(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 155 126 B2

(12) NEW EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the opposition decision:
**11.07.2001 Bulletin 2001/28**

(45) Mention of the grant of the patent:
**27.02.1991 Bulletin 1991/09**

(21) Application number: **85301409.0**

(22) Date of filing: **01.03.1985**

(51) Int Cl.7: **G07D 5/08**

# (54) Self tuning coin recognition system

Selbstabstimmendes Münzerkennungssystem

Système à auto-accordement pour la reconnaissance de pièces de monnaie

(84) Designated Contracting States:
**AT BE CH DE FR GB IT LI LU NL SE**

(30) Priority: **01.03.1984 US 585253**

(43) Date of publication of application:
**18.09.1985 Bulletin 1985/38**

(73) Proprietor: **MARS, INCORPORATED**
**McLean, Virginia 22101-3883 (US)**

(72) Inventor: **Heiman, Frederic P.**
**Los Gatos California 95030 (US)**

(74) Representative: **Burke, Steven David et al**
**R.G.C. Jenkins & Co.**
**26 Caxton Street**
**London SW1H 0RJ (GB)**

(56) References cited:
**EP-A- 0 017 370**
**EP-A- 0 058 094**
**EP-A- 0 060 392**
**EP-A- 0 072 189**
**EP-A- 0 101 276**
**WO-A-80/01963**
**DE-A- 3 103 371**
**DE-A- 3 345 252**
**DE-B- 2 612 613**
**GB-A- 1 397 083**
**GB-A- 1 482 417**
**GB-A- 2 038 062**
**GB-A- 2 087 548**
**GB-A- 2 132 805**
**US-A- 3 918 565**

- **Webster's Seventh New Collegiate Dictionary, G. & C. Merriam Company, Springfield, Massachusetts (US), 1971; pages 546 and 930**

EP 0 155 126 B2

## Description

### Technical Field

**[0001]** The present invention relates to the examination of coins for authenticity and denomination, and more particularly to an adjustment-free self-tuning mechanism for coin testing.

### Background Art

**[0002]** It has long been recognized in the coin examining art that the interaction of an object with a low frequency electromagnetic field can be used to indicate, at least in part, the material composition of the object and thus whether or not the object is an acceptable coin and, if acceptable, its denomination. See, for example, U.S. Patent No. 3,059,749. It has also been recognized that such low frequency tests are advantageously combined with one or more tests at a higher frequency. See, for example, our U.S. Patent No. 3,870,137.

**[0003]** Most known electronic coin testing mechanisms require for each coin test included therein at least one tuning element and at least one tuning adjustment during the manufacturing process to compensate for components which have slightly different values within tolerance and for variations in component positioning which occur during the construction of the coin testing apparatus. For example, in a low frequency coin test apparatus employing a bridge circuit, the bridge circuit is normally tuned in the factory by placing a known acceptable coin in the test position and balancing the bridge.

**[0004]** It is known, eg. from US-A-3918565, EP-A-0101276 and DE-A-3103371, to avoid problems resulting from manufacturing tolerances causing the same coin to produce different test results in different mechanisms by employing a setting-up operation, whereby sample coins are inserted into each mechanism, measurements derived from the testing circuitry are processed to generate acceptance limits, and these acceptance limits are subsequently used in the testing of coins. In this way, the acceptance limits will be individually adapted for each mechanism.

**[0005]** It is also known, e.g. from US-A-3918565, EP-A-0017370 and EP-A-0058094, to test coins by measuring the frequency of an electro-magnetic field to which the coin is subjected, and to use as a measurement the amount by which a frequency shifts in the presence of a coin, instead of the frequency value itself. This technique reduces errors resulting from variations in the testing conditions such as the idling frequency of the coin examination oscillator.

**[0006]** An additional problem long recognized in the coin testing art is the problem of how to compensate for component aging, for changes in the environment of the coin apparatus such as temperature and humidity changes, and for similar disruptive variations which result in undesirable changes in the operating characteristics of the electronic circuits employed in the electronic coin test apparatus.

**[0007]** Retuning of the test apparatus by a service person is one known response to the problem of component aging but such retuning is expensive and provides only a temporary solution to the problem. Discrete compensation circuitry has been developed to solve the environmental compensation problem. See, for example, our published European Patent Application No. 0034887. Further, an improved transmit-receive method and apparatus has been developed which eliminates the need for tuning adjustments or discrete compensation circuitry. See our published European Patent Application No. 0110510.

**[0008]** Reference is also made to GB-A-2132805 and DE-A-3345252, both of which were published after the priority date of the present invention. These documents disclose a coin checking device for checking that inserted coins meet an acceptable criterion for a particular coin denomination (which is selectable by operation of a switch). To meet this criterion, the measurement of a coin must fall within a predetermined range of the mean value of the measurements of a plurality of previous acceptable coins. The test results for each coin are compared against only a single acceptance criterion, which is appropriate to the selected denomination.

**[0009]** WO-A-80/01963 discloses an apparatus for distinguishing test items, particularly banknotes. Each measurement of a test item is statistically processed with measurements for earlier items to calculate a mean value and a dispersion value, these being used to set limit values to determine whether a subsequently tested item is genuine.

### Disclosure of Invention

**[0010]** The present invention is defined in the accompanying claims.

**[0011]** The operation of an embodiment of the present invention may be summarized as follows. A standard set of initial acceptance limits for any coin which is to be tested, such as the U.S. 5-cent coin, is initially stored

**[0012]** These initial limits are set rather wide so that virtually 100% acceptance of all genuine 5-cent coins is assured. During factory preparation of each individual coin test apparatus, acceptable coins are inserted into the apparatus and are tested by one or more sensors. A statistical function of the parameter measured by each sensor is computed. For example, a running average of the parameter can be computed. Once a predetermined number of acceptable coins have been accepted, a new acceptance limit is automatically established by the electronic coin testing apparatus. For example, the new acceptance limits can be set at the running average plus or minus a stored, preestablished constant or a stored, preestablished percentage of the running average. Alternatively, standard initial acceptance limits are not stored and tuning is begun by transmitting an instruction signal that the apparatus is to be tuned for a particular coin such as the 5-cent coin. Then, a predetermined number of valid 5-cent coins are inserted and tested. A single test coin representative of the average 5-cent coin may be used. A statistical function is computed and acceptance limits are set based thereon. Similarly, the process is repeated for additional denominations of coins which are to be accepted. In either case, the initial factory tuning is accomplished by merely inserting a predetermined number of valid coins. Once the apparatus is commercially operational, the statistical function is continuously recomputed by the electronic coin testing apparatus as additional acceptable coins are inserted. In order to compensate for environmental changes such as a change of temperature or humidity after a large number of coins have been accepted, the coin testing apparatus reweights the computation so that the computation of the statistical function is based upon information for only a predetermined number of the most recently inserted and accepted coins.

**[0013]** The self-tuning feature of a coin testing apparatus according to the present invention has the advantage of significantly reducing the time and skill required to originally tune the coin testing apparatus in the factory, thereby reducing the costs of labor used in the manufacturing process. Further, such apparatus continuously retunes itself during normal operation thereby compensating for parameter drift and environmental changes.

## Brief Description of Drawings

**[0014]**

Fig. 1 is a schematic block diagram of an embodiment of electronic coin testing apparatus in accordance with the invention;
Figs. 2A and 2B show a detailed schematic diagram of circuitry suitable for the embodiment of Fig. 1;
Fig. 3 is a schematic diagram indicating suitable positions for the sensors of the embodiment of Fig. 1; and
Fig. 4 is a flowchart of the operation of the embodiment of Fig. 1.

**[0015]** Although the coin examining method and apparatus of this invention may be applied to a wide range of electronic coin tests for measuring a parameter indicative of a coin's acceptability and to the identification and acceptance of any number of coins from the coin sets of many countries, the invention will be adequately illustrated by explanation of its application to identifying the U.S. 5-cent coin. In particular, the following description concentrates on the details for setting the acceptance limits for a high frequency diameter test for U.S. 5-cent coins, but the application of the invention to other coin tests for U.S. 5-cent coins, such as a high frequency thickness test, and to other coins will be clear to those skilled in the art.

**[0016]** The figures are intended to be representational and are not necessarily drawn to scale. Throughout this specification, the term "coin" is intended to include 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. Furthermore, from time to time in this specification, for simplicity, coin movement is described as rotational motion; however, except where otherwise indicated, translational and other types of motion also are contemplated. Similarly, although specific types of logic circuits are disclosed in connection with the embodiments described below in detail, other logic circuits can be employed to obtain equivalent results within the scope of the claims.

## Best Mode for Carrying Out the Invention

**[0017]** Fig. 1 shows a block schematic diagram of an electronic coin testing apparatus 10 in accordance with the present invention. The mechanical portion of the electronic coin testing apparatus 10 is shown in Fig. 3. The electronic coin testing apparatus 10 includes two principal sections: a coin examining and sensing circuit 20 including individual sensor circuits 21, 22 and 23, and a processing and control circuit 30. The processing and control circuit 30 includes a programmed microprocessor 35, an analog to digital (A/D) converter circuit 40, a signal shaping circuit 45, a comparator circuit 50, a counter 55, and NOR-gates 61, 62, 63, 64 and 65.

**[0018]** Each of the sensor circuits 21, 22 includes a two-sided inductive sensor 24, 25 having its series connected coils located adjacent opposing sidewalls of a coin passageway. As shown in Fig. 3, sensor 24 is preferably of a large diameter for testing coins of wideranging diameters. Sensor circuit 23 includes an inductive sensor 26 which is preferably arranged as shown in Fig. 3.

**[0019]** Sensor circuit 21 is a high frequency low power oscillator used to test coin parameters, such as diameter and material, and to "wake up" the microprocessor 35. As a coin passes the sensor 24, the frequency and amplitude of the output of sensor circuit 21 change as a result of coin interaction with the sensor 24. This output is shaped by the shaping circuit 45 and fed to the comparator circuit 50. When the change in the amplitude of the signal from shaping circuit 45 exceeds a predetermined amount, the comparator circuit 50 produces an output on line 36 which is conected to the interrupt pin of microprocessor 35. A signal on line 36 directs the microprocessor 35 to "wake up" or in other words, to go from a low power idling or rest state to a full power coin evaluation state. In a preferred embodiment, the electronic coin testing apparatus 10 may be employed in a coin operated telephone or other environment in which low power operation is very important. In such environments, the above described wake up feature is particularly useful. The above described "wake up" is only one possible way for powering up upon detecting coin arrival. For examples a separate arrival detector could be used to detect coin arrival and wake up the microprocessor.

**[0020]** The output from shaping circuit 45 is also fed to an input of the A/D converter circuit 40 which converts the analog signal at its input to a digital output. This digital output is serially fed on line 42 to the microprocessor 35. The digital output is monitored by microprocessor 35 to detect the effect of a passing coin on the amplitude of the output of sensor circuit 21. In conjunction with frequency shift information, the amplitude information provides the microprocessor 35 with adequate data for particularly reliable testing of coins of wideranging diameters using a single sensor 21.

**[0021]** The output of sensor circuit 21 is also connected to one input of NOR gate 61 the output of which is in turn connected to an input of NOR gate 62. NOR gate 62 is connected as one input of NOR gate 65 which has its output connected to the counter 55. Frequency related information for the sensor circuit 21 is generated by selectively connecting the output of sensor circuit 21 through the NOR gates 61, 62 and 65 to the counter 55. Frequency information for sensor circuits 22 and 23 is similarly generated by selectively connecting the output of either sensor circuit 22 or 23 through its respective NOR gate 63 or 64 and the NOR gate 65 to the counter 55. Sensor circuit 22 is also a high frequency low power oscillator and it is used to test coin thickness. Sensor circuit 23 is a strobe sensor commonly found in vending machines. As shown in Fig. 3, the sensor 26 is located after an accept gate 71. The output of sensor circuit 23 is used to control such functions as the granting of credit, to detect coin jams and to prevent customer fraud by methods such as lowering an acceptable coin into the machine with a string.

**[0022]** The microprocessor 35 controls the selective connection of the outputs from the sensor circuits 21, 22 and 23 to counter 55 as described below. The frequency of the oscillation at the output of the sensor circuits 21, 22 and 23 is sampled by counting the threshold level crossings of the output signal occurring in a predetermined sample time. The counting is done by the counter circuit 55 and the length of the predetermined sample time is controlled by the microprocessor 35. One input of each of the NOR gates 62, 63 and 64 is connected to the output of its associated sensor circuit 21, 22 and 23. The output of sensor 21 is connected through the NOR gate 61 which is connected as an inverter amplifier. The other input of each of the NOR gates 62, 63 and 64 is connected to its respective control line 37, 38 and 39 from the microprocessor 35. The signals on the control lines 37, 38 and 39 control when each of the sensor circuits 21, 22 and 23 is interrogated or sampled, or in other words, when the outputs of the sensor circuits 21, 22 and 23 will be fed to the counter 55. For example, if microprocessor 35 produces a high (logic "1") signal on lines 38 and 39 and a low signal (logic "0") on line 37, sensor circuit 21 is interrogated, and each time the output of the NOR gate 61 goes low, the NOR gate 62 produces a high output which is fed through NOR gate 65 to the counting input of and counted by the counter 55. Counter 55 produces an output count signal and this output of counter 55 is connected by line 57 to the microprocessor 35. Microprocessor 35 determines whether the output count signal from the counter 55 and the digital amplitude information from A/D converter circuit 40 are indicative of a coin of acceptable diameter or not by determining whether the outputs of counter 55 and A/D converter circuit: 40 or a value or values computed therefrom are within stored acceptance limits. When sensor circuit 22 is interrogated, microprocessor 35 determines whether the counter output is indicative of a coin of acceptable thickness. Finally, when sensor circuit 23 is interrogated, microprocessor 35 determines whether the counter output is indicative of coin presence or absence. When both the diameter and thickness tests are satisfied, a high degree of accuracy in discrimination between genuine and false coins is achieved.

**[0023]** Fig. 2 is a detailed schematic diagram of circuitry suitable for the embodiment of Fig. 1 including the following components:

| Resistors | |
|---|---|
| $R_1$ | 820 k |
| $R_2$ | 330 k |
| $R_3$ | 43 k |
| $R_4$,$R_9$,$R_{12}$ | 3.9 k |
| $R_5$,$R_{13}$,$R_{28}$,$R_{36}$ | 1 k |
| $R_6$,$R_{14}$,$R_{18}$,$R_{21}$<br>$R_{27}$,$R_{29}$,$R_{30}$,<br>$R_{31}$,$R_{34}$,$R_{38}$ | 100 k |

(continued)

| Resistors | |
|---|---|
| $R_7$ | 510 k |
| $R_8$ | 680 k |
| $R_{10}$ | 470 k |
| $R_{11}$ | 620 k |
| $R_{15}$,$R_{26}$ | 47 k |
| $R_{16}$ | 180 k |
| $R_{17}$ | 10 k |
| $R_{20}$ | 390 k |
| $R_{22}$,$R_{23}$ | 150 k |
| $R_{24}$,$R_{37}$ | 6.8 k |
| $R_{25}$,$R_{39}$,$R_{40}$ | 1 M |
| $R_{35}$ | 1.5 k |

| Inductive Sensors | |
|---|---|
| 24 | 3.5 mH |
| 25 | 400 uH |
| 26 | 240 uH |

| Capacitors | |
|---|---|
| $C_1$,$C_2$,$C_3$,$C_4$,$C_{15}$ $C_{16}$,$C_{17}$,$C_{22}$,$C_{23}$, $C_{34}$ | .luf |
| $C_5$ | 250 pf |
| $C_6$,$C_{33}$ | 510 pf |
| $C_7$,$C_8$ | 180 pf |
| $C_9$,$C_{10}$ | 100 pf |
| $C_{11}$,$C_{12}$,$C_{13}$,$C_{18}$ | .01 uf |
| $C_{14}$,$C_{21}$, | 10 uf |
| $C_{19}$,$C_{20}$ | 30 pf |

| Diodes | |
|---|---|
| $D_1$,$D_2$,$D_3$,$D_4$,$D_5$ $D_6$,$D_7$,$D_8$,$D_9$ $D_{11}$,$D_{12}$,$D_{13}$,$D_{14}$, $D_{17}$,$D_{18}$,$D_{20}$,$D_{21}$, $D_{22}$,$D_{23}$, | 1N4148 |
| $D_{15}$,$D_{16}$ | HSCH 1001 |

| Zener Diode | |
|---|---|
| Z | 4.7V |

| Transistors | |
|---|---|
| $T_1$,$T_2$,$T_3$ | 2N5089 |
| $T_4$ | 2N3392 |
| $T_5$,$T_6$ | 2N4356 |

| Battery | |
|---|---|
| LB | Saft LB2425 3 V Lithium |

| Oscillator | |
|---|---|
| O | Murata 2MHz Ceramic Resonator |

| Comparators | |
|---|---|
| $Comp_1$, $Comp_2$ | LM2903 |

| NOR Gates | |
|---|---|
| 61,62,63,64<br>65 | National Semiconductor 4001<br>National Semiconductor 4025 |

| Counter | |
|---|---|
| 55 | National Semiconductor CD 4520B |

| Enternal Memory | |
|---|---|
| 58<br>59<br>60 | 74C244<br>27C16<br>74C373 |

| Microprocessor | |
|---|---|
| 35 | Intel 80C39. |

**[0024]** Circuit blocks and elements in Fig. 2 corresponding to blocks and elements in Fig. 1 have been similarly numbered. In the electronic coin testing apparatus 10 shown in detail in Fig. 2, the blocks 15, 16 and 17 provide an appropriate level of base current to the transistors $T_1$, $T_2$ and $T_3$ of sensor circuits 21, 22 and 23 respectively. Sensor circuit 21 is a low power oscillator circuit having an inductive sensor 24 comprising two coils connected in series and located on the opposing sidewalls 36 and 38 shown in Fig. 3. The two coils of sensor 24 have a combined inductance of approximately 3.5mH and the sensor circuit 21 oscillates at an idling frequency of approximately 170kHz. An oscillating output signal from sensor circuit 21 is taken from point A and connected through shaping circuit 45 to A/D converter 41 and comparator circuit 50. The signal at point B is the envelope of the oscillation output signal of sensor circuit 21. When the sensor circuit 21 is unaffected by coins, the amplitude of the signal at the point B is approximately 3.5 volts. As a coin approaches and then passes sensor 24, the voltage at point B decreases until the coin is centered between the coils of sensor 24 and then increases again as the coin rolls away from the sensor 24. When the voltage level at point B changes by approximately .2 volts, the comparator circuit 50 produces an output on line 36 which is fed through a NOR gate and a diode to the interrupt port of microprocessor 35 and wakes up microprocessor 35. Amplitude and frequency information for diameter testing are then generated and evaluated as discussed above.

**[0025]** Sensor circuit 22 shown in detail in Fig. 2 is also an oscillator circuit and it produces frequency test information relating to the width of a coin passing sensor 25. The oscillator shown in Fig. 2 has an inductive sensor 25 comprising two coils connected in series and located on the opposing side walls 36 and 38 shown in Fig. 3. The two coils of sensor 25 have a combined inductance of approximately 400uH and the oscillator circuit has an idling frequency of approximately 750kHz.

**[0026]** The sensor circuit 23, the strobe sensor, has its inductive sensor 26 located after a coin routing gate 71 as shown in Fig. 3. The single coil of inductive sensor 26 has an inductance of approximately 240uH and sensor circuit

23 has an idling frequency of approximately 850kHz. The strobe sensor is used to detect coin passage, to prevent coin jamming and customer fraud.

**[0027]** The microprocessor 35 is a CMOS device with its RAM power supply 80 backed up by a 3 volt lithium battery LB. This power arrangement provides for nonvolatile memory. Other devices including EEPROM and NOVRAM devices can be used to achieve the same result. As shown in Fig. 2, the three chips labeled 58, 59 and 60 constitute the external program memory. Where a microprocessor 35 is used which has sufficient internal memory, such as an Intel 80C49, the chips 58, 59 and 60 may be eliminated.

**[0028]** In a preferred embodiment, the electronic coin testing apparatus 10 is incorporated into a coin operated telephone. In this embodiment, the apparatus 10 is only powered up when the phone is off-the-hook. When the phone is lifted off the hook, each of the sensor circuits begins to oscillate. The microprocessor 35 samples and stores idling or no coin amplitude ($A_o$) and frequency ($f_o$) values for sensor circuit 21 and frequency values for sensor circuits 22 and 23. Then, the microprocessor "goes to sleep" or enters a rest or standby mode. In this mode, it consumes very little power until an interrupt signal is produced on line 36 thereby indicating that a coin has been inserted and waking up microprocessor 35. Microprocessor 35 upon being awakened is fully powered and it evaluates the information from the sensor circuits 21 and 22 and determines whether or not the detected coin is an acceptable coin.

**[0029]** The method of the present invention will now be described in the context of setting coin acceptance limits based upon the frequency information from sensor circuit 21. As a coin approaches and passes inductive sensor 24, the frequency of its associated oscillator varies from the no coin idling frequency, $f_o$, and the output of sensor circuit 21 varies accordingly. Also, the amplitude of the envelope of this output signal varies. When this latter variation exceeds a predetermined limit, the microprocessor 35 recognizes that a coin has been inserted and wakes up. Microprocessor 35 then computes a maximum change in frequency $\Delta f$, where $\Delta f$ equals the maximum absolute difference between the frequency measured during coin passage and the idling frequency. $\Delta f = \max (f_{measured} - f_o)$. A dimensionless quantity $F \Delta f/f_o$ is then computed and compared with stored acceptance limits to see if this value of F for the coin being tested lies within the acceptability range for a valid coin. As background to such measurements and computations, see U.S. Patent No. 3,918,564. As discussed in that patent, this type of measurement technique also applies to parameters of a sensor output signal other than frequency, for example, amplitude. Similarly, while the present invention is specifically applied to the setting of coin acceptance limits for particular sensors providing amplitude and frequency outputs, it applies in general to the setting of coin acceptance limits derived from a statistical function for a number of previously accepted coins of the parameter or parameters measured by any sensor.

**[0030]** If the coin is determined to be acceptable, the F value is stored and added to the store of information used by microprocessor 35 for computing new acceptance limits. For example, a running average of stored F values is computed for a predetermined number of previously accepted coins and the acceptance limits are established as the running average plus or minus a stored constant or a stored percentage of the running average. Both wide and narrow acceptance limits are stored in the microprocessor 35. Alternatively these limits might be stored in RAM or ROM. In the embodiment shown, whether the new acceptance limits are set to wide or narrow values is controlled by external information supplied to the microprocessor through its data communication bus. Alternatively, a selection switch connected to one input of the microprocessor 35 might be used. In the latter arrangement, microprocessor 35 tests for the state of the switch, that is, whether it is open or closed and adjusts the limits depending on the state of the switch. The narrow range achieves very good protection against the acceptance of slugs; however, the tradeoff is that acceptable coins which are worn or damaged may be rejected. The ability to select between wide and narrow acceptance limits allows the owner of the apparatus to adjust the acceptance limits in accordance with his operational experience.

**[0031]** Other ports of the microprocessor 35 are connected to a relay control circuit 70 for controlling the gate 71 shown in Fig. 3, a clock 75, a power supply circuit 80, interface lines 81, 82, 83 and 84, and debug line 85. The microprocessor 35 can be readily programmed to control relay circuit 70 which operates a gate to separate acceptable from unacceptable coins or perform other coin routing tasks. The particular details of controlling such a gate do not form a part of the present invention. For further details of typical gate operation, see for example, U.S. Patent No. 4,106,610 See also, Plesko, "Low Power Coin Routing Gate", U.S. patent No. 4534459 (corresponding to EP-A-0154525 for details of a preferred gate suitable for use in conjunction with this invention.

**[0032]** The clock 75 and power supply 80 supply clock and power inputs required by the microprocessor 35. The interface lines 81, 82, 83 and 84 provide a means for connecting the electronic coin testing apparatus 10 to other apparatus or circuitry which may be included in a coin operated vending mechanism which includes the electronic coin testing apparatus 10. The details of such further apparatus and the connection thereto do not form part of the present invention. Debug line 85 provides a test connection for monitoring operation and debugging purposes.

**[0033]** Fig. 3 illustrates the mechanical portion of the coin testing apparatus 10 and one way in which sensors 24, 25 and 26 may be suitably positioned adjacent a coin passageway defined by two spaced side walls 36, 38 and a coin track 33, 33a. The coin handling apparatus 11 includes a conventional coin receiving cup 31, two spaced sidewalls 36 and 38, connected by a conventional hinge and spring assembly 34, and coin track 33, 33a. The coin track 33, 33a and sidewalls 36, 38 form a coin passageway from the coin entry cup 31 past the coin sensors 24, 25. Fig. 3 also shows the sensor 26 located after the gate 71, which in Fig. 3 is shown for separating acceptable from unacceptable coins.

**[0034]** It should be understood that other positionings of sensors may be advantageous, that other coin passageway arrangements are contemplated and that additional sensors for other coin tests may be used.

**[0035]** Fig. 4 is a flowchart of the operation of the embodiment of Figs. 1-3. According to one embodiment of the method of the present invention, for each denomination of coin to be accepted, initial acceptance limits for each test are stored in the microprocessor 35 of the electronic coin testing apparatus 10. These initial limits are set quite wide guaranteeing almost 100% acceptance of acceptable coins. These acceptance limits are used only in the original tuning. To tune the electronic coin testing apparatus 10, a predetermined number of known acceptable coins of each denomination are inserted. For example, eight acceptable 5-cent coins are inserted. The inserted coins are detected by the sensor circuit 21, microprocessor 35 is awakened, amplitude and frequency tests are conducted for each coin using sensor circuit 21, and a second frequency test is conducted using sensor circuit 22. Then, new acceptance limits are computed based on the test information for the eight acceptable coins. These new limits are used for testing additional coins which are inserted. By way of example, the frequency test using sensor circuit 21 will be further discussed, but it should be understood that similar processing is performed for each test undertaken in the coin validation process.

**[0036]** The flowchart of Fig. 4 illustrates the process involved in the coin telephone context. It will be understood that the method and apparatus of the present invention can be used in other contexts. The general method of Fig. 4 may be understood by taking all f variables as representing any function which might be tested, such as frequency, amplitude and the like, for any coin test. The specific discussion which follows will be in terms of frequency testing for United States 5-cent coins.

**[0037]** After a phone off-the-hook condition is detected, the microprocessor 35 is powered up, an idling frequency, $f_o$, is measured and stored and the microprocessor 35 enters its low power rest state. For initial calibration and tuning, a phone off-the-hook signal may be artificially simulated. Then, in one embodiment, a series of eight acceptable 5-cent coins are inserted to tune the apparatus for 5 cent-coins. Microprocessor 35 stays in its rest state until the first 5-cent coin is detected. The frequency of the output of sensor circuit 21 is repetitively sampled and the frequency values f-$_{measured}$ are obtained. A maximum difference value, $\Delta f$, is computed from the maximum difference between $f_{measured}$ and $f_o$ during passage of the first 5-cent coin. $\Delta f = \max(f_{measured} - f_o)$.

**[0038]** Next, a dimensionless quantity, F, is calculated by dividing $\Delta f$ by $f_o$. $F=|\Delta f|/f_o$. The computed F for the first 5-cent coin is compared with the stored acceptance limits to see if it lies within those limits. Since the first 5-cent coin is an acceptable 5-cent coin, its F value is within the limits. The first 5-cent coin is accepted and microprocessor 35 obtains a coin count C for that coin.

**[0039]** For the first coin the coin count C equals zero. C=0. This coin count is then incremented by one. C=C+1. The coin count C = 1 is now compared with the number 32. C = 32? Since C is not equal 32, the next step is to compare C with 8 to see if C is greater than or equal to 8. C ≧ 8? Since C is not greater than or equal to 8, the next step is to compute a new average F,$F_{AVE\ NEW}$, for 5-cent coins. $F_{AVE\ NEW} = (((C-1) \times F_{AVE\ OLD}) + F)/C$. $F_{AVE\ OLD}$ for the first coin equals 0. Consequently, $F_{AVE\ NEW} = F/C = F$. $F_{AVE\ NEW}$ is now stored as $F_{AVE\ OLD}$. $F_{AVE\ OLD} = F_{AVE\ NEW}$. This step completes the processing of the first 5-cent coin.

**[0040]** As additional 5-cent coins are inserted to tune the apparatus the process repeats until the eighth 5-cent coin is inserted. For the eighth 5-cent coin the coin count C=7, when it is incremented by 1 it becomes equal to 8. When C is now compared with 8 it is found to equal 8. As a result, a flag is set to use the computed $F_{AVE\ NEW}$ to determine the acceptance limits. $F_{AVE\ NEW}$ is computed as before, but now it is used in determining the acceptance limits for subsequently inserted 5-cent coins. The originally stored limits are no longer used. The new limits may be $F_{AVE\ NEW}$ plus or minus a constant, that is, upper limit = $F_{AVE\ NEW}$ $^+$ X. lower limit = $F_{AVE\ NEW}$ - X; or $F_{AVE\ NEW}$ plus or minus a fixed percentage of $F_{AVE\ NEW}$, upper limit = $(F_{AVE\ NEW})(1 + X)$, lower limit = $(F_{AVE\ NEW})(1-X)$; or computed from $F_{AVE\ NEW}$ in any logical manner. Once the apparatus is tuned as discussed above, it may be used in an actual operating environment.

**[0041]** As additional 5-cent coins are inserted, $F_{AVE\ NEW}$ and new acceptance limits are continually recomputed. If a coin other than an acceptable 5-cent coin is inserted, its F value will not be within the acceptance limits and that coin will be rejected. After that occurs, a new idling frequency, $f_o$, is measured and then microprocessor 35 returns to a rest state to await coin arrival.

**[0042]** The recomputation of $F_{AVE\ NEW}$ and the acceptance limits with each acceptable 5-cent coin after the eighth allows the system of the present invention to self-tune and recalibrate itself and thus to compensate for parameter drift, temperature and environmental shifts and the like. In order for this beneficial compensation to be achieved, it is important that $F_{AVE\ NEW}$ not become overly weighted by the previously accepted coins. Consequently, when the thirty-second 5-cent coin is inserted, the incremented count C = 32 and the process branches differently. When C=32, the coin count C is reset to 16. C = 16. The coin count value C = 16 is then used for computing $F_{AVE\ NEW}$. When the thirty-third coin is received, the coin count C = 16 is incremented for use in the later process steps. The above process continues indefinitely as additional 5cent coins are inserted.

**[0043]** As discussed above, the method of the present invention is not limited to frequency based testing. Neither is the statistical function limited solely to a running average. Further, while the specific example of the flowchart discussed above uses the numbers 8, 16 and 32 in the computation process, other predetermined numbers may be used without departing from the present invention. The values 8, 16 and 32 were selected because: a) $F_{AVE\ NEW}$ is fairly well determined after eight coins have been accepted; b) $F_{AVE\ NEW}$ becomes heavily weighted after 32 coins have been inserted so that the insertion of additional acceptable coins has little effect; and c) the number 16 is between 8 and 32.

**[0044]** The operation of the electronic coin testing apparatus 10 will be clear to one skilled in the art from the above discussion.

## Claims

1. A method of operating a coin testing apparatus (10) comprising testing a coin and determining from the results of the test whether the coin is acceptable and, if so, the denomination of the coin, the testing step comprising deriving a measurement of the coin and the determining step comprising using respective predetermined acceptance criteria for determining whether the measurement is indicative of an acceptable coin of a respective denomination, the method including the further step, if the coin is determined to be acceptable, of modifying the respective acceptance criterion for the coin denomination to an extent dependent upon said measurement so that the modified acceptance criterion can be used with a subsequently tested coin, wherein the method also includes the step of additionally changing the respective modified acceptance criterion for the coin denomination to select between relatively wide acceptance limits and relatively narrow acceptance limits, the latter reducing the likelihood that slugs will be accepted and thus cause modification of the respective acceptance criterion.

2. A method as claimed in claim 1, wherein the testing step comprises deriving a plurality of coin measurements and the determining step comprises using respective predetermined acceptance criteria to determine whether each measurement is indicative of an acceptable coin, the method including the step of modifying each acceptance criterion to an extent dependent upon the respective measurement if the coin is determined to be acceptable.

3. A method as claimed in claim 1 or 2, wherein the acceptance criterion is modified each time a tested coin has been determined to be acceptable.

4. A method as claimed in any preceding claim, wherein the step of modifying the acceptance criterion comprises computing a statistical function value from the coin measurement.

5. A method as claimed in claim 4, wherein the computing step involves calculating a running average of the measurements of coins determined to be acceptable.

6. A method as claimed in claim 5, wherein the running average is weighted so as to reduce the effect of the measurements of the earlier-tested coins.

7. A method as claimed in any preceding claim, wherein the step of modifying the acceptance criterion comprises computing acceptance limits for use with a subsequently tested coin, and storing the computed acceptance limits, whereby the measurement of the subsequently tested coin can be compared with the stored acceptance limits.

8. A method as claimed in any preceding claim, including a setting-up operation involving testing a plurality of coins and determining whether they are acceptable using an initial acceptance criterion, computing a statistical function value from the measurements of the coins determined to be acceptable, and employing a new acceptance criterion derived from the computed statistical function value after a predetermined number of coins have been determined to be acceptable.

9. A method as claimed in any one of claims 1 to 7, including a setting-up operation involving testing a predetermined number of coins of a known denomination to derive measurements of said coins, computing a statistical function value from said measurements and deriving an acceptance criterion from said statistical function value.

10. A method as claimed in any one of claims 1 to 7, including a setting-up operation comprising testing a single coin of known denomination to derive a measurement thereof, and calculating an initial acceptance criterion from said measurement.

**11.** Apparatus for testing coins, comprising:

test means (20) for producing an output signal indicative of a characteristic of a tested coin;
memory means for storing test limits associated with respective coin denominations;
means (35, 40, 55) to derive a test value from the output signal;
means to determine whether the tested coin is acceptable and, if so, the denomination of the coin, said determining means being operable to compare the test value with the stored test limits;
means for recomputing the test limits associated with a coin denomination if the tested coin is determined to be an acceptable coin of that denomination so that the recomputed test limits can be used for a subsequent coin; and
means for selecting between relatively wide and relatively narrow, recomputed test limits, the latter reducing the likelihood that slugs will be accepted and thus cause modification of the respective acceptance criterion.

**12.** Apparatus as claimed in claim 11, wherein the test means (20) comprises a sensor circuit (21,22) having a sensor (24,25) located adjacent a coin path for producing an output signal indicative of a characteristic of a tested coin on the coin path adjacent the sensor (24,25).

**13.** Apparatus according to claim 12 wherein the sensor circuit (21,22) is an oscillator circuit which produces an oscillating output signal.

**14.** Apparatus according to claim 13 wherein the means (40,55) to derive a test value from the output signal comprises an analog-to-digital converter circuit (40) for producing a digital output signal related to the amplitude of the oscillating output signal.

**15.** Apparatus according to claim 13 or 14 wherein the means (40,55) to derive a test value from the output signal comprises a counter circuit (55) for producing a digital output count related to the frequency of oscillation of the oscillating output signal.

**16.** Apparatus according to any one of claims 11 to 15 wherein the means to determine and the means for recomputing comprise a programmed microprocessor (35).

**17.** Apparatus according to claim 16 wherein the programmed microprocessor (35) stores the recomputed test limit each time a coin is found to be acceptable.

**18.** Apparatus according to any one of claims 11 to 17 further comprising means to switch the apparatus into a test limit setting mode in which at least one known acceptable coin is inserted and the apparatus (10) for testing coins derives initial test limits therefrom.

**19.** Apparatus according to any one of claims 11 to 18 wherein the recomputing means is operable repeatedly to recompute the coin test limits as coins are accepted so that subsequently inserted coins are tested based upon information from a plurality of recently previously inserted coins which have been accepted.

**20.** Apparatus according to any one of claims 11 to 19 wherein the test means (20) includes an electro-magnetic sensor (24;25).

**21.** Apparatus according to any one of claims 11 to 20 including a coin track (33,33a) along which coins roll edgewise past the test means (20).

**22.** Apparatus as claimed in claim 11, said apparatus comprising:

a coin receiving cup (31) for directing a coin which is inserted into said cup (31) to a coin passageway (33,33a, 36,38);
a coin sensor (24;25) of said test means (20) located adjacent a first position along said coin passageway (33,33a,36,38), said coin passageway serving to direct the coin from the coin receiving cup (31) to the first position and said coin sensor (24;25) producing an output signal when the coin is adjacent the coin sensor (24;25) indicative of whether or not the coin is an acceptable coin;
a coin routing gate (71) located adjacent a second position along said coin passageway (33,33a,36,38) downstream of the first position, said coin routing gate (71) operating to direct the coin;

means (70) for physically controlling the position of the coin routing gate (71); and

a processing means (35) comprising said determining means, said recomputing means and said memory means, said processing means (35) being connected to the coin sensor (24;25) and the means (70) for physically controlling the position of the coin routing gate (71), for receiving the output signal from the coin sensor (24;25), for retrieving the coin test limitsfrom the memory means, for computing a coin test value based on the output signal of the coin sensor (24;25) when the coin is adjacent the coin sensor (24;25), for determining if the coin has a first characteristic of an acceptable coin based on a comparison of the coin test value with the coin test limits, and for automatically using the coin test value to change the coin test limits stored in the memory means if the coin is an acceptable coin.

**23.** Apparatus according to claim 22, wherein the coin sensor (24) comprises an inductive sensor for sensing coin diameter and material.

**24.** Apparatus according to claim 23, wherein the inductive sensor (24) comprises two coils connected in series having a combined inductance of approximately 3.5 mH and forming part of a high frequency low power oscillator circuit (21) having an idling frequency of approximately 170 kHz.

**25.** Apparatus according to claim 23 or 24 wherein the processing means (35) is responsive to changes in both the amplitude and frequency of the output signal of the coin sensor (24) for purposes of determining whether the coin has two characteristics of an acceptable coin.

**26.** Apparatus according to claim 25 wherein the processing means (35) is further responsive to a change in the amplitude of said output signal exceeding a predetermined amount to switch itself from a low power idling state to a fully powered testing state.

**27.** Apparatus according to claim 22 wherein the coin sensor (25) comprises an inductive sensor for sensing coin thickness.

**28.** Apparatus according to claim 27 wherein the inductive sensor (25) comprises two coils connected in series having a combined inductance of approximately 400 µH and forming part of a high frequency low power oscillator circuit (22) having an idling frequency of approximately 750 kHz.

**29.** Apparatus according to any ode of claims 22 to 26 further comprising a second coin sensor (25) connected to the processing means (35) and located adjacent the coin passageway (33,33a,36,38) between the aforementioned coin sensor (24) and the coin routing gate (71).

**30.** Apparatus according to claim 29 further comprising an additional coin sensor (26) connected to the processing means (35) and located downstream of the coin routing gate (71).

**Revendications**

**1.** Un procédé de mise en oeuvre d'un appareil (10) d'essai de pièces comprenant l'essai d'une pièce et la détermination, à partir des résultats de l'essai, d'un caractère acceptable de la pièce et, dans le cas positif, de la dénomination de la pièce, l'étape d'essai comprenant une dérivation d'une mesure de la pièce et l'étape de détermination comprenant l'utilisation de critères d'acceptation prédéterminés respectifs pour déterminer si la mesure est indicative d'une pièce acceptable d'une dénomination respective,

le procédé incluant l'étape additionnelle consistant à modifier, si la pièce est déterminée comme acceptable, le critère d'acceptation respectif pour la dénomination de pièce, avec une ampleur qui dépend de ladite mesure de telle sorte que le critère d'acceptation modifié peut être utilisé pour une pièce essayée ultérieurement, le procédé incluant aussi l'étape consistant à modifier de plus le critère d'acceptation modifié respectif pour la dénomination de pièce afin de sélectionner entre des limites d'acceptation relativement larges et des limites d'acceptation relativement étroites, ces dernières réduisant la probabilité que des jetons soient acceptés et provoquent ainsi une modification du critère d'acceptation respectif.

**2.** Un procédé selon la revendication 1, dans lequel l'étape d'essai comprend la réalisation de plusieurs mesures de pièces et l'étape de détermination comprend l'utilisation de critères d'acceptation prédéterminés respectifs pour déterminer si chaque mesure est indicative d'une pièce acceptable, le procédé comprenant l'étape consistant à modifier chaque critère d'acceptation avec une ampleur qui dépend de la mesure si la pièce est déterminée comme acceptable.

3. Un procédé selon la revendication 1 ou 2, dans lequel le critère d'acceptation est modifié chaque fois qu'une pièce acceptée a été déterminée comme acceptable.

4. Un procédé selon une revendication précédente quelconque, dans lequel l'étape consistant à modifier les critères d'acceptation comprend le calcul d'une valeur de fonction statistique à partir de la mesure de pièces.

5. Un procédé selon la revendication 4, dans lequel l'étape de calcul implique le calcul d'une moyenne mobile des mesures de pièces déterminées comme acceptables.

6. Un procédé selon la revendication 5, dans lequel la moyenne mobile est pondérée de façon à réduire l'effet des mesures des pièces essayées en premier.

7. Un procédé selon une revendication précédente quelconque, dans lequel l'étape consistant à modifier le critère d'acceptation comprend le calcul de limites d'acceptation à utiliser avec une pièce essayée ultérieurement, et la mémorisation des limites d'acceptation calculées, grâce à quoi la mesure de la pièce essayée ultérieurement peut être comparée avec les limites d'acceptation mémorisées.

8. Un procédé selon une revendication précédente quelconque, comprenant une opération de réglage impliquant l'essai de plusieurs pièces et la détermination de leur caractère acceptable en utilisant un critère d'acceptation initial, le calcul d'une valeur de fonction statistique à partir des mesures des pièces déterminées comme acceptables, et l'utilisation d'un nouveau critère d'acceptation dérivé de la valeur de fonction statistique calculée après qu'un nombre prédéterminé de pièces ont été déterminées comme acceptables.

9. Un procédé selon l'une quelconque des revendications 1 à 7, comprenant une opération de réglage impliquant l'essai d'un nombre prédéterminé de pièces d'une dénomination connue pour réaliser des mesures desdites pièces, le calcul d'une valeur de fonction statistique à partir desdites mesures et l'établissement d'un critère d'acceptation à partir de ladite valeur de fonction statistique.

10. Un procédé selon l'une quelconque des revendications 1 à 7, comprenant une opération de réglage comprenant l'essai d'un pièce unique de dénomination connue pour en dériver une mesure, et le calcul d'acceptation initiale à partir de ladite mesure.

11. Appareil d'essai de pièces, comprenant

des moyens d'essai (20) pour produire un signal de sortie indicatif d'une caractéristique d'une pièce essayée;
des moyens de mémoire pour mémoriser des limites d'essai associées à des dénominations respectives de pièces;
des moyens (35, 40, 55) pour dériver une valeur d'essai à partir du signal de sortie; et
des moyens pour déterminer si la pièce essayée est acceptable et, s'il en est ainsi, la dénomination de la pièce, lesdits moyens de détermination pouvant fonctionner pour comparer la valeur d'essai avec les limites d'essai mémorisées;
des moyens pour recalculer les limites d'essai associées à une dénomination de pièce si la pièce essayée est déterminée comme pièce acceptable de cette dénomination de sorte que les limites d'essai recalculées peuvent être utilisées pour une pièce ultérieure; et
des moyens pour sélectionner entre des limites d'essai recalculées relativement larges et relativement étroites, ces dernières réduisant la probabilité que des jetons soient acceptés et provoquent ainsi une modification du critère d'acceptation respectif.

12. Appareil selon la revendication 11, dans lequel le moyen d'essai (20) comprend un circuit de capteur (21, 22) comprenant un capteur (24, 25) situé adjacent à un trajet de pièces afin de produire un signal de sortie indicatif d'une caractéristique d'une pièce essayée sur le trajet de pièces adjacent au capteur (24, 25).

13. Appareil selon la revendication 12 dans lequel le circuit de capteur (21, 22) est un circuit d'oscillateur qui produit un signal de sortie oscillant.

**14.** Appareil selon la revendication 13 dans lequel le moyen (40, 55) pour dériver une valeur d'essai à partir du signal de sortie comprend un circuit de convertisseur analogique-à-numérique (40) pour produire un signal numérique de sortie relié à l'amplitude du signal oscillant de sortie.

**15.** Appareil selon la revendication 13 ou 14 dans lequel le moyen (40, 55) pour dériver une valeur d'essai à partir du signal de sortie comprend un circuit de compteur (55) pour produire un compte numérique de sortie relié à la fréquence d'oscillation du signal oscillant de sortie.

**16.** Appareil selon l'une quelconque des revendications 11 à 15 dans lequel les moyens pour déterminer et les moyens pour recalculer comprennent un microprocesseur programmé (35).

**17.** Appareil selon la revendication 16 dans lequel le microprocesseur programmé (35) mémorise la limite d'essai recalculée chaque fois qu'une pièce est trouvée acceptable.

**18.** Appareil selon l'une quelconque des revendications 11 à 17 comprenant de plus des moyens pour commuter l'appareil en un mode d'établissement de limite d'essai dans lequel au moins une pièce connue acceptable est insérée et l'appareil (10) d'essai de pièces en dérive une limite d'essai initiale.

**19.** Appareil selon l'une quelconque des revendications 11 à 18 dans lequel les moyens pour recalculer peuvent fonctionner de façon répétée pour recalculer la limite d'essai de pièces lorsque des pièces sont acceptées de telle façon que des pièces insérées ultérieurement soient essayées sur la base de l'information provenant de plusieurs pièces insérées précédemment, de façon récente, qui ont été acceptées.

**20.** Appareil selon l'une quelconque des revendications 11 à 19 dans lequel le moyen d'essai (20) comprend un capteur électromagnétique (24; 25).

**21.** Appareil selon l'une quelconque des revendications 11 à 20 comprenant une piste de pièces (33, 33a) le long de laquelle les pièces roulent sur la tranche le long des moyens d'essai (20).

**22.** Appareil selon la revendication 11, ledit appareil comprenant:

une coupelle (31) de réception de pièces pour diriger vers un passage de pièces (33, 33a, 36, 38) une pièce qui est insérée dans ladite coupelle (31);
un capteur de pièces (24; 25) desdits moyens d'essai (20) situé adjacent à une première position le long dudit passage de pièce (33, 33a, 36, 38), ledit passage de pièces servant à diriger la pièce depuis la coupelle de réception de pièces (31) vers la première position et ledit capteur de pièces (24; 25) produisant, lorsque la pièce est adjacente au capteur de pièces (24; 25), un signal de sortie indicatif du caractère acceptable ou non de la pièce;
une porte d'acheminement de pièces (71) située adjacente à une deuxième position le long du passage de pièces (33, 33a, 36, 38) en aval de la première position, ladite porte d'acheminement de pièces (71) agissant pour diriger la pièce;
des moyens (70) pour commander physiquement la position de la porte d'acheminement de pièces (71); et
un moyen de traitement (35) comprenant lesdits moyens de détermination, lesdits moyens pour recalculer et lesdits moyens de mémoire, ledit moyen de traitement (35) étant relié au capteur de pièces (24; 25) et aux moyens (70) pour commander physiquement la position de la porte d'acheminement de pièces (71), pour recevoir le signal de sortie provenant du capteur de pièces (24; 25), pour récupérer dans le moyen de mémoire la limite d'essai de pièces, pour calculer une valeur d'essai de pièces sur la base du signal de sortie du capteur de pièces (24; 25) lorsque la pièce est adjacente au capteur de pièces (24; 25), pour déterminer si la pièce comporte une première caractéristique d'une pièce acceptable sur la base d'une comparaison de la valeur d'essai de la pièce avec la limite d'essai de pièces et pour utiliser automatiquement la valeur d'essai de pièces pour modifier la limite d'essai de pièces mémorisée dans le moyen de mémoire si la pièce est une pièce acceptable.

**23.** Appareil selon la revendication 22, dans lequel le capteur de pièces (24) comprend un capteur inductif pour capter le diamètre et la matière de la pièce;

**24.** Appareil selon la revendication 23, dans lequel le capteur inductif (24) comprend deux bobines reliées en série possédant une inductance combinée d'environ 3,5 mH et constituant une partie d'un circuit oscillant (21) à haute fréquence à basse puissance possédant une fréquence à vide d'environ 170 kHz.

**25.** Appareil selon la revendication 23 ou 24 dans lequel le moyen de traitement (35) est sensible à des modifications aussi bien de l'amplitude que de la fréquence du signal de sortie du capteur de pièces (24) dans le but de déterminer si la pièce possède deux caractéristiques d'une pièce acceptable.

**26.** Appareil selon la revendication 25 dans lequel le moyen de traitement (35) est en outre sensible à une modification de l'amplitude dudit signal de sortie qui dépasse une valeur prédéterminée pour se commuter elle-même d'un état de marche à vide à basse puissance à un état d'essai à pleine puissance.

**27.** Appareil selon la revendication 22 dans lequel le capteur de pièces (25) comprend un capteur inductif pour capter l'épaisseur de pièces.

**28.** Appareil selon la revendication 27 dans lequel le capteur inductif (25) comprend deux bobines reliées en série possédant une inductance combinée d'environ 400 µH et formant partie d'un circuit oscillateur à haute fréquence et à faible puissance (22) possédant une fréquence à vide d'environ 750 kHz.

**29.** Appareil selon l'une quelconque des revendications 22 à 26 comprenant de plus un deuxième capteur de pièces (25) relié au moyen de traitement (35) et situé adjacent au passage de pièces (33, 33a, 36, 38) entre le capteur de pièces mentionné (24) et la porte d'acheminement (71).

**30.** Appareil selon la revendication 29 comprenant de plus un capteur de pièces additionnel (26) relié au moyen de traitement (35) et situé en aval de la porte d'acheminement de pièces (71).

**Patentansprüche**

**1.** Verfahren zum Betreiben eines Münzprüfgerätes (10), bei dem eine Münze geprüft und aus dem Prüfergebnis bestimmt wird, ob die Münze akzeptierbar ist, und, falls dies so ist, der Wert der Münze bestimmt wird, wobei im Prüfschritt eine Messung für die Münze gewonnen wird und im Bestimmungsschritt entsprechende vorgegebene Akzeptanzkriterien verwendet werden, um zu bestimmen, ob die Messung eine akzeptierbare Münze eines entsprechenden Münzwertes anzeigt, wobei das Verfahren den weiteren Schritt beinhaltet, daß, wenn die Münze als akzeptierbar bestimmt wurde, das entsprechende Akzeptanzkriterium für den Münzwert um ein Maß geändert wird, das von der Messung abhängt, so daß das geänderte Akzeptanzkriterium bei einer anschließend geprüften Münze angewendet werden kann, wobei das Verfahren weiterhin den Schritt einer zusätzlichen Änderung des entsprechenden geänderten Akzeptanzkriteriums für den Münzwert beinhaltet, um zwischen relativ weiten Akzeptanzgrenzen und relativ engen Akzeptanzgrenzen auszuwählen, wobei letztere die Wahrscheinlichkeit verringern, daß münzartige Stücke akzeptiert werden und dadurch eine Änderung des jeweiligen Akzeptanzkriteriums bewirken.

**2.** Verfahren nach Anspruch 1, bei dem im Prüfschritt eine Mehrzahl von Münzmessungen abgeleitet wird und im Bestimmungsschritt entsprechende vorgegebene Akzeptanzkriterien verwendet werden, um zu bestimmen, ob eine jeweilige Messung eine akzeptierbare Münze anzeigt, wobei das Verfahren den Schritt des Modifizierens jedes Akzeptanzkriteriums in einem Ausmaße aufweist, das von der entsprechenden Messung abhängt, wenn die Münze als akzeptierbar bestimmt wird.

**3.** Verfahren nach einem der Ansprüche 1 oder 2, bei dem das Akzeptanzkriterium jedesmal modifiziert wird, wenn eine geprüfte Münze als akzeptierbar bestimmt wurde.

**4.** Verfahren nach einem der vorangehenden Ansprüche, bei dem der Schritt des Modifizierens des Akzeptanzkriteriums das Berechnen eines statistischen Funktionswertes aus der Münzenmessung beinhaltet.

**5.** Verfahren nach Anspruch 4, bei dem der Berechnungsschritt das Berechnen eines laufenden Mittelwerts aus den Messungen von Münzen beinhaltet, die als akzeptierbar bestimmt wurden.

**6.** Verfahren nach Anspruch 5, bei dem der laufende Mittelwert gewichtet wird, um den Effekt der Messungen zuvor geprüfeter Münzen zu verringern.

7. Verfahren nach einem der vorstehenden Ansprüche, bei dem im Schritt des Modifizierens des Akzeptanzkriteriums Akzeptanzgrenzen zum Anwenden auf eine anschließend geprüfete Münze berechnet werden und die berechneten Akzeptanzgrenzen gespeichert werden, wodurch die Messung der anschließend geprüften Münze mit den gespeicherten Akzeptanzgrenzen verglichen werden kann.

8. Verfahren nach einem der vorstehenden Ansprüche mit einem Einstellablauf, bei dem eine Mehrzahl von Münzen geprüft wird und mit einem Anfangsakzeptanzkriterium bestimmt wird, ob diese akzeptierbar sind, ein statistischer Funktionswert aus den Messungen der als akzeptierbar bestimmten Münzen berechnet wird und ein neues aus dem berechneten statistischen Funktionswert abgeleitetes Akzeptanzkriterium verwendet wird, nachdem eine vorgegebene Anzahl von Münzen als akzeptierbar bestimmt wurde.

9. Verfahren nach einem der Ansprüche 1 bis 7 mit einem Einstellablauf, bei dem eine vorgegebene Anzahl von Münzen eines bekannten Werts geprüft wird, um Messungen für die Münzen abzuleiten, ein statistischer Funktionswert aus den Messungen berechnet wird und ein Akzeptanzkriterium aus dem statistischen Funktionswert abgeleitet wird.

10. Verfahren nach einem der Ansprüche 1 bis 7 mit einem Einstellablauf, bei dem eine einzige Münze bekannten Wertes geprüft wird, um hieraus eine Messung abzuleiten, und ein Anfangsakzeptanzkriterium aus dieser Messung berechnet wird.

11. Gerät zum Prüfen von Münzen mit:

einer Prüfeinrichtung (20) zum Erzeugen eines Ausgangssignals, das eine Eigenschaft einer geprüften Münze anzeigt;
einer Speichereinrichtung zum Speichern von zu den entsprechenden Münzwerten zugehörigen Prüfgrenzen;
einer Einrichtung (35, 40, 55) zum Ableiten eines Prüfwertes aus dem Ausgangssignal; und
einer Einrichtung zum Bestimmen, ob die geprüfte Münze akzeptierbar ist, und, falls dies der Fall ist, des Münzwerts, wobei diese Bestimmungseinrichtung betätigbar ist, um den Prüfwert mit den gespeicherten Prüfgrenzen zu vergleichen;
eine Einrichtung zum Wiederberechnen der einem Münzwert zugehörigen Prüfgrenzen, wenn bestimmt wird, daß die geprüfte Münze eine akzeptierbare Münze dieses Wertes ist, so daß die wiederberechneten Prüfgrenzen für eine folgende Münze verwendet werden können; und
eine Vorrichtung zum Auswählen zwischen relativ weiten und relativ engen wiederberechneten Prüfgrenzen, wobei letztere die Wahrscheinlichkeit verringern, daß mümzartige Stücke akzeptiert werden und dadurch eine Modifikation des jeweiligen Akzeptanzkriterium bewirken.

12. Gerät nach Anspruch 11, bei dem die Prüfeinrichtung (20) eine Sensorschaltung (21, 22) mit einem Sensor (24, 25) aufweist, der benachbart zu einem Münzweg angeordnet ist, um ein Ausgangssignal zu erzeugen, das eine Eigenschaft einer geprüften Münze auf dem Münzweg benachbart zum Sensor (24, 25) anzeigt.

13. Gerät nach Anspruch 12, bei dem die Sensorschaltung (21, 22) eine Oszillatorschaltung ist, die ein Schwingungsausgangssignal erzeugt.

14. Gerät nach Anspruch 13, bei dem die Einrichtung (40, 55) zum Ableiten eines Prüfwertes aus dem Ausgangssignal eine Analog/Digital-Wandlerschaltung (40) aufweist, zum Erzeugen eines digitalen Ausgangssignals, das mit der Amplitude des Schwingungsausgangssignals zusammenhängt.

15. Gerät nach einem der Ansprüche 13 oder 14, bei dem die Einrichtung (40, 55) zum Ableiten eines Prüfwerts aus dem Ausgangssignal eine Zählerschaltung (55) aufweist, zum Erzeugen eines digitalen Ausgangszählwerts, der mit der Frequenz der Schwingung des Schwingungsausgangssignals zusammenhängt.

16. Gerät nach einem der Ansprüche 11 bis 15, bei dem die Einrichtung zum Bestimmen und die Einrichtung zum Wiederberechnen einen programmierten Mikroprozessor (35) aufweisen.

17. Gerät nach Anspruch 16, bei dem der programmierte Mikroprozessor (35) die wiederberechnete Prüfgrenze jedesmal speichert, wenn eine Münze als akzeptierbar befunden wird.

18. Gerät nach einem der Ansprüche 11 bis 17, das weiterhin eine Einrichtung aufweist, zum Schalten des Geräts in

eine Prüfgrenzen-Einstellbetriebsart, in der mindestens eine bekannte akzeptierbare Münze eingeführt wird, und das Gerät (10) zum Prüfen von Münzen daraus Anfangsprüfgrenzen ableitet.

**19.** Gerät nach einem der Ansprüche 11 bis 18, bei dem die Wiederberechnungseinrichtung wiederholt betätigbar ist, um die Münzprüfgrenzen wiederzuberechnen, wenn Münzen akzeptiert werden, so das nachfolgend eingeführte Münzen aufgrund von Information aus einer Mehrzahl, in jüngster Zeit zuvor eingeführter Münzen, die akzeptiert wurden, geprüft werden.

**20.** Gerät nach einem der Ansprüche 11 bis 19, bei dem die Prüfeinrichtung (20) einen elektromagnetischen Sensor (24; 25) aufweist.

**21.** Gerät nach einem der Ansprüche 11 bis 20 mit einer Münzspur (33, 33a), entlang der Münzen auf ihrem Rand an der Prüfeinrichtung (20) vorbeirollen.

**22.** Gerät nach Anspruch 11, aufweisend:

eine Münzaufnahmeschale (31) zum Leiten einer Münze, die in die Schale (31) hineingegeben wurde, zu einem Münzdurchlaufweg (33, 33a, 36, 38);
einen Münzsensor (24; 25) der Prüfeinrichtung (20), der benachbart zu einem ersten Ort entlang dem Münzdurchlaufweg (33, 33a, 36, 38) angeordnet ist, welcher Münzdurchlaufweg dazu dient, die Münze von der Münzaufnahmeschale (31) zu dem ersten Ort zu lenken, und wobei der Münzsensor (24; 25) ein Ausgangssignal erzeugt, wenn die Münze zum Münzsensor (24; 25) benachbart ist, das anzeigt, ob die Münze eine akzeptierbare Münze ist oder nicht;
ein Münzleittor (71), das benachbart zu einem zweiten Ort entlang des Münzdurchlaufwegs (33, 33a, 36, 38) stromab vom ersten Ort angeordnet ist, welches Münzleittor (71) dazu dient, die Münze zu leiten;
eine Einrichtung (70) zum physischen Steuern der Stellung des Münzleittors (71); und
eine Verarbeitungseinrichtung (35), die die Bestimmungseinrichrichtung, die Wiederberechnungseinrichtung und die Speichereinrichtung enthält, welche Bearbeitungseinrichtung (35) mit dem Münzsensor (24, 25) und der Einrichtung (70) zum physischen Steuern der Stellung des Münzleittors (71) verbunden ist, um das Ausgangssignal vom Münzsensor (24; 25) zu empfangen, um die Münzprüfgrenzen von der Speichereinrichtung zu gewinnen, um einen Münzprüfwert auf Grundlage des Ausgangssignals vom Münzsensor (24; 25) zu berechnen, wenn sich die Münze benachbart zum Münzsensor (24; 25) befindet, zum Bestimmen, ob die Münze eine erste Eigenschaft einer akzeptierbaren Münze aufweist, auf Grundlage eines Vergleichs des Münzprüfwertes mit den Münzprüfgrenzen, und zum automatischen Benutzen des Münzprüfwerts, um die Münzprüfgrenzen, wie sie in der Speichereinrichtung gespeichert sind, zu ändern, wenn die Münze eine akzeptierbare Münze ist.

**23.** Gerät nach Anspruch 22, bei dem der Münzsensor (24) einen induktiven Sensor aufweist, um den Durchmesser und das Material der Münze zu erfassen.

**24.** Gerät nach Anspruch 23, bei dem der induktive Sensor (24) zwei Wicklungen aufweist, die in Reihe geschaltet sind, eine kombinierte Induktivität von etwa 3,5 mH aufweisen und die Teil einer Hochfrequenz-Niederleistungs-Oszillatorschaltung (21) mit einer Leerlauffrequenz von etwa 170 kHz sind.

**25.** Gerät nach einem der Ansprüche 23 oder 24, bei dem die Verarbeitungseinrichtung (35) auf Änderungen sowohl in der Amplitude wie auch der Frequenz des Ausgangssignals vom Münzsensor (24) zum Zweck der Bestimmung, ob die Münze zwei Eigenschaften einer akzeptierbaren Münze aufweist, anspricht.

**26.** Gerät nach Anspruch 25, bei dem die Verarbeitungseinrichtung (35) weiterhin auf eine Änderung in der Amplitude des Ausgangssignals anspricht, die einen vorgegebenen Wert übersteigt, um sich selbst von einem Niederleistungs-Leerlaufszustand in einen Volleistungs-Prüfzustand zu schalten.

**27.** Gerät nach Anspruch 22, bei dem der Münzsensor (25) einen induktiven Sensor zum Ermitteln der Münzdicke aufweist.

**28.** Gerät nach Anspruch 27, bei dem der induktive Sensor (25) zwei Wicklungen aufweist, die in Reihe geschaltet sind, eine kombinierte Induktivität von etwa 400 µH aufweisen und Teil einer Hochfrequenz-Niederleistungs-Oszillatorschaltung (22) mit einer Leerlauffrequenz von etwa 750 kHz bilden.

**29.** Gerät nach einem der Ansprüche 22 bis 26, das weiterhin eine zweiten Münzsensor (25) aufweist, der mit der Verarbeitungseinrichtung (35) verbunden ist, und benachbart zum Münzdurchlaufweg (33, 33a, 36, 38) zwischen dem oben angegebenen Münzsensor (24) und dem Münzleittor (71) angeordnet ist.

**30.** Gerät nach Anspruch 29, das weiterhin einen zusätzlichen Münzsensor (26) aufweist, der mit der Verarbeitungseinrichtung (35) verbunden ist und stromab vom Münzleittor (71) angeordnet ist.

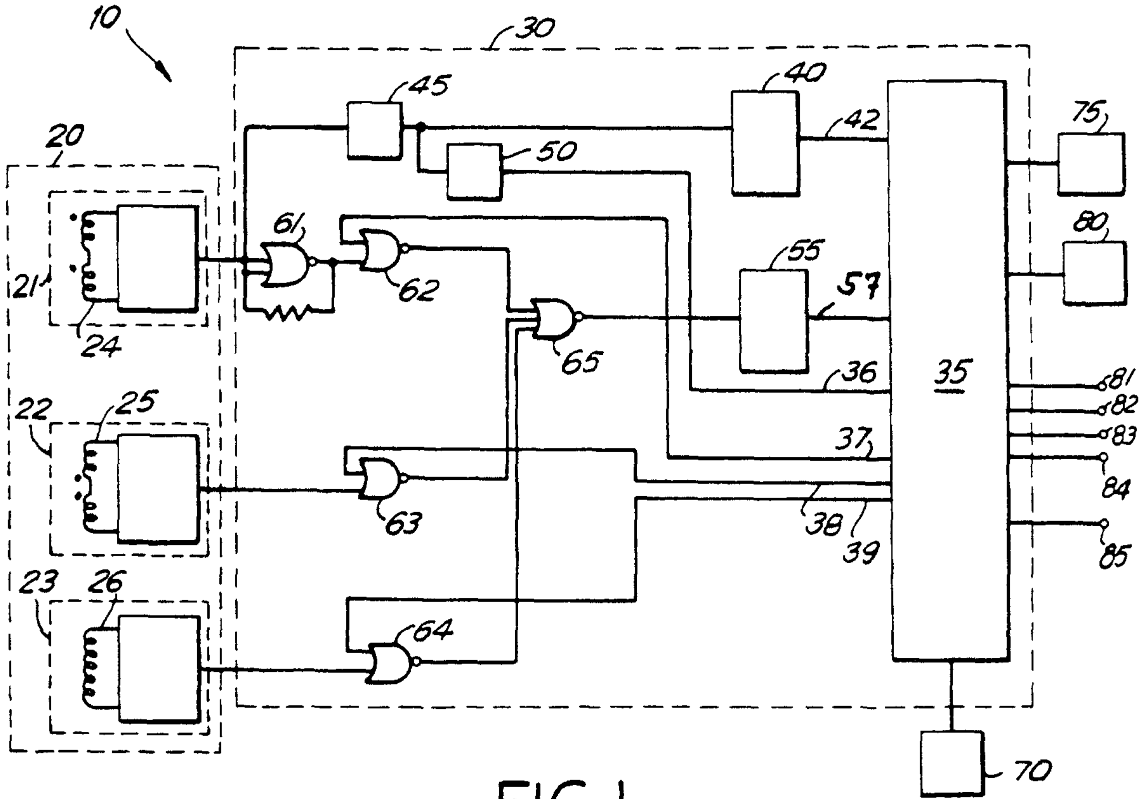
10
30
45
40
42
75
20
50
80
61
62
55
57
21
24
65
36
35
81
82
83
84
85
22
25
37
63
38
39
23
26
64
70

FIG.1

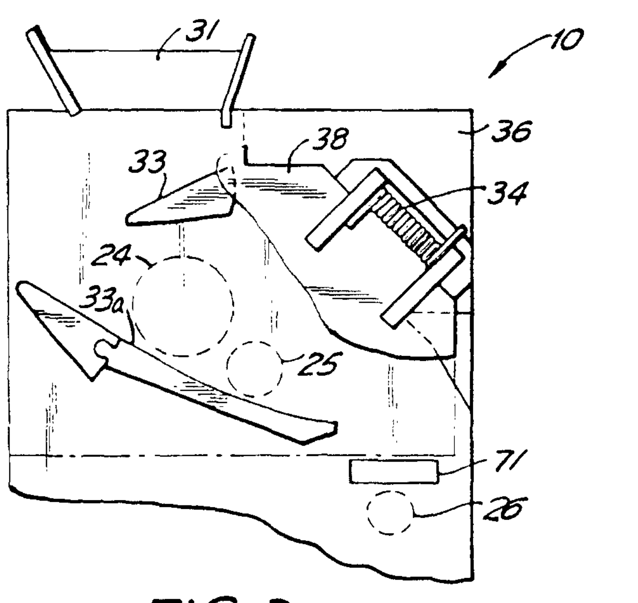
31
10
36
38
33
34
24
33a
25
71
26

FIG.3

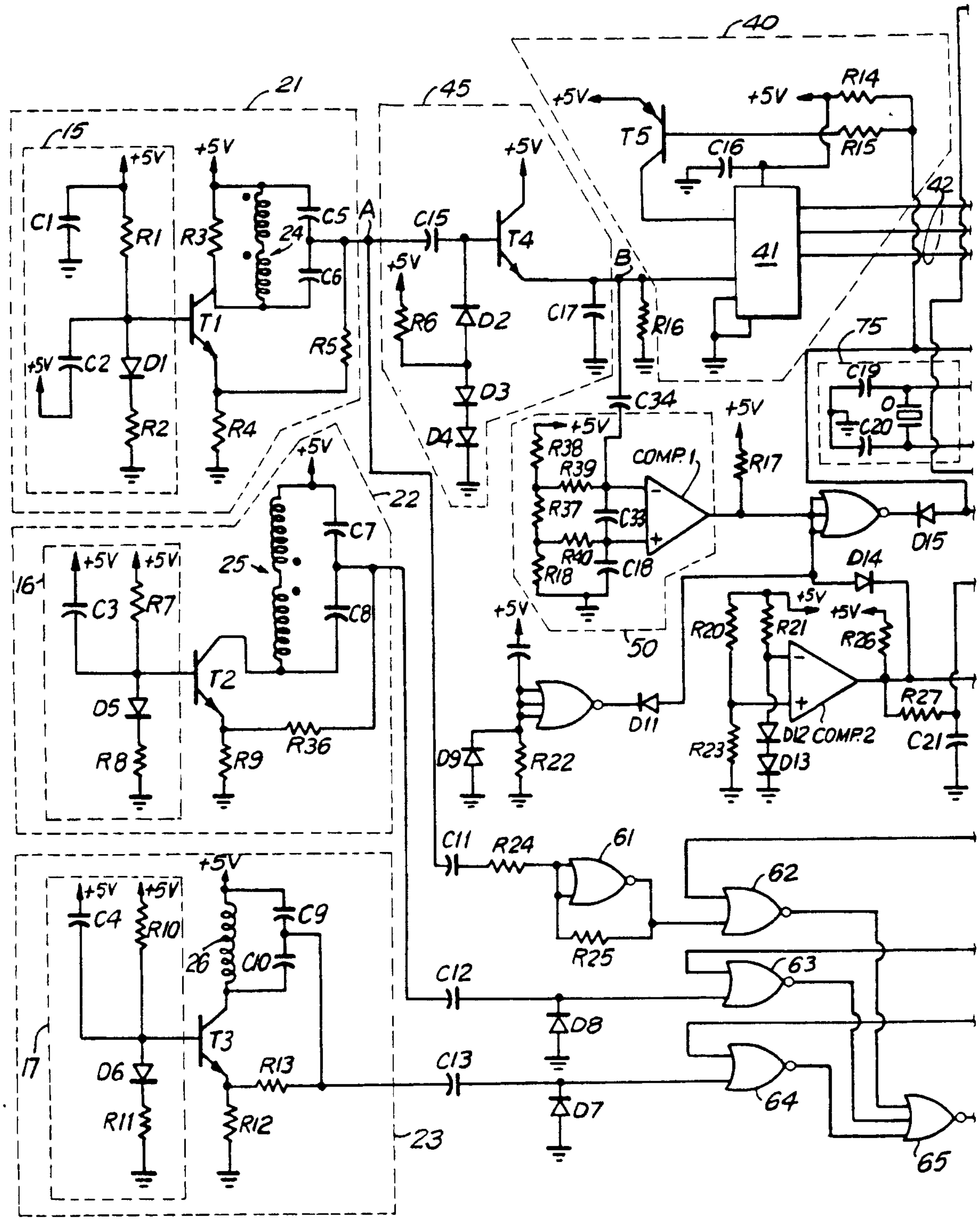
40
21
45
15
+5V
T5
C16
R14
R15
42
C1
R1
R3
C5
A
C15
T4
24
C6
41
B
C17
R16
T1
R5
R6
D2
D3
D4
C2
D1
R2
R4
75
C19
C20
C34
R38
R39
R37
R40
R18
C33
C18
COMP.1
R17
D15
D14
50
22
25
C7
C8
16
C3
R7
T2
D5
R8
R9
R36
R20
R21
R26
R23
D11
D9
R22
D12
D13
COMP.2
R27
C21
C11
R24
61
62
R25
63
C12
D8
C9
C4
R10
26
C10
17
T3
D6
R11
R12
R13
C13
D7
64
65
23

FIG.2A

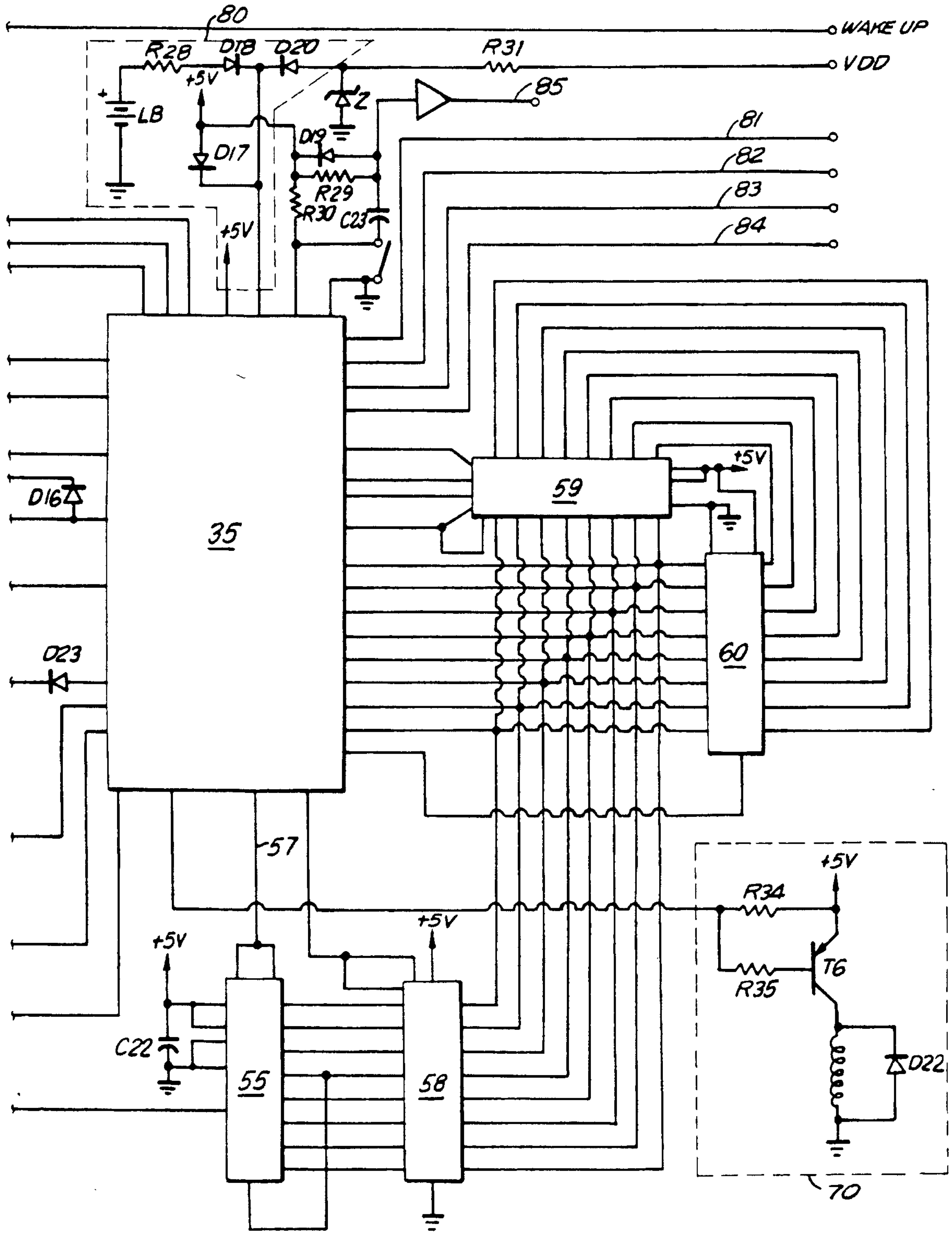
80
WAKE UP
R28
D18
D20
R31
VDD
+5V
LB
Z
85
D17
D19
81
82
R29
83
R30
C23
84
+5V
59
+5V
D16
35
D23
60
57
+5V
R34
R35
T6
+5V
+5V
C22
55
58
D22
70

FIG.2B

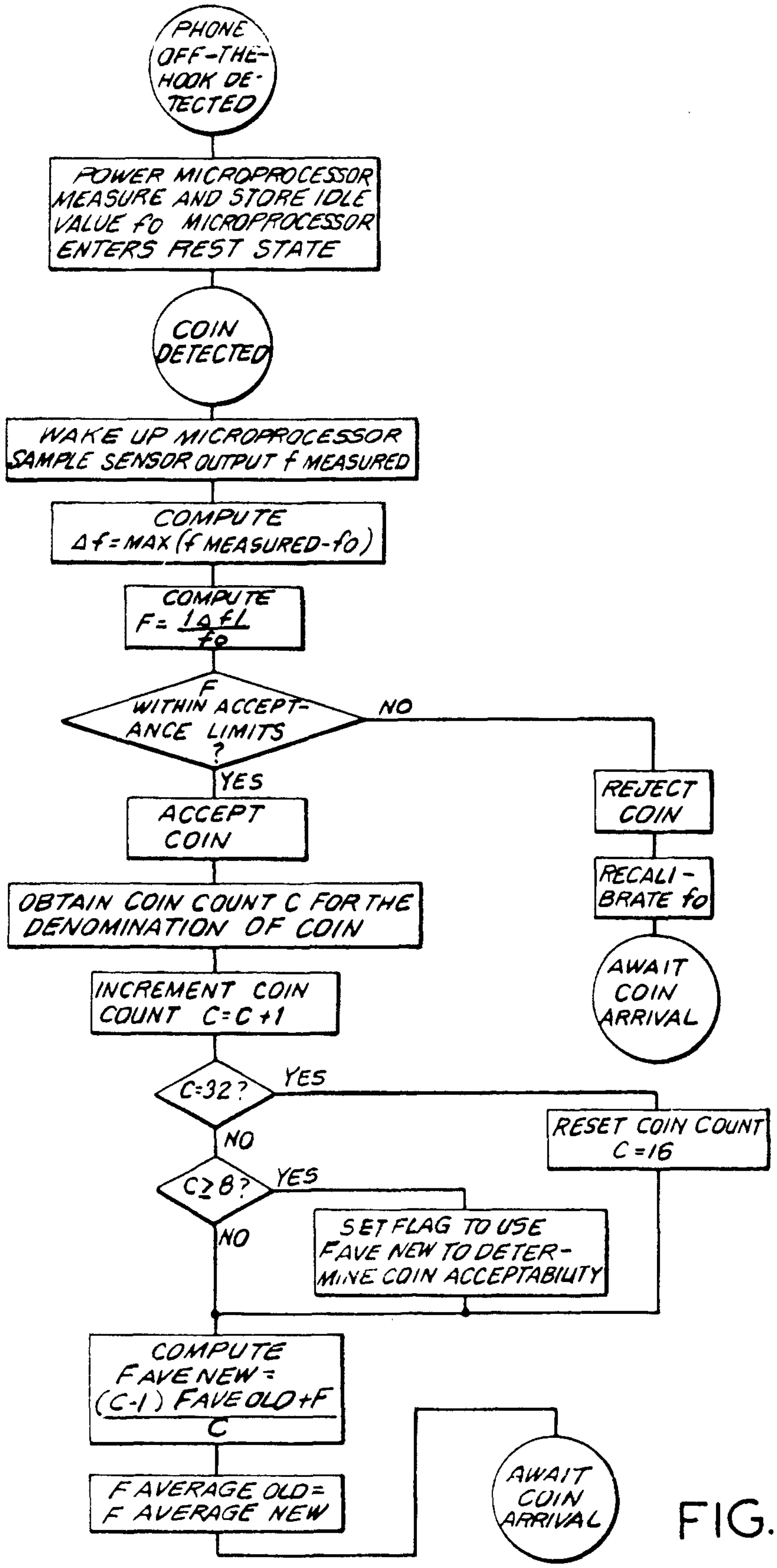
PHONE OFF-THE-HOOK DETECTED
POWER MICROPROCESSOR MEASURE AND STORE IDLE VALUE fo MICROPROCESSOR ENTERS REST STATE
COIN DETECTED
WAKE UP MICROPROCESSOR SAMPLE SENSOR OUTPUT f MEASURED
COMPUTE Δf = MAX (f MEASURED - fo)
COMPUTE F = |Δf| / fo
F WITHIN ACCEPTANCE LIMITS ?
NO
YES
ACCEPT COIN
REJECT COIN
RECALIBRATE fo
AWAIT COIN ARRIVAL
OBTAIN COIN COUNT C FOR THE DENOMINATION OF COIN
INCREMENT COIN COUNT C=C+1
C=32?
YES
RESET COIN COUNT C=16
NO
C≥8?
YES
SET FLAG TO USE FAVE NEW TO DETERMINE COIN ACCEPTABILITY
NO
COMPUTE FAVE NEW = ((C-1) FAVE OLD + F) / C
F AVERAGE OLD = F AVERAGE NEW
AWAIT COIN ARRIVAL

FIG.4