The novel electronic metal coin analyzer disclosed wherein a coin to be analyzed falls through an inductance coil which is coupled to the resonance circuit of an oscillator. As the coin falls through the coil, a dynamic change in inductance is produced in the coil, and a resultant dynamic change of operating frequency of the oscillator occurs. Specifically, for each coin, a band or plurality of frequencies will be generated as the coin drops through the coil. These frequency signals are further processed through a plurality of band pass filters, one band pass filter for each different type of coin, and serve to actuate a relay-operated coin deflector only if the signals are originated by a coin for whose acceptance the device is pre-set.

5 Claims, 4 Drawing Figures
Fig. 4
ELECTRONIC METAL COIN ANALYSER

BACKGROUND OF THE INVENTION

This application is a continuation-in-part of copending application Ser. No. 24,316 filed Mar. 31, 1970 now abandoned.

This invention generally relates to the electronic circuitry arts, and particularly concerns an electronic apparatus particularly adapted for analyzing metal coins.

A plurality of circuits, machines, and apparatus exist in the art for analyzing and counting metal coins. Such devices have their main field of utility in automatic vending machines, and in machines operative for the specific analysis and counting of coins. The typical prior art mechanisms serve to discern the type and validity of the coin by means of various selecters of the mechanical or electromechanical type or the basis of geometric characteristics of the coins such as the coin diameter, coin thickness, nature of the rim, whether smooth or knurled, the presence or absence of central bores, or on the basis of other physical characteristics of the coin such as weight. Such devices, however, are generally not suitable to discard counterfeit coins when, for example, the geometric characteristics of the counterfeit coin are sufficiently close to those of a genuine coin. This disadvantage of prior art mechanisms is particularly noted when the coins accepted by the machine are thereafter utilized for returning change to the user. Furthermore, such devices are subject to wear and therefore require frequent maintenance work.

Also in existence in the prior art are machines which utilize electronic selectors, rather than selecters of the mechanical or electromechanical type as above discussed. With such electronic mechanisms, the analysis of the coins is performed on the basis of determining one or more electrical characteristics of the material from which the coins are made, such as the magnetic permeability of the coin, or its electrical conductivity. Yet, the typical electronic device currently available in the art has the inconvenience of requiring an individual channel for each type of coin which the machine must be able to accept. Typical of this type of prior art electronic selector is that depicted in the Turillon U.S. Pat. No. 3,317,016 wherein a coin is dropped into the center of an inductance coil so as to vary the inductance thereof by a predetermined amount, this inductance variation producing a specified shift in the frequency generated by an oscillator coupled to the inductance coil.

SUMMARY OF THE INVENTION

As should be apparent, a need exists in this art for an apparatus which can recognize and select different types of coins, as well as separate good coins from counterfeit coins, on the basis of measurements of electrical and magnetic parameters which are characteristic of the coins, and which apparatus does not suffer from the disadvantages of the prior art as above discussed. It is the primary objective of the instant invention to provide such a machine which fills this need.

A further, more specific, yet equally important objective of the instant invention concerns the provision of an electronic device for the recognition or discernment of various types of coins while they drop in a free fall, without stopping within a single passage. As can be appreciated, such an electronic device would have great utility in automatic vending machines and in machines for the specific analysis and counting of coins.

These objects, as well as others which will become apparent as the description proceeds, are implemented by the instant invention in which the reading device essentially comprises a channel of plastic material around which a coil of copper wire is wound. The coins to be discerned are introduced into the device and fall freely through the channel under the influence of gravity. As such coins fall through the zone of the channel around which the coin is wound, a variation of the electromagnetic characteristics of the medium surrounded by the coil is therefore obviously produced and, thereby, a variation of inductance in the coil is evident.

This inductance variation of the coil takes place in what is termed a "dynamic" fashion in that, as the coin freely falls, a plurality of instantaneous different inductance changes takes place. Specifically, and in the event that the coin dropped has ferromagnetic characteristics, an increase in instantaneous inductance of the coil is noticed beginning from the initial inductance of the coil and gradually increasing so as to reach a maximum change of inductance at the instant wherein the coin is in the center of the coil. As the coin continues to fall, the inductance change of the coil decreases in like manner. Similarly, and for non-ferromagnetic coins, there prevails instead an effect of electrical conductivity and, in this event, a negative variation of inductance is produced due to losses caused by the Joule effect and the film effect. Importantly, however, the inductance variations of the coin for both the ferromagnetic or non-ferromagnetic coin is dynamic in that it continuously changes as the coin drops therethrough. Further, it should be appreciated that for both basic types of coins, for any given type of coin material, the variations in the absolute magnitude of coil inductance obtained is further a function of the geometric dimensions of the coins themselves.

The instant invention, therefore, is characterized by the fact that it comprises but a single channel for the introduction of coins of the various types and the utilization therewith of but a single reading device which is capable of identifying a given coin which is freely falling therethrough on the basis of inductance variations, as to the absolute value and design, of the reading coil.

In the preferred embodiment of the instant invention, the selector is characterized by the fact that the reading coil forms part of a resonant circuit of an oscillator having a "rest" frequency on the order of magnitude of 70 kHz. In this fashion, an instantaneous variation of the output frequency of the oscillator will occur due to each instantaneous change in inductance of the reading coil. Thus, for the instantaneous inductance variation of the coil associated with each point of the reading channel as the coin passes therethrough, there corresponds an instantaneous frequency variation of the oscillator. Thus, as a single coin drops through the coin channel and thus through the reading coil, a plurality of different frequencies will be generated by the oscillator, this plurality of frequency variations lying within a specific band of frequencies as predetermined for each different type or denomination of coin, and it is this band of frequencies generated for each coin which constitutes the signal for subsequently actuating the ana-
lyzing circuitry of the invention. This generation of a plurality of different frequencies by each coin passing through the coil in a free fall is an important aspect of the instant invention, as will be appreciated from the detailed description thereof hereinbelow.

So that the apparatus of the instant invention can be operated to discern and analyze a plurality of different coin types, such as different denominations of coins, the preferred embodiment of the instant invention comprises an analyzer or selector which is furthermore characterized by the act that the output of the oscillating circuit is applied to a certain number N of parallel circuits, equal to the number N of the coins of different types or denominations which the device is intended to discern. Each of these subsequent circuits are essentially formed by a band pass filter and by a suitable detector device. Each band pass filter has a pass band which corresponds to the band of frequencies caused to be generated by a different type of denomination of coin.

Thus, the output of the final signal detector device of the overall circuit serves to provide a signal identifying the type of coin, i.e., a signal which is present when and only when a coin associated to the specific circuit is falling through the coil. Accordingly, if a coin of a particular type or denomination associated with circuit number 2 is introduced into the coin slot and falls through the coil, the instantaneous frequencies of the oscillator will shift and be such that the plurality of frequencies generated by the oscillator due to the passage of this single coin merely involves or comprises the frequency band of the filter relating to circuit number 2. Consequently, there will be present an identifying signal at the output of the circuit, while none will be present at the output of the other parallel circuits.

For proper operation of the device, no identification signal must be present in the output of the individual circuits during the passage of a coin which does not belong to the group of N coins for which the selector has been pre-set. This correct operation is obtained merely through a suitable selection of the band width of the individual filters, this band width being correlated with the band of frequencies generated by the falling of each acceptable type of coin, as well as a suitable selection of the reciprocal positions or difference of these bands along the frequency scale.

The identification signals issuing from each single channel contain the necessary information for operation of the coin selection device, and for the operation of the device which accepts the coins which are considered genuine and which refuses those coins which are considered counterfeit. These signals passing through the individual band pass filters control a suitable processing and counting network and simultaneously are fed into the input of an OR circuit. If a coin which is considered genuine is introduced into the selector, a signal having the logical value 1 will be present as the output of one of the N parallel circuits, and therefore at the output of the OR circuit, a signal having the logical value 1 will be present. In case the coins are considered counterfeit, all of the N inputs of the OR circuit would have the logical value 0, i.e., an absence of a signal and likewise, the output of the 0 signal will have the logical value 0.

Therefore, the output from the OR circuit is adapted to control an exchange device for cashing the coins which are considered genuine and for refusing those coins which are considered counterfeit. In this respect, it should further be appreciated that the duration of the signal which presents itself at the output of the filter belonging to the general circuit is proportional to the time interval during which the instantaneous frequencies generated by the oscillator due to a single falling coin lies within the pass band of the filter. The subsequent detector circuit is designed to provide an output signal of well defined amplitude and duration only when the time interval of the input signal thereto exceeds a suitable limit value. By this time discrimination, the discernment of coins, such as counterfeit coins, is permitted even if the coins produce frequency variations of the same type, i.e. same size and similar absolute value, as a genuine coin since such frequency variations undoubtedly would not occur with a counterfeit coin for the same time interval as would be the case if the coin were genuine. This feature essentially provides discrimination as to coin size.

As concerns this time discrimination function, it should further be appreciated that the output of an individual filter will have a signal which is sufficiently long to be considered valid by the following detecting device only when the instantaneous frequency generated by the oscillator falls within and near the center of the pass band of one of the pass band filters at the moment wherein the falling coin is in the center of the reading coil. This manner of operation is assured through suitable selection of the time interval detection circuitry in association with the width and absolute value of the pass band filters as will appear hereinbelow.

The analyzer forming the subject matter of the instant invention can readily be pre-set for any type of coin since it is merely necessary to adapt a filter having a suitable pass band relating to the type of coin to enable the selector to recognize and count the coin.

Furthermore, the instant invention is capable of assessing the coins without need for stopping the travel of the coins in the reading coil. In other words, the coins are neither touched nor hindered during their free fall through the coil and the selector is sufficiently quick in its response to ascertain the passage of two or more coins introduced in succession and even in contact with each other in said selector.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be better understood and further features and advantages thereof will become apparent from the following detailed description of the preferred inventive embodiment, such description making reference to the attached drawings wherein:

FIG. 1 is a sectional view according to line 1—1 of FIG. 2 schematically representing the selector layout,

FIG. 2 is a cross-sectional view according to line II—II of FIG. 1,

FIG. 3 is a vertical sectional view according to line III—III of FIG. 1, and

FIG. 4 is a complete block diagram of the selector.

DETAILED DESCRIPTION OF THE PREFERRED INVENTIVE EMBODIMENT

Reference is now made to FIGS. 1—3 and particularly to FIG. 1 wherein it should be noted that the coins are introduced through a calibrated slot 10 or through
other known pre-selection means which prevent the introduction of coins which are bent, twisted, or having sizes exceeding those of the maximum coin size admitted, which could remain blocked within the device. The coins pass first through an entrance passage 12 having a rectangular cross-section, which can also be made from metallic material. Through the passage 12 the coins are fed to the reading device, generally indicated at 14, which comprises a conduit 16, made of electrically insulating and non-magnetic material, having also a rectangular cross-section. The conduit 16 is provided with a housing 18 for a reading coil 20, which is connected by means of a flexible wire (not shown) to the resonant circuit of an oscillator whose frequency it determines. Beneath the reading device 14 there extends a third conduit 22, which can also be made from metallic material. Conduit 22 has a housing 24 for a deflector 26, controlled by an electromechanical relay 28. In the location of the deflector the conduit 22 branches into two channels of a similarly rectangular section, which are directed into two different directions: the first, indicated at 30 in FIG. 1, conveys the good coins towards a cash box, while the second, indicated at 32, forms an inclined branch which directs the rejected coins towards the coin returning door of the vending machine.

FIG. 3 shows how in the preferred embodiment the deflector 26, in its rest or inoperative position, is positioned so as to convey the coins introduced through the slot 10 towards the coin restoring channel 32. This ensures that, in the case of failure of the device or in the absence of a feed voltage, any coin, whether good or counterfeit, is directly restored without the need of any additional moves.

Only when the device operates correctly and the introduced coin has been recognized as good and computed by the reading device 14, at the end of relay 28 a control pulse is present which, by actuating the deflector 26 causes the coin to be switched into the channel 30.

The block diagram of FIG. 4 shows a preferred form of circuit for the selector. The reading coil 20 is connected to the resonant circuit which determines the oscillating frequency of the oscillator 34, whose output is connected either directly, or, as it will be illustrated, through a block 52, in parallel to the input of a plurality of pass band filters F1 (r being = 1, 2, ... N) N being the number of coin denominations which the device must be capable of checking.

The output of each filter is connected to a detector device DR, essentially consisting, as far as the electrical functions are concerned, of an amplifier 36 for the filter signals, of a rectifying circuit 38 for the amplified signals, and of a relay 40. The detector device further functions as a time discriminator in that no output will be produced unless the time duration of the input was sufficiently long. This may be structurally achieved in various known manners, such as by the provision of a capacitor charging element and a discharge or breakdown device coupled to the rectifier output. The outputs of the various detecting devices control, through the connections 42, the successive counting circuit for the good coins and furthermore control in parallel a logical OR circuit, indicated at 44 in FIG. 4, whose output supplied a pulse when a pulse is present on one of the inputs. This latter pulse control through a monostable circuit 46, the relay 28 which actuates the deflector 26.

When a good coin 48, after having been introduced through slot 10, passes through the zone of the reading coil 20, this coin will produce a plurality of instantaneous variations in the inductance of the coil as above-described, so as to cause the oscillator 34 to generate a plurality of instantaneous frequencies. This plurality of instantaneous frequencies generated could correspond with the pass band of filter F1, which is provided for the particular type of coin introduced. Accordingly, this signal will pass through the filter and the filter will have an output therefrom which has a time duration which is sufficiently long to actuate the detecting device whose output will supply a signal having a logical level 1. At this point, it should be understood that the instantaneous frequencies generated by the oscillator due to the passage of a coin will have a bandwidth on the order of tens of thousands of Hz in the preferred inventive embodiment simply through selection of coil and oscillator parameters. Due to this wide band of frequencies generated for each coin, discrimination between the various types of coins can be made in a considerably more facile manner. This is another advantage of the "dynamic" frequency generation aspect of the instant invention.

Continuing, if the output from the detecting device has the logical level 1, this signal will actuate the coin counting device by means of connections 42. The same signal will also actuate relay 28 so as to switch the deflector 26 about its pivot 50 so as to close the entrance to the coin restoring channel 32, and so as to open the entrance of the channel 30 for a time which is sufficiently long to ensure the passage of the computed coin. Immediately thereafter, the relay 28 will revert to its inoperative position and the deflector 26 will again close the access to channel 30.

In order to simplify the design of the pass band filters and as to bring them to operate in a lower field of frequencies, between the output of the oscillator 34 and the input of the pass band filters a block 52 can be inserted, comprising a modulator which is piloted by a fixed frequency oscillator. Thereby, at the output of block 52 a signal can be obtained, whose frequency is smaller than the input frequency, and is equal to the difference between the frequency of the fixed oscillator and the frequency of the variable oscillator. Since the absolute frequency deviations of the variable oscillator are integrally rendered as absolute frequency deviations at the output of the modulator, while, on the other hand, the percent frequency deviations at the output of the modulator are increased, it is clear that also the ease of filtration increases, since it is based upon the percent frequency deviations and not on the absolute frequency deviations.

It is also possible to apply a plurality of the device just described to the same machine to control the same deflector, so that the coins dropped into the slot 10 will pass in succession through them. In this manner the selection can occur through a number of independent reading devices, to each being entrusted the task of identifying only one part of the group of N coins of different denominations which the selector must recognize and discern. For this purpose it is sufficient to connect each reading coil to an own oscillator followed by the assembly of filters and detecting circuits. By establishing the frequency of the various oscillators in a suit-
able manner, such an arrangement permits to adopt, for each group of coins assigned to a given reading device, that frequency at which the maximum percent frequency variations are obtained for those types of coins, so as to simplify the problems relating to the filtration.

In summary, then, it should be appreciated that the instant invention as described operates in an entirely different manner than the operation associated with the prior art, in that a true "dynamic" operation is effected. When a coin passes by the sensing inductance coil 20, a plurality of different variations of inductance of the coil takes place which causes the controllable oscillator means 34, which oscillator normally generates a given or rest output frequency, to vary its operating or output frequency from the given frequency to a plurality of selectively different frequencies, i.e., an entire band of frequencies for each coin. This band of frequencies is characterized and corresponds to a coin of one denomination or type. If a different type of coin passes by the inductance coil 20, the output from the oscillator 34 would exhibit a different band of frequency components. A plurality of detecting circuits coupled in parallel comprising band pass filters are connected to the output of the oscillator and each of these filters have a different pass band which corresponds to the bands of selectively different oscillator frequencies originated by each respective different type of "acceptable" coin. If any one of the filters exhibits an output then this indicates that proper instantaneous frequencies were generated by the oscillator. If the output occurs over a sufficient time duration, this fact, in addition to the proper frequency characteristics, is indicative of the presence of an "acceptable" coin and the coin deflection means is likewise actuated.

It is obvious that many and different variants and changes may be applied by the experts in the art to the above-illustrated preferred form of embodiment of the present invention, without departing from its spirit and scope, it being understood that all these variants and changes are encompassed within the scope of the invention.

What we claim is:

1. An electronic coin analyzing device for screening types of coins acceptable to a vending machine from coins not acceptable to a vending machine, said device comprising:
   a coin channel;

2. An inductance coil surrounding said coin channel; controllable oscillator means coupled to said inductance coil for normally generating a given output frequency, the output frequency of said oscillator means being varied from said given frequency to a plurality of other selectively different instantaneous frequencies within a band in accordance with instantaneous inductance variations in said coil caused by the falling of a coin therethrough; a deflector to cash in acceptable coins and to refund the non-acceptable coins; a plurality of filter means coupled in parallel to said oscillator, each of said filter means having a pass band which corresponds to the band of selectively different instantaneous oscillator frequencies originated by a respective type of acceptable coin, the pass bands of each filter being different to correspond to each respective different type of acceptable coin; and means coupled to each pass band filter and responsive to the output thereof for processing signals transmitted therethrough and for actuating said coin deflector, said means being responsive to the time duration of each such output.

3. A device as defined in claim 1, wherein a modulator coupled to a fixed frequency oscillator is inserted between said oscillator means and the pass band filter means, the output of said controllable oscillator means comprising a modulating frequency for modulating the output of said fixed frequency oscillator, said modulated output of said fixed frequency oscillator comprising the input to the pass band filter means.

4. A device as defined in claim 3, wherein said means processing signals transmitted through each pass band filter comprise, for each filter, a detector unit interposed between said filter and said deflector, each detector unit comprising a rectifying circuit, an amplifying circuit, and a relay connected in series to each other.

4. A device as defined in claim 3, wherein said means processing said signals additionally comprise an OR signal connected to all relays of the detector unit, a monostable circuit series connected to said OR circuit, and a deflector actuating relay series connected to said monostable circuit.

5. A device according to claim 3, wherein the output of each detector unit is series connected to a coin counting device.