND x1(a) < x2(a)?
p p p+1 p+1
S 1.23
yes
no
fetch Ak = { x1(a), x2(a), x2(f), x3(a) & x4(a) }
for k = p
S 1.25
store Ak = { x1(a), x2(a), x2(f), x3(a) & x4(a) }
for k = p
S 2.20
compare Ak = { x1(a), x2(a), x2(f), x3(a) & x4(a) }
with W = w1a, w2a, w2f, w3a, w4a
from EEPROM 12 for true coins
S 3.10

FIG.9

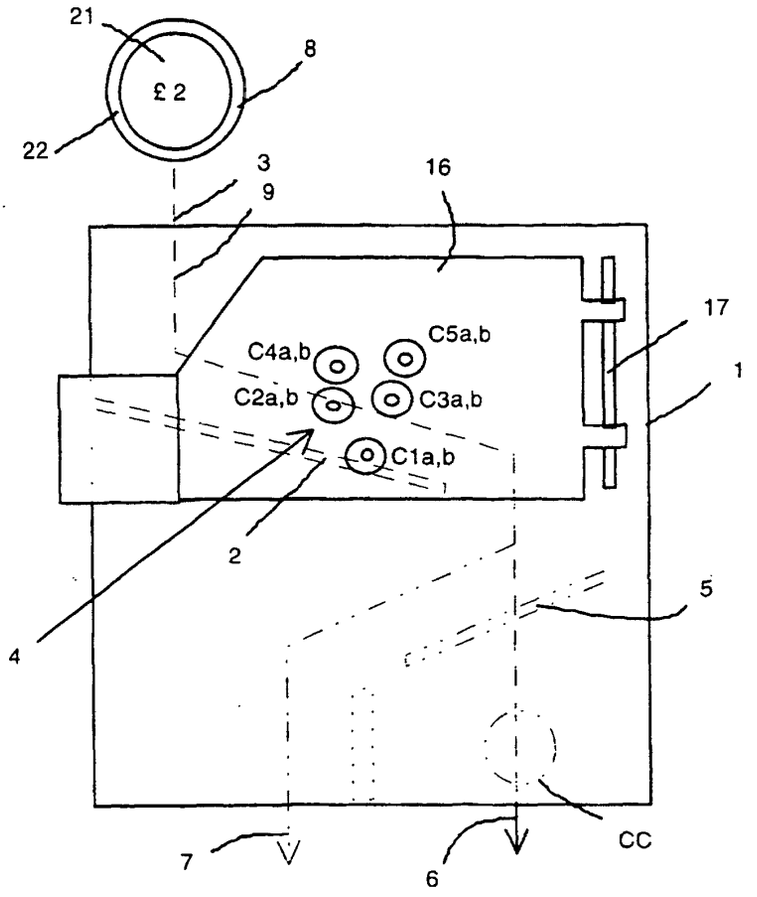

21
£ 2
8
22
3
9
16
17
1
C4a,b
C5a,b
C2a,b
C3a,b
C1a,b
2
4
5
7
6
CC

FIG.10

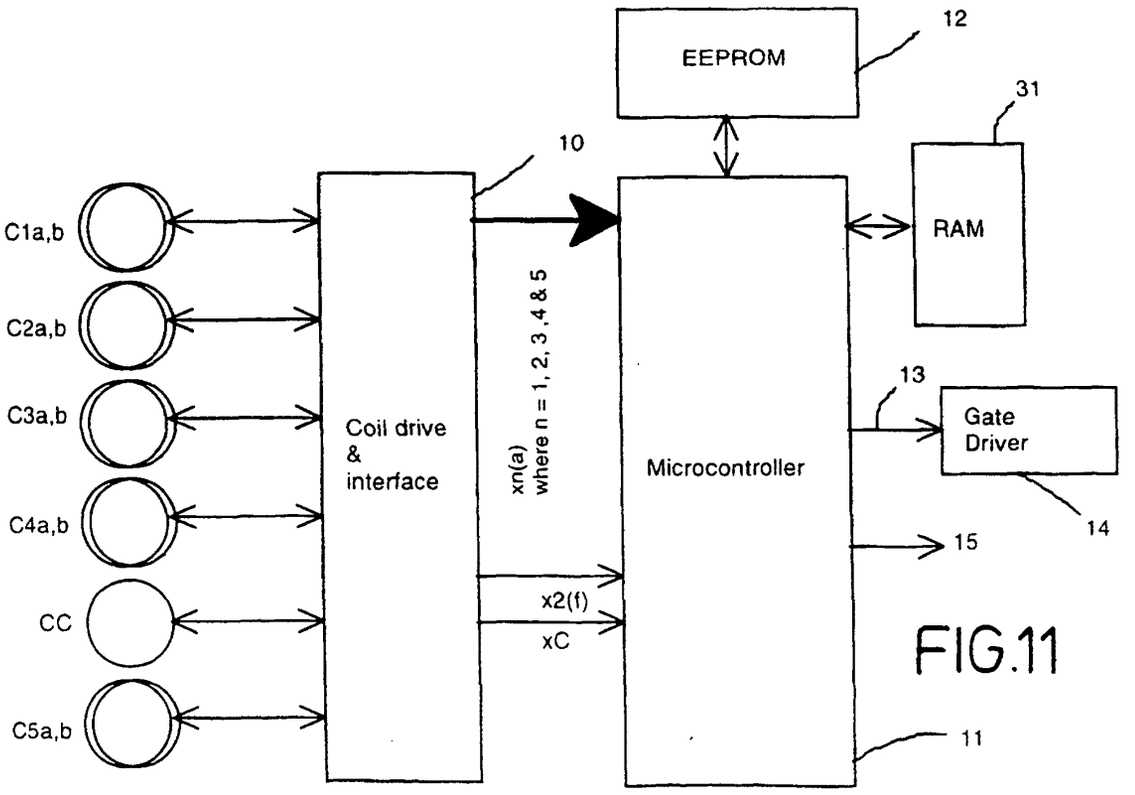

EEPROM
12
31
10
RAM
C1a,b
C2a,b
C3a,b
C4a,b
CC
C5a,b
Coil drive
&
interface
xn(a)
where n = 1, 2, 3, 4 & 5
Microcontroller
13
Gate
Driver
14
15
x2(f)
xC
11

FIG.11

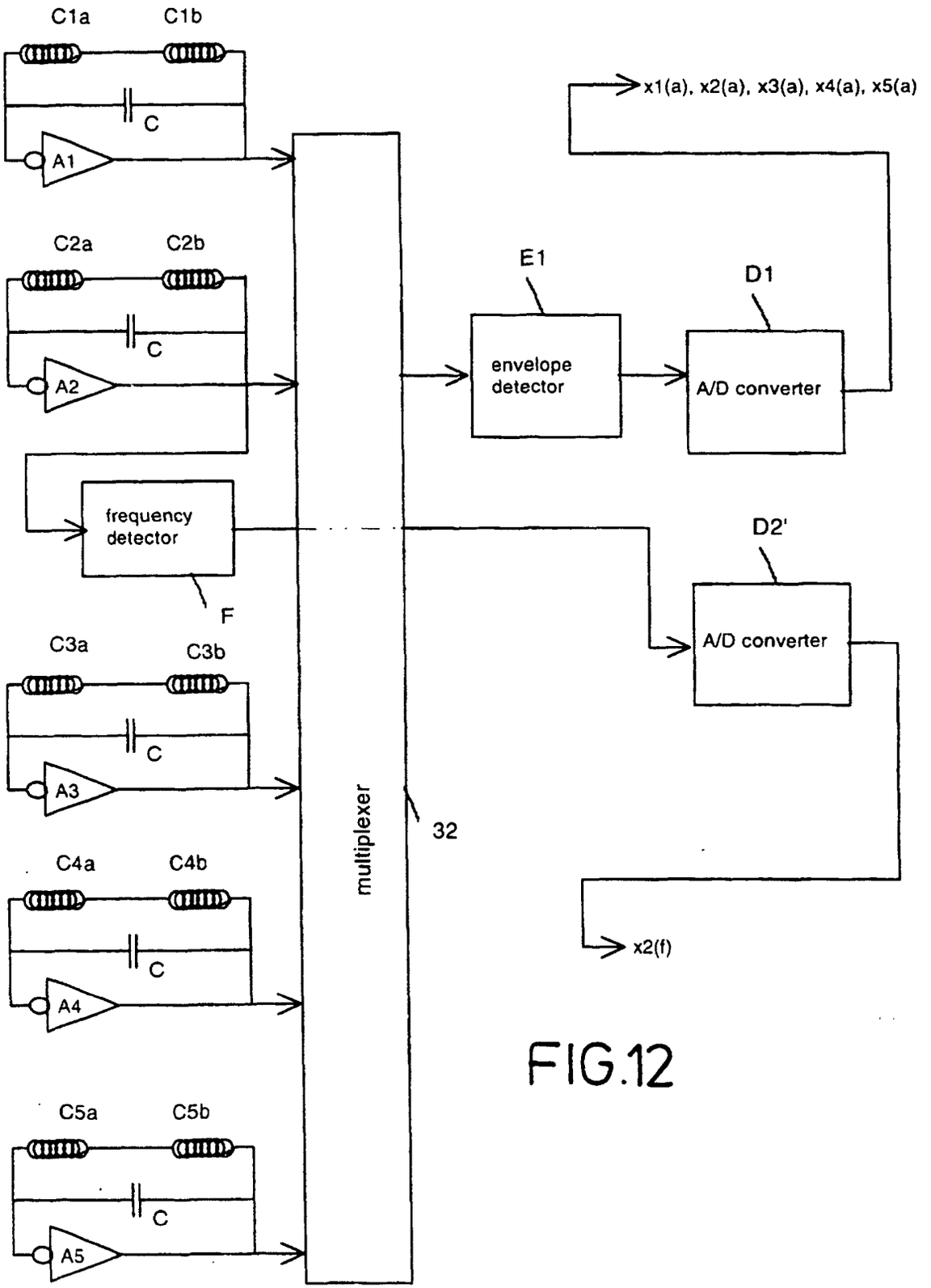

C1a
C1b
C
A1
C2a
C2b
C
A2
frequency detector
F
C3a
C3b
C
A3
C4a
C4b
C
A4
C5a
C5b
C
A5
multiplexer
32
E1
envelope detector
D1
A/D converter
x1(a), x2(a), x3(a), x4(a), x5(a)
D2'
A/D converter
x2(f)

FIG.12

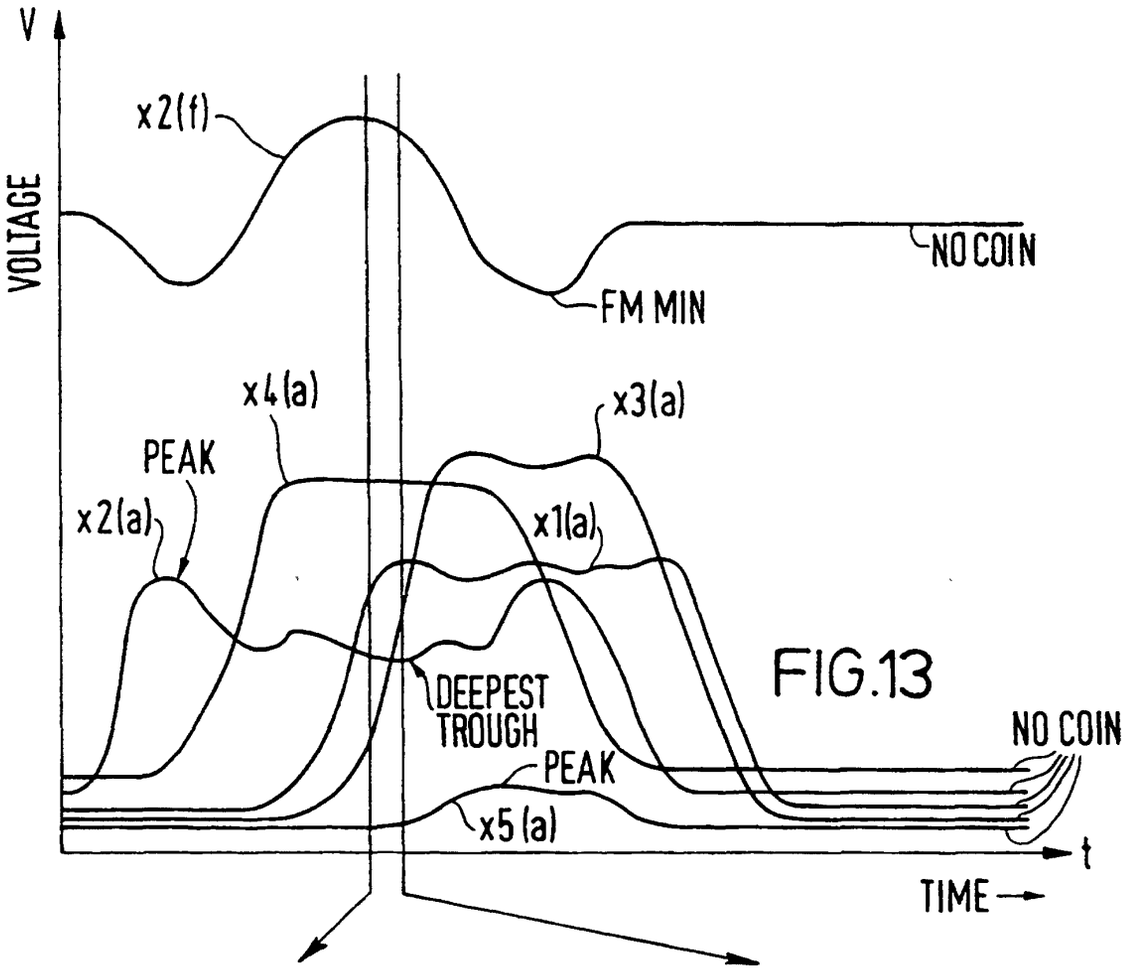

V
VOLTAGE
x2(f)
NO COIN
FM MIN
x4(a)
x3(a)
PEAK
x2(a)
x1(a)
DEEPEST
TROUGH
NO COIN
PEAK
x5(a)
t
TIME

FIG.13

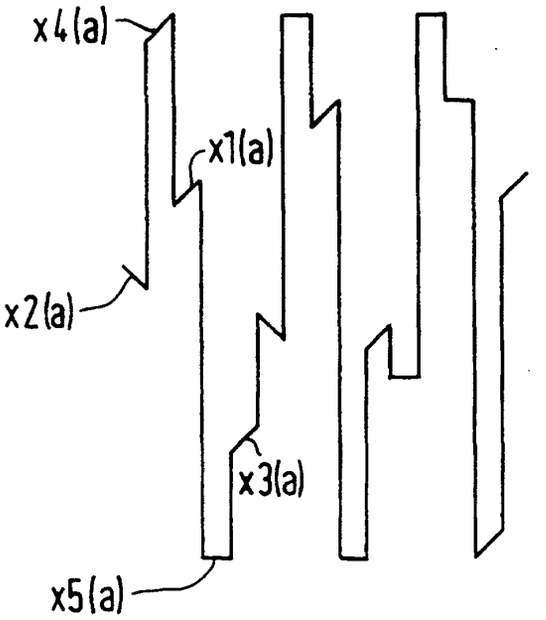

x4(a)
x1(a)
x2(a)
x3(a)
x5(a)

FIG.14

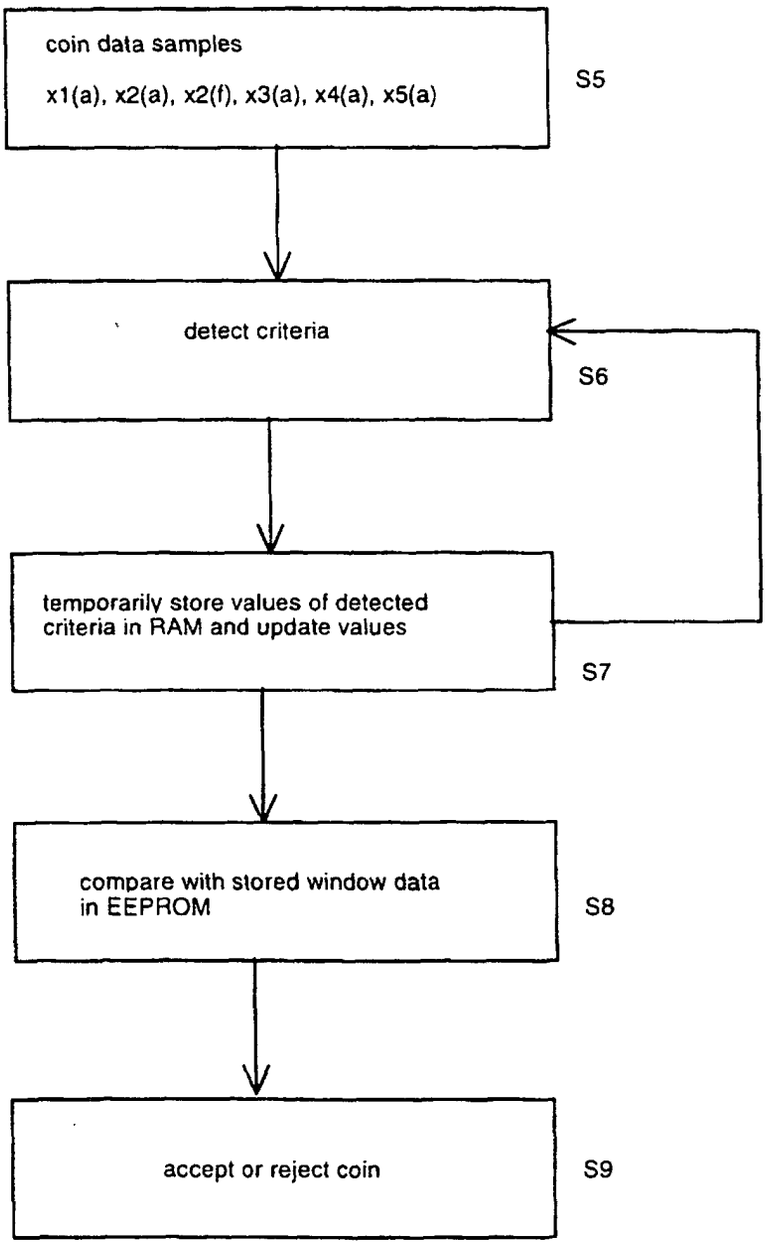

coin data samples
x1(a), x2(a), x2(f), x3(a), x4(a), x5(a)
S5
detect criteria
S6
temporarily store values of detected criteria in RAM and update values
S7
compare with stored window data in EEPROM
S8
accept or reject coin
S9

FIG.15