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DESIGN AND PRODUCTION OF A REMOTELY CONTROLLED SAFE BOX

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ABSTRACT

The safety box can be designed into various shapes and sizes and in modern times, safety boxes are not only used in the banks or institution but also at homes to protect and secure personal belongings because of its design and function. The safety box was designed and fabricated having a power rating of 180w and speed of 0.14m/s. An electromechanical device was used for the engine which was powered by electricity and a 12v battery when there is no power supply. The aim of designing and producing an remotely controlled safety box was achieved.
Key words: design, production, deposit box, safe, automate, remote

1.0 INTRODUCTION

A safety box is a secured container made of metallic materials with high level of impenetrability for the safety and protection of items stored in. The concept of safety boxes is generally used in banks, institutions and various offices. Safety boxes are used to store valuable possessions such as gemstones precious metals, currency, marketable securities, important document such as wills, property deeds and birth certificates or computer storage that need protection from theft, fire, water and tampering [1, 2, 3].

In modern times, safety deposit boxes are not only used in the banks, hotels or institutions but they are now used in homes to protect and secure personal belongings, because of its design and functions. Many individuals no longer take certain valuables to banks for safe keeping when they have safe deposit boxes at their various homes [1]. The home safe deposit box is of various sizes, shapes and design; it can be fixed in a wall or screwed to the floor depending on the type of design and it's well secured with keys and electric lock or combination locks.

The home safety deposit box is manually operated and is highly secured with a combination lock only few are designed with a key and electronic lock. The continuous usage or a regular safe deposit box is stressful as regards to its manual method of door operations. Withdrawals of items from safe deposit boxes through the use of combination locks are concurrently delayed at situations of hastiness; this could be as a result of close calibrations on locks or even mechanical faults. Also, in the cases of safe deposit box secured with keys, when a key to the safe is missing or lost, it leads to unauthorized access to the safe, lock replacement or destruction and this may cause damage of items.

The aim of this project is to design and construct the existing home safety deposit box which is been operated manually into an automatic operation controlled by a wireless remote.
The objectives are;

1) To construct the automatic home safe deposit box
2) To wirelessly control the opening and closing of the home safety deposit box

2.0 LITERATURE REVIEW

2.1 ENGINEERING MATERIALS

Materials of engineering refers to selecting the correct materials for the application in which the engineered part is been used. This selection process includes choosing the material, paying attention to its specific type or grade base on the required properties. Engineering materials are classified into metals, plastics, ceramics and composite. The properties that constitute the essential engineering data in the design of machine structure and controls, in analyzing and determining the efficiency of a machine are termed the properties of the materials. These properties comprise of physical, mechanical, thermal, electrical and magnetic properties. But due to the scope of this project, we will be focus on only the physical and mechanical properties of the materials used for the machine design [2].

2.2 PHYSICAL PROPERTIES

The physical properties of engineering materials are those properties that can be seen, felt, or easily measured. This includes size, shape, volume, surface area, density, mass and appearance.

In order to design equipment for handling storing and safe keeping of important valuables, their physical properties need to be known. The size, shape, cost and appearance of the materials are very important.

2.2.1 MECHANICAL PROPERTIES

The mechanical properties of engineering materials include: Strength, Hardness, Toughness, Ductility, Malleability and Resilience.

Mechanic properties of engineering materials are important in the design and recommendation of machine, because behaviors of this machine when subjected to the action of force are predicted by their mechanical properties.

2.3 LOCK

A lock is a mechanical or electrical fastening device that is release by physical object (such as key, key card, finger print, security token etc), by applying secret information (such as key code or password) or by a combination thereof.

The earliest known lock and key device was discovered in the ruins of Nineveh, the capital of ancient Assyria [4]. Locks such as this were later developed into the Egyptian wooden pin lock, which consisted of a bolt, door fixture, and key. When the key was inserted, pins within the fixture were lifted out of drilled holes within the bolt, allowing it to move. When the key was removed, the pins fell part-way into the bolt, preventing movement [5].

The warded lock was also present from antiquity and remains the most recognizable lock and key design in the Western world. The first all-metal locks appeared between the years 870 and 900, and are attributed to the English craftsmen. It is also said that the key was invented by Theodore of Samos in the 6th century BC.

Affluent Romans often kept their valuables in secure boxes within their households, and wore the keys as rings on their fingers. The practice had two benefits: It kept the key handy at all times, while signaling that the wearer was wealthy and important enough to have money and jewelry worth securing.

MODERN LOCKS

With the onset of the Industrial Revolution in the late 18th century and the concomitant development of precision engineering and component standardization, locks and keys were manufactured with increasing complexity and sophistication.

The lever tumbler lock, which uses a set of levers to prevent the bolt from moving in the lock, was perfected by Robert Barron in 1778. His double acting lever lock required the lever to be lifted to a certain height by having a slot cut in the lever, so lifting the lever too far was as bad as not lifting the lever far enough. This type of lock is still currently used today [5]. The lever tumbler lock was greatly improved by Jeremiah Chubb in 1818. A burglary in Dockyard prompted the British Government to announce a competition to produce a lock that could be opened only with its own key. Chubb developed the Chubb detector lock, which incorporated an integral security feature that could frustrate unauthorized access attempts and would indicate to the lock's owner if it had been interfered with. Chubb was awarded £100 after a trained lock-picker failed to break the lock after 3 months [6].

In 1820, Jeremiah joined his brother Charles in starting their own lock company, Chubb. Chubb made various improvements to his lock; - his 1824 improved design didn't require a special regulator key to reset the lock, by 1847 his keys used six-levers rather than four and he later introduced a disc that allowed the key to pass but narrowed the field of view, hiding the levers from anybody attempting to pick the lock [5].

The Chubb brothers also received a patent for the first burglar-resisting safe and began production in 1835. The earliest patent for a double-acting pin tumbler lock was granted to American physician Abraham O. Stansbury in England in 1805, but the modern version, still in use today, was invented by American Linus Yale, Sr. in 1848. This lock design used pins of varying lengths to prevent the lock from opening without the correct key. In 1861, Linus Yale, Jr. was inspired by the original 1840s pin-tumbler lock designed by his father, thus inventing and patenting a smaller flat key with serrated edges as well as pins of varying lengths within the lock itself, the same design of the pin-tumbler lock which still remains in use today. The modern Yale lock is essentially a more developed version of the Egyptian lock.

Despite some improvement in key design since, the majority of locks today are still variants of the designs invented by Bramah, Chubb and Yale.

MASTER KEYING

A master keyed lock is a variation of the pin tumbler lock that allows the lock to be opened with two (or more) different keys. This type is often used for doorlocks in commercial buildings with multiple tenants, such as office buildings, hotels, and storage facilities. Each tenant is given a key that only unlocks his own door, called the change key, but the second key is the master key, which unlocks all the doors, and is usually kept by the building manager, so he can enter any room in the building.

More complicated master-key lock systems are also made, with two or more levels of master keying, so there can be subordinate master keys that open only certain subsets of the locks, and a top-level master key that opens all the locks.

WAFER TUMBLER

A wafer tumbler lock is a type of lock that uses a set of flat wafers to prevent the lock from opening unless the correct key is inserted. This type of lock is similar to the pin tumbler lock and works on a similar principle. However, unlike the pin tumbler lock, where each pin consists of

two or more pieces, each wafer in the lock is a single piece. The wafer tumbler lock is often incorrectly referred to as a disc tumbler lock, which uses an entirely different mechanism. The earliest record of the wafer tumbler lock in the United States is the patent in 1868 by Philo Felter. Manufactured in Cazenovia, New York, it used a flat double-bitted key [1,3, 5].

In a cylindrical wafer tumbler lock, a series of flat wafers holds a cylindrical plug-in place. The wafers are fitted into vertical slots in the plug, and are spring-loaded, causing them to protrude into diametrically opposed wide grooves in the outer casing of the lock.

A rectangular hole is cut into the center of each wafer; the vertical position of the holes in the wafers vary, so a key must have notches corresponding to the height of the hole in each wafer, so that each wafer is pulled in to the point where the wafer edges are flush with the plug, clearing the way for the plug to rotate in order to open the lock. If any wafer is insufficiently raised, or raised too high, the wafer edge will be in one of the grooves, blocking rotation [2, 3, 5].

TYPES AND WAFER ARRANGEMENTS

Wafer tumbler lock configurations vary with manufacturer. The most common is the single-bitted, five-wafer configuration, most commonly found on desk and cabinet locks and some key switches. Some wafer tumbler locks use a stack of closely spaced wafers designed to fit a specific contour of a double-sided key and work on the principle of a carpenter's contour gauge.

Wafer tumbler locks can use single-bitted or double-bitted keys. Though wafer arrangements within the plug may vary, such as automotive locks, where the wafers are arranged in opposed sets, requiring a double-bitted key, the operating principle remains the same [1, 2, 4].

CRUSHABLE WAFER TUMBLER LOCK

At one time, several manufacturers made a "crushable wafer tumbler" for these locks, the idea being to simplify the task of rekeying for locksmiths and reduce the number of different wafers

that needed to be manufactured and stocked. To rekey such a lock, the locksmith simply replaced all the wafers with identical "crushable wafers", cut the new key, inserted the key into the plug, inserted the plug into a special "crushing" tool, and squeezed the handle of the tool, crushing the wafers to fit the key. It was quick and easy but had reliability problems: debris from the crushed wafers often remained in the plug causing wear and occasional jamming of wafers or the plug, and sometimes wafers crushed unevenly making them weak and causing them to break later in use. This system was eventually abandoned.

DISC TUMBLER LOCK

A **disc tumbler lock** is a lock composed of slotted rotating detainer discs. The lock was invented by Emil Henriksson (1886–1959) in 1907 and first manufactured under by the Abloy brand in 1918. Disc tumbler locks are composed of slotted rotating detainer discs. A specially cut key rotates these discs like the tumblers of a safe to align the slots, allowing the sidebar to drop into the slots, thus opening the lock. [1-6].

LEVER TUMBLER LOCK

A **lever tumbler lock** is a type of lock that uses a set of levers to prevent the bolt from moving in the lock. In the simplest of these, lifting the tumbler above a certain height will allow the bolt to slide past. The number of levers may vary, but is usually an odd number for a lock that can be opened from each side of the door in order to provide symmetry. A minimum number of levers

may be specified to provide an anticipated level of security. In modern times, these locks have declined in popularity because the pin tumbler lock is cheaper [4-6].

2.4.2 LOCKS WITH ELECTRONIC KEYS
ELECTRONIC LOCK

An electronic lock works by means of an electronic current and is usually connected to an access control system. In addition to the pin and tumbler used in standard locks, electronic locks connect the bolt or cylinder to a motor within the door using a part called an actuator. Types of electronic locks include the following:
A keycard lock operates with a flat card using the same dimensions as a credit card or US and EU driver's license. In order to open the door, one needs to successfully match the signature within the **keycard** [1-6].

SMART LOCK

A **smart lock** is an electro mechanics lock that gets instructions to lock and unlock the door from an authorized device using a cryptographic key and wireless protocol. **Smart locks** have begun to be used more commonly in residential areas, and have most likely grown in popularity due to widespread use of the Smartphone. Additionally, smart locks are gaining momentum in co working spaces and offices where smart locks often enable keyless office entry.

The electronic lock has many features that make it attractive to customers however, reliability. Before the late eighties there was no such thing as a commercial available electronic lock. They have only been around for just over twenty five years and only available for just fifteen years [3-5].

Common failures related to the electronic safe lock are as follows: the battery lead wire comes off or the battery connector breaks; the wire through the door gets pinched; one or more key pad fails from repeated use; failure of the electronic keypad; the lock solenoid; the keypad and wire are destroyed in a minor fire.

2.5 SAFE AND LOCK

Among the many uses of lock mechanisms over the last three thousand years, one of the most famous happened in the field of self-lockable enclosure that are used for storing valuable items against damage, theft and intrusion. For more than two thousand years, safes were primarily created mostly as an artistic endeavor, with intricate design and that were protected with simple and easy to break locks.

Refinement of metallurgy techniques and new lock designs in 18^{th} and 19^{th} century brought a time revolution into the world of safes. Introduction of steels enables the creation of much more durable which were fire resistance, chemical resistance and much harder to crack. As the metal industry adopted steel, vault started appearing all round the world giving banks, large businesses, casinos, schools and military buildings perfect place to store their intellectual properties, valuables and dangerous objects [1-6].

2.5.1 MECHANICAL SAFE LOCK

Mechanical locks include the combination of dial lock and the key operated lock. Good quality locks such as the S&G 6730 OR 8550 series are highly reliable. The 6730 is widely used in homes and commercial application. Failures of the mechanical locks are broken drive cam pin or loosed lock case screw or shifted dial rings due to lose screw or was struck. These are probably the most common problems and can occur from poor lubrication and abuse from people spinning the dial very hard.

2.5.2 KEYED SAFE LOCK

A key safe lock can replace the electronic and mechanical combination lock. It installed on the inside of the door and the key is inserted through the existing spindle hole in the door.

The length of the key depends on the thickness of the safe door.
Problems of the key lock are: Broken lever spring inside the lock; Disengage lever; Lost key and Bent or damage keys

3.0 MATERIALS AND METHOD

3.1 MATERIALS

The materials used for the construction of this machine were obtained from commercial sources in Makurdi metropolis, Benue state. The materials used for the construction are as follows: Bolts and nuts; Sheet metal; Angle bar; Paint; Electromechanical linear actuator (window regulator); Clutch cable; Gears; Pulleys; Fiber; Top bond; Color Wood; Aluminum sheet; Relays; Transmitter; Rectifier; Diode; Capacitors; Key; Receiver; Bolts and nuts; Washers; Pipes and Color wood.

3.1.1 TOOLS AND EQUIPMENT

The tools and equipment used during the construction of this machine are:

S/N	TOOLS/EQUIPMENT	USES
1	WELDING MACHINE	For welding metals or joining metals together.
2	CUTTING MACHINE	The cutting machine is used to cut sheet metals also the hacksaw was used in cutting the metals and rod into different shapes and sizes.
3	SPANNER	For driving bolts and nuts and the screw driver was used in driving the screws
4	HAND GLOOVES	For protecting the hands from the metal splash during welding
5	SAFTY GOOGLES	For protecting the eyes during welding
6	TAPE RULE	For taking measurements
7	ELECTRODE	For welding metals together

3.2 METHODS

Some locks mechanisms were studied related to the machine design were investigated by searching through literature and this include: Padlocks and keys; Multiple locks; Fake lock holes; Hidden locks; Combination locks and Electronic lock.

3.2.1 CONSTRUCTION

The main frame /structure of the box carry the entire weight of the machine. The main frame and the machine are both covered and welded together with the sheet metal. The total weights carried by the main frame/structure are: the weight of the electric motor and the rack (mechanism); the

weight of the battery; the weight of the housing; the weight of the load and cabinet slide and the weight of the door. The frame was extended a little bit to serve as seat for the battery. The three design factors considered in determining the material required for the frame are weight, strength and thickness. In this work, an angle bar of 1½ by 1½ and 2mm thickness is used to give the required rigidity.

3.2.2 THE ELECTROMECHANICAL LINEAR ACTUATOR (window regulator)

The electric motor produces the rotary motion and power in which the mechanisms is been operated. Motion is been transmitted from the motor to the mechanisms and doors by the means of gears, pulley, and cord. The electromechanical linear motor is responsible for making the door open and close. The motorize actuator take rotary motion and convert it into a linear motion of the door.

3.2.3 THE BATTERY

The battery is used to power on and operate the safe when there is no power supply. The battery used for the project is a 12v cell to give the require voltage to turn the induction motor.

3.2.4 THE ELECTRIC CIRCUIT

The electric circuit consists of resistors, capacitors, relays, LED, receiver, DE counter, regulator, diode, transformer and wires.

DISCRIPTION OF THE CIRCUIT

Current flows into the circuit from the main power supply or cell. The main purpose of the circuit is to receive signal from an external transmitter. The signal receive by the receiver in the circuit determine the rotation of the electric motor (induction motor).The circuit also act as a converter which convert the A.C supply into D.C and the current which flows into the circuit is also use to charge the battery. Two circuits were constructed for the purpose of this project and they are the power circuit and the wireless remote circuit

THE POWER CIRCUIT

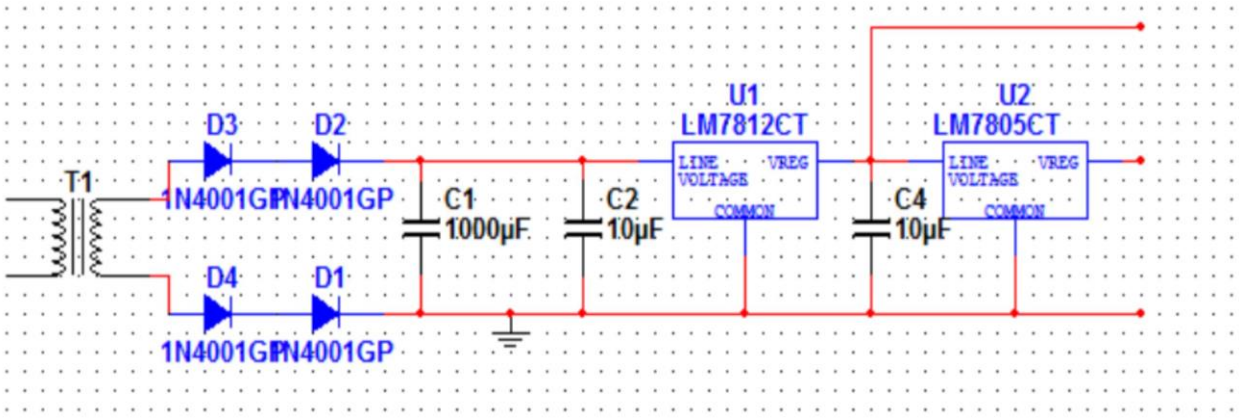
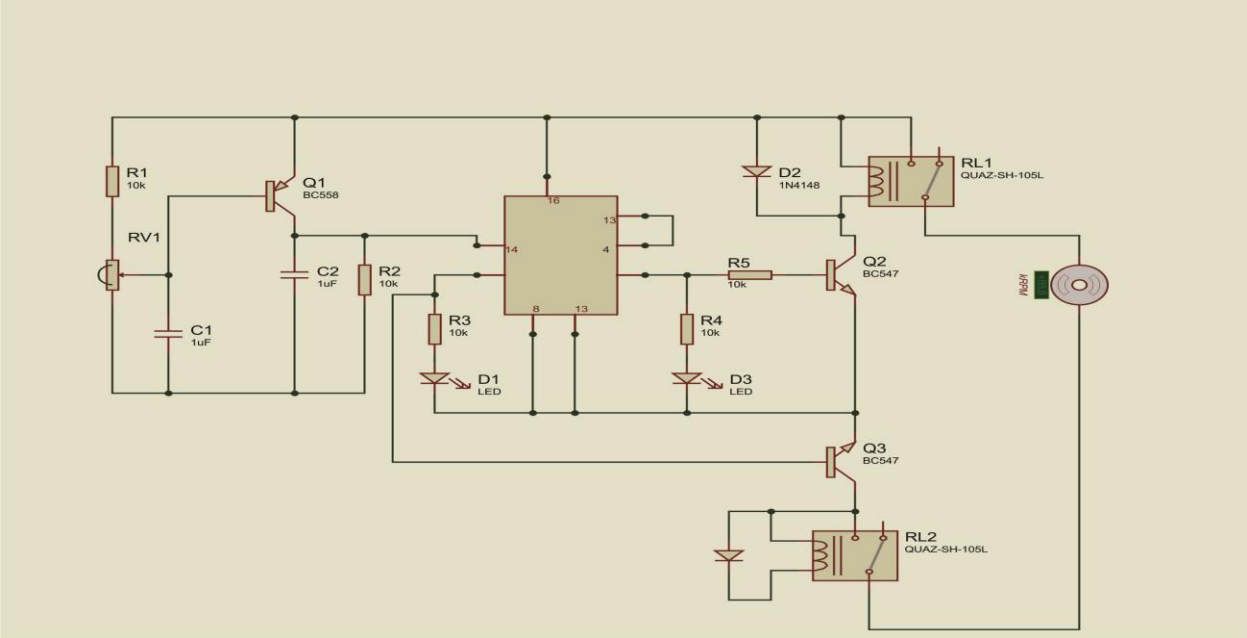


DIAGRAM OF THE WIRELESS REMOTE CIRCUIT



3.2.5 THE REMOTE

The remote consist of the transmitter, battery and capacitor. The main purpose of the wireless remote is to send signal to the circuit to determine the rotation of the motor.

3.2.6 THE KEY

The key is use to turn OFF and ON the current flowing into the circuit. Without the key and the remote, the safe cannot be operated. Three keys and lock were used in the construction of the box.

3.3 DESIGN ANALYSIS AND SELECTION OF MATERIALS

3.3.1 DESIGN CONSIDERATION

The following factors were considered in the design of the machine:

COST OF MATERIALS

Cost is usually an important factor in evaluating materials because in much application there is a cost limit for a material intended to meet the application requirements. When the material cost limit is exceeded, the design may have to be changed to allow for the use of a less expensive material. In some cases, a relatively more expensive material may eventually yield a less expensive product than a low-priced material that is more expensive to process.

AVAILABILITY OF MATERIALS

Materials must be available in abundance to ease the design and construction of any machine and subsequent production of such machine.

RESISTANCE TO SERVICE CONDITIONS

The machine operates with both electricity and battery. When the battery is faulty or need to be replaced and electricity is not constant, withdrawal of items from the safe becomes impossible.

3.3.2 MACHINE DISCRIPTION AND OPERATION PRINCIPLE

The machine consists of the following units: the room; the battery chamber; the electric circuit unit; the power unit; the engine unit; the frame and the door. In operation, when the key is turned ON, current flows from the mains into the converter (power unit). The power unit then converts the alternating current into a direct current which flows into the circuit box. When a button on the remote is been depressed, a signal is been transmitted from the wireless remote which is the received by a receiver in the circuit (wireless remote circuit).

The circuit is connected to the motor so the signal received by the receiver determines the direction of rotation of the motor. The motorized linear actuator converts the rotary motion of the motor into a linear motion on the rack consisting of a travelling sheet and cables on both side of the sheet. The travelling sheet on the rack is connected to the door by a means of spring, bolt and nut. The direction of rotation of the motor leads to the movement of the sheet on the rack and since the sheet is connected to the door; it also leads to the movement of the door as well. The clockwise motion of the electric motor leads to the opening of the door while the anti-clockwise motion of the electric motor leads to the closing of the door. The type of gear used in the linear actuator is the worm gear so that the door cannot be forced open.

GEAR DESIGN

A gear is a toothed machine part, such as a wheel on cylinder that mashes with another toothed part to transmit motion or to change speed and direction. Speed in various parts of a machine is usually determined by arrangement of gears. Gears can be used to reverse or otherwise change the direction of rotation. Gears of different size changes the speed of rotation.

SELECTION OF GEAR DRIVES

The various important factors upon which the selection of gear depends are: Service factor; Gear drive rating; Thermal capacity; Speed variation and Drive ratio.

TYPES OF GEARS

The various types of gears include: spur gear; helical gear; herringbone gear; bevel gear; worm gear; rack and pinion; internal gear; external gear; face gear and sprocket gear.

Gears may also be classified according to the position of axis of shaft of shaft

a) Parallel such as spur gear; helical gear; and rack and pinion
b) Intersecting such as bevel gear
c) Non-intersecting and non-parallel such as worm; and worm wheel gear.

WORM AND WORM WHEEL GEAR

The worm gears are widely used for transmitting power at high velocity ratios between non-intersecting shafts that are generally, but nut necessary, at right angles. It can give velocity ratios as high as 300:1 or more in a single step in a minimum of space but it has a lower efficiency.

The worm gearing is mostly used as a speed reducer, which consist of worm and worm wheel or gear. The worm (which is the driving member) is usually of a cylindrical form having threads of the same shape as that of an involutes rack. The threads of the worm may be left handed or right handed and single or multiple threads.

The worm wheel or gear (which is the driven member) is similar to a helical gear with a face curved to conform to the shape of the worm. The worm is generally made of steel while the worm gear is made of bronze or cast iron for light service.

Circular pitch

From equation,

$$\mathfrak{p} = \frac{3.1416}{P} \text{---------- (1)}$$

$$were\ \mathfrak{p} = circular\ pitch\ of\ worm; \qquad P = diametrial\ pitch.$$

$$from\ measurement, \mathfrak{p} = 0.2cm = 2mm.$$

$$Therefore, 2 = \frac{3.1416}{P}; \quad P = \frac{3.1416}{2} = 1.6mm$$

Lead of worm

From equation,

$$L = \mathfrak{p}n \text{---------- (2)}$$

Were n=number of thread on worm=12

Therefore, L=2x12; L=24mm.

Addendum

$$a = \frac{1}{P} \text{---------- (3)}$$

$$a = \frac{1}{1.6} = 0.63mm$$

(Dw) pitch diameter

From measurement, Dw=15mm

Lead angle of worm (γ)

$$\gamma = tan^{-1}\left(\frac{L}{3.1416Dw}\right) \text{---------- (4)}$$

$$\gamma = tan^{-1}\left(\frac{24}{3.1416x15}\right); \quad \gamma = tan^{-1}(0.5093) = 26.99^{\circ}$$

(Dg) pitch diameter of worm gear

$$Dg = \frac{Ng}{3.1416} \text{---------- (5)}$$

Were Ng=number of teeth on gear=65T

Therefore, $Dg = \frac{65}{3.1416} = 20.69mm$

Whole dept of teeth(hŧ)

$$h_ŧ = 0.6866\mathfrak{p} \text{---------- (6)}$$

$h_ŧ$=0.6866x2=1.37mm.

DETERMINATION OF TERMINAL VELOCITY

From equation, angular velocity of electric motor is;

$$\omega_1 = \frac{2\pi N}{60} \text{---------- (7)}$$

Where ω_1=Angular velocity of electric motor; N=Number of turns of the motor and N=82rpm.

Therefore, ω_1=8.59rad/sec

$$V_1 = \omega_1 r_1 \text{---------- (8)}$$

$V_1=V_2$ and V_1= velocity of the electric motor; r_1=Radius of the electric motor (0.019m)

Hence, V_1=0.16m/s.

Where V_2=worm velocity=Nw

Therefore,

$$\omega^2 = \frac{v^2}{r^2} \text{ where } r^2 = radius\ of\ worm.$$

$$From\ measurement, r^2 = 0.75cm = 0.0075m$$

$\omega_2 = \frac{0.16}{0.0075}$; ω_2=21.33rad/sec

Velocity of gear (Ng)

$$tan^{\gamma} = (\frac{Ng}{Nw})⅓ \text{----------} (9)$$

$$tan26.99 = (\frac{Ng}{0.16})⅓ ; \sqrt[3]{tan26.99} = (\frac{Ng}{0.16}); \sqrt[3]{0.509} = \frac{Ng}{0.16}$$

$0.16x0.798 = Ng$; Ng=0.13m/s

Linear velocity of worm (Vw)

$$Vw = \frac{LV^2}{60} \text{----------} (10)$$

$$Vw = \frac{24x0.16}{60} = 0.064ms^{-1}$$

Linear velocity of worm gear (Vg)

$$Vg = \frac{ЛDgNg}{60} \text{----------} (11)$$

$$\boldsymbol{Vg} = \frac{Лx20.69x0.13}{60} = 0.14ms^{-1}$$

From $V = \frac{d}{t}$ ---------- (12)

Were V=0.067m/s

From the formula,

Power input

$$Pin = IxV \text{----------} (13)$$

Where, I=current (A); V=Voltage

Therefore,

$$Pin = 15x12; Pin = 180w$$

From the formula,

$$P = tx\omega \text{----------} (14)$$

Where,

T=torque; and ω=angular velocity of the motor

$$t = \frac{P}{\omega} = \frac{180}{8.59} = 21 \text{ N-m}$$

Therefore,

Distance travelled by the door on the rack

From measurement d=0.56m; T=time taking; Therefore $t=\frac{d}{Vg}$; $T=\frac{0.56}{0.14}$ and T=4sec

CONSTRUCTION OF THE BOX

The materials used for the construction of the box are square pipes (1” side), aluminum sheet, fiber, steel sheet, and color wood. The square pipe was used to construct the structure of the box. Its dimensions are 22.3”x17”x25.5”. The top, bottom, back and side of the welded structure were

covered and welded with the metal sheet living the front to be covered by the sliding door and the engine room lid. The engine room lid dimension is 22.3”x5.5”. Aluminum sheet was used to partition the engine room which has a base area equal to that of the top. A compartment for battery and other electric units of dimension 17”x5”x25.5” was created on the right side of the box. This compartment was equipped with a door using a key lock. The aluminum sheet was used to cover the internal walls of the box with the fiber installed within the hollow walls. The color wood was used to partition the safe into different sizes were items to be saved are to be kept.

CONSTRUCTION OF THE ENTRANCE (DOOR)

The rectangular metal sheet sliding door was design to move in and out of its frame horizontally from the right, along a pair of parallel ball bearing rails. The metal frame made from the angle bar, protects the rails and conceals all edges of the sliding door when closed. The dimension of the door is 22”x18.5”. A lever was welded to the extreme left end of the sliding door. The lever was fastened to electrically powered engine connector, which was directly installed above the door frame. The connector moves horizontally to and fro along its rails and drags the door along as it moves. The engine movement is regulated by a remote control system.

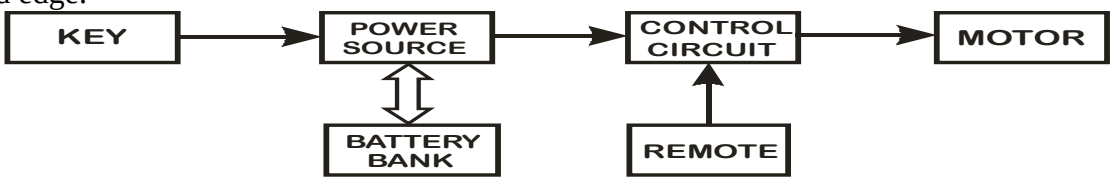
Finally, the engine compartment and the transmission system was covered by a lid of dimension 7.5”x22”x3.05”

3.3.3 CONSTRUCTION OF COMPONENT

The following procedures were carried out during the construction of the machine
>Marking out: This involves all the procedures in measuring out dimensions on the metal sheet, rod, pipes and angle bar. The major tools used for these steps were tapes, scribers, and rule.
>Cutting: This was done using a hack saw. The angle bar, pipes, and rod were cut into required sizes and the cutting machine was used to cut the metal sheet.
>Drilling: Some pieces of metal sheet, pipes and angle bar were placed on the drilling machine and held firmly by the vice. Holes were drilled into the sheet, angle bar and pipes for bolts to pass through and also for incorporating the door and the electric motor on the body and structure of the box making them one.

3.3.4 ASSEMBLY OF THE MACHINE

The process involve in the assembly of the machine were as follows:
>Welding: An electric arc welding method was used for joining the structure/frame of the box together and also for covering of the box with a metal sheet. The major tools used for this process were welding machine, electrode, welding shield, and gloves.
>Grinding: Grinding was done on the welded component to remove sharp edges and smoothen the welded edge.



BLOCK DIAGRAM OF THE ELECTRICAL SYSTEM

PAINTING

The materials used for painting of the box are brush, ash color paint, spray machine and paper tape. The procedures followed when painting the machine are: positioning of the box -the box was placed on a wheel 0.2m above the ground to avoid contact between the box and sand; Taping- Not all the part of the box needs to be painted so paper tape is used to cover the

unwanted area; and Painting- A brush was use in painting the sliding door while the spraying machine was use to spray or paint the box.

3.4 TESTING OF THE COMPONENT

>POWER TESTING

Power test was carried out after all electrical connection was made. This was to ensure that there is appropriate flow of current and also supply of current to the electric motor from the battery when there is no power supply from the mains.

>THE OFF AND ON KEY

The key acts like a switch turning on and off the power supply used in operating the safe. After connections were made, the key (switch) was tasted and no fault was detected. Current flow from the battery to the electric motor via the electric circuit and the led light was turned on indicating that the key has been turn on.

>CHECKING OF THE REMOTE

The remote was tested to see if signals can be transmitted to the receiver in the circuit.

3.4.1 ITEMS THAT CAN BE KEPT IN THE SAFE

Items that can be kept in the safe include:

1) **Property insurance policies and agent contact information.** You'll need this information right away if your house suffers damage and you need to know how to file a claim.
2) **Passports and original birth certificates**. These can be a hassle to replace and will come in handy to establish identity when traveling with children.
3) **A list of family doctors, prescription medications, and contact information for all pharmacies you use**. You may need these to get new supplies of medications you use on a regular basis.
4) **CDs or an external hard drive containing digital copies of all family photos**. It's a good idea to scan all older family photos and keep a digital copy of them as well. Your family memories in photographs are irreplaceable.
5) **Safe deposit box keys**. If you store valuables in a bank safe deposit box, you'll want to make sure you keep the keys to it in a safe place.
6) **Important papers related to investments, retirement plans, bank accounts, and associated contact information**. You may also want to keep some cash on hand for ready access in an emergency.
7) **Information on your outstanding debts, due dates, and contact information**. It's important to keep tabs on your finances and protect your credit, in the event you're displaced by a fire.
8) **Original Social Security cards**. These can take time to replace and may be needed to establish eligibility for benefits.
9) **Copies of your important legal documents, including powers of attorney, living wills, and health care proxies** -- both for yourself and for anyone else for whom you are designated attorney-in-fact or health care surrogate. Having access to these can help ensure the protection they were created to provide.
10) **Copy of wills and all wills in which you are designated the executor**. It's important to have access to these as safe deposit boxes are typically sealed upon notification of the box owner's death.
11) **Valuables: Jewelry, coins, cash**, etc. that you may want access to from time to time.
12) **Spare Keys and titles to all vehicles.** It helps to know where copies are in the case that you need them.

Of course, exactly what you choose to store in your fireproof safe will depend on your personal circumstances and the size and location of the safe.

3.4.2 MAINTAINANCE

The maintenance of the safe can be carried out as follows: cleaning of the safe always; turning off the key when not in use; checking the fuse and battery and replacement when they go bad and plugging the cable to the main supply to keep the battery charged.

Pictures of the safe deposit box after construction






Table 3.1: Material Cost

S/N	Materials	Quantity	Total Cost
1	ANGLE BAR (MILD STEEL)	2	1600
2	PIPES	4	1800
3	ALLUMINIUM SHEEET	1	1000
4	METAL SHEET	1	1500
5	TRANSFORMER	1	1500
6	DIODE	4	80
7	CAPACITORS	7	300
8	L7812(REGULATOR)	1	200
9	L78D5(REEGULATOR)	1	200
10	BC558(TRANSISTOR)	1	100
11	TRANSMMITER	1	200
12	RESISTORS	4	80
13	DE COUNTER	1	500

14	LED	3	60
15	ELECTRIC MOTOR	1	2000
16	BOLTS AND NUT	15	800
17	COLOR WOOD	1	1500
18	WIRE	2 YARDS	200
19	BATERY	1	1000
19	KEY	3	1000
20	RELAY	2	1000
21	CABINET SLIDE	1	700
22	CABINET HINGES	2	400
23	PAINT	1	800
24	REMOTE	1	200
25	TOTAL	-	₦17,320

Direct labor cost (DLC) is assumed to be 45% of the material cost;

$$DLC = \frac{45X17320}{100} = 774$$

Total labor cost=material cost +DLC
=17320+774
=₦18,094
Total cost for producing the safe deposit box is=₦18,094

4.0 RESULT AND DISSCUSSION

4.1 RESULT

The significance of this safe is its ability to be automated and operated wirelessly via a remote control. The use of battery aid the operator to operate the safe when there is no power supply. The Table 4.1 below shows the operation of the machine at different power supply. At 180w, the sliding door opens and closes in 4s and between 114w and 78w, the sliding door moves very slowly and below 78w, the door do not move at all. If there is no power supply and the battery cannot supply 9.5v-12amp to 12v-15amp for the safe to be operated then the battery should be changed.

Table 4.1

S/N	P(w)	V(volt)	I(amp)	T(N-m)	ω(rad/s)
1	**180**	**12.0**	**15.0**	**21.0**	**8.59**
2	**114**	**9.5**	**12.0**	**16.5**	**6.91**
3	**78**	**8.7**	**9.0**	**15.1**	**5.15**
4	**43**	**7.2**	**6.0**	**12.5**	**3.44**
5	**36**	**6.5**	**5.5**	**11.5**	**3.12**

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The safe can be hidden in walls or screwed to the floor and can be operated easily with the key and remote. The safe requires no expertise knowledge for its mode of operation and it's affordable and safe.

5.2 RECOMMENDATION

Further research is therefore recommended to be carried out on this topic to increase the speed at which the sliding door opens and closes, reduction in size of the box and a radio wave frequency should be use for more security.

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