COIN ARRIVAL SENSOR

Inventors: Guustaf Arthur Schwippert,
Pijnacker; Wouter Smits, Schiedam, both of Netherlands


Filed: Nov. 21, 1974

Appl. No.: 525,840

Foreign Application Priority Data
Nov. 22, 1973 United Kingdom 54319/73

U.S. Cl. 194/100 A

Int. Cl. 6 G07F 3/02

Field of Search 194/100 R, 10, 100 A, 99, 194/97; 133/2, 1 R

References Cited

UNITED STATES PATENTS
3,870,137 3/1975 Fougere 194/100 A

ABSTRACT

Apparatus for sensing the arrival of a coin in coin handling mechanisms and producing an output signal only if the coin is of an acceptable type of material. The coin is placed between transmitting and receiving coils. The transmitting coil produces an oscillating magnetic field with components of different frequencies. The amplitudes of the components of the two different frequencies are examined and if they correspond to the amplitudes for an acceptable type of material, e.g. conductive non-ferromagnetic, the apparatus indicates the arrival of a coin.

34 Claims, 23 Drawing Figures
This invention relates to coin handling mechanisms (e.g. for use in coin-operated vending machines), and especially to apparatus for sensing the arrival of a coin in a coin handling mechanism and for initiating a coin-identifying operation if the coin is of an acceptable type of material.

In some of the more advanced types of coin handling mechanisms such as, for example, mechanisms in which coins are authenticated by electronic or photo-electronic means, it is useful to have apparatus for sensing the arrival of a coin in the mechanism to activate the coin identifying apparatus and initiate a sequence of coin-identifying operations. For example, in a mechanism for determining the authenticity and/or denomination of coins which uses optical sensing means such as photo-electric cells with associated light sources, it is desirable to have the light sources turned on only while a coin is being processed by the mechanism, since this greatly extends the life of the light sources. It is preferable that the coin arrival sensor not be an optical sensor, since an optical sensor would necessitate another light source which would have to be turned on all the time. Furthermore, since optical coin-identifying systems cannot directly check the material of a coin, the coin arrival sensor is preferably one which determines whether the coin is of an acceptable material or an acceptable type of material.

According to the present invention there is provided apparatus for sensing the arrival of a coin in a coin handling mechanism and for producing an output signal when the coin is of an acceptable type of material comprising: transmitting means including at least one transmitting inductor, for generating an oscillating magnetic field having components of two substantially different frequencies; receiving means including at least one receiving inductor disposed in the magnetic field produced by said transmitting means, for detecting the amplitude of said components at the location of said receiving inductor; means for guiding a coin between the transmitting and receiving inductors so that a substantial portion of the magnetic energy received by said receiving inductor is transmitted through the coin; and means for comparing the amplitudes of the components detected by the receiving means with the corresponding amplitudes for coins of an acceptable type of material and for producing an output signal indicative of the arrival of a coin of an acceptable type of material when the detected amplitudes of both components correspond substantially to the amplitudes for a coin of an acceptable type of material.

The transmitting inductor radiates magnetic energy at two substantially different frequencies. This energy induces electrical signals of corresponding frequencies in the receiving inductor located opposite the transmitting inductor. A coin introduced into the coin handling mechanism is guided between the transmitting and receiving inductors so that a substantial portion of the energy propagating from the transmitting inductor to the receiving inductor passes through the coin. This affects the amount of energy received by the receiving inductor (and therefore the amplitudes of the signals induced therein) to a degree dependent on the material of the coin and the frequencies transmitted.

Thus, the apparatus of the present invention employs an oscillating magnetic field to determine the arrival of a coin within the coin handling mechanism. In addition to sensing the arrival of a coin, this coin arrival sensor examines the material of the coin as a preliminary test of coin authenticity. Since most of the world's genuine coins are made of conductive, non-ferromagnetic materials (e.g. copper, cupro-nickel, etc.), the arrival sensing apparatus may be arranged to produce the output signal only for the arrival of conductive, non-ferromagnetic coins only, thus eliminating many types of slugs (e.g. non-conductive slugs such as paper, plastic, and ferromagnetic slugs such as iron, steel, and ferrites) from consideration by the coin handling mechanism. For those countries where genuine coins are of other materials (e.g. ferromagnetic), the arrival sensing apparatus will be arranged to indicate the arrival of coins of this type of material.

With regard to the choice of the two substantially different frequencies, a first relatively low frequency is chosen so that ferromagnetic materials have a considerably greater effect on the amplitude of the transmitted electromagnetic energy at that frequency than non-magnetic materials. A second relative high frequency is chosen so that conductive materials, and particularly all acceptable coins of conductive materials, have a readily detectable effect on the amplitude of transmitted electromagnetic energy at that frequency. Accordingly, the arrival of a conductive, non-magnetic coin, for example, is indicated by a significant decrease in the amplitude of the high frequency signal induced in the receiving inductor together with a decrease in the amplitude of the low frequency signal less significant than the decrease that would indicate a magnetic material.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a front view of a portion of a coin handling mechanism showing one possible location for the inductors of a coin arrival sensor according to the present invention;

FIG. 2 is a sectional view taken along the line 2--2 in FIG. 1 with a schematic block diagram of the coin arrival sensor;

FIG. 3 is a detailed block diagram of one embodiment of circuitry for the arrival sensor of Figs. 1 and 2;

FIG. 4 is a series of signal traces, plotted against a common time axis, useful in understanding the embodiment of FIG. 3;

FIG. 5 is a detailed block diagram of a second embodiment of circuitry for the arrival sensor of Figs. 1 and 2;

FIG. 6 is a series of signal traces, plotted against a common time axis, useful in understanding the embodiment of FIG. 5;

FIG. 7 is a detailed block diagram of a third embodiment of circuitry for the arrival sensor of Figs. 1 and 2;

FIG. 8 is a series of signal traces, plotted against a common time axis, useful in understanding the embodiment of FIG. 7.

Throughout this specification and in the appended claims, the term "coin" is intended to mean genuine coins, tokens, counterfeit coins, slugs, washers, and any other item which may be used by persons in an attempt to use coin-operated devices.

In the coin handling device 10 shown in FIGS. 1 and 2, a coin enters the device through a coin entry 12 and
falls edge first onto the initial portion of a coin track 20 between parallel front and back plates 14 and 16. The coin rolls down this portion of the coin track 20, coming to rest in the position shown by dotted line 21 against a coin start gate 22. In this position the coin is between transmitting and receiving inductors 32 and 34 of a coin arrival sensor 30 according to the present invention. The inductors 32 and 34 are mounted opposite one another on the plates 14 and 16, respectively.

The inductors 32 and 34 are of such size and location that when any coin acceptable to the device 10 is at rest against the coin start gate 22, substantially all of the electromagnetic energy propagating from the inductor 32 to the inductor 34 passes through the coin.

When the arrival sensor 30 which includes low and high frequency power supplies 36 and 38 and a receiving circuit 40, detects a coin of an acceptable type of material between the inductors 32 and 34 as described in detail below, it produces an output signal applied to activate the start gate solenoid 42 and a coin identifying circuit 44. In response, the start gate solenoid retracts the start gate 22 into the back plate 16, allowing the coin to continue to roll down the coin track 20. When the coin identifying circuit 44 is activated, light sources associated with optical coin sensors 50 (e.g. photoelectric devices) are turned on. As the coin rolls down track 20 it passes the passage of the coin is sensed by the coin identifying circuit by means of the sensors 50. The coin identifying circuit 44 determines whether or not the coin is acceptable, for example, by optically examining its velocity, diameter, etc., as disclosed in U.S. Pat. No. 3,797,638. At the end of coin track 20 the coin drops toward a coin acceptance gate 52. If the coin has been identified as acceptable, the coin acceptance gate 52 is retracted and the coin falling from the end of the coin track 20 strikes the acceptance gate 52 and is diverted into a reject chute 56, which leads to a coin return window of the vending machine.

FIG. 3 shows one form of the circuitry of the coin arrival sensor 30 of this invention including the low frequency power supply 36 and the high frequency power supply 38, each of which is connected to a separate coil wound around the core of the transmitting inductor 32.

The low frequency power supply 36 produces an alternating current (a.c.) output signal having a first relatively low frequency (e.g. 50 or 60 Hz). The ultimate source of this signal may be mains. In that event, the power supply 36 may be a transformer for reducing the mains voltage to a safer level. The high frequency power supply 38 produces an a.c. output signal having a second relatively high frequency (e.g. 70 KHz). The power supply 38 may therefore be by any suitable a.c. signal generator, e.g. a square wave generator and a filter for filtering the square wave to produce a sinusoidal signal.

As mentioned above, the a.c. output signal of each of the power supplies 36 and 38 is applied to a separate coil on the core of the inductor 32. Accordingly, the inductor 32 produces an alternating magnetic field which is the superposition of the alternating magnetic fields due to each of the applied a.c. signals. This field radiates across the coin passageway above the coin track 20 in the apparatus of FIGS. 1 and 2 and induces an a.c. electrical signal in the coil of the receiving inductor 34. This induced signal has frequency components corresponding to the frequencies of the signals applied to the transmitting inductor 32. Therefore, the signal of the receiving inductor 34 is applied to low pass and high pass filters 60 and 70 which separate the low and high frequency components of that signal. The output signals of the low pass and high pass filters 60 and 70 are represented by the sinusoidal signal traces shown in FIGS. 4a and 4c, respectively. The portion of FIG. 4 to the left of time A-A represents the condition of the apparatus of FIG. 3 prior to the arrival of a coin. For ease of illustration, the output signals of filters 60 and 70 are represented in FIGS. 4a and 4c as having frequencies much lower than is actually the case. Moreover, the output signal frequency of the filter 70 is typically many times greater than the output signal frequency of the filter 60. At the time A-A, a conductive, non-magnetic coin arrives in the apparatus between the inductors 32 and 34 and remains there until a time B-B when the coin start gate 22 is retracted. During the period indicated between lines B-B and C-C there is again no detectable object between the inductors 32 and 34. At a time C-C a magnetic coin arrives in the apparatus between the inductors 32 and 34 and remains there until removed at a later time not shown.

When a coin is interposed between the inductors 32 and 34, the amplitude of one or both of the frequency components of the signal induced in the coil of inductor 34 may be reduced depending on the material of the coin. The following table illustrates the effect of various materials on the amplitude of the low and high frequency components of the induced signal:

<table>
<thead>
<tr>
<th>Material</th>
<th>Effect on 50 Hz Signal</th>
<th>Effect on 70 KHz Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper, Plastic</td>
<td>No Effect</td>
<td>No Effect</td>
</tr>
<tr>
<td>Copper</td>
<td>Slight Damping</td>
<td>Significant Damping</td>
</tr>
<tr>
<td>Copper-Nickel</td>
<td>Significant Damping</td>
<td>Heavy Damping</td>
</tr>
<tr>
<td>Iron</td>
<td>No Effect</td>
<td></td>
</tr>
<tr>
<td>Steel</td>
<td>Damping</td>
<td></td>
</tr>
</tbody>
</table>

Many of the world's genuine coins are made of conductive, non-ferromagnetic materials (e.g. copper or cupro-nickel). The presence of a coin of such material is indicated by significant damping of the 70 KHz signal coupled with only slight damping of the 50 Hz signal. Accordingly, the arrival sensor 30 is designed to recognise this condition and produce an output signal which is applied to the start gate solenoid 42 and the coin identifying circuit 44, when and only when this condition occurs. Non-conductive objects (e.g. paper or plastic) are not detected by arrival sensor 30 and must be removed from the coin mechanism before it can be used, for example by operation of a coin reject lever (not shown) which momentarily separates the front and back plates 14 and 16 and permits the object to fall from the mechanism in the usual manner. Magnetic coins are recognised by heavy damping of both the 50 Hz and 70 KHz signals. In the embodiment shown specifically in FIG. 3 this condition results in no output signal from arrival sensor 30 and necessitates operation of the coin reject lever to remove the coin from the coin mechanism. Alternatively, the system can be arranged to produce an output signal for activating the start gate solenoid (but not the coin identifying circuit 44) when heavy damping of both the low and high frequency signals is detected, thereby avoiding the necessity of oper-
ating the reject lever to purge the mechanism of a magnetic coin. In applications in which magnetic coins may be acceptable coins, the system can be arranged to produce an output signal for activating the start gate solenoid 42 and the coin identifying circuit 44 when heavy damping of both the low and high frequency signals is detected. Furthermore, if both magnetic and non-magnetic coins may be acceptable, the system may be modified to produce output signals indicative of whether the detected coin is magnetic or non-magnetic. These signals may be applied to the coin identifying circuit 44 to pre-condition that circuit to accept only a coin having other characteristics consistent with the magnetic or non-magnetic characteristics of the coin. These variations can be made in any of the specific embodiments shown in FIGS. 3, 5 and 7.

Returning to the embodiment shown in FIG. 3, the output signals of the low pass filter 60 is applied to one input terminal of a differential amplifier 66. The signal applied to the other input terminal of the amplifier 66 is a direct current (d.c. threshold signal represented by the straight line signal trace (−V) in FIG. 4c. All signal polarities referred to herein are entirely arbitrary. This threshold signal is generated by a rectifier circuit 62 and a voltage divider 64. The rectifier circuit 62 produces an output signal having a d.c. level proportional to the negative amplitude of the output signal of the low frequency power supply 36, i.e., a negative envelope signal. The level of the signal −V derived from this negative envelope signal is adjusted by voltage divider 64 to the desired negative threshold level −V applied to differential amplifier 66. The negative threshold level −V is chosen to be somewhat more positive than the negative peaks of the output signal of low pass filter 60 except when the output signal of the low pass filter 60 is damped to the degree associated with the presence of a magnetic coin between the inductors 32 and 34 as in the portion of FIG. 4 to the right of line C−C. In other words, the negative peaks of the output signal of low pass filter 60 will be more negative than −V when a conductive, non-magnetic coin is present between the inductors 32 and 34, but will become more positive than −V when a magnetic coin is present between the inductors 32 and 34. The differential amplifier 66 compares the levels of the signals applied to it and produces an output signal (represented by the signal trace of FIG. 4b) which is positive when the output signal of low pass filter 60 is more negative than −V and negative otherwise.

The output signal of the different amplifier 66 is applied to a rectifier circuit 68 which produces an output signal (represented by the signal trace of FIG. 4e) which is the positive envelope of the applied signal. Accordingly, the output signal of the rectifier circuit 68 is positive while the output signal of the differential amplifier 66 includes periodic positive spikes (as in the portion of FIG. 4b to the left of line C−C). When those positive spikes disappear, however, the level of the output signal of rectifier circuit 68 goes rapidly to zero (i.e., within a time period t_{13}) as in the portion of FIG. 4e to the right of line C−C. This latter condition is associated with the arrival of a magnetic coin between the inductors 32 and 34. The output signal of the rectifier circuit 68 is applied to one input terminal of a NAND gate 80. When the output signal of rectifier circuit 68 is positive, it is interpreted by the NAND gate 80 as logic 1, otherwise it is interpreted as logic 0. Logic signal levels referred to herein are also entirely arbitrary.

The circuitry associated with the high pass filter 70 is similar to that described above. Thus a rectifier circuit 72 and a voltage divider 74 (responsive to the output signal of the high frequency power supply 38) produce a positive threshold voltage +V (represented by the straight line signal trace of FIG. 4c) which is applied to one input terminal of a differential amplifier 76, (+V is not necessarily of the same magnitude as −V). This positive threshold voltage is chosen so that it is less positive than the positive peaks of the output signal of the high pass filter 70 except when there is a conductive object between inductors 32 and 34. The output signal of the high pass filter 70 is applied to the other input terminal of the differential amplifier 76. Accordingly, the differential amplifier 76 (generally similar to the differential amplifier 66) produces an output signal (represented by the signal trace of FIG. 4d) which is positive when the output signal level of the high pass filter 70 is less positive than +V and negative otherwise.

The output signal of the differential amplifier 76 is applied to a rectifier circuit 78 which produces an output signal (FIG. 4f) proportional to the negative envelope of the applied signal. Accordingly, the output signal of rectifier circuit 78 is negative while the output signal of the differential amplifier 76 includes periodic negative spikes (as in the portions of FIG. 4d to the left of line A−A and between lines B−B and C−C). When these negative spikes disappear (as in the portion of FIG. 4d between lines A−A and B−B and to the right of line C−C), the level of the output signal of the rectifier circuit 78 goes rapidly to zero (i.e. after a time t_{24}). For reasons explained below, t_{24} is preferably greater than t_{13}.

The output signal of the rectifier circuit 78 is applied to the remaining input terminal of the NAND gate 80. When the output signal of the rectifier circuit 78 is zero it is interpreted by NAND gate 80 as logic 1, otherwise it is interpreted as logic 0.

When both signals applied to the NAND gate 80 are logic 1 (as in the portion of FIG. 4 between lines A−A and B−B and after time t_{12}), the NAND gate 80 produces an output signal (see FIG. 4g) applied to a time delay unit 82 for activating the start gate solenoid 42 and the coin identifying circuit 44. This corresponds to the arrival of a conductive, non-magnetic coin between the inductors 32, 34. After a time delay t_{12} imposed by the time delay unit 82 (i.e. at time B−B in FIG. 4), the "gate open" command signal produced by the NAND gate 80 is applied to the start gate solenoid 42 and the coin is allowed to continue rolling down track 20 past the coin sensors 50. After time B−B in FIG. 4, the coin is no longer between the inductors 32 and 34 and the coin arrival sensor of FIG. 3 returns to its original condition. The time delay t_{12} ensures that all coins come to rest against the coin start gate 22 before being allowed to continue down the coin track 20.

As mentioned above, the portion of FIG. 4 to the right of line C−C represents the response of the apparatus of FIG. 3 to the arrival of a magnetic coin between the inductors 32 and 34. The output signal amplitudes of both of filters 60 and 70 drop below their respective reference signal levels (FIGS. 4a and 4c). The output signal level of the rectifier circuit 68 changes from logic 1 to logic 0 (FIG. 4e) and the output signal level of the rectifier circuit 78 changes from logic 0 to logic 1 (FIG. 4f). Since the response time t_{12}
of the rectifier circuit 78 is greater than the response time $t_{11}$ of the rectifier circuit 68, at no time following the arrival of the magnetic coin are the output signal levels of both rectifier circuits 68 and 78 logic 1. Accordingly, no gate open command signal is produced by the NAND gate 80 and the coin start gate 22 remains closed. As mentioned above, the magnetic coin is removed from the coin mechanism by operation of the coin reject lever (not shown).

In the alternative embodiment of the invention shown in FIG. 5, elements having the same reference number as elements in FIG. 3 apart from the prefix number 1 are generally similar. In the embodiment of FIG. 5 the reference signals applied to differential amplifiers 166 and 176 are generated from the filtered receiver signals rather than the transmitter signals as in the embodiment shown in FIG. 3. Accordingly, the leads 37 and 39 (shown in broken lines in FIG. 2) are not needed and can be omitted when the receiver circuit 40 is constructed as shown in FIG. 5.

In the embodiment shown in FIG. 5, the output signal of the receiving inductor 34 is amplified by an amplifier 158 to produce a received signal having a more convenient level. This amplified signal is filtered by low and high pass filters 60 and 70 in the embodiment shown in FIG. 3, albeit of somewhat greater amplitude as a result of amplification by the amplifier 158. These signals are generated by the sinusoidal signal traces in FIGS. 6a and 6c respectively. The several portions of FIG. 6 represent the same events represented by the corresponding portions of FIG. 4, that is, the portion of FIG. 6 between lines A—A and B—B represents the arrival of a conductive, non-magnetic coin, the portion to the right of line C—C represents the arrival of a magnetic coin, and the remaining portions represent the absence of any detectable object.

As in the embodiment shown in FIG. 3, the output signals of the filters 160 and 170 in the embodiment of FIG. 5 are respectively applied directly to one input terminal of differential amplifiers 166 and 176. The output signals of the filters 160 and 170 are also respectively applied to rectifier circuits 162 and 172. These rectifier circuits perform a function similar to the rectifier circuits 62 and 72 in the apparatus of FIG. 3, that is, they develop output signals which are proportional to the amplitude or envelope of the applied signal. These signals are represented by signal traces —V and +V in FIGS. 6a and 6c. As can be seen in FIGS. 6a and 6c, the output signals of each of the rectifier circuits 162 and 172 is normally about 10% below the level (i.e. amplitude) of the output signal of the associated filter. However, when the output signal level of either filter drops as a result of the arrival of a conductive object between inductors 32 and 34, it takes a short time for the output signal of the associated rectifier to adjust to a level 10% below the new filter output signal level. If the new filter output signal level is below the former level of the output associated rectifier circuit output signal, the rectifier output signal level will be greater than the filter output signal level for an interval of time $t_{24}$ or $t_{25}$, respectively. This causes the periodic spikes in the output signal of the associated differential amplifier 166, 176 to cease temporarily (see FIGS. 6b and 6d). As in the embodiment shown in FIG. 3, this causes the output signal of the associated rectifier circuit 168, 178 to change level after a time interval $t_{24}$ or $t_{25}$ (see FIGS. 6e and 6f).

The remainder of the circuit shown in FIG. 5 is substantially identical to the corresponding portion of FIG. 3. Thus if the output signal of the rectifier circuit 178 changes to the logic 1 state and the output signal of the rectifier circuit 168 remains in the logic 1 state, the NAND gate 180 produces an output signal which (after a delay $t_{25}$ imposed by delay unit 182) activates the start gate solenoid 42 and the coin identifying circuit 44 (see FIG. 6g between lines A—A and B—B). As in the embodiment shown in FIG. 3, the rectifier circuit 168 responds more rapidly than the rectifier circuit 178 (i.e. $t_{24}$ is greater than $t_{11}$) so that if both signals change level (as in the portion of FIG. 6 to the right of line C—C) indicating the arrival of a magnetic coin, the output signal level of rectifier circuit 168 changes level to logic 0 first, thereby blocking the NAND gate 180 and preventing a gate open command signal when the output signal of rectifier circuit 178 changes level to logic 1.

In the third embodiment shown in FIG. 7, elements having the same reference number, apart from the prefix, as elements in FIGS. 3 or 5 are generally similar. In FIG. 7 each of two differential amplifiers 266 and 276 basically compares two rectified versions of the output of filters 260 and 270. Reference signals are generated by devices 262, 264 and 272, 274 and applied to one input terminal of the amplifiers 266 and 276. Accordingly, the leads 37 and 39 shown in broken lines in FIG. 2 are not needed and can be omitted when receiver circuit 40 is constructed as shown in FIG. 7. Rectifier circuits 262 and 272 are characterised by response time constants $t_{24}$ and $t_{25}$ respectively. Rectifier circuit 263 (generally similar to rectifier circuit 262 but with a shorter response time constant $t_{24}$) produces a second rectified version of the output signal of low pass filter 260 which is applied to the remaining input terminal of amplifier 266. The two signals applied to the amplifier 266 are represented by the signal traces shown in FIG. 8a. Again, the portion of FIG. 8 between lines A—A and B—B represents the presence of a conductive, non-magnetic coin, the portion of FIG. 8 to the right of line C—C represents the presence of a magnetic coin, and the remaining portions of FIG. 8 represent the absence of any detectable object. The reference signal applied to the amplifier 266 (the dotted signal trace in FIG. 8a) is normally adjusted to a level slightly below the level of the output signal of the rectifier 263 by the voltage divider 264. This condition is illustrated to the left of line C—C in FIG. 8a. The slight damping of the output signal of the low pass filter 260 when a conductive, non-magnetic coin is interposed between the inductors 32 and 34 is not sufficient to cause the output signal of the rectifier 263 to fall below the reference signal level. As long as the output signal of the rectifier 263 is below the reference signal level, the output signal of amplifier 266 (shown in FIG. 8b) remains strongly negative. This negative signal is blocked by a diode 267. Significant damping of the output signal of low pass filter 260 (as the result, for example, of the appearance of a magnetic coin between the inductors 32 and 34) causes both signals applied to the amplifier 266 to drop (as in the portion of FIG. 8a to the right of line C—C). However, because $t_{24}$ is greater than $t_{25}$, the output signal of the rectifier 263 drops more rapidly, causing it to momentarily fall below the reference signal level. This causes the output signal of the amplifier 266 to change.
to a positive polarity as shown in FIG. 8b, applying a strongly positive signal to one input terminal of a signal adder 269.

In the high frequency section of the apparatus shown in FIG. 7, a rectifier circuit 273 (similar to the rectifier 272 but with a shorter response time constant $\tau_{272}$) produces a second rectified version of the output signal of the high pass filter 270 which is added to the output signal of the low frequency section by the signal adder 269. An amplifier 276 compares the output signal of the adder 269 to the reference signal generated by the devices 272, 274 as described above. (The two signals applied to amplifier 276 are represented by the signal traces shown in FIG. 8c, the dotted signal trace represents the reference signal). As long as the output signal of the amplifier 266 is negative, that signal has no effect on the output signal of the rectifier 273. The amplifier 276 therefore compares directly the output signal of rectifier 273 with the reference signal level produced by the devices 272, 274. By virtue of the voltage divider 274, this reference signal level is normally slightly below the output signal level of the rectifier 273 (as in the portion of FIG. 8c to the left of line A—A). When a conductive, non-magnetic coin is introduced into the coin mechanism, both signals applied to the amplifier 276 drop. However, because $\tau_{272}$ is greater than $\tau_{274}$, the output signal of rectifier 273 drops more rapidly, causing that signal to momentarily fall below the reference signal level (see the portion of FIG. 8c between lines A—A and B—B). Since there is no change in the output signal of the low frequency section, this reversal of signal levels in the high frequency section is detected by the amplifier 276. The output signal of the amplifier 276 (shown in FIG. 8d) therefore changes from negative to positive. This positive pulse is applied to a delay unit 282 as a gate open command signal. After a suitable delay, $\tau_{282}$, this signal is used to activate the start gate solenoid 42 and coin recognition circuit 44.

If a magnetic coin is introduced into the coin mechanism, similar events occur in the high frequency section of the apparatus. However, the strongly positive output signal of the low frequency section applied to the signal adder 269 keeps the signal applied to the associated input terminal of the amplifier 276 above the reference signal level applied to the other input terminal of the amplifier 276 (see the portion of FIG. 8c to the right of line C—C). This keeps the output signal of the amplifier 276 negative and prevents the apparatus from producing a gate open command signal. For this purpose, the response time of the low frequency section of the apparatus is preferably less than that of the high frequency section. Even after the disappearance of the positive signal from the low frequency section, the level of signal applied to the positive terminal of the amplifier 276 remains above the corresponding reference signal level and no gate open command signal is produced. The magnetic coin is removed from the coin mechanism by operation of the coin reject lever mentioned above.

It will be understood that the embodiments described herein are illustrative of the invention only and that various modifications can be made by those skilled in the art without departing from the scope of the invention. For example, although low and high frequencies of 50 to 60 Hz and 70 KHz, respectively, have been mentioned, it will be understood that any frequencies selected in accordance with the criteria set forth above can be used instead of those frequencies. With the low frequency reference signal level set approximately 20% below the received signal amplitude in the absence of any detectable object, all highly conductive objects are effectively transparent (i.e. do not cause the received signal amplitude to fall below the reference signal amplitude) for low frequencies in the range from about 25Hz to about 125 Hz. The very small Dutch nickel ten-cent coin (DFl.), 10) causes slightly less than threshold damping of the low frequency signal throughout this frequency range and is therefore identified as an acceptable coin. A 2.6 mm. thick copper disc is also identified as acceptable. With the high frequency reference signal set approximately 20% below the received signal amplitude in the absence of any detectable object, the high frequency section may be operated at frequencies above about 40 KHz. At this and higher frequencies a cupro-nickel Swiss half franc causes slightly more than threshold damping of the high frequency signal and is identified as acceptable. Different threshold limits and coin detection requirements may, of course, allow other low and high frequencies to be used.

What we claim is:

1. Apparatus for sensing the arrival of a coin in a coin handling mechanism and for producing an output signal when the coin is of an acceptable type of material comprising: transmitting means including at least one transmitting inductor, for generating an oscillating magnetic field having components of two substantially different frequencies; receiving means including at least one receiving inductor for detecting a magnetic field produced by said transmitting means for detecting the amplitude of said components at the location of said receiving inductor; means for guiding a coin between the transmitting and receiving inductors so that a substantial portion of the magnetic field is received by said receiving inductor is transmitted through the coin; and means for comparing the amplitudes of the components detected by the receiving means with the corresponding amplitudes for coins of an acceptable type of material and for producing an output indicative of the arrival of a coin of an acceptable type of material when the detected amplitudes of both components correspond substantially to the amplitudes for a coin of an acceptable type of material.

2. Apparatus according to claim 1 in which the transmitting means comprise an inductor core wound with two coils, the coils being connected to respective oscillator circuits oscillating at the said two different frequencies.

3. Apparatus according to claim 1 in which the receiving means includes high and low pass filters connected to the inductor for isolating the higher and lower frequency components.

4. Apparatus according to claim 1 in which the comparing means include two comparators, a first comparator connected to the receiving means for comparing the detected amplitude of the high frequency component with the output of a first reference signal generator the first comparator producing an output signal if the said detected amplitude so deviates from the reference signal as to correspond to the signal for a conductive coin, and a second comparator connected to the receiving means for comparing the detected amplitude of the lower frequency component with the output of a second reference signal generator, the second comparator producing an output signal if the detected amplitude so deviates from the reference signal as to correspond to the signal for a ferromagnetic coin, and com-
Apparatus according to claim 4 in which the said output signal of the first comparator corresponds to a logical value of 1 and the said output signal of the second comparator corresponds to a logical value 0, and the combinatorial means comprise a NAND gate, the NAND gate producing its output signal only if the signals from both comparators have a logical value 1.

Apparatus according to claim 4 in which the combinatorial means is adapted to combine the said output signal from the second comparator with the detected higher component to prevent it so deviating from the reference signal when a conductive ferromagnetic coin is present that the first comparator provides its output signal.

Apparatus according to any of claim 4 in which the reference signal generators are connected to the transmitting means to derive the reference signals from the currents that produce the high and low frequency magnetic fields.

Apparatus according to claim 4 in which the reference signal generators are connected to the receiving means to derive the reference signals from the high and low frequency components.

Apparatus according to claim 2 in which the receiving means includes high and low pass filters connected to the inductor for isolating the higher and lower frequency components.

Apparatus according to claim 10 in which the comparing means include two comparators, a first comparator connected to the receiving means for comparing the detected amplitude of the high frequency component with the output of a first reference signal generator, the first comparator producing an output signal if the said detected amplitude so deviates from the reference signal as to correspond to the signal for a ferromagnetic coin, and a second comparator connected to the receiving means for comparing the detected amplitude of the lower frequency component with the output of a second reference signal generator, the second comparator producing an output signal if the detected amplitude so deviates from the reference signal as to correspond to the signal for a ferromagnetic coin, and the combinatorial means for providing the output signal for the comparing means only when the first comparator is producing its output signal and the second comparator is not producing its output signal.

Apparatus according to claim 3 in which the second comparator is adapted to respond more quickly to the presence of a ferromagnetic coin than the second coin responds to the presence of a conductive coin.

Apparatus according to claim 2 in which the comparing means include two comparators, a first comparator connected to the receiving means for comparing the detected amplitude of the high frequency component with the output of a first reference signal generator, the first comparator producing an output signal if the said detected amplitude so deviates from the reference signal as to correspond to the signal for a conductive coin, and a second comparator connected to the receiving means for comparing the detected amplitude of the lower frequency component with the output of a second reference signal generator, the second comparator producing an output signal if the detected amplitude so deviates from the reference signal as to correspond to the signal for a ferromagnetic coin, and the combinatorial means for providing the output signal for the comparing means only when the first comparator is producing its output signal and the second comparator is not producing its output signal.

Apparatus according to claim 13 in which the second comparator is adapted to respond more quickly to the presence of a ferromagnetic coin than the second coin responds to the presence of a conductive coin.

Apparatus according to claim 5 in which the said output signal of the first comparator corresponds to a logical value of 1 and the said output signal of the second comparator corresponds to a logical value 0, and the combinatorial means comprise a NAND gate, the NAND gate producing its output signal only if the signals from both comparators have a logical value 1.

Apparatus according to claim 5 in which the combinatorial means is adapted to combine the said output signal from the second comparator with the detected higher component to prevent it so deviating from the reference signal when a conductive ferromagnetic coin is present that the first comparator provides its output signal.

Apparatus according to claim 11 in which the said output signal of the first comparator corresponds to a logical value of 1 and the said output signal of the second comparator corresponds to a logical value 0, and the combinatorial means comprise a NAND gate, the NAND gate producing its output signal only if the signals from both comparators have a logical value 1.

Apparatus according to claim 13 in which the said output signal of the first comparator corresponds to a logical value of 1 and the said output signal of the second comparator corresponds to a logical value 0, and the combinatorial means comprise a NAND gate, the NAND gate producing its output signal only if the signals from both comparators have a logical value 1.

Apparatus according to claim 11 in which the combinatorial means is adapted to combine the said output signal from the second comparator with the detected higher component to prevent it so deviating from the reference signal when a conductive ferromagnetic coin is present that the first comparator provides its output signal.

Apparatus according to claim 13 in which the combinatorial means is adapted to combine the said output signal from the second comparator with the detected higher component to prevent it so deviating from the reference signal when a conductive ferromagnetic coin is present that the first comparator provides its output signal.

Apparatus according to claim 5 in which the reference signal generators are connected to the transmitting means to derive the reference signals from the currents that produce the high and low frequency fields.

Apparatus according to claim 5 in which the reference signal generators are connected to the receiving means to derive the reference signals from the currents that produce the high and low frequency components.

Apparatus according to claim 6 in which the reference signal generators are connected to the transmitting means to derive the reference signals from the currents that produce the high and low frequency magnetic fields.
24. Apparatus according to claim 6 in which the reference signal generators are connected to the receiving means to derive the reference signals from the high and low frequency components.

25. Apparatus according to claim 7 in which the reference signal generators are connected to the transmitting means to derive the reference signals from the currents that produce the high and low frequency magnetic fields.

26. Apparatus according to claim 7 in which the reference signal generators are connected to the receiving means to derive the reference signals from the high and low frequency components.

27. Apparatus according to claim 17 in which the reference signal generators are connected to the transmitting means to derive the reference signals from the currents that produce the high and low frequency magnetic fields.

28. Apparatus according to claim 17 in which the reference signal generators are connected to the receiving means to derive the reference signals from the high and low frequency components.

29. Apparatus according to claim 18 in which the reference signal generators are connected to the transmitting means to derive the reference signals from the currents that produce the high and low frequency magnetic fields.

30. Apparatus according to claim 18 in which the reference signal generators are connected to the receiving means to derive the reference signals from the high and low frequency components.

31. Apparatus according to claim 19 in which the reference signal generators are connected to the transmitting means to derive the reference signals from the currents that produce the high and low frequency magnetic fields.

32. Apparatus according to claim 19 in which the reference signal generators are connected to the receiving means to derive the reference signals from the high and low frequency components.

33. Apparatus according to claim 20 in which the reference signal generators are connected to the transmitting means to derive the reference signals from the currents that produce the high and low frequency magnetic fields.

34. Apparatus according to claim 20 in which the reference signal generators are connected to the receiving means to derive the reference signals from the high and low frequency components.

* * * * *
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,918,563
DATED : November 11, 1975
INVENTOR(S) : Guustaaf Arthur Schwippert and Wouter Smits

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 2, line 26, after "frequency" insert a period --.--.
Col. 3, line 27, after "track" delete "it passes".
Col. 5, line 21, after "(d.c." insert a close parenthesis --).--.
Col. 10, line 62 (claim 4) "coil" should be --coin--.
Col. 11, line 23 (claim 8) after "according to" delete "any of".

Signed and Sealed this
sixteenth Day of March 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks