

COIN TESTING APPARATUS

The present invention relates to improvements in apparatus for testing coins.

In our United Kingdom Patent Specification No. 1483192, we describe a coin mechanism in which two coils are arranged on opposite sides of a coin passageway. One of the coils is a transmitter coil and is fed by two oscillators operating at high and low frequencies respectively. The other coil acts as a receiving coil and is connected to circuitry which examines the amplitude of the high and low frequency components of the signal induced in the receiving coil. When a coin or other article passes between the two coils the attenuation of the magnetic field between the coils is a function of the thickness of the article and the material from which it is made. By examining the change in amplitudes of the two components of the signal induced in the receiving coil it is possible to distinguish between coins of materials such as copper or cupro-nickel and articles of paper, plastic or ferrous metal.

It is possible to make such an apparatus more selective so that in addition to rejecting non-metallic objects and objects of ferrous metal it will also reject some denominations of unacceptable coins. This is achieved by reducing the range of amplitudes of the high and/or low frequency components for which the mechanism will give an acceptance signal. There are however difficulties in producing a reliable mechanism of this kind with high selectivity. Because of the nature of the mechanism it is necessary to adjust each mechanism individually before it is released from the factory in order to compensate for variations in components within the range of manufacturing tolerances, for example, variations in the air gap between transmitter and receiving coil. There are also the long term effects of temperature drift and long term aging of the components of the system.

The present invention is concerned to provide a mechanism which at least to some extent overcomes these disadvantages.

Although the invention will later be described with reference to a coin testing apparatus of the kind described above, it will be appreciated that the invention is applicable to other kinds of mechanism in which the
5 change in amplitude of a signal when a coin passes is examined.

According to the present invention there is provided apparatus for testing coins, comprising a coin passageway, means for producing an electrical
10 signal of which a parameter varies on the passage of a coin into a test position along the coin passageway in dependence on a characteristic of the coin, means for examining the variation of said parameter as a test for coin acceptability, automatic control means operative
15 to regulate the operation of said signal producing means so as to hold the value of said parameter at a controlled value in the absence of the coin, and means operative, while said parameter is varied from the controlled value due to presence of a coin, to store
20 said controlled value of said parameter, said parameter examining means being arranged to derive from said stored value of the parameter a reference value for comparison with the varied parameter value caused by presence of the coin to test for coin acceptability.

25 In a preferred embodiment a first electrical signal has an amplitude which varies on the passage of a coin into the test position. A variable gain amplifier receives the first electrical signal and produces a second electrical signal. A comparator
30 compares the value of the second signal with a fixed reference value and produces a difference signal which is used to control the gain of the amplifier to adjust the value of the second signal to correspond to the fixed reference value. Means are provided for sensing
35 the arrival of a coin in the vicinity of the test

position, the means being operative when the arrival of a coin is sensed to stop the gain of the amplifier being varied. The examining means then determines whether the value of the second signal when a coin passes into
5 the test position corresponds to the value for an acceptable coin.

With this arrangement the gain of the system is controlled so that the value of the second signal corresponds to the fixed value until immediately prior
10 to the arrival of the coin being tested. Thus, provided the circuit components have linear characteristics and are kept out of saturation the effects of long term temperature drift and aging and mechanical changes in the coin testing apparatus will have no effect on the
15 value of the second signal. Because the system gain is automatically set up by the comparator there is no need for initial adjustment of the apparatus.

In the preferred form of the invention the first signal is produced by a transmitting inductor
20 on one side of the coin passageway and a receiving inductor on the other side of the coin passageway, the transmitting inductor being fed with oscillating electrical signals of two substantially different frequencies, a higher frequency, for example 25kHz, and a
25 lower frequency, for example 3kHz, so as to produce an oscillating

magnetic field across the coin passageway. The inductors are so arranged that a substantial portion of the magnetic energy received by the receiving inductor is transmitted through the coin at the test position. The receiving inductor is connected to a high pass
5 filter and a band pass filter for isolating the high and low frequency components of the signal induced in the receiving inductor by the oscillating magnetic field. In the preferred embodiment the output of the high pass filter is fed to the variable gain amplifier and then to a precision rectifier and smoothing
10 circuit to provide the second electrical signal.

The band pass filter may also be connected to a variable gain amplifier the output of which is connected to a comparator and coin presence sensing arrangement as described above. However with the low frequency channel it may not be possible to use a
15 precision rectifier to provide the second signal because the period of the disturbance caused by the passing coin may be so close to the period of the oscillation that a smoothing circuit with a time constant that is sufficiently long to suppress the ripple voltage will also affect the amplitude of the second signal. In this case
20 therefore it is preferred to use a sample and hold technique for producing the second signal. For this purpose the output of the variable gain amplifier is fed forward on two paths. On one path the output is amplified and fed to a controlled switching device. On the other path the signal is squared, phase-shifted by 90° and
25 differentiated so as to produce pulses for controlling the controlled switching device which cause the switching device to be closed at the point when the signal from the amplifier is at a peak.

The coin presence sensing means may comprise an instantaneous level change comparator which is connected to detect
30 the change in level of the signal from the high pass filter when a coin passes. The output of the instantaneous level change comparator is used to control a normally-closed switch which is connected to the input of the comparator which compares the second signal with the reference value. The normally-closed switch is
35 connected to the comparator through a time constant circuit so that when the normally-closed switch is opened by the instantaneous level change comparator in response to a passing coin the long time

constant circuit serves to maintain the condition of the control circuit to the variable gain amplifier.

Not all coins may affect the voltage level of the low frequency component so that an instantaneous level comparator in the low frequency channel would not sense the presence of all coins. It is therefore preferred to use the instantaneous level change comparator which responds to a change in level of the output of the high pass filter for controlling a normally-closed switch connected to the input of the comparator for the low frequency component.

An embodiment of the invention will now be described by way of example with reference to the accompanying drawings of which:

Fig. 1 shows a block diagram of an apparatus according to the invention, and;

Fig. 2 shows a circuit diagram of the apparatus of Fig. 1.

Referring to Fig. 1, this shows a coin passageway 11 with an inclined coin track 12 on which a coin can roll through a test position 13. On opposite sides of the coin passageway at the test position 13 are two coils or inductors 14 and 15. Two oscillators 16 and 17 are connected through a summing circuit 18 and a buffer circuit 19 to the coil 14 which serves as a transmitting coil. The oscillator 16 operates at a relatively low frequency, say 3kHz, and the oscillator 17 operates at relatively high frequency, say 25kHz. The coil 14 is fed with a composite electrical signal with 3kHz and 25kHz components. The coil serves as a transmitting coil and generates a magnetic field across the coin passageway. The coil 15 on the opposite side of the passageway serves as a receiving coil and is so arranged that a coin passing between the coils 14 and 15 attenuates the received signal, the amount of attenuation being a function of the coins conductivity and its thickness. A particular metal may attenuate one frequency to a greater extent than the other frequency. By comparing the attenuation produced by a coin under test at both frequencies with ranges of values for particular denominations of acceptable coins, a coin test with good selectivity as to coin material and thickness can be performed. In practice it may be sufficient to test for each particular denomination of coin at one frequency only, the frequency chosen

for that coin being the one that gives the better attenuation, 50% attenuation being the optimum. Alternatively there may be ranges of values for high and low frequency attenuation for each denomination of coin and a coin will only pass the test if the attenuation at high and low frequencies corresponds to the ranges of values for the same denomination of coin.

The output from the receiving coil 15 is fed to a buffer and amplifying circuit 20 and then split into the two frequencies of the oscillators 16 and 17 by a high pass filter 21 and a low frequency band pass filter 22. The separated high frequency signal is amplitude controlled by a voltage controlled variable gain attenuator/amplifier 23. The control of the amplifier will be described below. The output of the amplifier 23 is half-wave rectified by a precision half-wave rectifier 24 and inverted. At this stage a fixed gain is also introduced. The output of the rectifier 24 is held out of saturation by applying a suitable reference voltage to the positive input of the operational amplifier 25 (see Fig. 2) of the precision rectifier 24. The half-wave rectified wave form is smoothed by a smoothing circuit 26 of short time-constant to provide a d.c. voltage proportional to the amplitude of the signal from the high pass filter 21. The short time-constant is chosen as to keep ripple voltage to a minimum while allowing the output to follow the attenuation of the signal during the passage of a coin between the coils.

The output of the smoothing circuit 26 is fed through a normally-closed analogue switch 27 to a long time-constant circuit 28 and a high impedance buffer 29. The output of the high impedance buffer is compared with a zenered reference voltage from the voltage reference source 30 by means of a comparator or integrator 31. The difference error signal is integrated and used to control the gain of the voltage controlled amplifier/attenuator 23. When the switch 27 is closed the gain of the amplifier 23 will be varied until the error signal at the integrator is zero at which time the voltage from the buffer 29 will correspond to the fixed reference voltage from the reference source 30. Long term changes in any of the components are compensated for by the loop changing its gain until there is again zero error. In order to

hold the voltage at the input to comparator, 31 constant maximum gain in the feedback loop is required but in order to prevent instability a capacitor 40 is connected across the comparator to reduce the gain at relatively high frequencies.

5 An instantaneous level-change comparator 32 is connected to the output of the short time-constant smoothing circuit 26 to detect the initial rise in level caused when a coin enters between the transmitting and receiving coils. Coins of all materials will cause some attenuation of the high frequency component. Detection
10 of the initial rise in level by the instantaneous level comparator 32 causes it to issue an output signal which opens the normally-closed analogue switch 27. When the switch 27 is open the loop conditions present before the coin arrived are maintained on the other side of the analogue switch by the long time-constant
15 circuit 28 and the high impedance buffer 29 so that the gain of the amplifier 21 is held constant while the coin is validated.

 The voltage difference between the output of the short time-constant circuit 26 and the high impedance buffer 29 is fed to a window comparator 33. The window comparator determines
20 whether the maximum voltage difference developed when a coin passes falls within a range for an acceptable coin.

 The low frequency channel is similar in some respects to the high frequency channel and corresponding components have been given the same reference numerals in Fig. 1 and Fig. 2. There are
25 however two major differences.

 Firstly the loop switch 27 in the low frequency channel is operated by the same instantaneous level comparator 32 as the high frequency channel. This is necessary because all coins will cause some attenuation in high frequency component but not
30 necessarily in the low frequency component. This arrangement also avoids unnecessary duplication of circuitry.

 Secondly, rather than converting the a.c. signal to a d.c. signal by a precision rectifier, a sample and hold technique is used. The output of the voltage controlled amplifier/attenuator 23 in the
35 low frequency channel is split into a forward signal path and a control channel. The signal in the forward path is fed to an amplifier 34 which is biased to near the positive rail so that only

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the negative half-cycle remains out of saturation after amplification. The amplified signal is fed to an analogue switch 35. The control signal is squared by a pulse-shaping circuit 36, shifted in phase by 90° by a phase shifter 37, and differentiated by a differentiating circuit 38 to produce sampling pulses on the peaks of the forward signal. The sampling pulses cause the analogue switch to be closed on the peaks of the forward signal and the output of the switch is then stored on the capacitor of the short time-constant circuit 26. The long term loop control of the low frequency channel is the same as for the high frequency channel. The voltage difference developed between the output of the short time-constant circuit 26 and the high impedance buffer 29 is fed to a window comparator 33 which compares the maximum value with ranges for the low frequency component for acceptable coins.

The advantages of the sample and hold technique are that there is no practical lower limit on the channel frequency that can be used, that very low ripple voltages can be achieved and that sampling the amplified a.c. wave form from a low output impedance source allows coin attenuation approaching 100% to be measured without rate of change of voltage restrictions on the short time-constant components.

In Fig. 2 the integrated circuits are of the following type:

NO.	IC 1	IC 2	IC 3	IC 4	IC 5	IC 6	IC 9
TYPE	4061 BCP	uAF 774PC	TL084 CN	4016 BCP	MC 3340	MC 3340	uAF 774PC
0v	PIN 14	PIN 4	PIN 4	PIN 14	PIN 8	PIN 8	PIN 4
-5v	—	—	—	—	—	—	—
-112v	—	PIN 11	PIN 11	—	PIN 3	PIN 3	PIN 11
-13 v	PIN 7	—	—	PIN 7	—	—	—



CLAIMS:

1. Apparatus for testing coins, comprising a coin passageway, means for producing an electrical signal of which a parameter varies on the passage of a coin into a test position along the coin passageway in dependence
5 on a characteristic of the coin, means for examining the variation of said parameter as a test for coin acceptability, automatic control means operative to regulate the operation of said signal producing means so as to hold the value of said parameter at a controlled value in the
10 absence of the coin, and means operative, while said parameter is varied from the controlled value due to presence of a coin, to store said controlled value of said parameter, said parameter examining means being arranged to derive from said stored value of the parameter a
15 reference value for comparison with the varied parameter value caused by presence of the coin to test for coin acceptability.

2. Apparatus according to claim 1, wherein said
20 parameter of said electrical signal is the amplitude of that signal.

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3. Apparatus according to claim 2, wherein the parameter examining means comprises a comparator arranged to compare the value of said parameter when the coin is in the test position with a predetermined fraction of the stored value of said parameter.

4. Apparatus according to claim 3 or 4, wherein the comparator has a first input connected to the output of the electrical signal producing means and a second input which is connected by way of a long time constant circuit and a normally-closed switch, when closed, also to the output of the electrical signal producing means, the switch being arranged to be opened during the determination of coin acceptability and the long time constant circuit serving to maintain the stored value of the signal to the second input of the comparator.

5. Apparatus according to claims 2, 3 or 4, wherein the automatic control means comprises a variable gain amplifier in the electrical signal producing means, the gain of the amplifier being arranged to be varied so as to hold the value of the said parameter at said controlled value in the absence of a coin.



6. Apparatus according to claim 5, comprising
a further comparator arranged to compare a signal, whose
level is derived from the value of said parameter, with a
preset reference value and to generate accordingly a
5 difference signal for controlling the gain of the variable
gain amplifier so as to tend to hold the level of the
derived signal equal to the preset reference value.

7. Apparatus according to claim 6, comprising
10 a capacitive device connected across the further comparator
to reduce the gain of the comparator at higher frequencies.

8. Apparatus according to any one of claims 2 to
7, wherein the electrical signal producing means is
15 arranged to produce an oscillating electrical signal which
is attenuated when a coin passes through the test position,
and comprises a sampling circuit arranged to sample peaks
of the oscillating signal, the examining means being
arranged to detect whether the amplitudes of the sampled
20 peaks are indicative of an acceptable coin.



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9. Apparatus according to any one of claims 2 to 8, wherein the electrical signal producing means includes a transmitting inductor on one side of the coin passageway arranged to produce an oscillating magnetic field across the coin passageway on being fed with an oscillating electrical signal, and a receiving inductor on the other side of the coin passageway, the inductors being so arranged that a substantial proportion of the magnetic energy received by the receiving inductor is transmitted through the coin when in the test position.

10. Apparatus according to claim 9, as appended to claim 8, comprising two signal producing means, the transmitting and receiving inductors being common to both, one including a high pass filter and the other a low pass filter arranged to isolate the high and low frequency components, respectively, of the signal induced in the receiving inductor by the oscillating magnetic field in response to feeding the transmitting inductor with oscillating electrical signals of two substantially different frequencies which are a higher frequency and a lower frequency, the said one signal producing means further comprising the precision rectifier followed by a smoothing circuit arranged to convert said oscillating signal into a DC signal and the other signal producing means further comprising the sampling circuit.



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11. Apparatus according to claim 10, as appended
to claim 4, comprising means responsive to the variation
of said parameter for the high frequency component
indicating arrival of a coin in the vicinity of the test
position, so as to open the normally closed switch.

12. Apparatus according to claim 4 or any one of
claims 5 to 11 as appended to claim 4, wherein the
normally closed switch is opened by circuit means responsive
to the rate of change of said parameter becoming equal to
a predetermined level so as to open the switch.

13. Apparatus for testing coins substantially as
hereinbefore described with reference to Figure 1 or
Figures 1 to 4 of the accompanying drawings.

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