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(54) Coin checker.

(57) An apparatus for checking coins (2) as to whether they are genuine coins of a preselected denomination or not, comprising a chute (3) along which coins (2) are fed one by one by transport means (9, 10), camera means (7, 8) for imaging each coin and producing an image signal representative of the image of the coin, and control means (13) for judging, in response to the image signal, whether each coin is genuine or not. For accurately checking the coins even if they are stained or dust covered, a plurality of slits (4*a*-4*d*,) are formed in a prescribed pattern in the chute (5) intermediate the opposite ends thereof, and a dark box (5) is disposed on one side of the chute for providing an optically dark space which is open to the slits in the chute and in which a coin sensor (6) is disposed. Thus the coin sensor can optically sense each coin traveling over the slits, whereupon camera means (7, 8) are actuated for imaging the coin over the slits.

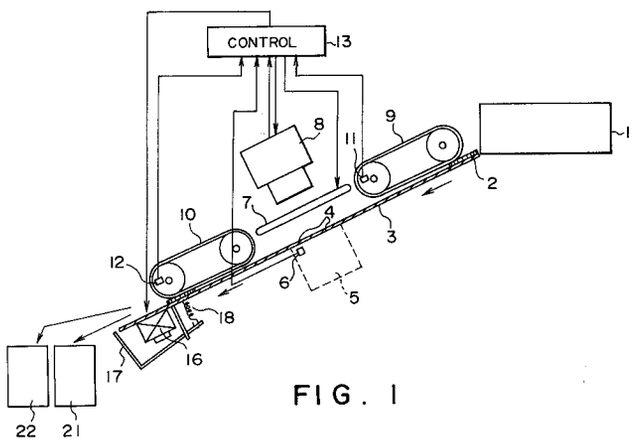

FIG. 1

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BACKGROUND OF THE INVENTION

This invention relates to an apparatus for checking coins as to whether they are genuine coins of a given denomination or not, with or without the capability of sorting them accordingly, and with or without the capability of counting the coins that have proved to be genuine, as well as those which have proved otherwise. The apparatus according to the invention finds use as a coin checker, banking machine, vending machine or the like.

Known machines of this general character may be broadly classified into two categories, one being the mechanical type relying on the diameters, weights or like properties of coins, and the other being the electronic type relying on the magnetic, optical or like characteristics of coins. Both types are alike, however, in that the coins are checked while they are sliding, rolling or falling along a predefined passageway.

A problem common to such conventional machines is that the coins are easy to jam in the passageway, particularly if they are stained or dust covered or if the coins or the passageway is wet. Even if the coins do not jam, the stained, dust covered, or moist coins have been very liable to travel at variable speed past the check station on the passageway. Such changes in traveling speed have often resulted in errors in coin identification.

SUMMARY OF THE INVENTION

The present invention seeks to check coins more accurately than heretofore even if the coins are fed at variable speed because of stains or dust accumulations thereon or by moisture.

The invention also seeks to feed coins one by one more positively than heretofore along a predetermined path even if they are supplied in a batch and if they are stained or dust covered or wet.

Briefly, the invention may be summarized as an apparatus for checking coins as to whether they are genuine coins of a preselected denomination or not. Included is a coin chute having a plurality of slits formed in a prescribed pattern at a check station intermediate an entrance end and an exit end thereof. Also, at the check station, a dark box is disposed on one side of the chute for providing an optically dark space which is open to the slits in the chute and which has an optical coin sensor disposed therein. Disposed on another side of the chute is a camera means for imaging each coin traveling over the slits in the chute. A control means is electrically connected to the coin sensor and the camera means for causing the latter to image each coin in response to a signal from the coin sensor and for judging, in response to an image signal from the camera means, whether each coin is a genuine coin of a preselected denomination or not.

Positioned in the dark space, the coin sensor can accurately detect the arrival of each coin at the check station as the coin, traveling down the chute, covers the slits open to the dark space. This method of coin detection is totally unaffected by stains or dust accumulations on the coin. The control means on inputting the coin arrival signal from the coin sensor causes the camera means to image the coin at the check station. The image signal from the camera means is sent back to the control means, which then determines whether the coin is genuine or not by the known pattern matching method.

According to a further feature of the invention, coins are forcibly fed along the chute by transport means. Typically, the transport means comprises a belt conveyor for transporting the coins from the entrance end to the check station, and another such conveyor for transporting the coins, after having been checked, from the check station to the exit end. Each conveyor has an endless belt capable of frictional engagement with the coins, so that the coins are forcibly transported one by one down the chute in sliding contact therewith, against the possibility of jamming on the chute.

In order to further preclude the danger of coin jamming, the coins may be transported at a lower speed by the upstream conveyor than by the downstream conveyor. In this manner there will be no likelihood of two or more coins collecting at the check station, awaiting discharge by the downstream conveyor.

The above and other features and advantages of this invention and the manner of realizing them will become more apparent, and the invention itself will best be understood, from a study of the following description and appended claims, with reference had to the attached drawings showing a preferable embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a combined pictorial and block diagrammatic illustration schematically showing some essential parts of the coin checker constructed in accordance with the novel concepts of this invention;

FIG. 2 is a top plan of the showing of **FIG. 1**;

FIG. 3 is a perspective view of the coin checker;

FIG. 4 is an enlarged plan view of the check station of the coin chute in the **FIGS. 1-3** coin checker;

FIG. 5 is an enlarged view of the control panel of the **FIG. 3** coin checker; and

FIG. 6 is a flow chart explanatory of the operation of the coin checker.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention will now be described in detail as embodied in the illustrated coin checker which successively checks a number of coins to determine whether they are genuine coins of any given denomination or not and which sorts the coins accordingly. **FIGS. 1** and **2** schematically illustrate only those parts of the coin checker which are essential for the understanding of the invention, and **FIG. 3** shows a typical external appearance of the complete coin checker.

With reference to **FIGS. 1** and **2** in particular the coin checker includes a hopper 1 into which coins to be checked are charged. Centrifugally flung away one by one from the hopper 1, the coins 2 are to be loaded on a sloping chute 3 at its entrance end, shown directed to the right in **FIGS. 1** and **2**, and to travel therealong to its exit end past a check station intermediate the entrance and the exit ends.

At the check station the chute 3 has formed therein a plurality of slits indicated at 4 in **FIG. 1** and shown more clearly in **FIG. 4** in plan view and on an enlarged scale. It will be seen that four slits 4*a*-4*d* of the same shape and size are provided radially at constant angular spacings. More specifically, the slits 4*a* and 4*b* are aligned longitudinally of the chute 3, and the other two slits 4*c* and 4*d* transversely of the chute.

As shown also in **FIG. 4**, as well as in **FIG. 1**, a dark box 5 is mounted to the underside or back side of the chute 3, that is, the side opposite to the one on which the coins 2 travel. The dark box provides an optically dark space to which the slits 4 are open directly. A coin sensor 6 in the form of a photodetector or photosensor is disposed within the dark box 5, in a position of registry with the slit 4*b*, for optically sensing each coin traveling over the slits 4 in a manner yet to be described.

Also disposed at the check station, and on the front or top side of the chute 3, are coin imaging means comprising a stroboscope 7 of annular shape and an electronic imaging device 8 such as a charge coupled camera. The stroboscope 7 and camera 8 are arranged coaxially with each other, normal to the plane of the chute 3, and concentrically with the radial arrangement of the four slits 4. The imaging means 7 and 8 image each coin traveling over the slits 4, when that coin is sensed by the coin sensor 6, and provides an electric coin image signal representative of the coin.

FIGS. 1 and **2** further reveal an upstream conveyor 9 for forcibly transporting the successive coins along the chute 3 from the entrance end to the check station, and a downstream conveyor 10 for forcibly transporting the coins along the chute from the check station to the exit end. Both conveyors 9 and 10 are shown as belt conveyors, each comprising a pair of pulleys and an endless belt running thereon. The endless belts are capable of frictional engagement with the coins, transporting them in sliding contact with the chute. It is understood that both belt conveyors 9 and 10 are driven by separate electric motors, not shown.

At 11 and 12 in **FIG. 1** are shown speed sensors, which can also be photodetectors, for sensing the peripheral speeds of the drive pulleys of the belt conveyors 9 and 10. Drive pulley speed signals from these speed sensors 11 and 12, as well as a coin image signal from the camera 8, are sent to control electronics 13. Constantly monitoring the traveling speeds of the belt conveyors 9 and 10, the control 13 controls the unshown drive means of the belt conveyors so that the downstream conveyor 10 transports the coins at higher speed than does the upstream conveyor 9. No problem will normally occur, however, if both belt conveyors run at the same speed. Preferably, and as shown in **FIG. 2**, a pair of coin guides 14 with flaring upstream ends may be provided on the chute 3 on both sides of the upstream conveyor 9, and another similar pair of coin guides 15 on both sides of the downstream conveyor 10.

Adjacent the exit end of the chute 3 there are provided means for sorting the coins and directing them to two different paths according to whether they are good or band, that is, whether they are genuine coins of some particular denomination or not. As depicted in both **FIGS. 1** and **2**, such sorting means include a deflector 17 pivotable between a retracted position, in which it lies under the chute 3, and a working position in which it projects into the chute. Normally held retracted under the bias of a helical extension spring 18 as shown in **FIG. 1**, the deflector 17 pivots against the force of the spring when a deflector actuator, herein shown as a solenoid 16, is energized in response to a signal from the control 13.

As will be noted from both **FIGS. 2** and **3**, the exit end of the chute 3 communicates with a good coin discharge port 19 and a bad coin discharge port 20. The good coin discharge port 19 is open to an optional good coin recovery box 21, and the bad coin discharge port 20 to an optional bad coin recovery box 22.

When a coin at the check station is judged to be good by the control 13, the deflector 17 will be held retracted, allowing that coin to travel straight from the downstream belt conveyor 10 and fall into the good coin recovery box 22. If the coin proves to be bad, on the other hand, then the solenoid 16

will be energized thereby pivoting the deflector 17 to the working position. The deflector 17 in its working position will deflect the bad coin away from the straight path and direct it toward the bad coin discharge port 20, from which the coin will fall into the bad coin recovery box 22.

Preferably, and as indicated at 23 and 24 in **FIG. 2**, two additional optical coin sensors may be provided adjacent the good coin discharge port 19 and bad coin discharge port 20, respectively. The good coin sensor 23 and bad coin sensor 24 may both be connected to the control 13 in order to enable the same to know that the coins are being sorted correctly. Due to some machine trouble or other, troubles being almost unavoidable in this and any kinds of machines, a coin that has been judged to be good may be sensed by the bad coin sensor 24, and a coin that has been judged to be bad by the genuine coin sensor 23. In such cases either the complete machine may be set out of operation, or an alarm may be triggered off, and the incorrectly sorted coins may be rechecked as required.

As pictured in **FIG. 3** and in more detail in **FIG. 5**, the coin checker has a control panel 25 having various control and display means arranged thereon. Before studying these control and display means, it must be pointed out that this machine can be set in either check mode or teach mode. The machine checks coins when set in check mode. Preparatory to coin checking, however, the machine needs reference data on the head and tail patterns of the coins of each denomination to be checked. The teach mode is therefore first selected to teach the machine the reference data. It relies on the reference data to determine whether each coin is a proper coin of the specified denomination or not in the subsequent check mode of operation.

With reference now directed to **FIG. 5** the control panel 25 includes a "Coin Count" screen 26 which displays in real time during check mode of operation both the number of coins that have proved good and the number of coins that have proved otherwise. The screen 26 consists of two sections, with the top section indicating the number of good coins and the bottom section indicating the number of bad coins. The "OK" and "NG" signs 27 will be lit up to denote what the counts mean. During teach mode, on the other hand, the "Coin Count" screen 26 indicates the number of sample coins whose head pattern has been taught, and the number of those whose tail pattern has been taught. A reset pushbutton switch 28 is to be depressed by the operator for resetting the counts only in check mode.

A "Teaching" section 29 includes several light emitting diodes (LEDs). These LEDs are to glow individually to indicate the progress of teaching during teach mode of operation.

A "Mode Select" switch 30 is to be actuated by the operator for setting the machine in either check mode or teach mode.

The control panel 25 further includes a set of "Pattern Select" pushbutton switches 31 to be selectively depressed to indicate the particular denomination of coins to be checked or to teach. Any depressed switch will blink, indicating that some particular denomination of coins has been chosen for checking or teaching. Any constantly glowing switch or switches indicate that the corresponding denomination or denominations of coins have been taught and, therefore, that the switch or switches may be depressed for immediate commencement of check mode. Any unlit switch or switches indicate that the machine has not learned about the corresponding denomination or denominations of coins and, therefore, that the machine must first be set in teach mode by the "Mode Select" switch 30.

The preferred form of coin checker according to the invention being constructed as the foregoing, its operation will now be described with reference to the flow chart of **FIG. 6**. The operation of the coin checker starts with the choice of either teach mode or check mode at step S_1. Assume that the "Mode Select" switch 30, **FIG. 5**, has now been actuated to set the machine in teach mode, for causing its control electronics 13, **FIG. 1**, to store the reference data representative of the patterns or pattern characteristics of both head and tail of the coins of a desired denomination.

In that case a suitable number of good coins of the desired denomination may be introduced into the hopper 1, **FIGS. 1-3**. according to step S_2. As these sample coins travel one by one down the chute 3, the control 13 will automatically collect the required reference data at step S_3.

Upon completion of the teach mode the "Mode Select" switch 30 may be set in check mode. A batch of coins of the presumably desired denomination may now be charged into the hopper 1, as indicated at step S_4. Centrifugally driven away from the hopper, the cons will travel one by one down the chute 3 as the upstream conveyor 9, **FIGS. 1** and **2**, forcibly transports them in sliding contact with the chute, as at steps S_5 and S_6. The speed of the upstream conveyor 9 is such that each coin on being frictionally engaged by the conveyor belt will be accelerated down the chute, with the consequent creation of a conveniently large space from one coin to the next.

Then comes the step S_7, the sensing of the arrival of each coin at the check station by the coin sensor 6, **FIGS. 1** and **4**. The coin sensor 6 will signal the control 13 when a coin comes over the slits 4 in the chute 3 whereupon the control will cause the stroboscope 7 to flash, as at step S_8,

and the camera 8 to shoot the coin, as at step S_9. The camera 8 will then send an image signal, representative of the image of the coin, to the control 13, which will then process the image signal for subsequent pattern matching, as at S_{10}.

It cannot be expected, however, for every coin to travel past the geometrical center of the four slits 4*a*-4*d* in radial arrangement, so that the camera will image the successive coins in more or less different positions over the slits. The control 13 should therefore be informed of exact positions of the coins for efficient determination of their goodness or badness by the known pattern matching method. The exact positioning of coins has so far been made even more difficult by metallic particles or other matter that may be attached to the coins, or by the reflection of light from possible scratches or other surface imperfections of the chute.

Such difficulties are overcome according to the invention by creating the four slits 4*a*-4*d* in the chute 3 and by providing the optical coin sensor 6 within the dark box 5 covering the slits. The coin sensor can sense the periphery of each coin at a plurality of different points, so to say, without being affected by foreign matter that may be attached thereto. The control 13 is thus enabled to determine the exact position of the coin over the slits and hence to judge its identity by the pattern matching method.

More specifically, at the judgment step S_{11}, the control 13 compares the head or tail pattern of the coin with the reference head and tail patterns that have been taught previously. If the coin is good, its pattern will agree with either reference pattern. A 100 percent agreement is not a necessity, however. Coins of the same denomination may not necessarily be exactly alike, but slight differences may exist according to the years of their mintage. Such coins can nevertheless be judged to be good or bad according to whether their likeness to the reference patterns comes up to, or falls short of, a critical percentage that may be predetermined statistically.

Judged good at the step S_{11}, the coin will be accelerated down the chute 3 by the downstream conveyor 10 and fall from the good coin discharge port 19 into the good coin recovery box 21, according to steps S_{12} and S_{13}.

If the coin proves bad at the judgment step S_{11}, on the other hand, then the control 13 will cause the solenoid 16 to be energized, as at step S_{14}, and hence to pivot the deflector 17 to its working position against the force of the tension spring 18, **FIG. 1**. Then the bad coin will be accelerated down the chute 3 by the downstream conveyor 10 and, after hitting the deflector 17, fall from the bad coin discharge port 20 into the bad coin recovery box 22, according to steps S_{12} and S_{15}.

As has been stated, it is preferred that the running speed of the downstream conveyor 10 be higher than that of the upstream conveyor 9. This difference admits of some variable delay in the traveling speed of the coins past the check station. The coins will not jam at the check station as they are moved away therefrom at a higher speed by the downstream conveyor 10 than the upstream conveyor 9 brings the coins to the check station.

Despite the foregoing detailed disclosure, it is not desired that the present invention be limited by the exact details of the illustrated embodiments or the description thereof, since a variety of modifications or alterations will readily suggest themselves to one skilled in the art to conform to design preferences or to the requirements of each specific application of the invention. For example, the illustrated four slits of radial arrangement might be combined into a single opening of cruciate shape, such a single opening being considered essentially comprised of four slits or slots and hence within the scope of this invention. Also, transport means other than the illustrated belt conveyors might be adopted to move coins along the chute, all that is required being that the coins be fed one by one past the check station without jamming.

Claims

1. An apparatus for checking coins as to whether they are genuine coins of a preselected denomination or not, comprising a chute (3) along which coins (2) are fed one by one, camera means (7, 8) for imaging each coin and producing an image signal representative of the image of the coin, and control means (13) for judging, in response to the image signal, whether each coin is genuine or not, characterized in that a plurality of slits (4*a*-4*d*,) are formed in a prescribed pattern in the chute (5) intermediate the opposite ends thereof, that a dark box (5) is disposed on one side of the chute for providing an optically dark space which is open to the slits in the chute and in which a coin sensor (6) is disposed for optically sensing each coin traveling over the slits, and that the camera means (7, 8) are disposed on another side of the chute for imaging each coin traveling over the slits when the coin is sensed by the coin sensor.

2. An apparatus as claimed in claim 1, characterized in that the slits (4*a*-4*d*) are arranged radially at constant angular spacings.

3. An apparatus as claimed in claim 1, characterized in that the slits include a first pair of slits (4*a*, 4*b*) aligned longitudinally of the chute (3),

and a second pair of slits (4*c*, 4*d*) aligned transversely of the chute.

4. An apparatus as claimed in claim 1, characterized in that the transport means (9, 10) are provided for forcibly transporting the coins one by one along the chute (3).

5. An apparatus as claimed in claim 4, characterized in that the transport means comprise a first conveyor (9) for transporting the coins from the entrance end of the chute (3) toward the slits (4*a*-4*d*) therein by holding the coins in sliding contact with the chute, and a second conveyor (10) for transporting the coins from the slits toward the exit end of the chute by holding the coins in sliding contact with the chute.

6. An apparatus as claimed in claim 5, characterized in that the second conveyor (10) transports the coins at a higher speed than does the first conveyor (9).

7. An apparatus as claimed in claim 5, characterized in that the first and the second conveyors (9, 10) are belt conveyors, each including an endless belt capable of frictional engagement with the coins.

8. An apparatus as claimed in claim 1, characterized in that sorting means (16, 17, 18) are disposed adjacent the exit end of the chute (3) for sorting the coins according to whether they are genuine coins of a preselected denomination or not.

9. An apparatus as claimed in claim 8, characterized in that the sorting means comprises a movable deflector (17) for causing the successive coins to travel to different paths according to whether they are genuine coins of a preselected denomination or not, and a deflector actuator (16) for actuating the deflector.

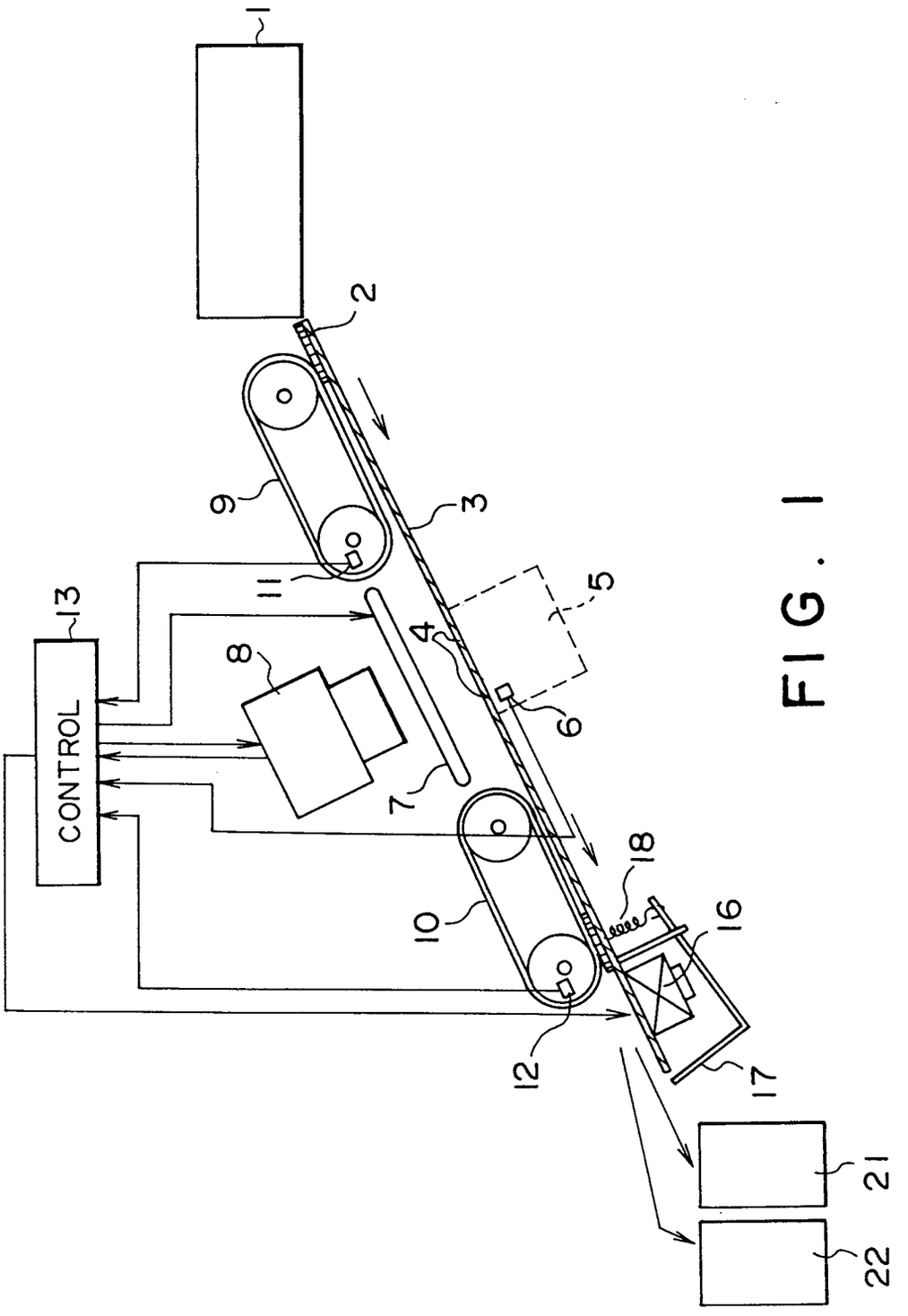

FIG. 1

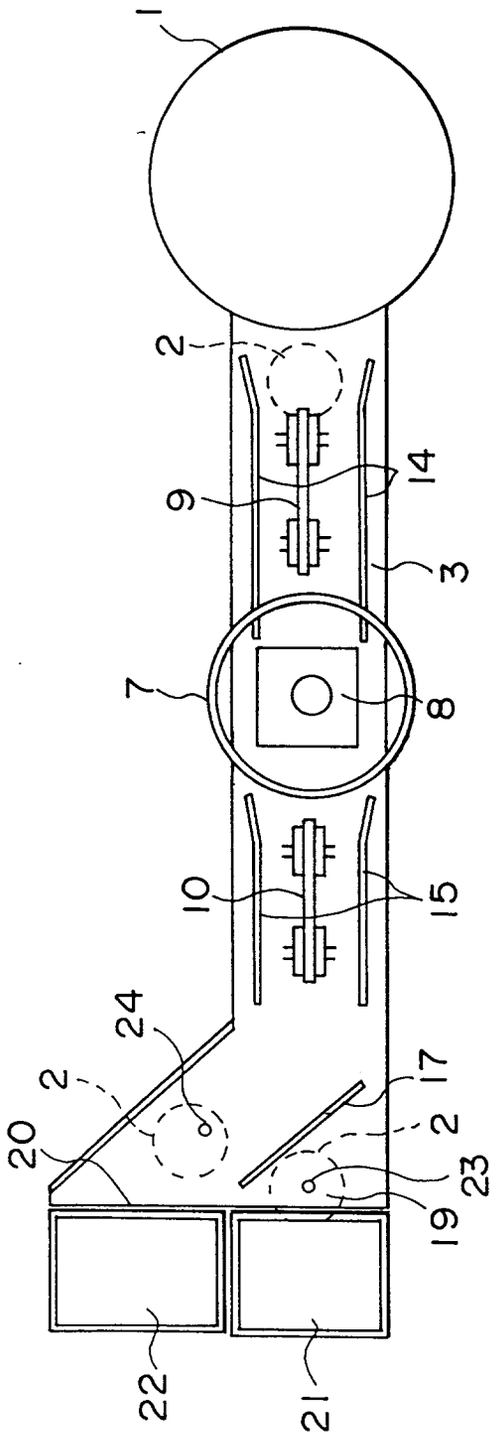

FIG. 2

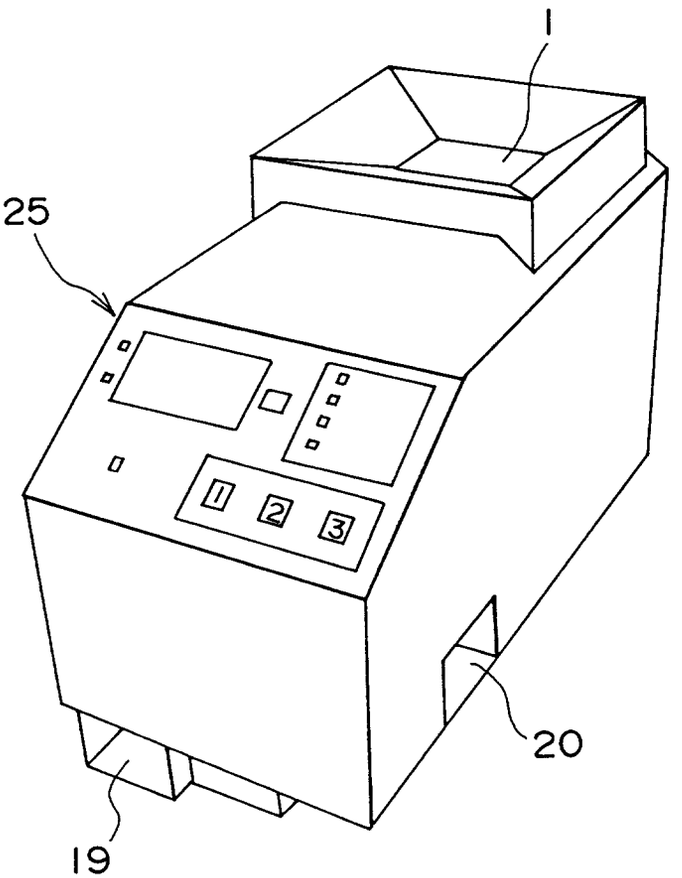

FIG. 3

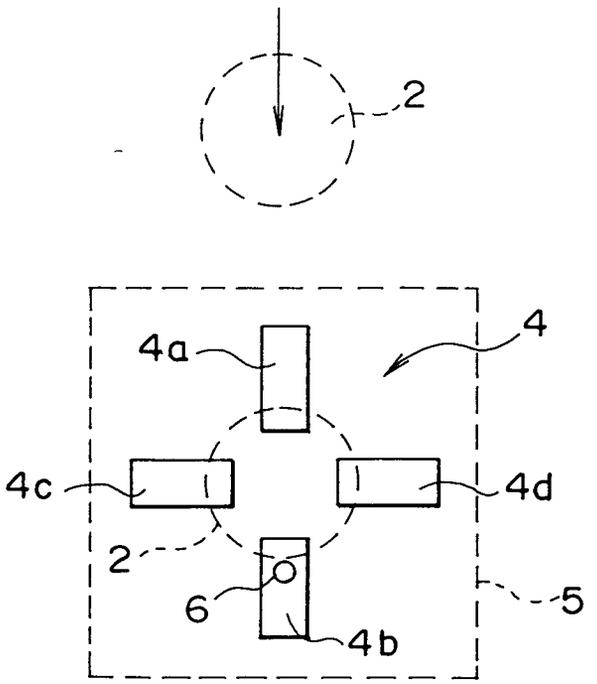
2
4
4a
4c
4d
2
6
4b
5

FIG. 4

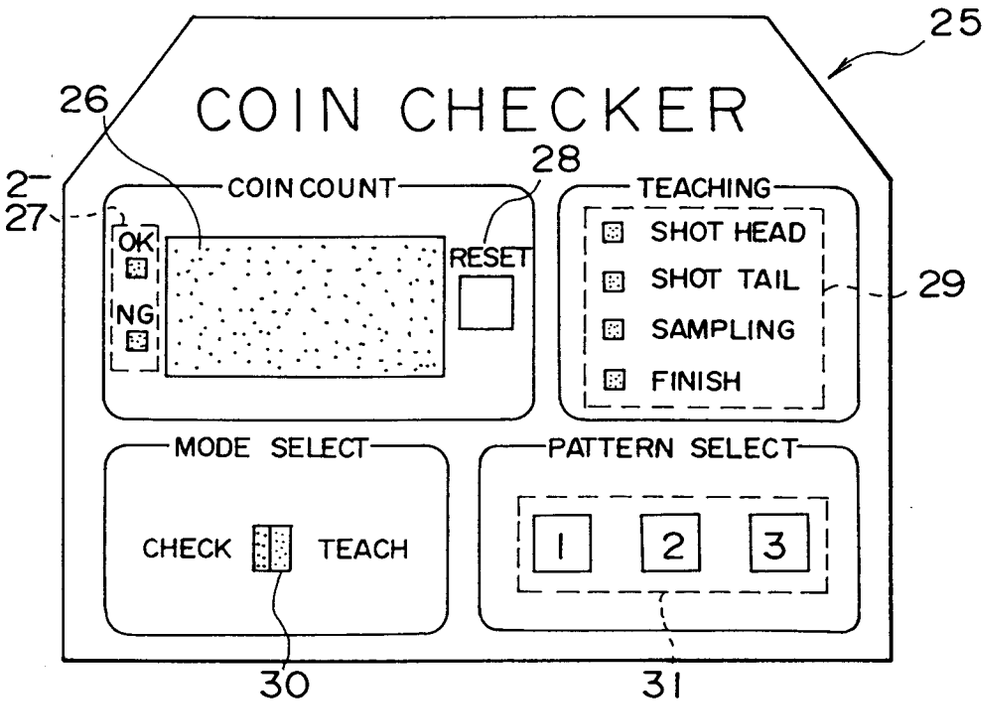
25
COIN CHECKER
26
28
2
27
COIN COUNT
TEACHING
OK
NG
RESET
SHOT HEAD
SHOT TAIL
SAMPLING
FINISH
29
MODE SELECT
PATTERN SELECT
CHECK
TEACH
1
2
3
30
31

FIG. 5

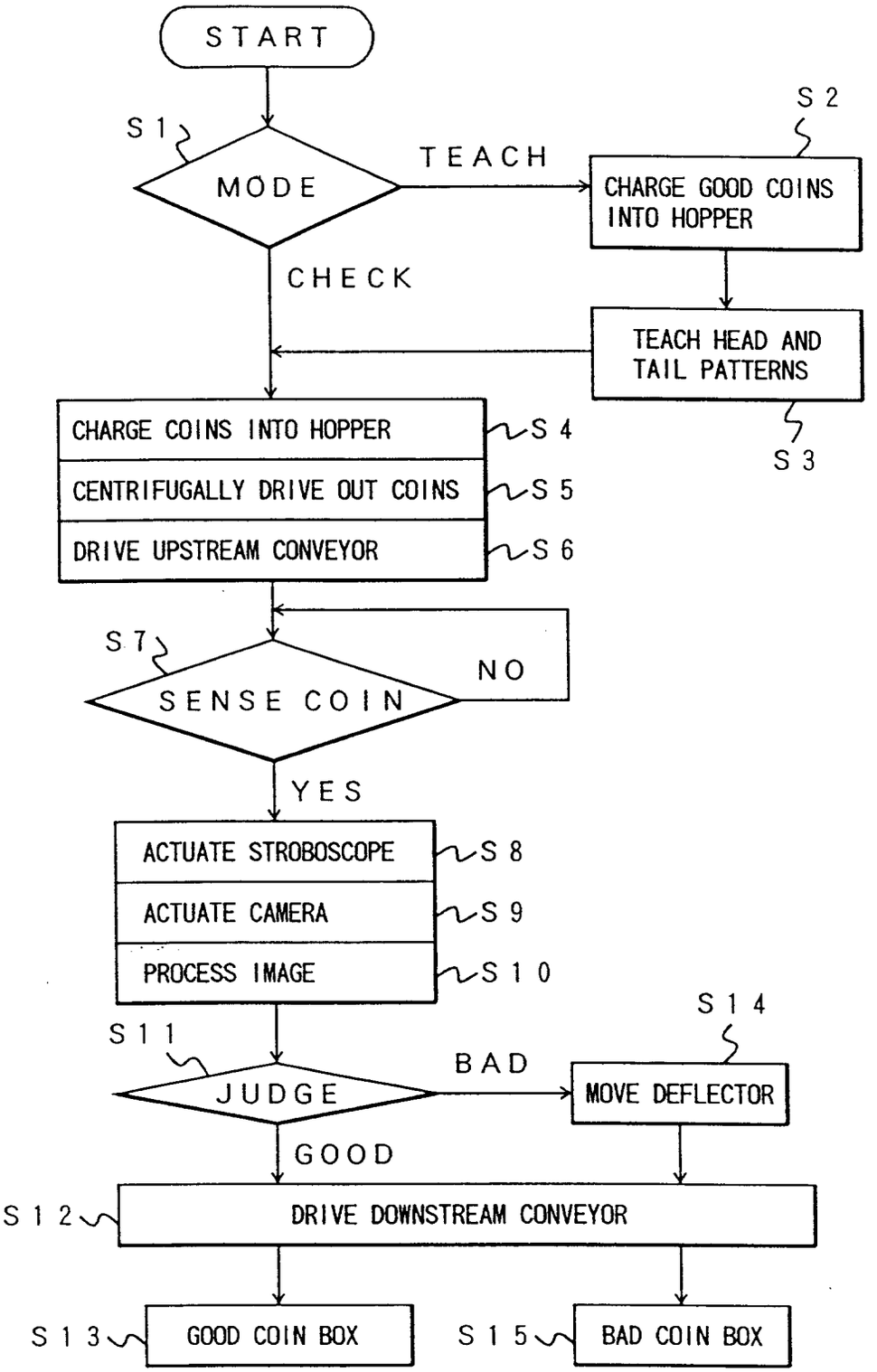
START
S1
MODE
TEACH
S2
CHARGE GOOD COINS INTO HOPPER
CHECK
TEACH HEAD AND TAIL PATTERNS
S3
CHARGE COINS INTO HOPPER
S4
CENTRIFUGALLY DRIVE OUT COINS
S5
DRIVE UPSTREAM CONVEYOR
S6
S7
SENSE COIN
NO
YES
ACTUATE STROBOSCOPE
S8
ACTUATE CAMERA
S9
PROCESS IMAGE
S10
S11
JUDGE
BAD
S14
MOVE DEFLECTOR
GOOD
S12
DRIVE DOWNSTREAM CONVEYOR
S13
GOOD COIN BOX
S15
BAD COIN BOX

FIG. 6