

Appraisal of Currency Counters Used in the Banking Industry

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Abstract

The need for accurate counting of bank notes by bankers is of utmost importance as most of their daily activities revolve round cash transactions. Also of great importance is the need to detect fake notes, this is where currency counters come in handy. They do not only provide the banker with ease for counting cash but also help in the detection of fake notes. The malfunctioning of this device can be frustrating to the banker who relies heavily on this machine to carry out his or her cash transactions; hence there is a great need for proper evaluation, monitoring, and maintenance on the components of these machines. This study tends to evaluate the technique employed in the counting process of the currency counting machine, the detection of fake notes by the counting machine, the sorting of bills of different denominations. The component parts of most of the counting machines like the ICs, relays, resistors capacitors, LCDs and transformers, the required precautions and maintenances to be carried out on the machine to ensure the optimum utilization.

Keywords: counting machine, fake note detection, florescence detection, UV light and bill sorting

1.0 Introduction

The use of money as a means of exchange between two parties cannot be over emphasized since its preference to the trade-by-barter system. Money which exists as paper cash or as coin, the latter though gradually losing its relevance in the society requires counting by both giver and receiver.

Counting money by hand can take a lot of time and is not always accurate. A bill counter can speed up this process and reduce error to a great extent. A bill counter will make up its own cost simply by saving on time and errors. Money counters are ideal for use in banks, for fund raisers, retail stores and other financial dealing bodies.

A currency-counting machine therefore is a machine that counts money either stacks of banknotes or loose collections of coins. Counters may be purely mechanical or use electronic components. The machines typically provide a total count of all money, or count off

specific batch sizes for wrapping and consequently for storage [1].

The various types of counting machines includes Basic Note counter, counterfeit detection machines and High Speed Heavy duty cash counting machine. All these are available to suit different type of customers like banks, big and small business houses, retailers etc.

The first automatic bill counting machines (or banknote counting machines) were introduced in the 1920s in the United States, "The Federal Bill Counter Company", which is located in Washington D.C (USA), introduced the first automatic *money counter machine* during the 1920's. These money counting machines were basically designed for enhancing the effectiveness and also for decreasing the errors of the employees who worked in Federal Reserve Bank. These *money counter machine* will automatically stop when the counts of the programmed batch of bills are completed [2].

In the year 1962, new technology was developed for counting the banknotes. This *money counter machine* was introduced by the "Tokyo Calculating Machine Works of Shinagawa". As this *money counter machine* had an exponential increase in accuracy and speed, they quickly replaced the traditional models and started to rule the market [3].

In 1981 computerized friction note counters were introduced in the form of the REI High-Speed machine, which sped up note counting to 72,000 notes per hour and eliminated the need for manual sorting and counting completely. This innovative machine could also sort notes according to their value and remove counterfeit or heavily damaged notes. Many of these features are present in today's note counting machines, some of which can detect a note's security features (e.g. magnetic ink, ultraviolet ink, magnetic strip, note density etc.) to identify counterfeit and damaged notes [4].

Basic banknote counters provide a total count of the notes in the supply hopper. More advanced counters can identify different bill denominations to provide a total currency value of mixed banknotes, including those that are upside down. Some banknote counters can also detect counterfeit bills either magnetically and/or using blacklight. Blacklight (UV) based detectors exploit the fact that in many countries, real banknotes have fluorescent symbols on them that only show under a black light. Also, the paper used for printing money does not contain any of the brightening agents which make commercially available papers fluoresce under black light. Both features make counterfeit notes both easier to detect and more difficult to successfully produce.

Electronic counting systems, with no moving parts, exist that count both notes and coins on the same machine and sum the value of all denominations counted. They are normally used to count individual deposits and do not sort or check for counterfeit or damaged notes. These money counters do not examine each note or coin separately but work by using finely calibrated load cells to assess a number of notes or coins at a time, and using a constantly

updated, stored average weight to compute the number of pieces it has been presented with. These machines often use complex algorithms to take into consideration the variation in the condition of the money arising from wear, humidity and production variances.

Electronic money counters tend to be small in size, silent, battery operated, very fast and accurate. They are often used on the desktops of bank tellers to check customer deposits or withdrawals or by retailers to count money from cash registers. Although their capability varies by model, typically they can count both notes and coins and check standard bank bundles or bags/rolls of coin to ensure that they are correct. This technology was invented in 1979 by Edgar Biss who went on to form the global company Tellermate [5].

Other extra features that facilitate everyday contact with cash may also be present. For example, additions functions, batch functions and format recognition.

2.0 Review of Related Works

There has been a research effort on the appraisal of the currency counting machine, some of these efforts are previewed as follows:

[2], wrote that currency counters were designed to increase efficiency in tellers (bank's staff who handles cash transactions) and reduce human error. This innovative machine dominated the market for its increased speed and accuracy. Nevertheless, more was to be expected from this wonderful machine.

[3], in his project published online considered the principle of operation of the counting machine as regards to its counting process but he focused deeply in the fake note detection of the currency counting machine and the internal components of a particular currency counting machine.

He pointed out that the currency counting machine works on the principle of the breadth of the bundle of currency with a roller which has rods in a continuous pattern and the roller moves these rods with a particular speed and the 2 rollers moves the bundle of the currency

and just move out the single currency one by one at a constant and high speed. He also stated that it contains a transducer which detects how many single currencies have passed out in front of it.

He also analyzed the use of counting machines in the detection of fake notes with focus on the rupees (Indian currency). He also threw light on the inspection methods needed to be carried out to uphold the authenticity of the rupee. These inspections according to him are broadly divided into two methods, the first-line inspection method and the second-line inspection method. The first-line inspection method comprised of Varied-Density Watermarks, Ultraviolet fluorescence, Intaglio printing, Microtext, Holograms and Kinegrams. On the other hand, the second-line inspection method consists of Isochecks/Isograms, Fibre-based certificates of authenticity, Colour and feature analysis [6].

However, this write up not only throws light to the technique involved in the counting process of the currency counting machine, the use of the counting machine to detect fake notes with focus on the Nigerian naira and its security features but also the use of the currency counter as a sorter, precautions to be taken while handling most of these machines and the maintenance to be carried out for optimum utilization.

2.1 Counting Process

A stack of bills are placed in a compartment of the machine, and then one bill at a time is mechanically pulled through the machine. By counting the number of times a beam of light is interrupted, the machine can count the bills. By comparing an image of each bill to pattern recognition criteria, the machine can figure out the denominations of the bills and how much genuine money was placed in the compartment [7].

All currency counters have a special hopper where bills are placed. The amounts of bills that can be placed in the hopper vary. As a general rule, a bill counter can usually accept about half the used bills as it can accept new bills. If your

machine can accept 100 new bills, it will usually accept about 50 used bills.

Most bill counters use some sort wheel or roller to pull money into the machine. The bill counters utilize a rubber wheel that has special grooves on it, making it easier to pull the bills in without jamming. Some bill counters require fanning of the bills before they are placed into the machine.

As the bills are pulled into the currency counter, special fanning wheels separate the bills. These fanning wheels look a lot like a circular plastic claw. As these bills are run through the machine, they pass in front of an optical sensor that detects the edge of the bill. As each bill runs past this sensor, it is counted up and added to a final tally. The entire counting process, from start to finish, takes just milliseconds. Many currency counters can count on average 1,000+ bills per second.

Many currency counters now offer the option of batch counting. This means you can tell the machine that you want it to count 100 bills or any number of choice and then stop. This may be for organizational or storage reasons. Once the counter has counted 100 bills, you remove the stack and it begins counting again. The batch amount can be changed by the operator [8].

However, most of these currency counters have been criticized of their inability to consider damaged or repaired genuine notes as the sensors discriminates these notes from the undamaged ones.

2.2 Counterfeit Bill Detection

With the advanced printing, copying and electronic scanning technologies available today, the need to validate currency authenticity has increased dramatically, increasing the demand for continuous improvement of counterfeit detection technologies. Authentication function needs detailed analyses of chemical & physical properties of Bank Note Paper, varied inks, resins, security threads, chemical used in the printing process.

One of the functions which a counting machine can offer is detection of fake bills. The machine

equipped with this function invariably should be capable of not allowing any fake note to pass as genuine. It is possible only with the detectors specially developed. These machines can verify not only the images but also can check the chemical and physical properties of papers, inks, resins and other materials used in production of note [9].

Some banknote counters can detect counterfeit bills either magnetically and/or using blacklight. Blacklight (UV) based detectors exploit the fact that in many countries, real banknotes have fluorescent symbols on them that only show under a black light. Also, the paper used for printing money does not contain any of the brightening agents which make commercially available papers fluoresce under black light. Both features make counterfeit notes both easier to detect and more difficult to successfully produce.

Security features easily noticeable to the public differ from note to note. The most common, however, are the security thread and the watermark. The security thread comes in different forms on different notes. The watermark is a figure or design incorporated into the paper during its manufacture and appearing lighter than the rest of the sheet when viewed in transmitted light.

Figures used as watermark on the Nigerian Naira are the eagle and the bust of Nigeria's important personalities some of whose pictures appear on the note itself. Coins have latent image (a new security feature for coins) milled or coarse edge. Also the distinguishing features which can immediately be recognized by touch and visibility are raised print, the security thread and the watermark [10]

Other areas such as the portrait, lettering and the denominational numerals on the front and the back are embossed. The raised print provides the facility, while the security thread, which ordinarily, looks broken but is not when held against the light, has "CBN" in small lettering printed on both sides of the notes. The Naira notes are also protected against photocopying. There are features, which are visible under ultraviolet light; for example, the serial number

on each note is black, but turns green under ultraviolet light [10].

Some models detect counterfeit bills either magnetically and/or using ultraviolet light. Ultra Violet Light Detector is used in Currency counters. Currency created by a color copier or printer produces an image that rests on the surface of paper that can easily be seen when UV light is placed over it.

Tiny particles of toner outside the image can also be easily seen with a UV light. Bill counters and counterfeit detectors have a UV light built into the machine. If a counterfeit bill is run through the machine, an alarm or light will alert you that the banknote is counterfeit. Magnetic sensors: Magnetic sensors run over each bill and are designed to search for certain components of banknotes that cannot be seen by the naked eye. Machines automatically detect and match the piece against the already-programmed components of legitimate bills. When a suspicious note is found, the operator is notified immediately [11].

The electronics, are a highly a mixed-signal system driven by a DSP (Digital Signal Processing) or MCU (Multipoint control Unit) for system processing, which is surrounded by a high performance analog products.

Ultraviolet, infrared & magnetic sensing are the typical detection techniques used today to verify the inherent characteristics of banknotes. More advanced systems, capture the banknote images with a CIS (Contact Image Sensor) or CCD (charge coupled device) scan, enabling the recognition of denomination, serial number and other aspects of each note.

Contact Image Sensors (CIS) are a relatively recent technological innovation in the field of optical flatbed scanners that are rapidly replacing CCDs in low power and portable applications. As the name implies, CISs place the image sensor in near direct contact with the object to be scanned in contrast to using mirrors to bounce light to a stationary sensor, as is the case in conventional CCD scanners.

A CIS typically consists of a linear array of detectors, covered by focusing lenses and

flanked by red, green, and blue LEDs for illumination. The use of LEDs allows the CIS to be highly power efficient, allowing scanners to be powered through the minimal line voltage supplied via a USB connection. CIS devices typically produce lower image quality compared to CCD devices; in particular, the depth of field is greatly limited, which poses a problem for material that is not perfectly flat. However, a CIS contact sensor is smaller and lighter than a CCD line sensor, and allows all the necessary optical elements to be included in a compact module, thus helping to simplify the inner structure of the scanner. With a CIS contact sensor, the scanner can be portable, with a height of only around 30 mm. CIS is both a key component of, and widely used in, scanners (especially portable scanners), electrographs, bar code readers and optical identification technology.

- Fluorescence detection uses UV light to check for missing marks & irradiation response of the fake notes.
- Magnetic ink & different patterns of security strip can be detected by using the magnetic head with a precision amplification scheme.

- Infrared penetration is used to the thickness detection of the banknote & the absorption of infrared signals to identify the genuine banknotes.

The response signals of these various transducers are low level signals which are very sensitive to system noise. As such a high performance signal conditioning design is required. Multiple channel input, high resolution data converters help simplify the design layout & ensure the accurate measurement [12].

However, Speed lowers the authentication accuracy by not getting enough time to pip into the time differences between genuine and fabricated security features. At the most, some of the machines can detect very poorly fabricated notes but not skillfully fabricated fake notes. Authentication can only be carried out with high end light cum Image cum digital technology. The fastest fake note detector that is available in the international market takes minimum 3 seconds for thorough checking of notes. Such machines mostly have facility for single note manual feedings.

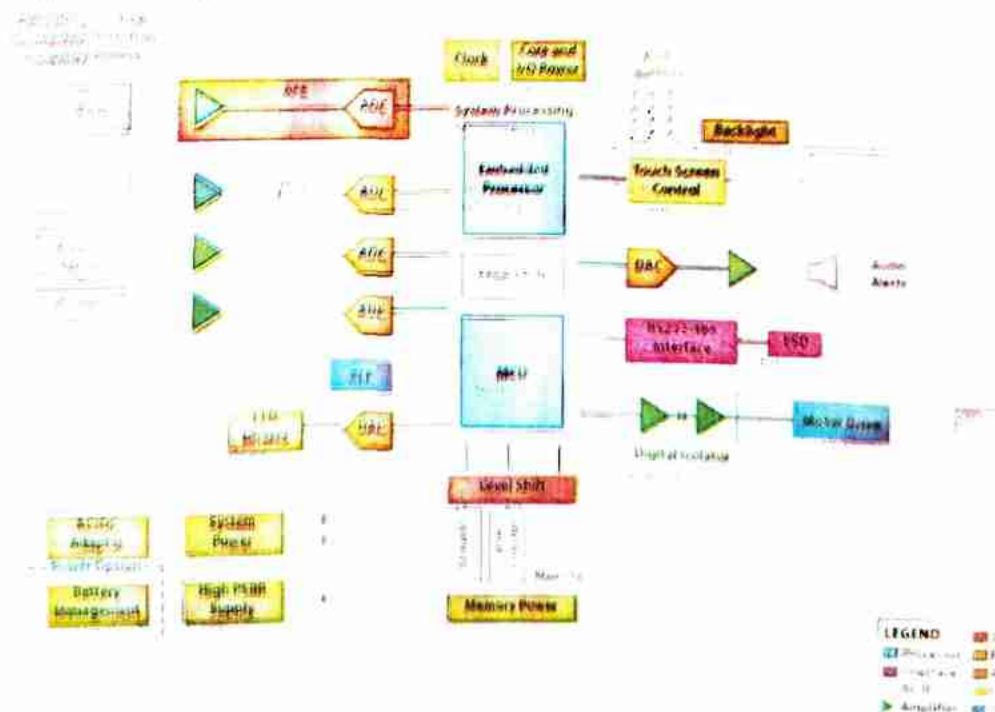


Figure 1: shows the Block diagram (SBD) for a Currency Counter supporting ultraviolet, infrared, and magnetic sensing, and CIS / CID imaging for banknote verification, and a powerful processor or microcontroller analytics processing for banknote verification.

3.0 Bill Sorting (Different Denominations Detection)

Aside from counting the number of bills, detecting fake notes, the counting machine can also function as a bill or note sorter. The counter which possesses this ability or function first of all memorizes the size of the first counted note, if a note whose size is different from the memorized value is detected, the machine will stop. Some of these machines detect size difference both widthwise and lengthwise.

The difference between note sizes of different denominations is detected by checking the width of each note to be counted. The machine is setup so that it can detect notes of different denomination when the size difference is 5mm or more.

When the machine stops after detecting a different denomination note, the detected note is removed from the stacker then the counting is continued.

An improved method and apparatus for discriminating between currency bills of different denominations uses an optical sensing and correlation technique based on the sensing of bill reflectance characteristics obtained by illuminating and scanning a bill along its narrow dimension. A series of detected reflectance signals are obtained by sampling and digital processing, under microprocessor control, the reflected light at a plurality of predefined sample points as a currency bill is moved across an illuminated strip with its narrow dimension parallel to the direction of transport of the bill.; The sample data is subjected to digital processing, including a normalizing process, whereby the reflectance data represents a characteristic pattern that is unique for a given bill denomination and incorporates sufficient distinguishing features between characteristic patterns for discriminating between different currency denominations.

A plurality of master characteristic patterns is generated and stored using original bills for each denomination of currency to be detected. The pattern generated by scanning a bill under test and processing the data samples is compared with each of the pre-stored master patterns to generate, for each comparison, a

correlation number representing the extent of similarity between corresponding ones of the plurality of data samples for the compared patterns.; Denomination identification is based on designating the scanned bill as belonging to the denomination corresponding to the stored master pattern for which the correlation number resulting from pattern comparison is determined to be the highest, subject to a bi-level threshold of correlation.

3.1 Electrical Components

- ✓ Integrated Circuit
- ✓ LCD
- ✓ DC motors (3)
- ✓ Drill Motor
- ✓ Relays
- ✓ Transformer
- ✓ Diodes
- ✓ Resistors
- ✓ Capacitors

Brief descriptions of these components are as follows:

(a) *Integrated Circuit (IC)*

The IC e.g. AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4 Kbytes of Flash Programmable and Erasable Read Only Memory (PEROM). The device is manufactured using Atmel's high density non-volatile memory technology and is compatible with the industry standard MCS-51 $\bar{O}$ instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C51 is a powerful microcomputer which provides a highly flexible and cost effective solution to many embedded control applications.

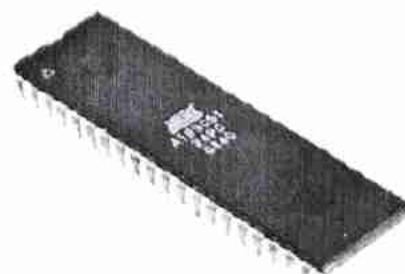


Figure 2: Integrated Circuit

(b) Relay

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits, repeating the signal coming in from one circuit and re-transmitting it to another. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

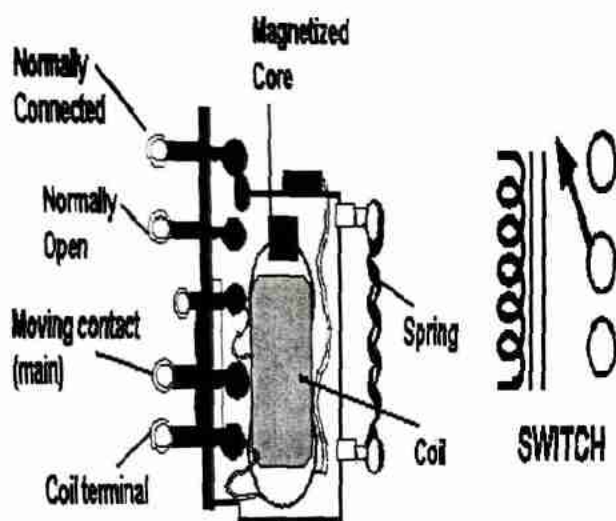


Figure 3: Relay

A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays".

(c) Resistors

Resistors (R) are the most commonly used of all electronic components, to the point where they are almost taken for granted. There are many different resistor types available with their principal job being to "resist" the flow of current through an electrical circuit, or to act as voltage droppers or voltage dividers. They are "Passive Devices", that is they contain no

source of power or amplification but only attenuate or reduce the voltage signal passing through them. When used in DC circuits the voltage drop produced is measured across their terminals as the circuit current flows through them while in AC circuits the voltage and current are both in-phase producing 0° phase shift.

(d) Capacitor

Just like the Resistor, the Capacitor or sometimes referred to as a Condenser is a passive device, and one which stores energy in the form of an electrostatic field which produces a potential (Static Voltage) across its plates. In its basic form a capacitor consists of two parallel conductive plates that are not connected but are electrically separated either by air or by an insulating material called the Dielectric. When a voltage is applied to these plates, a current flows charging up the plates with electrons giving one plate a positive charge and the other plate an equal and opposite negative charge. This flow of electrons to the plates is known as the Charging Current and it continues to flow until the voltage across the plates (and hence the capacitor) is equal to the applied voltage V_c .

(e) Liquid Crystal Display

A liquid crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals (LCs). LCs do not emit light directly. LCDs are more energy efficient and offer safer disposal than CRTs. Its low electrical power consumption enables it to be used in battery-powered electronic equipment. It is an electronically modulated optical device made up of any number of segments filled with liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in color or monochrome.

(f) Voltage Regulator

The 78xx (sometimes LM78xx) is a family of self-contained fixed linear voltage regulator integrated circuits. The 78xx family is commonly used in electronic circuits requiring a regulated power supply due to their ease-of-use and low cost. For ICs within the family, the xx is replaced with two digits, indicating

the output voltage (for example, the 7805 has a 5 volt output, while the 7812 produces 12 volts). The 78xx line are positive voltage regulators: they produce a voltage that is positive relative to a common ground. There is a related line of 79xx devices which are complementary negative voltage regulators. 78xx and 79xx ICs can be used in combination to provide positive and negative supply voltages in the same circuit.

(g) *Transformer*

A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled conductors—the transformer's coils. A varying current in the first or primary winding creates a varying magnetic flux in the transformer's core and thus a varying magnetic field through the secondary winding. This varying magnetic field induces a varying electromotive force (EMF), or "voltage", in the secondary winding. This effect is called inductive coupling [13].

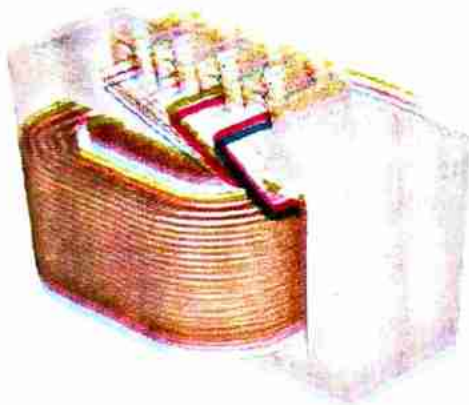


Figure 4: Transformer

3.2 External Components of the Counting Machine

The following are the external components of most counting machines:

- Hopper: This is where the notes to be counted are placed
- Auxiliary hopper plates: These guide plates for leading the notes into the feeding mechanism
- Handle: Used for carrying the machine
- Paper thickness adjustment screw: Used to make the machine count notes smoothly regardless of paper thickness that may vary with denominations

- Stacker: Counted notes are stacked in the stacker
- Power switch: Main power on/off switch
- Connecting port for I/F connector: Used to connect a communication line.

3.3 Precautions for Handling the Counting Machine

While handling the counting machine there are some precautions worth taking to ensure the optimum use of the counting machine. These are:

- i. **Damp and/or badly stained notes** should be avoided.
- ii. Ensure that no foreign body e.g. piece of paper, paper clip, dust, etc is mixed with bundle or batch of notes to be counted.
- iii. Folded or curled notes should be straightened before they are set on the hopper.
- iv. For brick notes (bundle of new notes which are stucked to each other by ink), bend and flex the stack before it is set on the hopper.
- v. Align the long and short edges of the notes by lightly tapping the stack; insufficient alignment may cause an operation error.
- vi. Do not install the machine in places where the flooring cannot support the unit load or unstable places with slanting or uneven flooring. Installing in such places may result in cave-in accidents or sudden moving of the unit causing injury to people.
- vii. Ensure that the ventilation ports are not obstructed as the obstruction of the ventilation ports might lead to accumulation of heat inside the machine thereby resulting in fire.
- viii. Ensure the machine is properly grounded to assure safe operation and to prevent troubles caused by static electricity.
- ix. Do not use or place any combustible material such as thinner or flammable gas or highly volatile substance in the periphery of or inside the machine.

3.4 Maintenance of the Counting Machine

1. Sensors are used for the counting system of most of these machines, as these sensors are of optical construction, the system may cause miscounting should dust, dirt etc stick to the sensors, hence, the sensors should be cleaned with brush when counting operations is finished.
2. Piece of paper, dust and/or trash etc accumulated in the hopper and/or stacker may be taken into the machine; this may cause a malfunction of the machine. Clean the hopper and stacker with brush.
3. Use a blower to blow off the dust and particles that might have settled on the components
4. Do not use chemicals for cleaning the machine.
5. Lubricate the bearings with suitable grease when they tend to stiffen.
6. Clean the machine after turning off the power switch.
7. Do not place the machine in any location where the product might get water on it. Should water enter the product it would cause poor insulation, fires or electrical shocks.
8. Service the machine at list once in a month. This should however be done only by trained personnel.

3.5 Factors to Consider in Making a Choice of Counting Machine

1. The Reliability of the counter: This goes to determine the life span of the counting machine or the Mean Time Before Failure (MTBF) of the counting machine. Has the machine been built to meet the international EMC standards?
2. Sensitivity of the Sensors: One of the important factors to consider in a currency counting machine is the sensitivity of the sensors. This is not only the ability of the counter to sense bills for counting but also its ability to detect fake notes and at what speed

can it be able to discriminate between genuine notes and the fake ones.

3. Indifference to torn and taped notes: A factor also to be considered in counting machines is whether it has in built features to be able to ensure that when a damaged or repaired note is passed through it with other notes, it can still give an accurate count of the notes passed
4. Speed of counting: The minimum time it takes for the note counters to count a given set of notes with utmost accuracy or no error is of worth noting.
5. Hopper capacity: The number of bills the hopper is able to accommodate. This however varies depending on whether the bills to be counted are new bills or whether it's old ones. The later occupies more space hence for a given hopper; it has the ability to contain more new bills than the older ones.
6. Stacker capacity: The number of bills the stacker is able to accommodate. The condition is the same as that of the Hopper above.

4.0 Conclusion

Currency counting machine is very important for all the people who deal with a large amount of currencies every day like the banks, as the currency counting machine will help to count the notes correctly. One will also be able to get rid of the tension and confusions, which are faced while counting the notes. Currency counting machines will also help to save a lot of time, which would have been wasted on counting the money by hand. Instead of wasting time, one can concentrate on the other aspects, which will help in developing business.

Also the currency counters can help reduce loss of funds through fake note detection. However, these machines are to be properly taken care of and maintained. It should also be serviced at least once every month depending on the usage for optimum utilization.

Before buying a currency counting machine for one's needs, it is very important to find a

good and reputed manufacturer in the market. One should also consider the type of work that has to be carried out by the currency counting machine as there are different types of money counter machines available in the market to suit ones requirements.

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