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71 Applicant: **BONELCO INDUSTRIES, LIMITED**  
**Unit 2, 505 Orchard Road**  
**Stortford Lodge Hastings(NZ)**

72 Inventor: **Plester, David John**  
**Flat 2, 27 Wright Street**  
**Wainuiomata Wellington(NZ)**

72 Inventor: **Watson, Duncan Karl**  
**36 Victory Avenue**  
**Karori Wellington(NZ)**

72 Inventor: **Pullman, Royce Lyndall**  
**11 Jutland Street**  
**Lower Hutt Wellington(NZ)**

74 Representative: **Taylor, Derek George et al,**  
**MATHISEN, MACARA & CO. The Coach House 6-8**  
**Swakeleys Road**  
**Ickenham Uxbridge UB10 8BZ(GB)**

54 **Article detection and recognition.**

57 A programmable coin acceptor which is readily reprogrammed to accept different coin sets is described. The acceptor includes a detector (10) which generates an alternating magnetic field through two spatially symmetric flux paths (23,25). Disposed in each of the flux paths (23,25) is a detector coil (22,26). When the acceptor is in use a coin is passed through one of the flux paths (23). The resulting difference in the flux through the two paths (23,25) induces a voltage across the detector coils (22,26). The amplitude of this voltage and its phase relative to the excitation voltage are derived and compared with stored information to determine whether the coin should be accepted. The stored information may readily be changed for a new coin set by switching the acceptor to programming mode and passing selected coins from the coin set through the detector (10) in a predetermined manner.

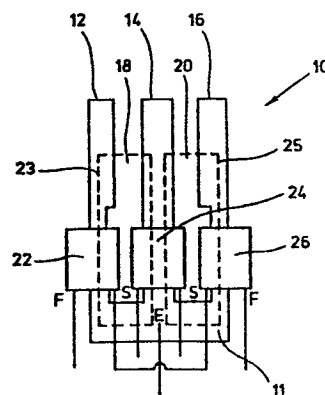


FIG. 1

Article detection and recognition

This invention relates to article detection and recognition and in particular, but not solely, a trainable device for recognising a coin or metallic token.

5 Coin detectors are well-known. However, as the detection is in general done by mechanical means the detectors have the following disadvantages:

1. Coins are generally sorted by size, weight or thickness and as the mechanisms are primarily of a mechanical nature the mechanism is prone to jamming when an irregular object is inserted. For example, the mechanical detectors are easily fouled by non-standard articles, such as can tear tabs, bottle tops, paper clips or washers.
- 10 2. The mechanical units usually rely on gravity for determination of the weight of the article and are consequentially are often sensitive to physical orientation, some units being unreliable if placed only a few degrees from vertical.
- 15 3. As the coin is detected mechanically, delicate hardware alterations are necessary to reprogram the detector for different coin denominations or sets. If the new coins are of a substantially different size sufficient alteration may not be possible.
- 20 4. Due to the mechanical nature of the detection method only a limited number, two or three, coins can be detected by a single detector.
- 25 5. Most mechanical detectors will not reject invalid objects without the need for a reject lever or button and will not reject coins in power-off conditions.
- 30 6. The sensitivity of the detector is usually insufficient to distinguish between a washer and a coin or token of a similar size and weight.

There are however a few types of electronic coin recognition units available which overcome some of the disadvantages outlined above. However they tend to be difficult to reprogram

for other coin sets and do not usually accommodate coins or tokens that are substantially different in size, weight or shape from the coins or tokens for which they were originally designed.

5 It is therefore an object of the present invention to provide an article detector/recognition unit and associated methods which go at least some way to overcoming some of the above mentioned disadvantages or at least provide the public with a useful choice.

10 Accordingly in a first aspect the invention consists in an electromagnetic article detector comprising:

a source of magnetomotive force which produces time varying magnetic flux through at least one magnetic flux path; magnetic flux sensing means which produce an output which is a function of at least part of said time varying magnetic flux; and

15 an article sensing region in said time varying magnetic flux through which, in use, an article is passed;

in use the passage of said article through said sensing region disturbs the time varying magnetic flux, causing a change in the output of said sensing means.

20 In a second aspect the invention consists in an article detection method including the steps of:

generating a time varying magnetic flux in at least one flux path; and

25 detecting the change in the flux through at least said one flux path due to the presence of an article in part of said one flux path.

30 In a third aspect the invention consists in an article recognition unit including an electromagnetic article detector as defined above further including:

data derivation means which derive data characteristic of articles which are to be recognised from said magnetic flux sensing means output;

35 an information store which stores information characteristic of articles which are to be recognised, said

information being comparable with said data; and

comparison means which determine whether there is a substantial correspondence between said derived data and said stored information.

5 In a fourth aspect the invention consists in an article recognition method including an article detection method as defined above further including the steps of:

deriving data from said detected change in the flux; and  
comparing said derived data with stored information;

10 said information characteristic of articles which are to be recognised being comparable with said data to determine whether there is a substantial correspondence between said data and said stored information characteristic of one of said articles which are to be recognised.

15 In a fifth aspect the invention consists in a trainable or programmable article recognition unit including:

an article detector with an article sensing region which produces an output when an article capable of being detected is present in said sensing region;

20 a microprocessor means connected to the output of said article detector;

memory accessible by said microprocessor for storing data derived from said detector output on articles to be recognised;

25 said microprocessor means having an output for signalling the type of article recognised;

training/recognition selection means to select either training or recognition modes of operation for the unit;

30 said microprocessor being configured such that when the training mode is selected by said training/recognition selection means said microprocessor evaluates data contained in the detector output obtained by passing one or more articles through said article sensing region and stores information calculated from said data in said memory characteristic of one or more of said detected articles for use in subsequent  
35 recognition;

said microprocessor being further configured such that

when said recognition mode is selected by said training/recognition selection means, said microprocessor evaluates the detector output obtained by passing an article through said article sensing region to produce recognition data and compares said recognition data with said stored information to determine whether there is a substantial correspondence between said data and said stored information characteristic of one of the articles which are to be recognised.

In a sixth aspect the invention consists in a method of training an article recognition unit comprising the steps of: configuring said article recognition unit into a training mode,

passing one or more articles through an article detector which is part of said article recognition unit;

said article recognition unit subsequently automatically evaluating data collected thereby; and

storing information characteristic of one or more of said articles for use in subsequent article recognition.

The invention consists in the foregoing and also envisages constructions of which the following gives examples.

The preferred forms of the invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a plan view of an article detector.

Figure 1A is a circuit diagram of the article detector of Figure 1.

Figure 2 is a block diagram of an article recognition unit including the article detector of Figure 1.

Figure 3 is a flow diagram of the software used in the article coin recognition unit of Figure 2.

The article detector of the present invention detects a coin or token or other article by the effect of this article on alternating magnetic flux. The article detector is described by way of example with reference to its use in a coin or token recognition unit to be used in a vending machine, telephone call box, change giver or the like.

The sensor comprises a symmetrical laminated iron core 11 with identical air gaps 18 and 20 between each of the outer limbs 12 and 16 and the centre limb 14. Electrical windings 22, 24 and 26 are located on each of the three iron limbs 12, 14 and 16 of the detector 10. The number of turns and winding geometry of the coils 22 and 26 on the outer limbs is identical.

The arrangement of the core 11 and the coils 22, 24 and 26 is not unlike that of a transformer in that an alternating current flowing through coil 24 will induce a voltage in coils 22 and 26. In use a low voltage (2 volt RMS) 2.9 kHz alternating voltage is applied to the central coil 24. The resulting current induces a symmetric alternating magnetic field passing through coil 24 when air gaps 18 and 20 are empty. The magnetic flux in this magnetic field may be thought of as being generated in magnetic circuits 23 and 25 which are equivalent when air gaps 18 and 20 are empty. However due to the air gaps 18 and 20 in the flux path there is at least some leakage of the magnetic current flux from the magnetic circuits.

Coils 22 and 26 are connected in series opposing configuration as shown. With the placement of the coils 22, 24 and 26 suitably adjusted the voltage induced across coils 22 and 26 is approximately zero when gaps 18 and 20 are empty. This is because the magnetic circuits 23 and 25 are effectively in parallel and have equal amounts of magnetic flux generated therein inducing equal voltages in coils 22 and 26.

However, when a coin is present, for example in air gap 18, the effective reluctance of the magnetic circuit 23 is changed. This is due, in part, to the reluctance and the conductivity of the coin. If the reluctance of the coin is different from air the reluctance of circuit 23 will be changed. Also coins are in general conductive eddy-currents are induced in the coin and these currents in turn induce a field which tends to oppose the external field according to

Lenz's Law. Therefore, as in general, the effective reluctance of magnetic circuit 23 is increased, a smaller magnetic flux passes through circuit 23 and as a consequence a larger magnetic flux flows through parallel circuit 25 which now has a reluctance lower than that of circuit 23. Therefore the voltages induced across coils 22 and 26 by the flux are in general different when a coin is present air gap 18, and the resulting output signal which is the voltage across coils 22 and 26 is changed. (i.e. is non-zero).

It has been found that the phase of the voltage induced across coils 22 and 26 relative to the voltage applied across coil 24 in general changes when an article is present in the sensing region. This phase change when used with the amplitude change gives a remarkably accurate indicator as to the identity of an article in the sensing region.

The physical arrangement of the detector may be varied in numerous ways which would be apparent to those skilled in the art. However, it is preferred that the output signal from the detector be zero when an article is not present in the sensing region. The essential features are the production of an alternating magnetic field and the detection of a change in the magnetic field due the presence of a coin or token or other article and particularly its physical dimensions, resistance, reluctance etc.

In the most simple variation of the above arrangement the excitation voltage is connected across the combination of coils 22 and 26 and the detected voltage is the voltage induced in coil 24. Similarly in this arrangement if there is no coin in either of air gaps 18 or 20 the output signal from coil 24 will be substantially zero.

The detector is calibrated on assembly by soft mounting the coils 22, 24 and 26 and making the connections as shown in Figure 1A. Coil 24 is connected to a function generator 19 producing an alternating voltage output of 3.14 volts at 2.9 kHz. The coils 22 and 26 are connected to either a digital volt meter or an oscilloscope signified by 21 in Figure 1A. The relative positioning of the coils is then

adjusted to provide a minimum output voltage from coils 22 and 26 as read on the digital volt meter 21 and the coils fixed in position. This minimum voltage should be substantially zero (preferably less than about 6 millivolts RMS).

5           In detection use the detector 10 may, for example, be incorporated in a coin recognition unit as shown in Figure 2. The coil 24 is supplied with an excitation voltage and the resulting voltage induced in the combination of coils 22 and 26 is detected. When a coin or the like is present in the air gap  
10           the output signal from coils 22 and 26 changes. This output signal can be compared with reference values and used to detect and identify the article.

          In the embodiment shown the parameters of the output voltage used for article recognition are the amplitude of the  
15           output signal of the detector 10 and the phase of the output signal from detector 10 relative to the excitation voltage applied across winding 24.

          These values are derived for each coin that passes through the detector 10 and compared with stored values contained in  
20           electrically erasable read only memory (EEROM) 36 by microprocessor 34 to determine whether the article detected corresponds to those which the detector is programmed to recognise. Output lines 44 provide information to the vending machine or the like as to whether the detected article is a  
25           coin of a denomination which the detector is programmed to recognise.

          A terminal interface 38 is also provided to facilitate development and maintenance. Terminal interface 38 is used to connect a terminal 40 to the device. A watch-dog timer 42 is  
30           also provided to reset the microprocessor if an unforeseen condition arises.

          The amplitude parameter is measured using the amplitude detection circuitry 30 which includes an eight-bit analog to digital converter (A/D). The low voltage AC signal produced by  
35           coils 24 and 26 is rectified and smoothed to provide a stable DC voltage for the A/D. The A/D is also provided with a

reference voltage input which is used to make the output of the amplitude detection circuitry 30 substantially independent of the oscillator excitation voltage and substantially independent of temperature and ageing effects.

5       The phase detection circuitry 32 includes a counter which is used to count the duration between zero crossings of the excitation voltage and the output signal. The counter operates when both signal and reference voltages are positive. The counter is driven by a 1.5 megahertz signal and is thereby  
10       sufficient to give 0.1° sampling uncertainty.

      The output signals from the amplitude detection circuitry 30 and the phase detection circuitry 32 are fed to the microprocessor 34. The microprocessor 34 is used to process the information provided by the detection circuitry 30 and 32.

15       The microprocessor determines phase and amplitude values for each coin passing through the coin slot 20. These values in use are compared with a set of phase and amplitude values stored in EEROM 36 to determine whether the detected "coin" is of the correct "denomination" or identity. The microprocessor  
20       after determining whether the "coin" is valid then provides an output signal on output lines 44 indicating the type of "coin" detected or whether the "coin" is invalid.

      EEROM 36 is used to store phase and amplitude information for the coin set for which the unit is programmed. Three  
25       identical look-up tables are used so that corruption of up to two of the tables will not effect the correct operation of the detector. EEROM 36 provides a non-volatile alterable form of memory. It is desirable to have the stored phase and amplitude information stored in a non-volatile device, but erasable  
30       under program control in the training mode.

      It should be appreciated, however that numerous alternatives to an EEROM are possible including RAM with battery back-up. An EPROM, PROM or a bank of switches may also be used, but self-programming of the circuitry would then be  
35       less practicable if not impossible.

The microprocessor 34 is an Intel 8031 which has internal RAM and a UART on board requiring only an external line driver 38 for terminal communication. The terminal 40 is not needed in normal operation, but may be useful if modification of the unit is likely in the future or for testing faulty boards or for verifying the suitability of new coin sets.

When a terminal is connected to the coin rejector board the RXD (receive data) line is high and in the quiescent (non-sending) state. When a terminal is not present, the RXD line is low in steady state conditions. When this condition is detected the board reverts automatically to a periodic self-checking mode.

Watch-dog restart circuitry 42 is provided to reset the system if the program becomes locked up. This "locking-up" may result from several conditions including brown-out due to low power supply voltage, electrical noise which might corrupt instructions from memory and software bugs that have not been corrected. If any of the above conditions occur a vending machine which incorporates the present invention should be left in an idle state until a serviceperson fixes the fault. The watch-dog timer 42 includes a single chip CMOS oscillator and ripple-down counter and is set for time out of about 1 second. The advantage of this type of circuit is that it will operate down to three volts without locking up itself and will keep attempting to restart the processor. Also, in normal operation, the microprocessor frequently resets the counter.

There are five output lines 44 provided, one for each coin, one of which is strobed active low for 200 milliseconds when a valid coin is recognised. These output lines also indicate when a non-valid "coin" is detected and provide error messages. LED's are also connected to the output lines 44 and are used in the training mode described below.

#### Normal Operation

In normal operation the coin recognition unit is installed inside a vending machine, runs independently, and signals the type of coin recognised to the vending machine control

microprocessor through the five output lines 44.

A reset 46 is executed on power-up and may also be induced by the watch-dog timer 42 or a reset function from the terminal 40. After a reset 46 the system is initialised 48 and various self-tests are performed 50.

During the self-test 50 the program ROM contents are check-summed. The EEROM is checked. If the EEROM has not been programmed the microprocessor waits for training or programming instructions as described below. If the EEROM has been programmed the look-up table is check-summed and a copy of the look-up table is copied into RAM.

As the economic viability of the coin vending machine depends on the security of the data stored in the table in the EEROM it is desirable to ensure that proper data is maintained therein. Therefore frequent verification of the data is performed. Three copies of the information for a coin set are stored in the EEROM 36 and the first correct table is copied into RAM. Any faulty tables in EEROM 36 found during the check are rewritten to the EEROM 36.

The operation of the A/D is also checked and a check is done on the core noise to determine whether there is an object lodged in the core or whether the transformer is out of balance or the leads broken etc. The phase circuitry is also checked. A check 66 for a terminal is made at power-up and frequently during normal operation.

If a terminal is present the UART on the 8031 is configured and a flag set allowing messages to be sent when requested during program execution. Operation with the terminal connected disables the periodic self-checking routine. If a terminal is not connected, the board rate timer register is used for periodic self-checking of the EEROM contents (every 45 seconds), and message transmission is disabled.

In the main program loop the following conditions are continually polled.

- a single character received 68 from the terminal.
- the presence 54 of a coin in the transformer 54.
- programming switch set on 60.
- a check 66 on the terminal connection status 66.
- 5 - a check 64 to verify the EEROM coin parameter table is performed if terminal is not connected.

For the purposes of acquiring data, a "frame" of eight cycles of the excitation voltage is defined. For each of eight cycles of the 2.928 kHz excitation voltage an amplitude value  
10 is read from the A/D. At the end of the eight cycles, the amplitude values are averaged with rounding in the least significant bit. During these eight cycles a count is made by the phase circuitry to provide data on the relative phase of the exciting (reference) and induced (signal) waveforms.

15 Coins are detected on an amplitude threshold basis with some delay being used (about 1 msec) to reduce sensitivity to noise spikes. (5% of the full scale value for about 1 millisecond is used which corresponds to approximately 9 successive A/D samples). From laboratory test work it has been  
20 determined that when the coin is in the centre of the core the amplitude value is at a maximum. The phase value however is relatively constant while any part of the coin is in the core. Amplitude values are acquired in routine 56 until a maximum is found. Subsequently amplitude and phase information  
25 characteristic of the coin is recorded. To determine an amplitude value eight values are read from the A/D and averaged. This averaging reduces the effects of noise and rounding is used during the arithmetic operations to reduce truncation error. The phase value is also determined by  
30 averaging eight values with rounding in the final bit.

Further frames are processed until the amplitude drops below the coin detection threshold. Thereby two conditions may be checked for (1) a "coin" passing through the core too quickly (noise); (2) a "coin" stuck within the core. In both  
35 these cases the phase and amplitude data values are rejected.

The check 54 to determine whether there is a coin in the

core is performed by checking the amplitude value. If the amplitude value exceeds the threshold value for more than about 1 millisecond a coin is deemed to be present in the core, thus transferring program control to the coin processing routine 56.

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In routine 56 the amplitude value is read from the amplitude circuitry 30 and a peak amplitude value waited for. When a peak value has been received the amplitude and phase values are determined as outlined above.

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The amplitude ( $A_n$ ) and phase ( $P_n$ ) values obtained are compared 58 with the five entries currently stored in the RAM parameter table ( $A_r(i)$ ,  $P_r(i)$ ,  $i = 1, 2, 3, 4, 5$ ). The closest match is found according to:

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$$y = \min \{ k_1 \cdot \text{mod} |A_n - A_r(i)| + k_2 \cdot \text{mod} |P_n - P_r(i)| \} \quad 1 < i < 5$$

$$k_1 = 1.0$$

$$k_2 = 0.5$$

20

The value  $y$  is then compared to a threshold of 7 which represents a "radius" around the reference value. If  $y$  is below the threshold, the coin is accepted, an output corresponding to closest match value of  $i$  then appears on the output lines 44. Otherwise the coin is ignored and there is no change on the signalling lines 44. The detection threshold allows for variations of a few bits either way in both amplitude and phase. It should be noted that the formula used above for measuring the degree of correspondence between the data obtained and the information stored may be readily modified.

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If the coin is in the core for more than 512 frames, which corresponds to approximately 1.5 seconds, then the coin is assumed to be stuck, and an appropriate signal appears on lines 44.

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#### Training Mode

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There is a training switch 41 provided with the microprocessor 34 which is read in routine 60 and is used to

indicate whether the unit is to be in normal operation or in training mode 62. The state of programming switch 41 is checked with a 20 millisecond debounce. Training is carried out when the unit is switched on for the first time or can be done at any time to alter the data stored in EEROM 36.

In training mode 62 the coin acceptor is "trained" to recognise a coin set. This is done by simply turning the training switch 41 on and passing a coin, of each denomination comprising the set, four times through the sensing region. The coin recognition unit may be programmed to recognise a set of coins containing up to five different denominations although this number is easily varied by changing the software.

The amplitude and phase values representative of each coin denomination are then automatically stored in EEROM 36. When the programming switch 41 is turned off normal operation resumes with the coin acceptor "trained" for the new coin set.

In training mode 62 an LED corresponding to the coin being programmed is lit. This LED goes off when the coin passes through the core. If the coin gets stuck all LED's are illuminated and the coin is ignored. To ensure that the amplitude and phase values obtained are representative of the type of coin, the coin has to be entered four times, and four consecutive close matchings must be obtained. The criteria for a close match is the same as that used in the decision routine 58. If four consecutive close matches are not found the counter resets and four new coins must be inserted complying to the criteria mentioned above. This prevents possible errors due to, for example, three five cent coins and one ten cent coin being inserted.

When four consecutive close matches have been obtained the amplitude and phase values are averaged, with rounding, and the result is placed in a coin table in RAM. On completion of the training procedure this table is written into the EEROM 30 in triplicate. Thus reprogramming of the EEROM occurs after five coin types have been entered or when the training switch 41 is turned off.

If the training switch 41 is turned off during the training process to abort the procedure, the effect on the EEROM 36 depends on the stage of coin entry. If no coins have been entered no change is made to the coin table in the EEROM 36. If one to three coins have been entered updates are only made to the EEROM 36 when valid data has been acquired. i.e. if the switch 41 is turned off before data for the first coin was finalised the EEROM 36 is cleared. In this condition it is not possible to match any coins. This condition may be useful in disabling a faulty machine for instance. If four to seven coins have been entered the information is updated for one coin and the locations for the other four coins are cleared to zero. If eight to eleven coins have been entered the information for the first two coins is updated and the remaining three locations for coin information are cleared to zero. The reprogramming of the EEROM is similar for twelve to fifteen, sixteen to nineteen and twenty to twenty-four coins entered. Each time the training mode is entered training begins a new. Training does not recommence from where it has been left. To selectively alter one value, a special mode 77 can be used when a terminal is connected to the board as outlined below.

When a terminal 40 is connected a received character is analysed 68 to determine what action is to be taken by the processor. If an X is received a system reset 46 results. If a P is received program control is transferred to setting routine 70. If a V is received program control is transferred to view routine 72. If any other character is received the terminal displays a question mark (?) and control is returned to the main program.

The setting routine 70 is used to write data for a specific coin into EEROM 36. The view routine 72 is used to display the contents of the EEROM table and the RAM table.

It is possible to train the unit with the terminal connected. Training proceeds in a similar fashion to that described previously and the amplitude and phase values are

displayed on the terminal screen with suitable identifying indicia.

It is also possible to recognise coins with the terminal connected and the resulting phase and amplitude data is displayed together with the match value which is a measure of correspondance between the value obtained for the coin and the nearest match. Also if the match value is less than the threshold value the coin type which is recognised is also displayed.

The hardware used in the coin detector recognition unit of the present invention is given by way of example and may be easily replaced by circuitry adapted for a particular application. Also the software used may also be extensively modified without departing from the scope of the present invention.

For example the specific phase and amplitude parameters calculated may be replaced by any suitable parameter, or combination of parameters, obtained from the output of the detector 10 which effectively, uniquely, identify a coin. Similarly the formula used for obtaining a measure of the degree of correspondence between the data obtained during detection and the information stored may also be replaced by any other suitable formula. For example, numerous suitable formulae are available from various branches of mathematics such as statistics, calculus of errors, geometry etc.

The article detector of the present invention has numerous uses in detecting and recognising articles which will alter the magnetic flux in the magnetic circuits 23 and 25. Therefore this invention is not limited to a coin acceptor, but could be used for recognising tokens or for example detecting and identifying articles on a production line with a view to sorting or some other operation. The invention is not limited to conducting articles as articles made of substances with magnetic properties could also be detected.

The output signal from the coin acceptor of the present invention would normally be used to gate a coin to an

appropriate collection receptacle in a vending machine or the like. Coins that are not identified will preferably be allowed to fall into a reject shoot and be returned to the purchaser. It should also be noted that coins must enter the core one at a time. The output signal would preferably be used to provide a count value for the coin towards the purchase price of an item.

The detector 10 of the present invention when used with a vending machine may be mounted in any orientation which provides a stable repeatable and bounce free passage for the coins through one gap 18 or 20. Either gap may be used, but reprogramming will be necessary if for some reason the other gap is used. For proper operation the detector 10 should be placed away from magnetic fields and magnetic objects should not be placed in close proximity to the gap.

If tokens are used care should be taken to ensure that the tokens are produced within strict tolerances so that reliable detection by the present detector is possible.

The advantages of the coin detector of the present invention are its accuracy in detection and its ability to reject a wide variety of common objects such as washers, paper clips, tear tabs, bottle tops etc whilst reliably recognising a relatively large number of coins. This is possible as the coin identification is done by a non-contact process and therefore mechanism is less likely to be fouled by non-standard articles. The size of the slot is advantageous as the possibility of non-valid articles blocking the sensing region is reduced. It is also an advantage that the accuracy of the present detector does not depend on the orientation of the detector i.e. the detection technique does not rely on gravity. It is a further advantage that reprogramming of the unit for a new set of coins may be done by simply retraining the unit and does not require the use of special tools or altering the programming of the microprocessor. This reprogrammability is unique to the present coin detector and is due in part to the accuracy of the detection method used. Also due to the large slot size and the method of detection a single

coin slot can be used for all coins or tokens. The slot is large enough to accept a New Zealand fifty cent piece which is one of the largest coins in the world.

5 The accuracy of the coin detector of the present inventions is such that it is able to detect the difference between a New Zealand 2 cent piece and an Australian 2 cent piece.

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Claims:

1. An electromagnetic article detector comprising:  
a source of magnetomotive force (24,28) which produces  
time varying magnetic flux through at least one magnetic flux  
path (23);  
magnetic flux sensing means (22,26) which produce an  
5 output which is a function of at least part of said time  
varying magnetic flux; and  
an article sensing region (18) in said time varying  
magnetic flux through which, in use, an article is passed;  
in use the passage of said article through said sensing  
10 region (18) disturbs the time varying magnetic flux, causing a  
change in the output of said sensing means (22,26).
2. An electromagnetic article detector as claimed in claim 1  
wherein said source of magnetomotive force (24,28) produces a  
15 substantially spacially symmetric time varying magnetic field  
comprising two substantially equivalent magnetic flux paths  
(23,25) when no article is present in said article sensing  
region (18) and said sensing region (18) is disposed in one of  
said magnetic flux paths (23,25).
- 20 3. An electromagnetic article detector as claimed in claim 2  
wherein said magnetic flux sensing means (22, 26) is adapted to  
sense any difference between the flux in each of said  
equivalent magnetic flux paths (23, 25) resulting when an  
25 article is present in said sensing region (18).
4. An electromagnetic article detector as claimed in any one  
of claims 1 to 3 wherein magnetic flux path shaping means (12,  
14, 16) form part of said magnetic flux paths.

5. An electromagnetic article detector as claimed in claim 4 wherein said magnetic flux path shaping means (12,14,16) is a transformer-like core (11,12,14,16), said source of magnetomotive force is one or more coils (24) wound on said core (11), and said magnetic flux sensing means (22,26) comprises one or more coils (22,26) wound on said core (11).
6. An article detection method including the steps of:  
generating a time varying magnetic flux in at least one flux path (23); and  
detecting the change in the flux through at least said one flux path (23) due to the presence of an article in part (18) of said one flux path.
7. An article detection method as claimed in claim 6 wherein said time varying magnetic field is produced through two substantially spatially symmetric flux paths (23,25) and said sensing region (18) is disposed in one of said paths (23).
8. An article detection method as claimed in claim 7 wherein the difference of the flux through each of said two flux paths (23,25) is detected.
9. An article recognition unit including an electromagnetic article detector (10) as claimed in any one of claims 1 to 5 further including:  
data derivation means (30,32) which derive data characteristic of articles which are to be recognised from said magnetic flux sensing means (22,26) output;  
an information store (36) which stores information characteristic of articles which are to be recognised, said information being comparable with said data; and comparison means (34) which determine whether there is a substantial correspondence between said derived data and said stored information.

10. An article recognition unit as claimed in claim 9 wherein said data derivation means (30,32) includes amplitude means (30) which derive amplitude data from said magnetic flux sensing means (22,26) output, and phase means (32) which derive  
5 phase data from the relative phase difference between a voltage producing said magnetomotive force and the output of said magnetic flux sensing means (22,26);

said information store (36) includes a phase/amplitude information store (36) which stores phase and amplitude  
10 information, characteristic of articles which are to be recognised, said phase and amplitude information being comparable with said phase and amplitude data; and

said comparison means (34) is configured so as to determine whether there is a substantial correspondence between  
15 said phase and amplitude data and at least part of said stored phase and amplitude information which part is characteristic of one of said articles which are to be recognised.

11. An article recognition method including an article  
20 detection method as claimed in any one of claims 6 to 8 further including the steps of:

deriving data from said detected change in the flux; and  
comparing said derived data with stored information;

said information characteristic of articles which are to  
25 be recognised being comparable with said data to determine whether there is a substantial correspondence between said data and said stored information characteristic of one of said articles which are to be recognised.

12. An article recognition method as claimed in claim 11 wherein said data includes data on the amplitude of the  
30 detected change in flux and data on the phase of the detected flux relative to a voltage producing said flux;

said information includes phase and amplitude information  
35 for each of said articles which are to be recognised which is

comparable with said phase and amplitude data respectively; and  
said comparison is made between said derived phase and  
amplitude data and said stored phase and amplitude information  
respectively.

6 13. A trainable or programmable article recognition unit  
including:

an article detector (10) with an article sensing region  
(18) which produces an output when an article capable of being  
detected is present in said sensing region (18);

10 a microprocessor means (34) connected to the output of  
said article detector (10);

memory (36) accessible by said microprocessor (34) for  
storing data derived from said detector (10) output on articles  
to be recognised;

15 said microprocessor means (34) having an output for  
signalling the type of article recognised;

training/recognition selection means (41,34) to select  
either training or recognition modes of operation for the unit;

20 said microprocessor (34) being configured such that when  
the training mode is selected by said training/recognition  
selection means (41) said microprocessor (34) evaluates data  
contained in the detector output obtained by passing one or  
more articles through said article sensing region (18) and  
stores information calculated from said data in said memory  
25 (36) characteristic of one or more of said detected articles  
for use in subsequent recognition;

30 said microprocessor (34) being further configured such  
that when said recognition mode is selected by said  
training/recognition selection means (41), said microprocessor  
(34) evaluates the detector output obtained by passing an  
article through said article sensing region (18) to produce  
recognition data and compares said recognition data with said  
stored information to determine whether there is a substantial  
correspondence between said data and said stored information  
35 characteristic of one of the articles which are to be  
recognised.

14. A trainable or programmable article recognition unit as claimed in claim 13 wherein said article detector (10) is the article detector (10) claimed in any one of claims 1 to 5.

5 15. A trainable or programmable article recognition unit as claimed in claim 13 or claim 14 wherein said memory (36) is non-volatile.

10 16. A method of training an article recognition unit as claimed in any one of claims 9, 10, 13, 14 or 15 comprising the steps of:

configuring said article recognition unit into a training mode,

15 passing one or more articles through an article detector (10) which is part of said article recognition unit;

said article recognition unit subsequently automatically evaluating data collected thereby; and

storing information characteristic of one or more of said articles for use in subsequent article recognition.

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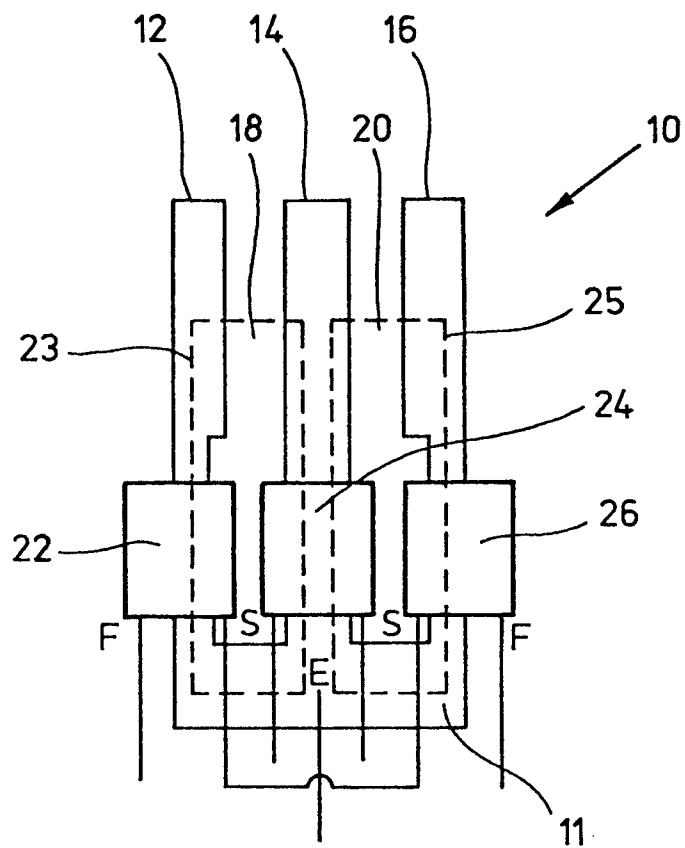


FIG. 1

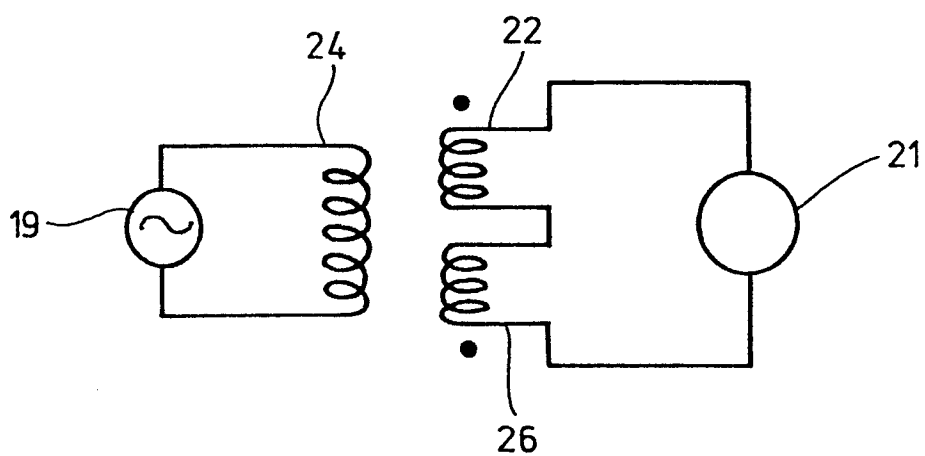


FIG. 1A

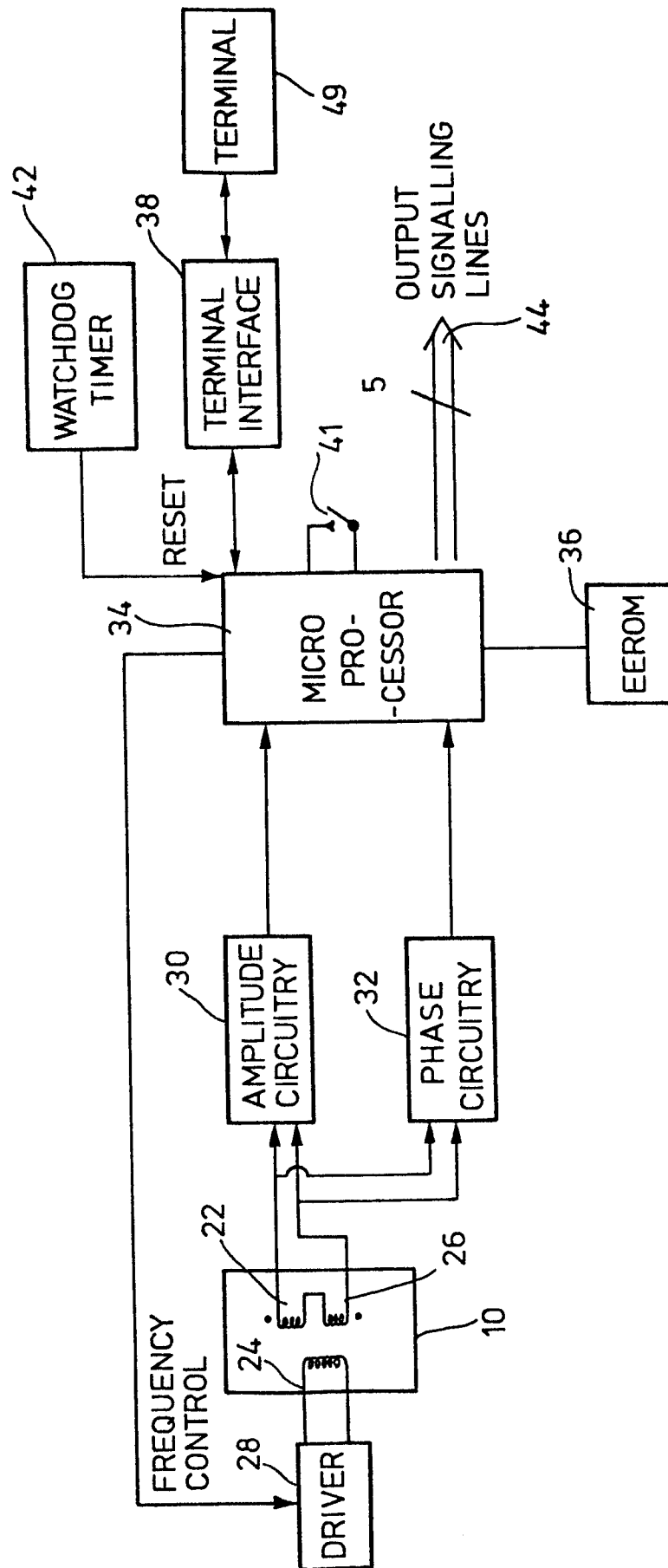


FIG. 2

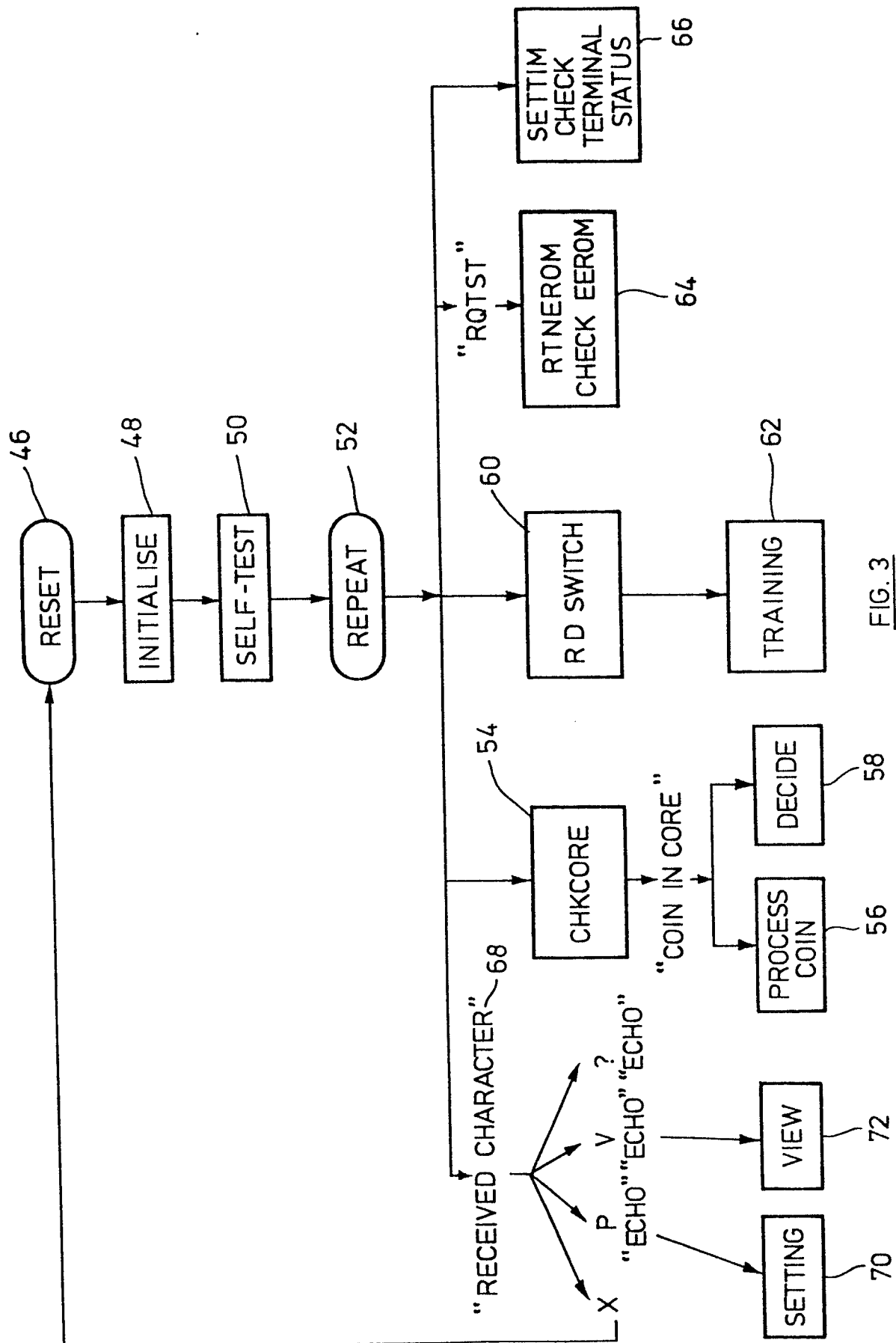


FIG. 3