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(54) **Coin acceptor or rejector.**

(57) The invention provides a multiple coin detecting apparatus for use in coin-operated machines for discriminating between denominations of coins and genuiness of coins. Essentially, the apparatus consists of a coin receiving and guiding free-fall chute (21). An instantaneous analysis is made of the chute by a coil (L51) which surrounds the hollow chute (21) and comprises a primary coil and a secondary coil. The apparatus immediately directs predetermined acceptable coins to an acceptance chute (26), and all other unacceptable coins are directed to the rejection chute (25).

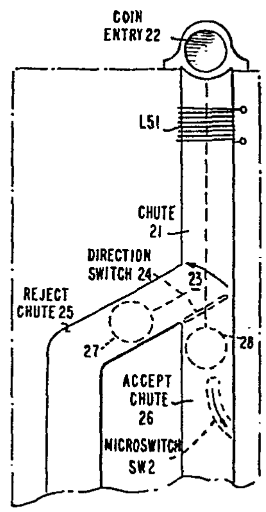

Fig. 1

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COIN ACCEPTOR OR REJECTOR

The present invention relates to coin detecting apparatus. More particularly, the invention relates to coin detecting apparatus for distinguishing genuine coins from slugs, spurious coins, and the like.

The principal object of the present invention is to provide a multiple coin detecting apparatus which accepts genuine coins regardless of their type, size, metal content and newness and which rejects non-genuine, spurious coins and the like, regardless of their type, size and newness.

Another object of the invention is to provide coin detecting apparatus which may be conveniently incorporated into coin-operated machines and the like.

Another object of the invention is to provide coin detecting apparatus which electronically rejects all non-genuine coins, and the like, regardless of whether they are ferrous or non-ferrous, thereby eliminating the need for permanent magnets or other scavenging devices.

In accordance with the present invention, there is provided a multiple coin detecting apparatus for discriminating between denominations of coins and genuineness of coins so as to exclude from acceptance any coins which have not been specifically selected for acceptance, such apparatus comprising: an oscillator circuit having a resonant tank circuit which provides amplitude modulation of the signal produced by the oscillator circuit in accordance with the losses of the tank circuit; coin directing means of insulating material having a vertical upper section and a vertical accept channel forming a completely free-fall chute for acceptable coins, and a second channel for directing slugs and other unacceptable coins to a predetermined locality; the resonant tank circuit having an inductance means positioned completely around the coin directing means such that the inductance means forms an air-cored coil, with the coins passing therethrough forming the core of said coil, and the losses of the tank circuit being determined by the metal content of the coin; and direction switching means for selectively accepting and rejecting coins and the like in accordance with the respective amplitude of a control signal with the direction switching means comprising a movably mounted member, and an accept solenoid for moving said member to an accept position dependent on its condition or energization.

More particularly, according to the present invention, the air-cored coil comprises a primary on said hollow core which with said resonant tank circuit performs a second function of inducing eddy currents in the coin, and has a secondary coil surrounding said primary coil and having windings protruding a specified distance over the edges of said primary coil at a predetermined angle in relation to the windings of said primary coil and providing a secondary fluctuation in conjunction with the primary coil voltage fluctuation, such voltage fluctuations being of opposing polarities.

The invention also provides a multiple coin-detecting apparatus wherein the primary and secondary voltage fluctuations are fed into independent analogs to digital converters and associated R-S flip-flops and provide a digital pattern for evaluating each coin on the bases of genuineness and denomination.

In order that the invention may be readily carried into effect, it will now be described with reference to the accompanying drawings, wherein:

Fig. 1 is a schematic side elevation of an embodiment of the basic coin detecting apparatus to which the present invention relates;

Fig. 2 is a perspective view showing the secondary coil arrangement extending over left-hand and right-hand edges of the primary coil according to the present invention;

Fig. 3 is a top view of Fig. 2;

Fig. 4 is a front view of Fig. 2;

Fig. 5 is a schematic diagram for processing the oscillator voltage to detect a coin; and

Fig. 6 is a logic circuit of a part of Fig. 5.

According to Fig. 1 of the drawings, the apparatus of the present invention has a coin receiving chute 21 positioned substantially vertically and which comprises any suitable electrically insulating material such as, for example, a suitable synthetic material such as, for example, acrylic material. The chute 21 has a coin entry 22 at its upper end for admitting coins into said chute. The chute 21 functions as a coin director to guide coins, slugs, spurious coins, and the like, to a predetermined locality 23.

An inductance winding L51 of the resonant tank circuit of an oscillator circuit, hereinafter described, is wound around the chute 21. A coin, and the like, inserted in the coin entry 22 drops down the chute 21 through the center of the inductance winding L51 thereby producing losses therein. A direction switch 24 comprising a movable member, controlled in position by solenoids, is movably positioned in the chute 21 in the locality 23. Under the control of solenoids, the direction switch 24 selectively accepts and rejects coins, and the like, in accordance with a control signal provided by the control circuit.

Guides extend from the chute 21 at the locality 23. The guides comprise a reject chute 25 for directing rejected spurious coins, slugs, and the like, to a reject area and an accept chute 26 for directing accepted genuine coins to an accept area. When the direction switch 24 is in the position shown in Fig. 4, it directs a non-genuine or spurious coin 27 into the reject chute 25. When the direction switch 24 is in the position opposite that shown in Fig. 1, it directs a genuine coin 28 into the accept chute 26. The reject chute 25 and the accept chute 26 preferably comprise the same material as the chute 21. A microswitch SW2 is position in the accept chute 26 and functions as hereinafter described.

When a genuine or non-genuine coin, spurious coin, slug, and the like, is dropped in the coin entry 22 (Fig. 1) and passes through the inductance winding L51 of the resonant circuit, it reduces the quality factory Q of said inductance winding, thereby increasing the losses of said inductance winding and reducing its efficiency and thereby reducing oscillator activity.

In accordance with the present invention an improved oscillator circuit is provided wherein a secondary coil is placed in close proximity to a particular area of the primary coil with its windings forming an angle between ten and forty degrees in relation to the primary windings. When the total number of windings on the secondary coil is equal to the total number of windings on the primary coil, the following novel effect is observed.

The winding of the tank coil according to the present invention is shown in Fig. 2. In that coil, a coil is first wound on a hollow core to provide a hollow primary coil C200. Thereafter, two secondary coils are each separately wound on a solid core, removed from the core and flattened to provide two U-shaped coils. These coils C201 are then folded around the primary coil C200, so that the secondary coils C201 protrude over left-hand and right-hand edges of the primary coil C200 by 1/8" and at an angle α of 10° to 40° in relation to the primary coil windings C200. The ends of the coils C201 are connected in series.

When any non-ferrous metal is inserted into the tank coil, the primary voltage is decreased. However, with the aforementioned secondary coil structure, the secondary voltage does not follow conventional transformer action but rather a retrocede action is observed whereby the secondary voltage increases in magnitude. The word 'retrocede' (to give back to, to grant back) most clearly defines this newly observed effect of the granting back of otherwise wasted energy radiated by the material passing through the coil. The ratio of the rise in the retrocede energy effect is surprisingly large compared to the drop of energy in the primary coil. When the oscillator is operating with 6 volts peak-to-peak across L-51, typically the regular drop effect for a brass slug the size of a 50 cent piece causes a drop in primary voltage of 1.25 volts, while the retrocede voltage rise is 2.5 volts.

This increase in energy in the secondary coil is not proportional to the decrease in energy in the primary coil, but both the increase in the secondary energy and the decrease in primary energy are directly proportionate to the material which causes the change. This retrocede action is due in part to the recovery of energy produced by the otherwise wasted Eddy currents radiated by the material. The rise in secondary voltage is surprisingly not strongly dependent on the lateral position of the material in the coil. It appears that the more noble (i.e. the more conductive) the matal used, the retrocede effect is more pronounced.

This retrocede effect in secondary voltage is not present for ferrous materials. However, ferrous materials with some non-ferrous content will produce this effect to a greater or lesser degree depending upon the ratio of the ferrous to the non-ferrous materials. An explanation for this is that while the predominate reason for losses in the primary circuit with non-ferrous materials is due mainly to Eddy current losses, hysteresis losses do not play a major role. Conversely, with ferrous materials, hysteresis losses predominate and cancel out what might have been recovered from Eddy currents. This retrocede effect allows two independent parameters to be identified and measured; one parameter related to the amount of non-ferrous material, the other related to the amount of ferrous material.

A practical application for this retrocede sensor is an analyzer for coins which can be used in single or multiple-coin applications.

Coins which are accepted (while all other slugs, spurious and other foreign coins are rejected) are determined solely by the information decoded from the logic available.

According to the present invention, single or multiple-coin analysis can be applied to any coin of any size of any country in any combination as well as any desired token or combination of tokens and coins. Metal and other materials with any kind of magnetic or conductive properties may be analyzed in this manner.

It will thus be understood that the present invention provides an oscillator circuit having a tank coil L51 which is constructed as described immediately above. In conjunction with this further embodiment, Figs. 5 and 6 show components C105, D103, R104, C108, R106, R107, R108,R109, R110, R111 and R112 as forming a diode pump circuit which serves to rectify the oscillation produced by TR101 resulting in a DC voltage across C108, which is proportional to the peak-to-peak voltage across L102. The value of C108 is selected to be large enough to ignore any instantaneous amplitude changes. This provides a reference voltage which can be used to compensate for any drift in the oscillator amplitude. The DC voltage available across C108 (VOLTAGE A) is therefore a function of the long-term amplitude of the oscillator.

Components C104,D101,R105,VR101,D102, C109 and R101 form a similar diode pump circuit providing a separate DC voltage acorss R101 (VOLTAGE B). In this instance C109 is selected small enough so that instantaneous amplitude changes will be recognized. Therefore the DC voltage across R101 is a function of the instantaneous amplitude of the oscillator. The voltage level across R101 may be preset by VR101 which is connected to the discharge path of the diode pump circuit.

Components D104, R103 and C107 serve to rectify the secondary voltage appearing across the retrocede sensing coil L103. Therefore the DC voltage (VOLTAGE C) appearing across R103, is a function of the instantaneous voltage acorss L103.

These three separate voltage levels (VOLTAGE A, VOLTAGE B and VOLTAGE C) are utilized in the following manner:

VOLTAGE A is divided by R106, R107, R108, R109, R110, R111, and R112 and is used as a reference for the non-inverting input of a string of voltage comparators M1-M7. VOLTAGE B is adjusted by VR101 to be slightly above the VOLTAGE A. This voltage is applied to the inverting inputs of the same voltage comparator string M1-M7. In this condition all comparator outputs are low, and will remain so, as long as VOLTAGE B remains slightly higher than VOLTAGE A.

A similar resistor divider network, R115, R116, R117, R118, R119 and R120 is also connected to VOLTAGE A. This network is used as a reference for the inverting input of a separate string of voltage comparators M8 - M12. The non-inverting input of these comparators M8-M12 is then capacitively coupled to VOLTAGE C via C111 and R113. In this condition, all these comparator outputs will be low.

The SET input of an R-S type flip-flop is connected to each comparator M1-M7 output so that, should any comparator momentarily go high, its corresponding R-S flip-flop will be set. All the flip-flop reset inputs are connected together and capacitvely coupled to the output of comparator M-1 via C110.

In operation, when a coin passes through the coil configuration primary voltage decreases as already described. Because the coin is in free fall, this reduction in amplitude is only momentary. Therefore, VOLTAGE A remains unaffected while VOLTAGE B drops to the instantaneous value.

The instant that VOLTAGE B falls below the reference voltage of M-1, the output of M-1 will go high and reset all flip-flops via C110. Should VOLTAGE B fall below the reference voltage applied to any of the other comparators, M-2, M-3, M-4, M-5, M-6 and M-7, the appropriate outputs will also go high. Any output that is thus rendered high will set its appropriate flip-flop, providing a logic code which corresponds to the analog voltage drop. Whereas the analog voltage drop was momentary, the resulting logic code is held for further digital comparison.

Concurrently with the voltage drop effect, the retrocede effect is also taking place, and depending upon the ferrous or non-ferrous nature of the coin used, VOLTAGE C will be rising during this time. As the voltage rise exceeds the reference voltages on comparators M-8, M-9, M-10, M-11 and M-12, the appropriate outputs of these comparators will be rendered high, thus setting up a similar combination of flip-flops to correspond with this rise in voltage; a direct function of the retrocede effect.

In order to determine which coins are to be validated, the exclusive flip-flop set-up pattern is decoded from the appropriate flip-flops Q and $\overline{Q}$ outputs. In the example shown in Figs. 11 and 12, the U.S. Five Cent, Ten Cent, Twenty-five Cent, Fifty Cent and Susan B. Anthony One

Dollar coins have been decoded. The LOGIC TRUTH TABLES I and II show how this decoding logic was established. The output of each appropriate decoder gate identifies each coin as follows:

5-cent coin - IC -24

10-cent coin - IC -22

25-cent coin - IC -23

50 cent coin - IC -26

SBA $1 coin - IC -25

A low output would indicate recognition of that particular coin.

RETROCEDE EFFECT LOGIC TRUTH
TABLE I
(For M-8 through M-12)

	5¢	10¢	25¢	50¢	$1.00	Brass slug 50¢ size	Steel Washer
.5v level M-12	1	0	1	1	1	1	0
1v level M-11	0	0	0	1	1	1	0
1.5v level M-10	0	0	0	1	0	1	0
2v level M-9	0	0	0	0	0	1	0
2.5v level M-8	0	0	0	0	0	1	0

LOSSES EFFECT LOGIC TRUTH TABLE II
(For M-1 through M-7)

	5¢	10¢	25¢	50¢	$1.00	Brass slug 50¢ size	Steel Washer
.25v reset level M-1	1	1	1	1	1	1	1
.5v level M-2	1	1	1	1	1	1	1
1v level M-3	1	0	1	1	1	1	1
1.25v level M-4	1	0	0	1	1	1	1
1.75v level M-5	0	0	0	1	1	0	1
2v level M-6	0	0	0	0	0	0	1
2.25v level M-7	0	0	0	0	0	0	1

The outputs of IC-22, IC-23, IC-24, IC-25 and IC-26 will always be high unless rendered low by the exclusive flip-flop pattern corresponding to each of the specified coins. An OR function of these outputs is performed by IC-27, IC-28, and IC-29 causing IC-29 to go low should any of the individual decoders (IC-22, IC-23, IC-24, IC-25 and IC-26 go low.

The output of IC-29 is connected to one input of a two- input NOR gate IC-30. The other input of this NOR gate is used to inhibit the gate until such time that the coin has completely passed through the sensing coil. This information is available from the output X of M-1 and thus the connection to M-1.

Under these conditions IC-30 can only trigger the one shop formed by IC-31 and IC-32 when both of the following conditions are met:

Condition 1: Coin has made complete passage through the sensing coil.

Condition 2: Coin has been recognized by flip-flops as one to be accepted.

The output of IC-32 is connected via R122 to the base of transistor TR102.

The ACCEPT SOLENOID L104 is connected to the collector circuit of this transistor TR-102. The result is that the solenoid will actuate the coin diverter mechanism whenever any one of the acceptable coins has passed completely through the sensing coil. Any spurious object will not cause this effect.

While the invention has been described by means of specific examples and in specific embodiments, I do not wish to be limited thereto, for obvious modifications will occur to those skilled in the art without departing from the spirit and scope of the invention.

WHAT IS CLAIMED

1. A multiple coin detecting apparatus for discriminating between denominations of coins and genuineness of coins so as to exclude from acceptance any coins which have not been specifically selected for acceptance, comprising:

(a) an oscillator circuit having a resonant tank circuit which provides amplitude modulation of the signal produced by the oscillator circuit in accordance with the losses of the tank circuit;

(b) coin directing means of insulating material having a vertical upper section and a vertical accept channel forming a completely free-fall chute for acceptable coins, and a second channel for directing slugs and other unacceptable coins to a predetermined locality;

(c) said resonant tank circuit having an inductance means positioned completely around the coin directing means such that said inductance means forms an air-cored coil, with the coins passing therethrough forming the core of said coil, and the losses of the tank circuit being determined by the metal content of the coin;

(d) direction switching means for selectively accepting and rejecting coins and the like in accordance with the respective amplitude of a control signal, said direction switching means comprising a movably mounted member, and an accept solenoid for moving said member to an accept position dependent on its condition of energization; further characterized in that:

(e) said coil comprises a primary on said hollow core which with said resonant tank circuit performs a second function of inducing eddy currents in the coin, and

(f) a secondary coil surrounding said primary coil and having windings protruding a specified distance over the edges of said primary coil at a predetermined angle in relation to the windings of said primary coil and providing a secondary fluctuation in conjunction with the primary coil voltage fluctuation, such voltage fluctuations being of opposing polarities.

2. A coin detecting apparatus as defined in claim 1, wherein said windings on said secondary coil are equal to the number of windings on said primary coil.

3. A coin detecting apparatus as defined in claim 1, wherein said predetermined distance is substantially equal to 1/8".

4. A coin detecting apparatus as defined in claim 1, wherein said predetermined angle is within the range from 10° to 40°.

5. A coin detecting apparatus as defined in claim 1, wherein an increase in secondary voltage is substantially independent of the lateral position of the coin.

6. A coin detecting apparatus as defined in claim 1, wherein an increase in secondary voltage is substantially

dependent on the conductivity of the metal of the coin.

7. A coin detecting apparatus as defined in claim 1, including rectifying means for rectifying oscillations from said oscillator circuit into a corresponding DC voltage across a capacitor and proportional to peak-to-peak voltage across said primary coil, said capacitor being sufficiently large so that instantaneous amplitude changes are negligible and a reference voltage is thereby produced for compensating against drift in the oscillator amplitude, said DC voltage across said capacitor being a function of the long-term amplitude of said oscillations.

8. A coin detecting apparatus as defined in claim 7, including additional rectifying means for providing a separate DC voltage across a resistor and dependent on the instantaneous amplitude of said oscillations.

9. A coin detecting apparatus as defined in claim 8, including means for rectifying voltage across said secondary coil and appearing across a resistor connected in parallel with said secondary coil, said voltage across said resistor not being a function of the instantaneous voltage across said primary coil but rather being a function of the amount of non-ferrous metal contained in the coin sample detected by the secondary coil.

10. A coin detecting apparatus as defined in claim 9, including a plurality of voltage comparators, said

first-mentioned DC voltage being applied to said comparators and comprising a reference for inverting inputs thereof, said second mentioned voltage being substantially greater than said first-mentioned voltage being applied to the non-inverting inputs of said comparators, said comparators having outputs at a low level when said second-mentioned voltage is substantially greater than said first-mentioned voltage.

11. A multiple coin detecting apparatus according to claim 1 wherein said secondary coil produced enhanced secondary retrocede voltages in excess of those normally produced by mutual inductance or transformer action.

12. A multiple coin detecting apparatus according to claim 1 wherein said primary and secondary voltage fluctuations are fed into independent analog to digital converters and associated R-S flip-flops and provide a digital pattern for evaluating each coin on the bases of genuineness and denomination.

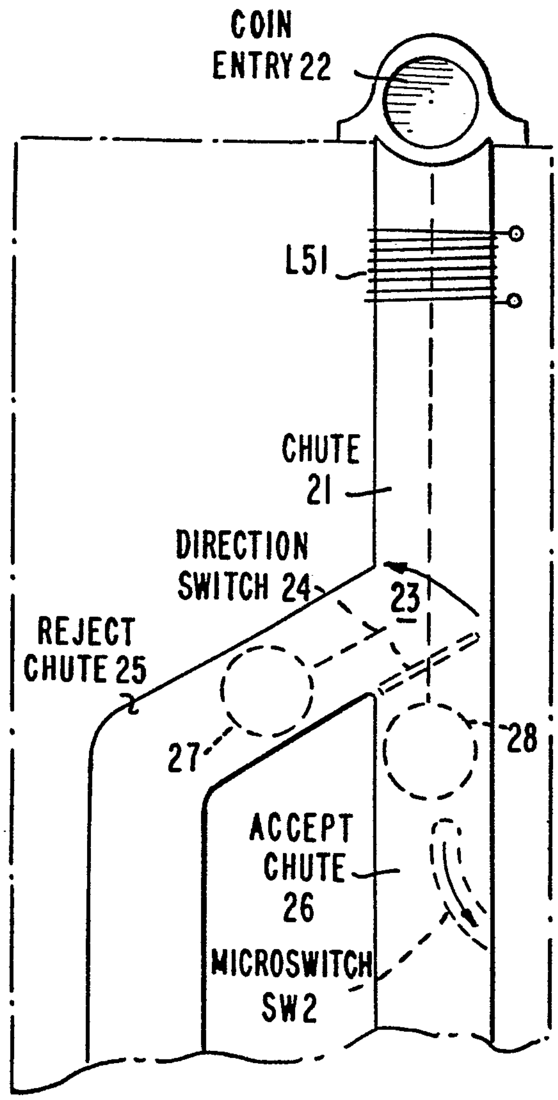

COIN
ENTRY 22
L51
CHUTE
21
DIRECTION
SWITCH 24
23
REJECT
CHUTE 25
27
28
ACCEPT
CHUTE
26
MICROSWITCH
SW2

Fig. 1

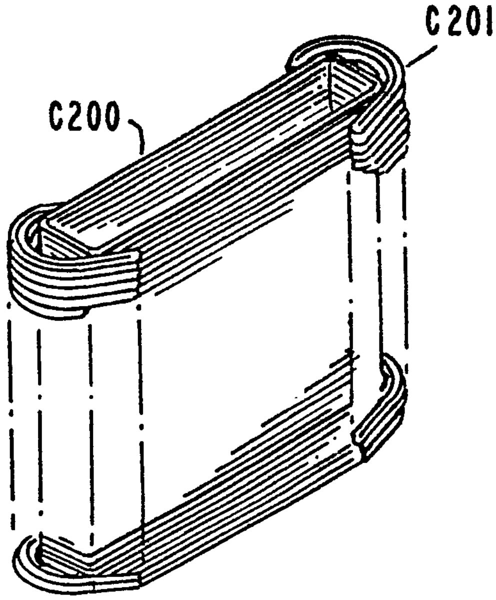
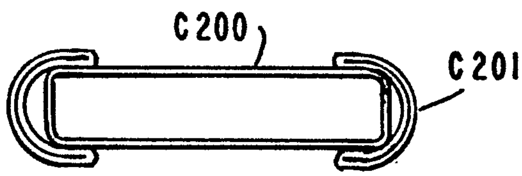


Fig. 2

Fig. 3



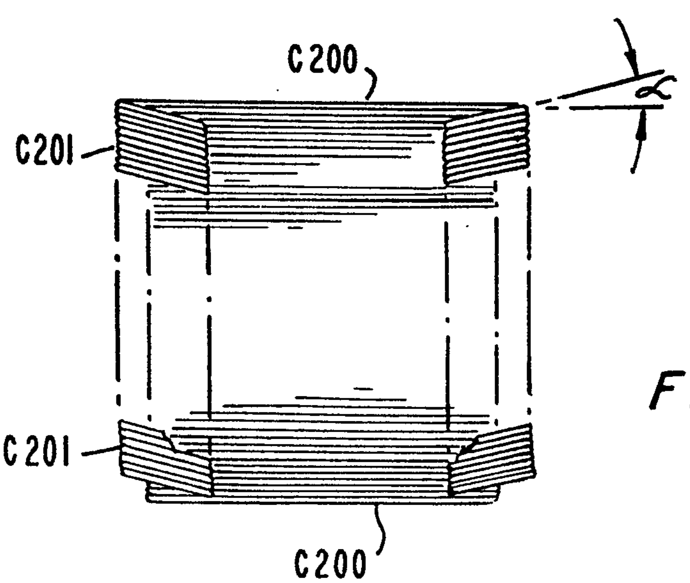
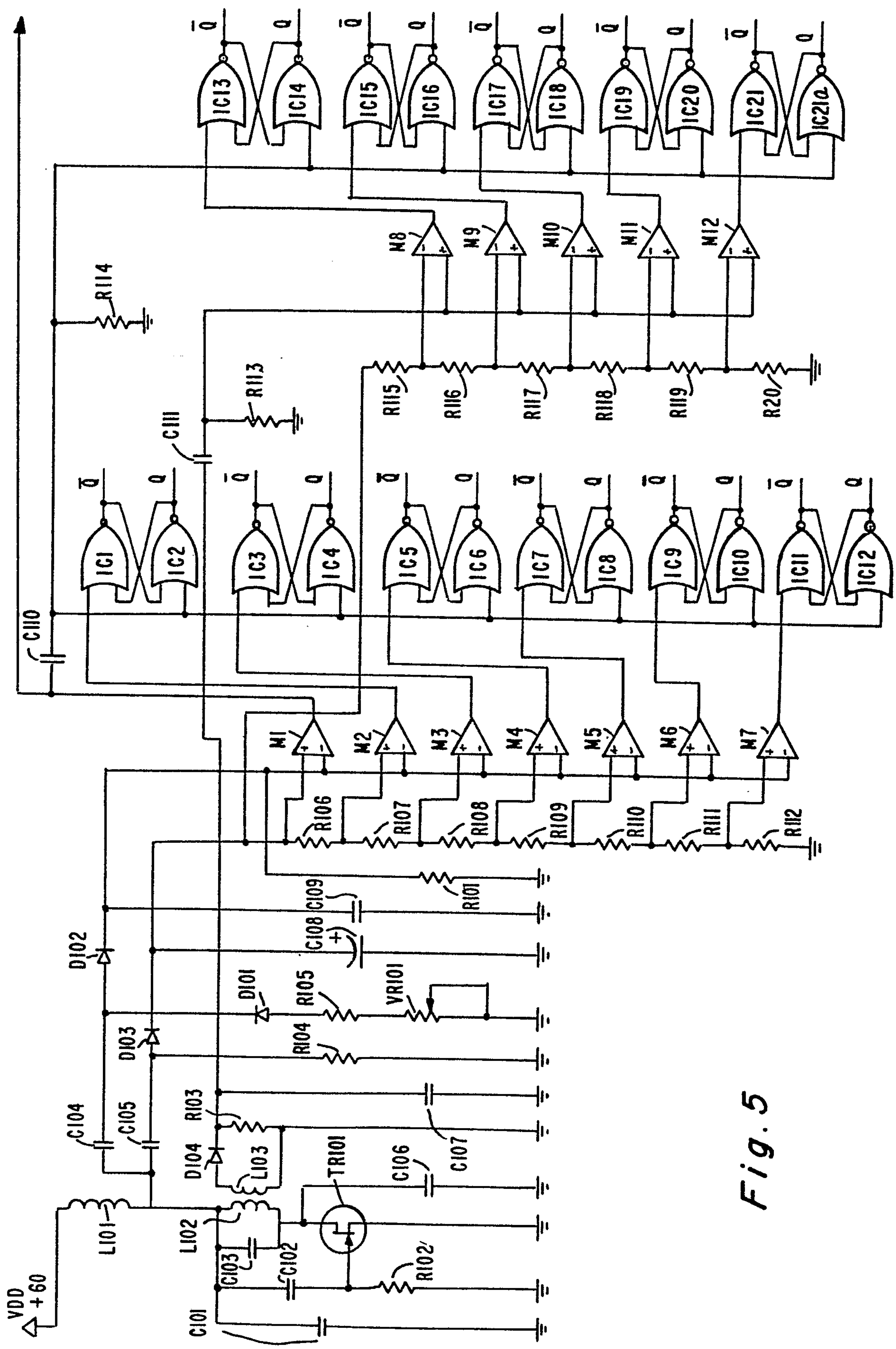


Fig. 4


VDD
+60
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L102
L103
C101
C102
C103
C104
C105
C106
C107
C108
C109
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D101
D102
D103
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TR101
VR101
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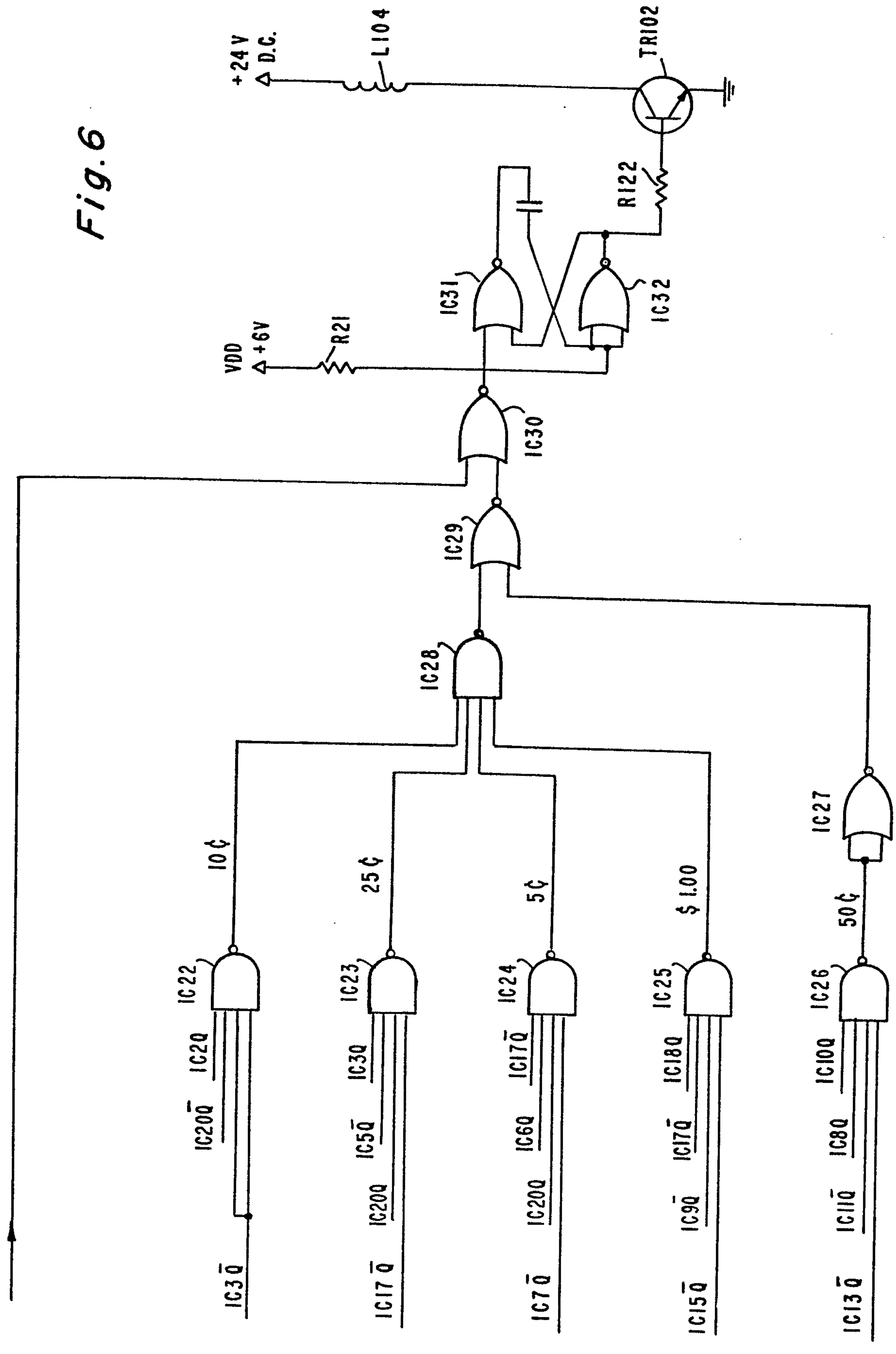
Q
Q̄

Fig. 5

Fig.6


+24 V D.C.
L104
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R122
IC31
IC32
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R21
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IC29
IC28
IC27
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25¢
5¢
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50¢
IC22
IC23
IC24
IC25
IC26
IC2Q
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IC10Q
IC8Q
IC11Q̄
IC13Q̄

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European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 82 40 0162

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
A	EP-A-0 016 696 (GAEA TRADE AND DEVELOPMENT COMPANY LTD.) *Abstract; page 11, paragraph 2 - page 26, paragraph 2; figures 1,4,5*	1,8	G 07 F 3/02
A	US-A-4 128 158 (J.L.DAUTREMONT) *Abstract; column 1, line 45 - column 2, line 47; figure 1*	1	
A	US-A-4 226 323 (J.L.DAUTREMONT) *Abstract; column 1, line 65 - column 2, line 36; figure 1*	1	
A	DE-A-2 916 123 (W.HANKE) *Page 8, paragraph 3 - page 21, paragraph 2; figures 1-4*	1,10	TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
A	GB-A-1 578 767 (Y.HAYASHI) *Page 1, line 32 - page 3, line 2; figures 1-4*	1,12	G 07 D 5/00 G 07 D 5/08 G 07 F 3/00 G 07 F 3/02 G 01 V 3/10
A	US-A-3 933 232 (B.C.SEARLE) *Abstract; column 1, line 52 - column 5, line 27; figures 1,2*	1,10	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27-09-1982	RUDOLPH H.J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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