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COIN ROUTING DEVICE

This invention relates to coin handling apparatus and particularly to the devices used in such apparatus for the routing of coins.

5 Such devices may for example take the form of movable gates. A gate may for example be movable between a first position, in which it diverts coins along a first path, and a second position in which it either diverts coins along a second path, or simply
10 moves out of the way so that coins can pass unimpeded to the second path.

Other coin routing devices include those which actually transport a coin. For example, a coin
dispenser may include a slide which has an aperture
15 for receiving a coin from a stack of coins in a tube, the slide being movable to deliver the coin to a location at which it is released from the slide and delivered to a dispensing path.

The devices described above conventionally use
20 spring-biased solenoids for providing the actuating force. The solenoid armature or plunger is coupled to the coin routing member, such as the gate or dispensing slide. The solenoid is normally de-energised, and the armature and coin routing member biased by a spring to

a desired position. If the member is a gate, it may for example be biased to a position in which it causes coins to be diverted to a reject path. If the member is a slide, it may be biased to a position for receiving
5 a coin from a storage tube. The device is actuated by energising the solenoid, which causes the armature or plunger to retract against the force of the spring and thus shifts the coin routing member.

These devices require a great deal of power.
10 It is necessary for the solenoid to produce enough energy to shift the coin routing member against the force of the spring, and to hold the member in its shifted position for the required period of operation, before allowing it to retract under the force of the
15 spring. The solenoid armature is generally made of iron, which has a high density. The armature must have a relatively large cross-sectional area for the solenoid to produce the necessary force, and therefore the total mass of the armature is fairly high. The
20 large inertia and frictional forces thus increase the required solenoid force.

Further, in many circumstances it is necessary to operate the device very quickly. For example, if the coin routing member is a gate in a coin validator,

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it is essential that the gate be capable of being fully shifted in the time between a coin leaving a testing station and its arrival at the gate. It is desirable for the distance travelled by the coin to be
5 small in order to minimise the size of the validator, and therefore this time period is very short.

In addition, a commonly-occurring fraudulent operation involves attaching a coin to a length of thread so that it can be withdrawn from the validator
10 after it has been found acceptable. To prevent this, it is desirable for the gate to shift back to its normal position very quickly after the coin has passed the gate so that the coin is prevented from being withdrawn.

15 Increasing the speed of operation requires the use of a stronger spring, which thus increases the required power of the solenoid. In addition, the initial velocity of the coin routing member as the solenoid is energised should be as high as possible.
20 However, it is during this initial part of the stroke of the solenoid actuator that the force of the solenoid is weakest. It is therefore necessary for the solenoid to be even more powerful so as to overcome this problem and achieve the desired initial velocity.

25 The use of powerful solenoids is a significant disadvantage when the overall power consumption of the

coin handling apparatus is to be minimised, such as when the apparatus is to form part of a pay-telephone which is driven by the telephone line current. Also, powerful solenoids are heavy and unwieldy.

5 According to the invention there is provided a coin routing device comprising a coin routing member which is selectively movable between first and second positions for controlling the path of a coin, an actuator for the member, the actuator comprising an
10 electrical conductor mechanically coupled to the member, and a magnet so arranged with respect to the conductor that electrical current through the conductor causes relative movement therebetween and thus moves said coin routing member, and a drive
15 circuit for energising the actuator, the drive circuit being operable to apply current in a first direction through said conductor to move said member from the first to the second position, and being operable to apply current in the reverse direction to move the
20 member back to its first position.

 Thus, there is no longer any need to use a spring for retracting the member. This reduces the power required to move the coin routing member, and increases the speed of operation. In addition, it is
25 no longer necessary to use energy to hold the coin routing member against the force of a spring at either of its locations.

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If desired, however, a small biasing force such as that provided by a relatively weak spring, or gravity, could be used to hold the member at one of its positions. It may be found desirable also to maintain a current flow
5 through the conductor to hold the member at its other position against this biasing force, although of course the total energy consumption would still be substantially less than that required if the biasing force were of the strength required to produce the desired retraction
10 operation.

The use of a small biasing force has the advantage that the gate is less liable to shift due to vibration of the apparatus, and ensures that when the apparatus is not powered, the gate is biased to a desired position, such
15 as a position wherein inserted coins will be delivered to a reject chute.

Preferably, the conductor, which may be a coil, is arranged to intersect substantially the same amount of flux through the path of movement. This means that the
20 force applied to move the coin routing member is substantially constant. This increases the efficiency of the device, and decreases the overall power consumption. Because the initial force applied is now fairly substantial, unlike in the prior art solenoid devices, the initial
25 acceleration is fairly high, so that the overall time of

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operation, and hence power consumption, are low.

Because the coin routing member does not need to be attached to an iron armature, the overall mass of the moving part of the actuator is reduced, which results in a further reduction in power consumption.

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The coin routing member may be a gate, e.g. a blade gate which is moved linearly in a direction transverse to the paths taken by the coins, or a flap which is pivoted into and out of the path of the incoming coins, or may be a member for transporting coins between locations, such as a coin slide.

An arrangement embodying the invention will now be described by way of example with reference to the accompanying drawings, in which:-

Figure 1 is a side elevation of a coin validator having a coin routing device of the present invention;

Figure 2 is a perspective view, partly in section, of the coin routing device;

Figure 3 is a diagram of a circuit for driving the device; and

Figure 4 is a diagram of waveforms of signals occurring within the circuit of Figure 3.

The coin validator 2 of Figure 1 receives coins at a hopper 4. The coins fall onto a snubber 5 and are directed along a main validation path 6 so that they roll down a ramp 7 and pass electromagnetic sensors 8. The sensors 8 test different properties of each coin to determine whether or not it is a valid, acceptable coin.

After passing the sensors 8, the coins travel toward a coin routing device 10 located behind a side

wall 12 of the validator.

The device 10, which will be described in detail subsequently, has a blade gate 14 which normally extends through a slot 16 in the side wall 12. Thus, coins
5 will be diverted by the gate 14 to roll down a ramp 18 into a reject chute 20.

If, however, the validator circuitry coupled to the sensors 8 deems the incoming coin to be valid, an

electrical signal is sent to the device 10 to cause the blade gate 14 to withdraw through the slot 16. Thus, the valid coin will fall directly into an accept chute 22.

5 A sensor 24 may be used to indicate that the coin has correctly passed into the accept chute 22.

 Instead of the blade gate 14, the device 10 may have a flap gate which can be pivoted from a position in which it is substantially coplanar with the side wall 10 12 to a position in which its upper edge obstructs the entrance to the accept gate 22 thereby to divert coins to the reject chute 20.

 The device 10 is shown in more detail in Figure 2.

 The device 10 has a magnet 26. This is preferably 15 a permanent magnet, as shown, but may alternatively be an electromagnet.

 The magnet 26 is cylindrical and has opposite poles at its upper and lower ends.

 The magnet 26 is seated on a mild steel member 20 28 which has a central spigot 30. A mild steel disc 32 is located on top of the magnet 26 and surrounds the upper end of the spigot 30.

 The blade gate 14 is attached by a pin 34 to a shaft 36 which is attached at its lower end to a cylindri-

cal bobbin 38. The shaft 36 and bobbin 38 are integrally formed by injection moulding. If desired, the gate 14 could be part of this integral moulding.

5 A coil 40 is wound around the bobbin 38 between upper and lower externally-projecting flanges 42 and 44.

The bobbin 38 and surrounding coil 40 extend into the annular gap between the disc 32 and the central spigot 30.

10 The blade gate 14, shaft 36 and bobbin 38 are movable between the upper position shown, in which the lower end of the coil 40 is positioned between the disc 32 and spigot 30, and a lower position, where the blade gate 14 is withdrawn from the path of the coins
15 in the validator, and the upper part of the coil 40 is located between the disc 32 and the spigot 30.

The coil 40 is connected to pins 46 at the upper end of the bobbin 38. The pins 46 are connected by very flexible wires 48 to terminals 50 to which external
20 connections (not shown) are made. The wires 48 extend through holes 52 in a dust cover 54 which surrounds the shaft 36 and bobbin 38.

The operation of the device 10 is as follows.
It will be appreciated that with the arrangement shown,

the coil 40 has a first magnetic pole surrounding its outer circumference, and an opposite magnetic pole at its interior. Thus, a magnetic flux flows radially through the coil windings.

5 When a drive circuit to be described subsequently applies a voltage of a first polarity to the terminals 50, the current flowing in the coil travels in a circumferential direction, and produces a resulting force on the gate 14, shaft 36 and bobbin 38 which is directed
10 vertically downwardly, as seen in the drawing. The gate 14 thus moves out of the path of the coins. During the movement of the gate, the size of that part of the coil 40 which is located in the flux path between the disc 32 and the central spigot 30 remains constant, and
15 thus the resultant force is constant.

To move the gate 14 back to its original position, the drive circuit applies a voltage of opposite polarity to the terminals 50. The reversal of the direction of current flow results in the force applied to move the
20 gate 14 being directed vertically upwardly as seen in

Figure 2. The gate 14 is thus moved back into the path of the incoming coins.

The bobbin 38 is perforated as indicated at 56 to ensure that air can pass freely out of the space between the bobbin 38 and the spigot 30, and therefore will not impede movement; the perforations also reduce the total weight of the moving parts.

Referring to Figures 3 and 4, the drive circuit 100 for the device 10 is arranged to apply drive current to the coil 40 in both forward and reverse directions to produce the required movement of the gate 14.

The circuit has power supply terminals 102 for receiving a supply voltage of, for example, 5 volts. The main current-carrying electrodes of a first pair of transistors 104 and 106 are connected in series with the coil 40 and between the power supply terminals 102. When both transistors are switched on, current flows through the coil 40 in a first direction to cause the gate 14 to retract.

The main current-carrying electrodes of a second pair of transistors 108 and 110 are connected in series with the coil 40 and between the power supply terminals 102, so that when these transistors are switched on current flows through the coil 40 in the reverse direction to cause the gate 14 to be pushed back

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toward its original position.

The transistors could for example be field effect transistors, or bipolar transistors. They are all connected in parallel with diodes 112 to protect them from the reverse voltages generated by switching the coil inductance.

The transistors 104 to 110 are controlled by the remaining parts of the circuitry, which are described in the following.

When a valid coin is detected, an accept pulse A (see Figure 4) is delivered to a terminal 114. The pulse is delivered via a resistor 116 to the base terminal of the transistor 106 to turn it on.

The pulse A is also delivered to one input of a NAND gate 118 which receives at its other input a 50 KHz square wave pulse C. The pulse A is thus inverted and modulated by the 50 KHz pulse, to produce signal D which is applied via a resistor 120 to the transistor 104. This causes the transistor 104 to be repeatedly switched on and off for the duration of the pulse A. Thus, the coil 40 is repeatedly energised to retract the gate 14.

It is found that this method of driving the coil 40 using successive short pulses, rather than driving the coil using a continuous pulse such as pulse A, results

in more efficient energisation of the coil and less current consumption, because the effective power supplied to the coil can be matched with its impedance. A prototype device had a coil with an impedance of 5.1 mH, a d.c. resistance of 73 ohms, and a power requirement of about 80 mW. With a supply voltage of 5 volts, this could be driven efficiently using pulses having a mark-space ratio of 1:1.

A capacitor 122 may be provided to supply the current pulses and thereby result in a more regular drain on the power source.

To return the gate 14 to its original position, a pulse B is generated by a NAND gate 124. The gate 124 has one of its inputs connected to the positive supply rail, and its other input connected via resistors 126 and 128 and a diode 130 to the positive supply rail. The pulse A is supplied via a capacitor 132 to the junction 133 between the resistors 126 and 128.

Positive transitions of the pulse A have no significant effect on the voltage at the junction 133 due to the clamping effect of the diode 130. However, a negative transition of the pulse A will cause the voltage at the junction 133 between the resistors 126 and 128 to drop, so that the voltage at the output of the gate 124 will rise. After a predetermined period, in this

case about 20 mS, determined by the values of the resistor 128 and the capacitor 132, the capacitor 132 charges up, so that the voltage at the junction 133 between the resistors 126 and 128 rises. After it reaches a predetermined level, the voltage at the output of the gate 124 falls.

The pulse B obtained in this manner is applied via a resistor 134 to the transistor 110 to turn it on, and is also applied to a NAND gate 136 where it is inverted and modulated by the 50 KHz pulse C before being applied via a resistor 138 to the transistor 108 so that the latter is repeatedly switched on and off. The coil 40 is thus repeatedly energised in such a manner as to cause the gate 114 to return to its original position.

It will be noted that a failure of the source of clock pulses C to logic zero will be safe because the transistors 104 and 108 will be off, and therefore excessive continuous current cannot be switched through the coil 40.

In the embodiment described, the pulse A has a length such that the coil is energised to move the gate fully to its retracted position, and is kept energised to hold the gate in position. The pulse A may therefore be slightly longer than the pulse B. If desired, a small

biasing force may be arranged to hold the gate in its opposite position while the coin is de-energised, so as to avoid the risk of the gate accidentally moving due to vibration of the apparatus and to ensure that the gate is in the correct position when the apparatus is not powered. The biasing force could be provided by a weak spring, or possibly by gravity.

It will be appreciated that the energy required to hold the gate in its retracted position against the small biasing force is substantially lower than that required to produce the retraction movement, because it is no longer necessary to accelerate the gate. Accordingly, in order further to reduce the power consumption, in a modified embodiment the frequency or mark-space ratio of the pulses C is altered during the time that the gate is held in its retracted position so as to produce a smaller force on the coil 40. When the gate is moving back to its original position, it is being assisted by the relatively small biasing force and therefore one could arrange for the frequency or mark-space ratio of the pulses C during the time in which the coil is being returned to its original position to differ from that used in the period in which the gate is being retracted. However, as the biasing force is preferably very small compared with the force required to produce the desired movement of the gate, this may not be worthwhile.

In an alternative modification, no power is supplied to the coil 40 while the gate is in its retracted position.

In both the above modifications, the pulses
5 for retracting the gate and returning the gate to its original position are separated by an interval in which either no energy is supplied to the coil, or a reduced amount of energy is supplied. Such an arrangement can conveniently be achieved by generating a
10 first pulse, during which the coil is retracted, using a timer which is actuated by the leading edge of the accept pulse A, and generating a second pulse, during which the gate is returned to its original position, using a second timer which is actuated by the trailing edge of
15 the accept pulse A.



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CLAIMS:

1. A coin routing device comprising a coin routing member which is selectively movable between first and second positions for controlling the path of a coin, an
5 actuator for the member, the actuator comprising an electrical conductor mechanically coupled to the member, and a magnet so arranged with respect to the conductor that electrical current through the conductor causes relative movement therebetween and
10 thus moves said coin routing member, and a drive circuit for energising the actuator, the drive circuit being operable to apply current in a first direction through said conductor to move said member from the first to the second position, and being operable to
15 apply current in the reverse direction to move the member back to its first position.
2. A device as claimed in claim 1, wherein said member comprises a gate for selectively diverting a
20 moving coin.
3. A device as claimed in claim 2, wherein said gate is arranged to be moved linearly by said actuator.

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4. A device as claimed in claim 2, wherein said gate is arranged to be pivoted by said actuator.

5. A device as claimed in claim 1, wherein said member is operable to receive a coin at a first
5 location and is caused by the actuator to transport the coin to a second location.

6. A device as claimed in any preceding claim, wherein said conductor comprises a coil having a
10 plurality of turns.

7. A device as claimed in claim 6, wherein said magnet is arranged to produce a magnetic field extending radially through the coil.

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8. A device as claimed in claim 7, wherein the magnet is arranged to produce a field which extends through an area of the coil of substantially constant size throughout the movement of the member.

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9. A device as claimed in claim 7 or claim 8, wherein the magnet has a first pole located inside the coil and a second pole surrounding the coil.



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10. A device as claimed in any preceding claim, including semiconductor switching devices for selectively applying a drive voltage across said conductor in either of forward and reverse directions.

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11. A device as claimed in any preceding claim, wherein said drive circuit is operable to apply pulses of current to said conductor in order to shift said member between the first and second positions.

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12. A coin routing device substantially as herein described with reference to the accompanying drawings.
