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COIN TESTING DEVICE

This invention relates to coin testing devices.

5 In coin-receiving apparatus, such as automatic vending machines, it is known to provide a plurality of coin testing devices for conducting different tests on coins (which term includes real currency coins, tokens and imitations or slugs of various kinds) inserted into the apparatus and using the results of the tests to
10 determine whether an inserted coin is acceptable, or not, for the purposes of the particular apparatus.

There is a continuing need for reliable tests which will produce information useful for the above purpose.

15 The present invention provides apparatus for discriminating between 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 passing along a coin path, a light
20 detector arranged to detect light reflected from the coin edge, and means arranged to detect whether or not the slope of the detector output signal is consistent with a predetermined threshold criterion.

The invention is particularly concerned with
25 determining whether or not a coin, passing through

5 a coin testing device, has a faceted edge. An example of such a coin is the British fifty pence piece which has seven identical convex facets round its edge, the radii of curvature of these facets being substantially greater than the mean radius of the coin itself.

10 When a round coin with a smooth edge moves past a light emitter, which throws light onto the edge of the coin, and an adjacent light detector, which detects light reflected from the edge of the coin, the form of the output pulse from the light detector depends on the size, or radius, of the coin. A beam of light striking the edge of the coin will, upon reflection, be spread more if the coin is of small radius than if the coin is of large radius. Consequently the output pulse
15 from the detector will be longer and of lower amplitude for a small coin, and shorter and of greater amplitude for a large coin. A milled edge on the coin reduces the amplitude of the resultant pulse.

20 However, we have found that in the case of a coin with a faceted edge, such as the British fifty pence coin, the form of the detector output signal is substantially different from that to be expected from a round coin of the same mean diameter or radius, the most significant difference, for the purposes of the present
25 invention, being that it contains within the duration

of the detector pulse a portion of exceptionally high slope. The same applies to coins having flat facets round their edges, such as the Australian fifty cent coin and Hong Kong five dollar coin, and also to coins
5 having facets round their edges which are at least to some extent concave. In this specification, references to coins having faceted edges include coins of which the edge facets are flat, convex or concave.

The light detector output signal may be applied to
10 a circuit for sensing its slope and comparing the sensed value with a reference value. In the case of the British fifty pence coin, the maximum slope of the light detector output signal is much greater than it would be for a non-faceted coin of similar size, and
15 there is no round coin of sufficiently large diameter to produce a similar degree of slope in the output signal. Consequently, whether or not the slope of the output signal exceeds a reference value forms a very reliable test for distinguishing the British fifty
20 pence coin from any round coin. In practice, other tests will also be employed in reaching a firm decision to accept or reject a coin as being, or not, a fifty pence coin.

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From a further aspect, the invention comprises a method of discriminating between 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, detecting light reflected from the coin edge, and determining whether or not the slope of the detected light is consistent with a predetermined threshold criterion.

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

Figure 1 illustrates a coin testing device in accordance with the invention; and

Figure 2 shows waveforms useful in explaining the operation of the device shown in Figure 1.

In the device illustrated an inclined coin passageway 2 is defined in any suitable manner, as is known in the art. One portion of the passageway is an inclined lower surface 4 along which a coin 6 can move in the direction of the arrow. Located above the coin passageway is a unit 8 which contains a

light emitter such as a light emitting diode (LED) 10 and a light detector such as a photosensitive transistor 12, separated by a partition 14.

5 LED 10 is energised from a suitable source and emits light towards the passageway 2 through an opening 16 and a lens (not shown) which defines a divergent beam of 40° solid angle. As coin 6 passes beneath the unit 8, some of the emitted light is reflected from the edge of the coin facing the unit, and passes
10 through a further aperture 18 to reach the detector 12 which produces an output signal corresponding to the amount of light received. Aperture 18 also is provided with a lens (not shown) giving detector 12 a 40° viewing angle.

15 If the coin 6 were a perfectly round coin having a smooth edge, and a radius R, the light after reflection from its edge would be angularly spread to a degree approximately inversely proportional to the radius R. That is to say, the smaller the coin the greater the
20 spread and conversely the larger the coin the smaller the spread. Consequently, for a coin of smaller radius, the output signal from detector 12 will be a relatively long and shallow pulse, whereas for a larger coin it will be a much sharper pulse. Figure 2 shows in broken
25 lines a pulse 20 such as might be produced by a round

coin having the radius R .

The coin 6 illustrated in Figure 1 is a British fifty pence coin having seven convex facets on its edge, some of these facets being indicated by references 22. The radius of curvature of each of these facets r , is in fact much greater than the mean radius R of the coin as indicated by the radii of the uppermost facet 22 which are shown in broken lines in Figure 1 and indicated by the reference r . A facet of the coin therefore produces relatively little spread of the reflected light and so the output signal from detector 12 is of high amplitude and relatively short duration as indicated by the full line at 24 in Figure 2. Thus, although the coin has a mean radius R , it produces an output pulse more appropriate to a coin having the much larger radius r , that is to say a pulse having a substantially different form from that produced by a round coin of similar size, as can be seen from the difference between curves 20 and 24 in Figure 2.

In the embodiment described, the output signal from detector 12 is applied to a buffer amplifier 26 having unity gain, which is intended primarily for impedance matching purposes, and from there to a filter 28, which is a high pass filter passing only frequencies above 30 Hz. This passes only the higher frequency

components of the pulses 20 or 24 and consequently its output signal for pulse 24, which has relatively sharply sloping leading and trailing edges, consists of respectively positive and negative peaks 30 and 32, whereas its output signal in response to the pulse 20, having only a very shallow slope, is virtually negligible but in fact is shown for the sake of illustration as very shallow pulses 34 and 36 in Figure 2.

The output of filter 28 is applied to a comparator 38, a second input of the comparator 38 having a reference signal at a level A applied thereto by a reference signal generating circuit 40, which is adjustable.

It can be seen from Figure 2 that the level of the reference signal A can be set such that a pulse 30 obtained from a faceted coin will trigger the comparator circuit, but the very small signals obtained from a similar sized round coin will not, so that the output signal at the output 42 of the comparator circuit will give an indication, assuming similar diameters, as to whether or not the coin which has passed the unit 8 was faceted.

Instead of a high pass filter being employed ahead of the comparator 38, any other circuit may be employed which will produce an output signal whose amplitude varies substantially in dependence upon the average

slope of the leading and/or trailing edges of an input pulse, such as a differentiating circuit.

5 It is also possible, and in practice more usual, for a fifty pence piece to present to the light emitter and detector one of the corners which join two of its facets. This produces a dip in the output signal of detector 12, for example in the manner illustrated by the chain-dotted curve 44 in Figure 2. However, although the curve has its maximum amplitude reduced, it still
10 includes a steeply sloping portion capable after differentiation or filtering of generating a slope-indicative signal large enough to exceed level A.

As mentioned previously, in practice other tests will have to be satisfied before a coin is accepted as
15 a fifty pence coin. In this particular example, a thickness testing device 46, an electrical conductivity testing device 48, and a mean diameter testing device 50, all of which may in themselves be of known kind, are positioned on the coin path (though shown separated from it for
20 simplicity), and their outputs along with that of comparator 42 are applied to logic circuitry 52. Circuitry 52 is so arranged that it produces an output signal at a terminal 54 to indicate acceptance of a coin as a fifty pence coin only when all four testing
25 devices produce outputs appropriate for a fifty pence

coin. It should be noted that this requires the logic
circuitry to give a positive response only when the mean
diameter test, and the optical edge test which has been
described, indicate an inconsistency between mean
5 diameter as measured by the mean diameter testing device
and "apparent" diameter as measured by the optical edge
test, this inconsistency being characteristic of a faceted
coin.



CLAIMS

1. Apparatus for discriminating between 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 arranged to detect light reflected from the coin edge, and means arranged to detect whether or not the slope of the detector output signal is consistent with a predetermined threshold criterion.
- 10 2. Apparatus according to claim 1, wherein the detecting means comprises a filtering circuit arranged to pass high frequency components of the detector output signal and a comparator arranged to detect whether the output signal from the filtering circuit
15 is greater or less than a predetermined reference level.
3. Apparatus according to claim 1, wherein the detecting means comprises a differentiating circuit arranged to receive the detector output signal and
15 a comparator arranged to determine whether the output signal from the differentiating circuit is greater or less than a predetermined reference value.



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.
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 opening and a further lens to provide the photosensitive transistor with an acute viewing angle.
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 for discriminating a faceted coin from a non-faceted coin of substantially the same size, comprising testing means



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arranged to check the mean diameter of the coin and circuitry arranged to produce an accept signal only if the slope of the detector output signal is appropriate to a round smooth-edged coin having a diameter greater than an acceptable mean diameter for the coin indicated by the testing means.

8. Apparatus according to claim 7, comprising respective further testing means arranged to test the conductivity and thickness of the coin, said logic circuitry being arranged to produce an accept signal only if, additionally, the output signals from the further testing means are each indicative of the faceted coin concerned.

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



10. A method of discriminating between 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, detecting light reflected from the coin edge, and determining whether or not the slope of the detected light is consistent with a predetermined threshold criterion.
11. A method according to claim 10, wherein said criterion is that the rate of change of the output signal from a detector receiving the reflected light exceeds a threshold level.
12. A method of discriminating between faceted and non-faceted coins of substantially the same size, substantially as hereinbefore described with reference to Figures 1 and 2 of the accompanying drawings.



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13. A method of discriminating a faceted coin from a non-faceted coin of substantially the same size, comprising throwing light onto the edge of a coin passing along a coin path, using a detector to detect light
5 reflected from the edge of the coin, testing the mean diameter of the coin, and treating the coin as a faceted coin only if the slope of the detector output signal is appropriate to a round smooth-edged coin having a diameter greater than that indicated by the
10 mean diameter test.

14. A method of testing the curvature of a coin, comprising throwing light onto the edge of the coin while passing along a coin path, using a detector to detect
15 light reflected from the coin edge, and producing an output signal representative of the slope of the detector output signal.

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