

COIN TESTING DEVICE

5 This invention relates to coin testing devices,
for example for use in automatic vending machines, and
in particular to coin testing devices which sense a
characteristic of a coin by throwing light upon it,
detecting the light reflected from it, and providing
information about a characteristic of the coin in
dependence upon the result of the detection of the
reflected light.

10 A specific application of that type of coin test-
ing device has been described in our United States
Patent No. 4,172,222 (British Application No.
50386/76). That Patent describes a device the main
15 function of which is to distinguish between the British
fivepence coin and the German 1 Deutschmark coin.
These two coins are difficult to distinguish from each
other because their diameters, thicknesses, and the
materials from which they are made, are almost identi-
20 cal. However, the British fivepence coin has a milled
edge whereas the German 1 Deutschmark coin has a smooth
edge with only a minor amount of figuring engraved in
it. This difference is detected by allowing the coin
to pass beneath a light emitter, with its edge directed
25 towards the emitter, and sensing the light reflected
from the edge by means of a sensor located quite close
to the emitter. The milled edge of the fivepence coin
reflects light more diffusely than the smooth edge of
the

1 Deutschmark coin and consequently the broader spread
of reflected light causes the detector to emit a longer
output pulse when a fivepence coin moves past it, than
when a 1 Deutschmark coin moves past it. A signal having
5 an amplitude proportional to this pulse length is generated
and compared with a signal of reference amplitude. The
two types of coin are distinguished according to whether
the amplitude of the signal derived from light reflected
from the coin is greater than, or less than, this reference
10 amplitude.

In order that a particular design of coin testing
device may be used for a wide variety of applications in
different countries, and preferably for all applications in
all countries, it is desirable that the coin path or
15 passageway through the device be capable of allowing passage
of coins of all diameters up to the maximum diameter which
will be encountered. If the light emitter and detector just
described are positioned so that the largest coin can freely
pass beneath them, then smaller coins such as the fivepence
20 and 1 Deutschmark coins, pass beneath them with their edge
located a substantial distance from them. It has been
found that in these circumstances the differences in pulse
length from the detector are much less than when the coin
edges are very close to the emitter and detector, and
25 consequently distinguishing between these two coins on the

basis of pulse length becomes less reliable.

5 An aspect of the present invention is a method of discriminating between circular coins of substantially the same size but having different edge characteristics, comprising throwing light onto the edge of a coin passing along a coin path, using a detector to detect light reflected from the coin edge, and detecting whether the mean rate of change of the amount of light detected is greater or less than a predetermined value.
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A further aspect is an apparatus capable of carrying out such a method.

— It has been found that even when a light emitter and the light detector are not located very close to the coin edge, the slope of the pulse does differ
15 sufficiently, as between a fivepence coin and a 1 Deutschmark coin, to enable discrimination between these coins with an acceptable degree of reliability, so that the above aspect of the present invention enables sufficiently reliable discrimination between
20 these types of coin in a coin testing device which is arranged to be able to accommodate also coins which are substantially larger.

Another difficulty which has been encountered in
25 prior coin testing devices using electronic components

is that the characteristics of the components change due to ageing, and also change with temperature variations. This is especially true of light emitting diodes (LEDs) whose gain, i.e. light output intensity in relation to current input, can vary over a very wide range.

Variation of such characteristics causes corresponding variation in the value of light detector output signals produced by reflected light from a particular type of coin and it will be appreciated that this can cause an unacceptable degree of unreliability when coin discrimination is carried out by comparing such output signals with a fixed reference signal.

A further aspect of the invention is to incorporate at least the light emitter, which preferably is a solid state light emitter such as an LED, into a feedback loop so that fluctuations in its light output are at least approximately compensated for by adjustments of its power input.

In a preferred embodiment which will be described below, the light emitter and the light detector are incorporated into the feedback loop, the detector being arranged to receive at all times a small proportion of light direct from the emitter, and consequently the feedback loop then tends to compensate not only for variations in characteristics of the emitter, but also

variations in characteristics of the detector, so that over a long period of time the quiescent output from the detector remains at a substantially constant level and that the amplitude of an output pulse superimposed upon that level, and in response to a coin of given characteristics, will vary much less with the passage of time, and with variations in temperature, than would otherwise be the case.

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In order that the invention may be more clearly understood, a preferred embodiment thereof will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which:

5 Figure 1 is a schematic diagram of a coin testing device in accordance with the invention, and

Figure 2 shows light detector output pulses obtained from fivepence and 1 Deutschmark coins.

Referring to the drawings, the coin passageway 2
10 is mechanically defined in any suitable manner so that each coin 4 inserted into the device may pass down this passageway, for example by rolling along a surface 6.

Adjacent to the passageway 2, and directed towards the edge of the coin 4, are located a light emitter 8 such
15 as an LED and a light detector 9 such as a phototransistor. Conveniently, these are accommodated in a unit 10 which is spaced sufficiently far away from surface 6 to allow passage between it and surface 6 of a coin of the maximum diameter likely to be inserted in the device.

20 Normally, with no coin present in the passageway 2, the output signal from the detector 9 will be at a substantially constant quiescent level indicated at A in Figure 2. This signal is amplified by a buffer amplifier 12, the main purpose of which is to match impedances, and
25 applied to a gate circuit 14 which is normally closed.

The emitter 8 is emitting light through an aperture 15 in the unit 10, and a lens (not shown) which produces a beam having a solid angle of divergence of 40° . The light enters the passageway 2 but in the absence of a coin no significant proportion of this light is reflected back to the detector 9. However, as coin 4, which can be assumed to be a fivepence coin, moves in the direction of the arrow, light from emitter 8 strikes its edge and is reflected through a further aperture 15' in unit 10 to the detector 9, whose output signal consequently rises. The aperture 15' is also provided with a lens (not shown) which gives detector 9 a viewing angle of 40° . The typical shape of the pulse produced at the output of detector 9 as the coin travels completely past the emitter 8 and detector 9 is shown by the curve 16 in Figure 2. If the coin had been a 1 Deutschmark coin, with a smooth edge as distinct from the more diffusely reflecting milled edge of a fivepence coin, then the output pulse, although not greatly shorter, would have a sharper form as indicated by curve 18 in Figure 2.

However, and referring again to curve 16, the output signal is applied to a disturbance detector 19 which is designed to produce an output signal in response to a change in its input signal equal to or greater than the amount B (arranged to be outside the noise band) in Figure 2. Consequently, it produces this output signal at time t_1 when

signal 16 has changed by this amount. The output signal from disturbance detector 19 triggers a monostable circuit 20, the output signal of which opens gate 14 for a pre-set period of time ΔT sufficient to accommodate a substantial portion of the rise of curve 16. During period ΔT the signal 16 is applied to one input of a comparator circuit 22, to the other input of which a signal of amplitude C is applied from an adjustable reference circuit 24.

At the end of period ΔT , it can be seen that signal 16 has reached a level D which is less than C and consequently the comparator circuit 22 is not triggered and does not produce an output signal at its output 26. Gate 14 is closed by monostable circuit 20 at the end of period ΔT .

If the coin had been a 1 Deutschmark, the output signal 18 would have been produced from the detector 9. Disturbance detector 19 is then actuated at a time t_2 . Starting then, the monostable circuit 20 holds gate 14 open once again for the same time period ΔT . The main part of the slope of the leading edge of signal 18 is steeper than that of signal 16 and by the end of period ΔT signal 18 has reached a level E greater than reference level C so that during period ΔT the comparator 22 does produce an output signal at its output 26.

It can be seen that production, or not, of an output signal at output 26 during the period ΔT may be used in subsequent circuitry to indicate whether or not the coin had the edge reflecting characteristic of a 1 Deutschmark coin,

or of a fivepence coin. It can also be seen that this is achieved by measuring the slope of the pulse produced by each type of coin and, in particular, measuring the amount by which the pulse signal increases during a constant
5 period of time immediately following the time when it is detected that a pulse is actually being received.

Figure 1 also illustrates a feedback loop which will now be described. The feedback loop contains a gate circuit 28 whose output is applied to one input of an integrating
10 amplifier 30, which may be an operational amplifier with capacitative feedback and very high input impedance, to the other input of which a reference signal is applied from a reference signal generating circuit 32. The output of the integrating amplifier is applied to a control input of a
15 current control circuit 34 which controls the current supply from a source to the LED 8. The feedback loop is optical from LED 8 to detector 9, by virtue of a small aperture 36 formed in a partition 38 within unit 10. The loop continues from detector 9 through buffer amplifier 12 to the input of
20 gate 28.

In the quiescent condition, with no coin present in passageway 2, gate 28 is open, detector 9 is generating a small output signal owing to light received from LED 8 through feedback aperture 36, integrating amplifier 30 is
25 integrating the difference between this output signal and

the reference signal provided by circuit 32, to generate an error signal, and the error signal is being employed to adjust the current control circuit 34 in such manner that the output signal from detector 9 is maintained at or very close to the value of the reference signal from circuit 32. This being set to a substantially constant value, the output signal from detector 9 also remains at a substantially constant value. This situation will be maintained over long periods of time despite changes in the characteristics of the components in the feedback loop. Such changes occur most notably in LED 8, due to passage of time and to temperature fluctuations, and also to a lesser extent in detector 9, for the same reasons.

In this manner, LED 8 and detector 9 are maintained in conditions of operation such that, upon arrival of a particular coin at any time over a very long period, and irrespective of the prevailing temperature, the pulse produced at the output of detector 9 will have an approximately constant form. Therefore, once the device has been initially set with reference level C from circuit 24 adjusted to produce adequately reliable discrimination as indicated by the output from comparator 22, this reliability will be maintained to a much better extent than would be possible without the feedback loop.

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The function of gate 28, in conjunction with a further monostable circuit 40, is to ensure that the feedback loop does not suppress the pulse generated by a coin, which it would otherwise tend to do in its attempt to maintain the output of detector 9 constant. When the disturbance detector 19 detects the approach of a coin at time t1 or t2 (Figure 2) it triggers monostable circuit 40 which in turn closes gate 28 for a fixed period of time $\Delta T'$ so that during most of the duration of the pulse the feedback loop is inactive. However, since closure of the gate 28 is equivalent to insertion of a very high impedance in the signal input to integrating amplifier 30, the amplifier output responds only very gradually to this condition and in fact the effect imposed on current control circuit 34 is so small as to be negligible.

Gate 28 is re-opened by monostable circuit 40, preferably before the termination of the pulse, so that the circuit is restored to its normal condition ready to sense a further coin which may be following very closely after the first one.

Since it is the light emitter 8 whose characteristics are most subject to variation through ageing and temperature changes, it may be sufficient to stabilise only this component of the system, in which case instead of feedback light being received by the main light detector 9, a separate feed-

back light detector may be provided, receiving some of the light from emitter 8, and the output of this further detector may be applied to an error-detecting circuit such as the integrating amplifier already described, to develop

5 • an error signal for controlling the power supply to emitter 8, thus rendering the light output of the latter constant.



CLAIMS:

1. Apparatus for discriminating between circular coins of substantially the same size but having different edge characteristics, comprising a light emitter arranged to throw light onto the edge of a coin
5 passing along a coin path, a light detector for detecting light reflected from the coin edge, and detecting means arranged to produce an output signal indicative of whether the mean slope of a portion of the detector output pulse which is produced when a coin passes the
10 detector is greater or less than a predetermined reference value.
2. Apparatus according to claim 1, wherein said portion is the rise of the detector output pulse over
15 an interval of predetermined duration following the level of said pulse becoming equal to a coin arrival threshold.
3. Apparatus according to claim 2, wherein the
20 detecting means comprises a disturbance detector responsive to the detector output signal rising above said arrival threshold, a comparator circuit for



comparing the detector output signal with said pre-determined reference value, a gate circuit arranged, when open, to feed the detector output signal to the comparator circuit, and a monostable circuit
5 controlled by the disturbance detector for closing the gate circuit for a predetermined time following response of the disturbance detector to the detector output signal rising above said arrival threshold.

10 4. Apparatus according to any preceding claim, wherein the emitter and detector are mounted in a common unit and separated from one another by a partition.

15 5. Apparatus according to any preceding claim, wherein the emitter comprises a light emitting diode provided with an opening and a lens to define a divergent light beam and the detector comprises a photosensitive transistor provided with a further
20 opening and a further lens to provide the photosensitive transistor with an acute viewing angle.

25 6. Apparatus according to claim 5, wherein the opening and lens associated with the light emitting diode define a divergent beam of about 40° solid angle and the viewing angle of the photosensitive transistor is about 40° also.



7. Apparatus according to any preceding claim, wherein the light emitter is provided with means for adjusting the intensity of the emitted light and a feedback loop is arranged to control the adjusting means so as to tend to keep the emitted light intensity constant.

8. Apparatus according to claim 7, as appended to claim 3, wherein the feedback loop comprises means to derive an error signal in dependence on the difference between the detector output signal and a preset reference value, a monostable circuit responsive to the output of the disturbance detector, and a gate circuit controlled by the monostable circuit so as to disconnect the detector output signal from the error signal deriving means for a duration similar to that of the detector output pulse, following response of the disturbance detector to the detector output signal rising above said arrival threshold.

9. Apparatus according to claim 8, wherein the error signal deriving means is an operational amplifier with capacitative feedback and very high input impedance.



10. Apparatus according to any one of claims 7 to 9 as appended to claim 4, wherein an opening in the partition is arranged to allow a proportion of the emitted light to pass directly to the light detector.

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11. Apparatus according to claim 7, comprising a further light detector arranged to receive a proportion of the emitted light directly from the light emitter, said further light detector forming part of said

10 feedback loop.

12. Apparatus for discriminating between circular coins of substantially the same size but having different edge characteristics, substantially as
15 hereinbefore described with reference to Figures 1 and 2 of the accompanying drawings.

13. A method of discriminating between circular coins of substantially the same size but having different
20 edge characteristics, comprising throwing light onto the edge of a coin passing along a coin path, using a detector to detect light reflected from the coin edge, and detecting whether the mean rate of change of the amount of light detected is greater or less than a
25 predetermined value.

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14. A method of discriminating between circular coins of substantially the same size but having different edge characteristics, substantially as hereinbefore described with reference to Figures 1 and 2 of the
5 accompanying drawings.

The text of the specification has been reproduced by photocopying the applicants original typescript. It may contain a few amendments which are difficult to read. The original typescript containing these amendments may be inspected on the premises of the Patent Office