Control Technology

Design Brief

Issue: To build a safe for a client. An interview will be made to determine the needs and see the constraints and specifications of the client. I will examine the situation formulate a brief with specifications and answer as best I can.

Constraints:

- Due date 22 of September.
- Budget is $60.
- Materials: mild steel, wood, timbers, plastics, electrical components and tools.
- Safe operation: Control system keypad and LCD screen, use of Picaxes. Locking system of solenoids, mechanical gears, levers, pins or other locking mechanisms.
- A secondary entry method if main method of entry malfunctions.

Analysing the Situation.

Factors associated with resources.
This is the equipment, facilities and knowledge we can have access to. This being tools, machinery, design equipment and the help and expertise.
-Access to electrical tools for assembly of circuit. Clippers, strippers, pliers, soldering iron, wire, solder, screwdrivers, woodwork tools components supplied and if not there at present we are able to request the desired component.
-Access to computers for programming and design and also the use of Auto cad and Virtual Lathe software for design purposes.
-Metal work equipment use of welding equipment, arc welder to be use but limitation of one person at a time. Another restraint is that of only simple jobs nothing intricate.
-Metal turning on Lathe for hinges and door knob for the safe.
-Also access to woodwork tools as well.

Information: Help available from teacher Mr Duplessis and if he doesn't know will assist in finding the solution. Also he can help in construction and problem solving of circuits. Mr Locke his knowledge in use of the Lathe and using the welder also assistance in design situation.
Bright sparks – www.brightsparks.org.nz a New Zealand based programme to help young people and to introduce them to the field of electronics and technology. This provides the ability to use the Hub a forum on the website where questions can be asked and answered to a solution also they provide help with components.
My Client – Mr Simpson said he will fully participate and am welcome to interview him further.

Factors associated with Client Issue.

Factors arising to where technological process will be undertaken.
- Circuit assembly.
Safety – Shoes worn at all times in workshop. Safety goggles worn to protect eyes form solder, work stations covered. Appropriate tools and equipment, nothing dangerous with damaged wires of badly worn tips on irons.
Use of gloves when working with PCB making chemicals. Well ventilated area so less inhalation of fumes. Class room situation that has safety kill switch if anything goes wrong.

Welding Safety.

Well ventilated welding bay. Protective clothing, welding apron if possible, full face and eye protector and welding curtain to protect others from the arc. No flammable materials near by.

Lathe.

Safety goggles, proper foot wear.
The preparation and set up of tools and lathe machine. The process of producing the piece, that the equipment is correctly set, managed and maintained. Tools such as chisels and other gear are sharp and correctly used so as to avoid injury.

Factors associated with client.

- My Client is a computer teacher so is able to operate electronically controlled devices.
- If keypad to be used should have more then 4 pin numbers as any less is a security problem.
- Also something that gives character and enjoyable to use.

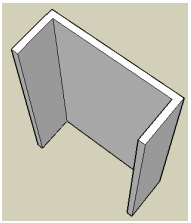
- He is a Basketball coach and manager as well.
- Not too serious on security obviously depending on what it is to be secured.
- He wishes it to contain bank details, jewellery and other documents. Client is willing to help and I' am welcome to an interview. Just to make an appointment if I need to see him.

Factors associated with design.

- One issue that may affect design is that of New Zealand safety organisation OSH (occupation safety and health.
- There are no political, cultural or social issues affecting this design.

Categorisation of points.
1- factors associated with client.
2- factors associated with resources.
3- factors associated with design.

Importance of key factors.
Factors:
1a. Identify your client's attitude towards high tech solution.
1b. Identify your client's type of lifestyle, values and perspectives.
1c. Is your client readily available.
2a. Identify the materials and machinery available at school.
2b. Are there any materials and machinery or materials that you may need and aren't available.
2c. Any other factors, such as training, speciality tools manufacturing techniques that cannot be accessed or limited.
2d. Are there any economical constraints.
3a. Is there an New Zealand legislation that will have an effect on your design.
3b. Are there any political issues effecting design.
3c. Are there any cultural issues effecting design.
3d. Are there any other social issues that may effect on the design.



Revised brief.

- Design is restricted due to the type of metal used being that of channel Iron.
- Paint will be available use of a spray gun with various colours.
- Construction of safe the welding still only one person at a time can use the welder. The time issue can be over come by another person working on hinges or circuit.
- The use of Google Sketch up to make sketches and concept ideas.
- Virtual lathe to get a hang of the lathe before we use the proper thing.
- Secondary entry system to be kept.
- To prevent the messy and time consuming process of PCB making pre-made boards will be used.

This was the interview and the end result with my client Mr Ali Simpson computer teacher at Sacred Heart College.

Interview:

Q: What will you be keeping in the safe?
A: Documents, Bank details, jewellery.

Q: Where will you be keeping the safe?
A: Some where blending with the back ground such as a panel.

Q: Security wise.
A: Where would it be kept or secured.
– as a draw
- as a cabinet
- A painting

Q: Access to safe
A: - key
- keypad
- swipe card
- thumb pad
- more then 4 digits

Home environment.
Q: Who will have access to the safe? A: One person or if married the clients wife.
Q: Would you want a portable safe or a fixed one? A: fixed bolted down.

Results from Interview:
Contents of safe: Documents, Bank details, Jewellery.
Security of safe: Bolted down, blending of in environment.
Size: Yet to be finalised but a set size from the teacher.
Access: 1 person but 2 if married, thumb pad, keypad, card system.

Conclusion:
From the interview I found that contents of the safe would be personal details, jewellery and other documents. The security of the safe can be accessed by two people my client and if married his wife. If a keypad to be used more then 5 digits must be programmed as anything smaller then 5 is easier to crack. Also in accessing the safe if possible a thumb pad or an alternative creative method to get into the safe, cards, lock or other methods. The safe best to be bolted down or disguised in the surroundings or where it wishes to be placed.

Fabrication work.

Tool: Lathe.

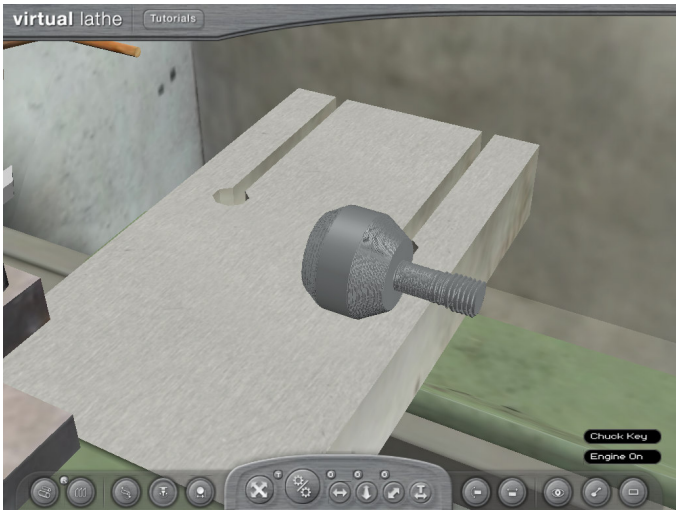
In constructing the safe two hinges and a door knob must be made. All in showing skill on using the lathe and coming out with a finished product.

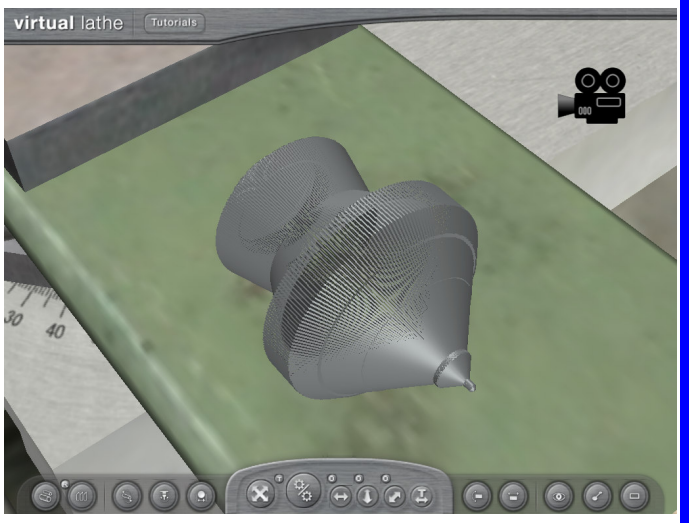
The Bullet hinge:

The type of hinge we would be making on the lathe is a bullet hinge. Two will be made so when attached to the door will be placed in opposite directions of each other locking in the door as well.
We sawed of roughly about 80 mm long round bar with a diameter of approximately 15mm. We then cut the bar in half with one piece being about 35 mm long and the other 45 mm long. First we placed the hinge in the lathe and faced each sides of, then we began to turn the 45 mm hinge in by 15mm giving that a 9mm diameter so that the end of the bullet hinge will be drilled with a 10mm bit about 15 mm in, also giving a final taper turn to each hinge. This was repeated again ending with two machined bullet hinges.

The door knob.

For the door knob we cut another piece from the round bar about 45mm. We faced both sides of the knob then began shaping it. One side we gave it a taper of about 35 degree angle. Then we turned the knob around, went in about 25 mm giving it a 9 diameter bit which would be placed in the door by drilling a 9mm hole a welding the knob from the other side. With this same side we gave it another taper a bit steeper of 45 degree angle. Finishing with a smooth and holding door knob.

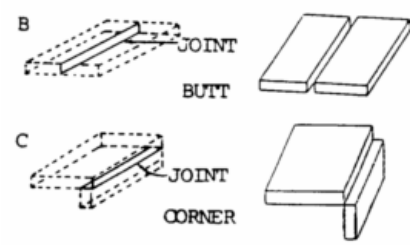




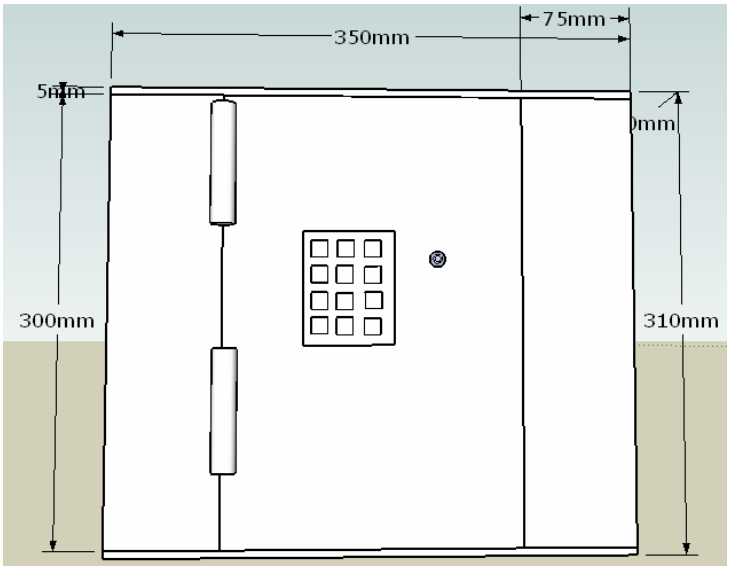
Arc Welding :

Construction of the safe has been done by welding. The type of welder used was an arc welder. Arc welding is done by using a power supply to create an electric arc between the work piece and the rod. This was all done on a welding bench with a lead attached to the bench from the power supply and connected with an electrode rod where the electric current is used to make an arc from the rod to the work piece.
The rod it self is a consumable electrode rod that is a piece of steel coated in a flux, when the arc is made making the weld the coated flux protects the weld from oxidation and contamination by producing a CO^2 gas. With the protection of the weld the flux causes slag which must be knocked away so as not to damage the weld.

The steel was bought from Fletcher steel and came pre-cut to ordered measurements. The safe consists of two channel irons dimensions being width - 75mm, length - 200mm, height - 300mm. All finished of with four pieces of sheet metal 5mm thick, 2 pieces being 200mm wide 300 mm high. One piece being the back of the safe and the other the door of the safe. Not all pieces came to length some had to be cut. This was done using a power band saw this saw was accurate because the metal could be fixed to the saw and saw could be left to cut where set.
First the safe was all tact welded together so as to see how it looks and so crucial mistakes aren't made. Then when every thing looks right the final welds can be made.



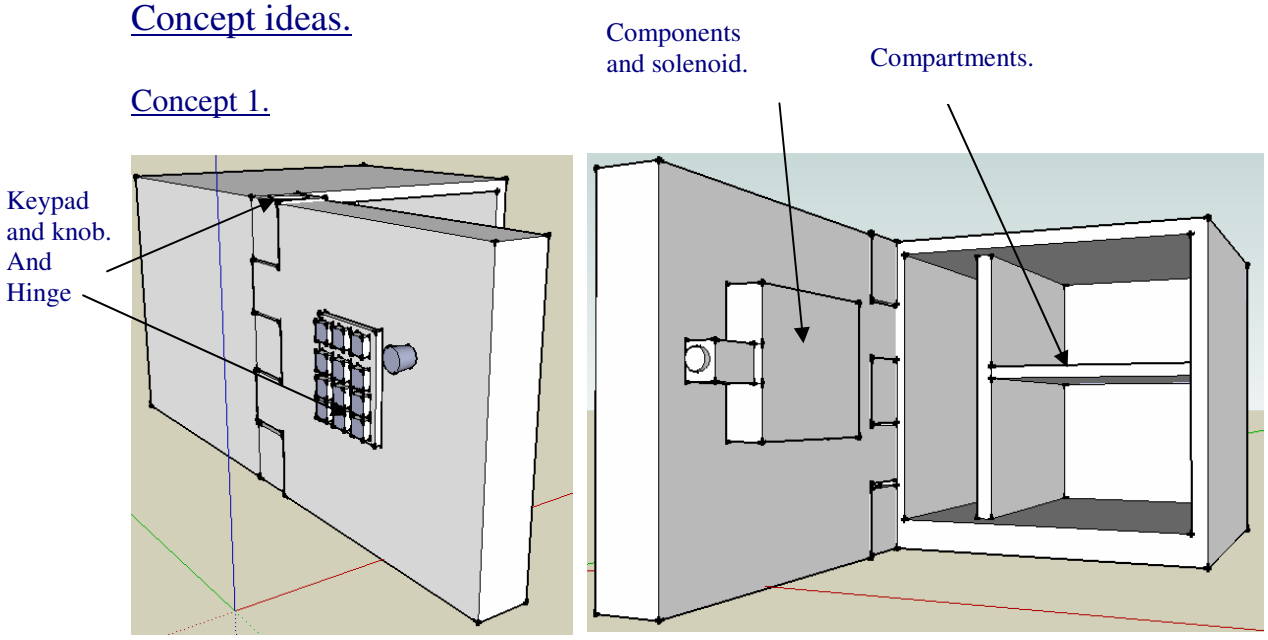
The final welds were a combination of butt joints and corner joints. Butt joint shown is two pieces sitting next to each other touching with a weld going across the sides touching. This was used for welding the back of the safe and the hinges to the safe.
The corner joint shown, is two pieces welded with one on a right angle to the other. This was used in welding the top and bottom of the safe.
The welds made were done by moving the welder slowly so as to give a thick and solid weld. The earlier tact welds could not be kept permanent as they can be knocked of easily with a hammer but were useful and helping to plan the final construction.
The angle grinder was used to repair any mistakes caused by welding and to give the safe a clean and reasonable finish so that it can be painted on later on.



The Dimensions of the safe come to about a width of 350mm, length of 200mm and height of 310 mm.

Concept ideas.

Concept 1.



This is the first concept of the electronic safe. This was before we were given the design restraints and the material to be used.

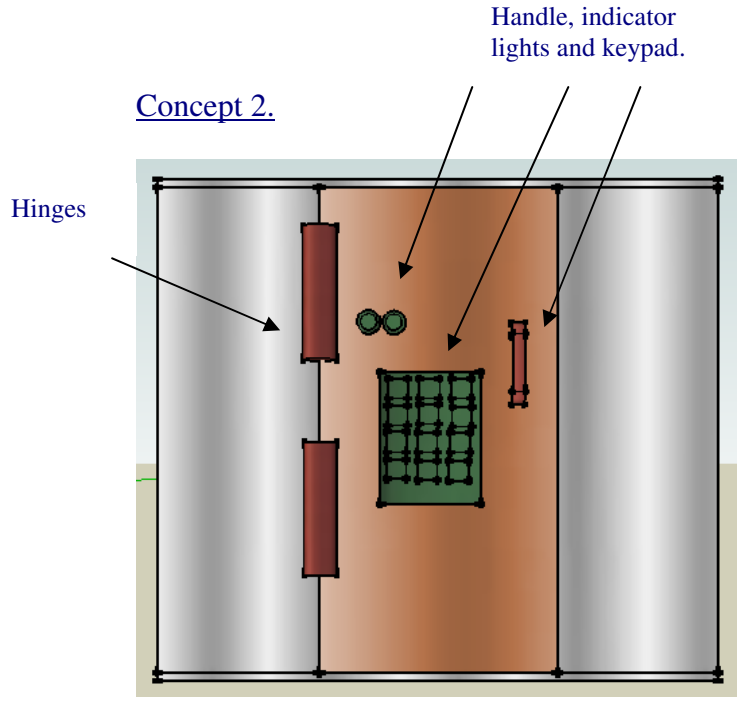
The safe its self was to be made from steel, wood and other different materials. The compartments of the safe has been split into three sections either made from wood or plastic dividers. The vertical sitting divider would be permanent sitting holding paper or other important documents. The other two compartments can be made into one with the middle divider being removable depending on what the client wishes to keep in the safe.

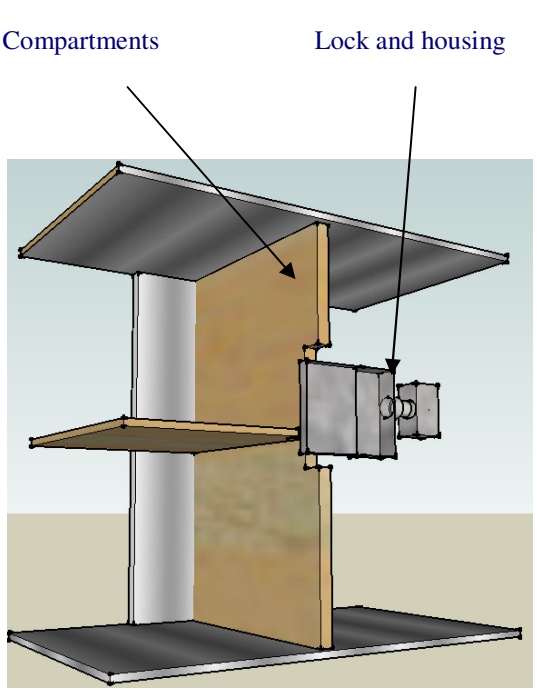
The hinge of the safe was to be one complete bar that slotted through set holes with pins holding the top and bottom with coverings on either end. Because of how easy this design of the hinge would make to the thief a solid bar or locking system in the hinge to prevent the easy access into the safe. The safe will be locked by a solenoid with components on the back of the door with receiver of the lock being in the wall of the safe. Solenoid would be activated by a keypad controlled by a picaxe with a pin of a set number that the client asks for. A door knob designed for grip that makes it easier to open the safe and gain access to the contents.

Positives of this design.
- Good design of compartments giving the option to easily store paper and the choice on storing large or small objects.
- Thick doors and walls make it harder to break or get into.

Negatives of this design.
- Hinge badly designed a single straight bar holding the door is not practical as relatively easy methods can be taken in removing the hinge and separating the door from the safe.
- The locking system on such a thick door and rest of the safe may not be practical as selected lock may not be strong enough.

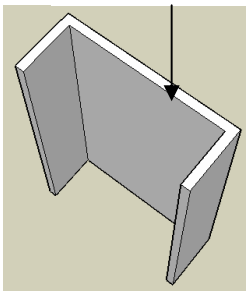
Concept 2.





This is the Second concept after materials and more detail into what we would be using was made clear. The skeletal structure of the safe would consist of two channel irons being approximately 75mm by 200mm, height 300 and being a bout 10mm thick. With four other pieces of various sizes of flat steel to make top, bottom back and door. With this changes could be made and adjusted to reach a favourable solution for my client.

Channel Iron.



The compartment of the safe was not changed too much with there being larger room to fit documents and the adjustable compartment remaining. But considering the nature of the channel iron we see that it restricts entrance and moment in the safe. Changes were made to the locking system. Because of the weight and size of the steel it was suitable to keep the locking and components on the door as the door is only 5 mm thick and the type of lock used as being suitable. The solenoid lock was improved giving it an appropriate housing of the bolt when it is locked. Two lights added as indicators and give communication to the user.
The door handle changed making it easier to open and close the door being of a more U shape design then a knob. The hinge changed as the previous hinge being of a poor design and the difficulty of making such a hinge made it practical to go a head with the bullet hinge. The hinge is of two parts with one being inserted into the other allowing it to rotate and hold in place. Two of these hinges were made with them being in opposite directions of each other.

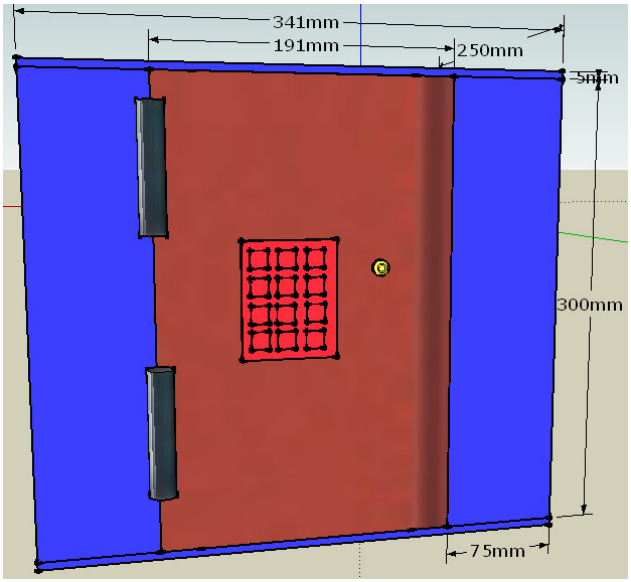
Positives of this design.

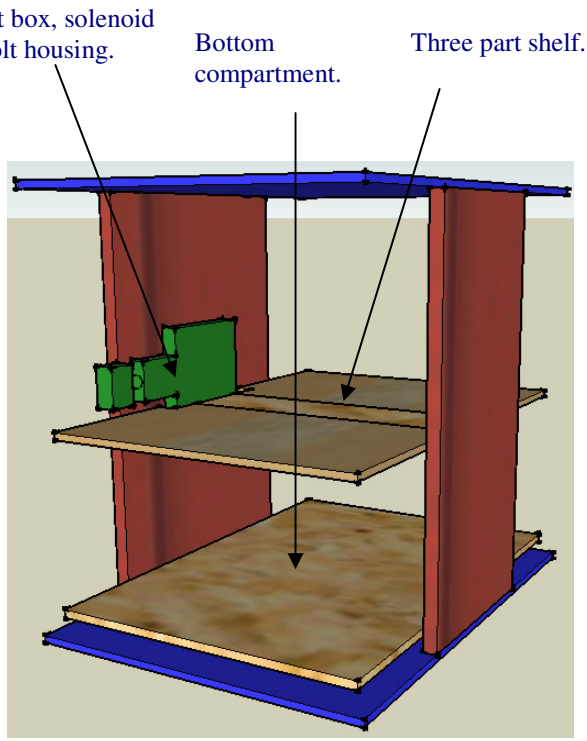
-The hinges are good improvement from the original with making it less expansive and easier to build and operate.
-The locking system of the bolt having a proper housing giving further security and hold to the lock.

Negatives of this design.

-The compartments with the channel iron in place the freedom of movement is very limited. Because the horizontal divider is in the middle it gives little room.
-Handle is of a good design but may need to be changed due to restraints and problems in production of the handle.

Concept 3.





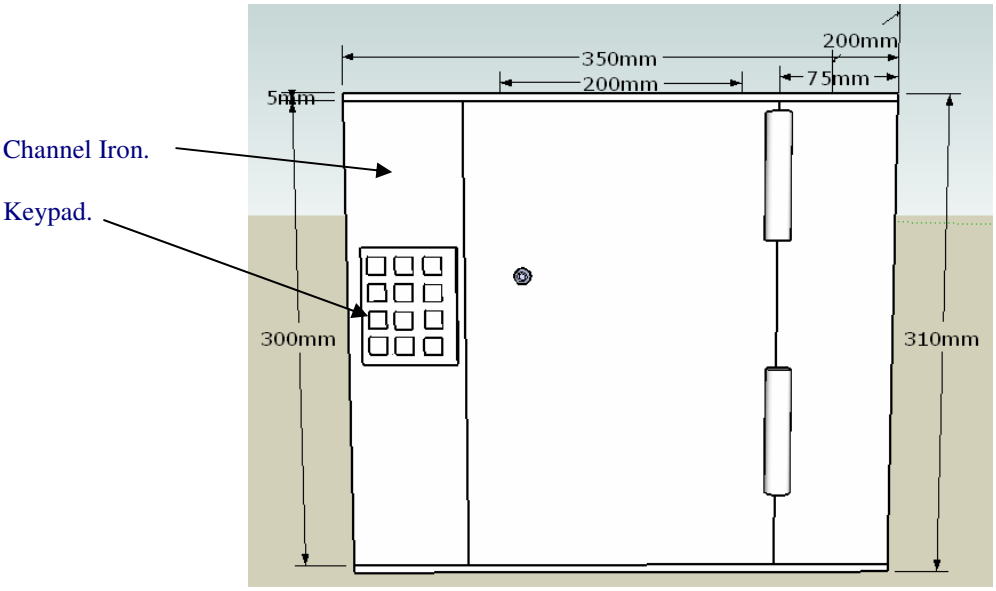
This is the third concept of the safe. The dimensions of the safe close to finalisation with the size of the channel iron decided on. While the door and the backing to be resolved. Also a different set up of compartments and door size to accompany it.

The door size made wider along with the back to about 190mm making it a longer safe. Making the channel irons further apart from each other giving more room. Was unable to keep the original safe shelf structure of the compartments due to the size of door and channel iron. But still the nature of the shelf was kept with sections of the safe being removable. Compartments are made into two with a removable shelf. The shelf has three parts each being able to move so as to make room for paper and other documents. Middle and one other part removed so documents can be placed in easily with parts being replaced underneath. Two parts of the shelf maybe replaced so as able to keep a large item on one side and two small items on top and beneath the compartment shelf.
Indicator lights removed due construction of circuit and style of knob changed. Knob was changed because of the difficulty in constructing a full handle. Knob was made on a lathe and given tapered edges making it an easy to use and neat looking knob. Circuit and lock kept on the inside of the door as with the solenoid and the housing of the bolt. The bottom compartment was to hold a sensor or activator to alert the person of something is in the safe or is not a trick light part of the circuit. Hinges kept the same the choice of bullet hinges impacting on the requirements of the build and the construction of the safe. Colour scheme chosen as what safe might look like finished.

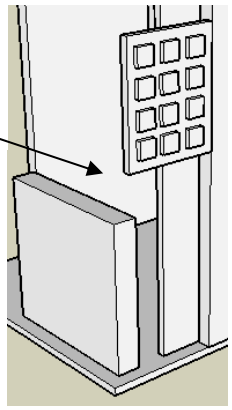
Positives of this design.
Construction of the knob fits well in constraints and in producing the finished knob.
New compartment structure making it easier to access and store items.

Negatives of this design.
The length of the door and backing not so there still causing bit of an entry problem.
The keypad and components sitting on the door has found to be hard to attach to the door so a different design to be considered.

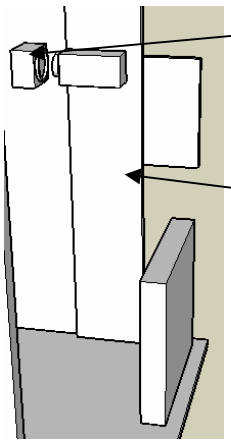
Chosen Concept final design.

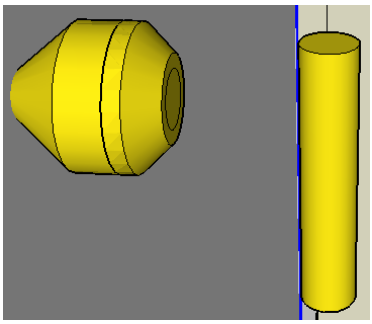


This is my chosen design. It has revised measurements of the previous concept design. A suitable position for the keypad and solenoid housing found. Knob design has been kept with only the position of the hinges changed.



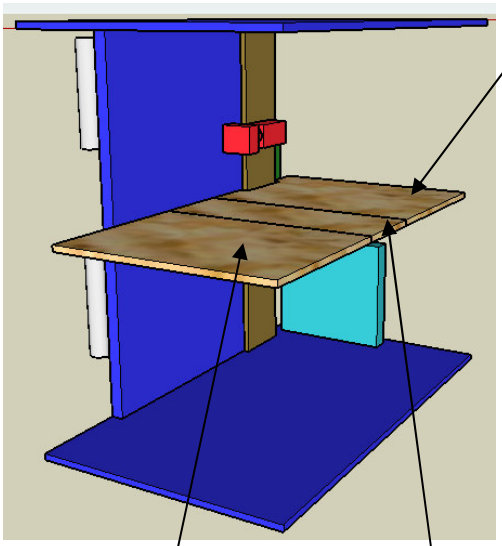
The keypad and solenoid was changed from sitting on the door to being placed on the side of the door in the channel iron. This was done because it made it easier to place batteries circuit and box on the side. The solenoid is also placed on the channel iron so as just the solenoid bolt housing is fixed to the door.
A door jam was added to prevent the door from swinging all the way inwards which could damage the hinges or contents inside.





The bullet hinges finalised put on the right hand side enabling door to swing to the right. The door knob kept with its tapered design provides better grip then the handle design.

Part 1.



The compartment setup of concept 3 has been kept. The size of the door and the nature of the shelf enables paper and other documents to be kept neatly also enabling room for other items to be kept under the shelf. Shelf can be adjusted. Parts 1 and 2 or 3 and 2 can be removed to create a one sided shelf enabling more room on one side. The shelf operates by removing one side along with part 2. Documents are place on top of the sitting side with the other sides added to finish of the shelf.

Part 3.

Part 2.

Electronics.

The circuit is controlled by a Picaxe 28 which can be programmed to suit different uses. In use with the safe the Picaxe is connected with a keypad which is the main form of control and part of entry to the safe, also a piezo, led and other indicators.

Programming determines the buttons pushed to enter and control the safe. There can be different variations to the programming with this being an example of programming used in the circuit.

```
init:
let b0 = 0
goto scan

scan:
let b1 = 0
let pins = %00000001
if pin0 = 1 then add1
if pin1 = 1 then add2
if pin2 = 1 then add3

let b1 = 3
let pins = %00000010
if pin0 = 1 then add3
if pin1 = 1 then add2
if pin2 = 1 then add1

let b1 = 6
let pins = %00000100
if pin0 = 1 then add1
if pin1 = 1 then add2
if pin2 = 1 then add3

let b1 = 9
let pins = %00001000
if pin0 = 1 then add3
if pin1 = 1 then add2
if pin2 = 1 then add1
goto scan

add3: let b1 = b1 + 3
goto test

add2: let b1 = b1 + 2
goto test

add1: let b1 = b1 + 1
goto test
```

This is the start of the programming, a variable is created to store information to it later on.

Once it is told to scan it sets the variable b1 to 0. It turns on output pin 0 (%00000001) indicating that numbers on that row could be pushed. The number pushed is determined by this sequence of code (if pin0 = 1 then add 1). In this case because pin 0 is high the first row of (1,2,3) is active, this code (if pin0 = 1 then add 1) lets you determine which of the numbers can be pushed as the final access code.

Sets Output pin 1 on high meaning second row is active giving the option to push either (4,5,6).

Sets Output pin 2 on high meaning third row is active giving the option to push either (7,8,9).

Sets Output pin 3 on high meaning fourth row is active giving the option to push either (*,0,#).

This part of the code determines which of the three digits in each section above will be the correct number to enter the safe. The b1 + a number is what says which pin is correct and which is not.

```
test:sound 5,(124,30) 'produce a sound
let b0 = b0 + 1
if b0 = 1 then test1
if b0 = 2 then test2
if b0 = 3 then test3
if b0 = 4 then test4
goto init
```

This section produces a sound each time a button is pushed. This section also determines how many pin numbers there can be. Also says which pin is the correct pin in connection with the above programming. If pin 4 on the keypad was pushed and the programming found its way to test 4 if would be the wrong pin because pin 5 was programmed.

```
test1: if b1 = 8 then scan
goto init
test2: if b1 = 3 then scan
goto init
test3: if b1 = 1 then scan
goto init
test4: if b1 = 5 then open
goto init
```

This is the section of the programming which allows and disallows the button that was pushed in being part of the whole pin number. The sequence of numbers must be pushed correctly as well because each time a pin is pushed it goes to back to scan to receive the next pin. Once everything is pushed in sequence the last pin opens the safe.

```
open:
sound 5, (120,40,120,50)
pause 1000
high 6
wait 5
low 6
let pins = %00000000 'set all pins LOW
goto init
```

This is the section of programming that tells what happens when the pin is entered correctly. An upbeat sound is played with a 1 second pause then the solenoid opens. It opens allowing you five seconds to open the door before the solenoid locks and pin must be entered again. After it has been opened all output's are turned of and revert back to the beginning waiting to be entered again.

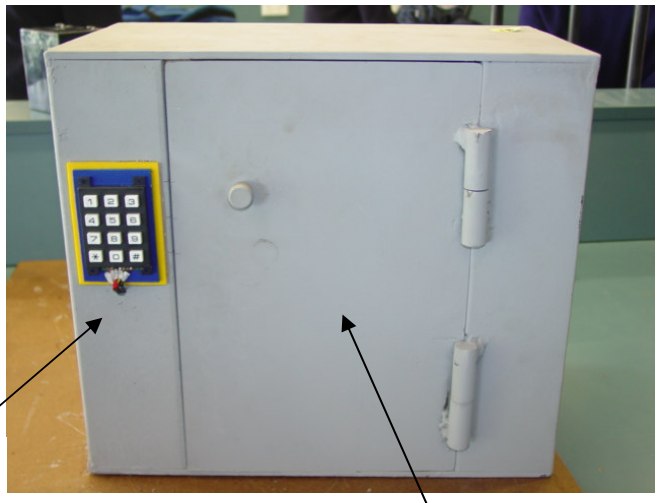
This is the base of the programming with more can be added which means more options and capabilities of the circuit. This can be ways of by passing all this code is something goes wrong or a new process is to be added to the circuit.

The Finishing of the safe.

With the completion of the welding preparation for making the safe look a bit more appealing can begin. First the rough areas and edges of the safe must be cleaned and shaped. To get rid of the sharp edges on the side of the safe a rasp was used until a suitable tapered like edge was made. In cleaning the areas around the welds the grinder was used getting rid of excess flux or other markings. Grinder was also used to clean the welds up and flatten them a little to make a smooth finish. A hole was drilled on the side of the door on the channel iron so keypad can be threaded to and making it easier to place circuit in the safe.
Once the cleaning was complete bog or body filler was used to cover the welded areas and gaps. Bog is a two part patty like substance that has the fill and the hardener. The fill can be added in any amounts depending on how much will be used and the hardener is only added in small amounts. Bog is then mixed turning a pail colour of the hardener, then is ready to be applied. Enough bog should be applied that the gaps and areas are well covered and that the desirable outcome can be achieved. After bog is set overnight and hard sanding and shaping of the bog can begin. Sand paper was used of 120 grit roughness and a sanding block to achieve a good sanding. Preferably this is to be done outside as very dusty and mask should be used. With the sanding continuous rubbing along the bogged areas until desired surface achieved but being careful not to rub too hard exposing the metal underneath. With the safe the bog was made smooth so if you ran your finger of the areas it would not be different from the metal to the bog.

Appling bog to safe.

After the sanding and desired state is achieved and the safe is dusted and wiped clean spray painting can begin. Because of the metal used car primer grey colour was used which protects the metal from rust and provides a base coat. This is done with a spray gun in a ventilated spray booth. Paint is added into the container mixed with mentholated spirits. Once paint is ready gun is hooked up to air compressor and painting can begin. The gun has two modes when trigger is lightly touched only air is released, when trigger held tightly air is released along with air sprayed on to the required areas. Spraying is done with a sweeping technique across the work to be sprayed on, and triggered only touched when aimed at work to be painted. Once all areas are sprayed the insides as well work can be left to dry then second coat can be applied as well as the surface that could not be sprayed the first time. After undercoat finished chosen paint scheme can be painted.

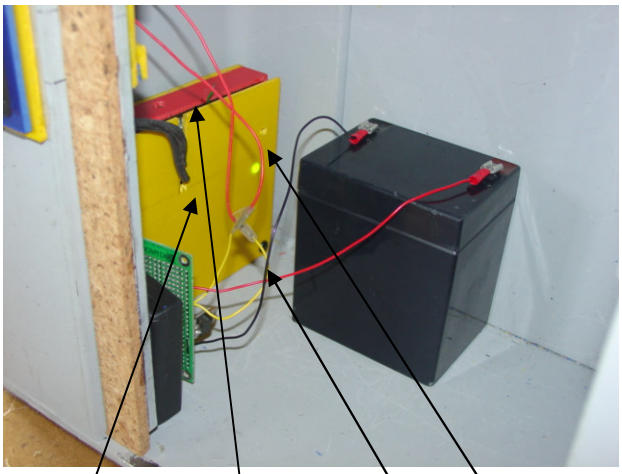


Hole drilled for keypad.

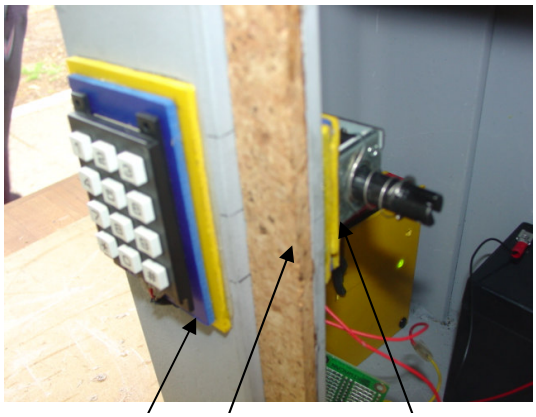
Finished area spray painted.

Internals of the safe.

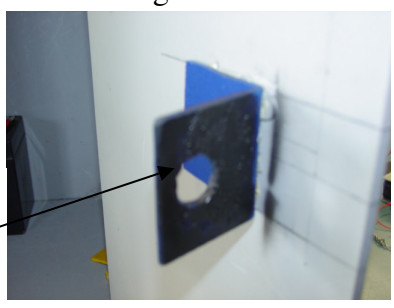
The circuit box of the safe was constructed using plastics. The base of the box was 100mm by 100mm with the sides being 20 mm by 100mm or cut of due to the nature of the box. Cutting was mostly done with a band saw but hack saw was also used and the materials were easy to work with. Inside the box two supports were made in two corners so circuit can sit nicely. In one of the supports a hole was drilled so as the receiving end of a pin can be fixed in to the base. This is so circuit can be place on top and pin fixed securely with circuit. The sides were glued on to the base using cement glue made for gluing plastics. With the circuit in place makings could be made for appropriate holes. Holes were made to make way for wires of the battery and other components. This was done with a drill and finished of with a round rasp. Another pin receiver was placed on the edge of the top of one of the corners of the box so as a cover could be place on to the box with another pin. Holes were drilled in the cover of the box to make way for the led and to hear the sound from the piezo. Also a slim piece cut away so as to enable easy removal of cover in the way of the keypad wires.



Also made was a sliding platform for the solenoid. The solenoid sits on the platform with a bracket fixed to one side of the channel iron, to hold it and a stopper to stop it from sliding all the way off. The sliding platform was made so that the solenoid and circuit can be removed easily for any reason.



The outside to the safe a platform was made giving the keypad a suitable position and ease of use for entry. Tow pieces of plastic stuck together with the cement glue. The base piece was about 80mm by 50mm and the second piece 5mm shorter. The keypad was then glued on.
Applied to the safe was a door jam and on the jam strip of cork tile to cushion the door. A stronger glue was used then the cement so as able to stick plastic and wood to metal, this was an epoxy two part glue that needed to be mixed before applying. Keypad was glued on with a hot glue gun. Hot glue gun is a gun with a heating element and glue stick that squirts runny hot glue.
The part taken to receive the bolt was made from plastic and bent to a 90 degree angle. Then the hole was marked out inline with the receiving bolt then drilled. Plastic was glued on with the epoxy glue.

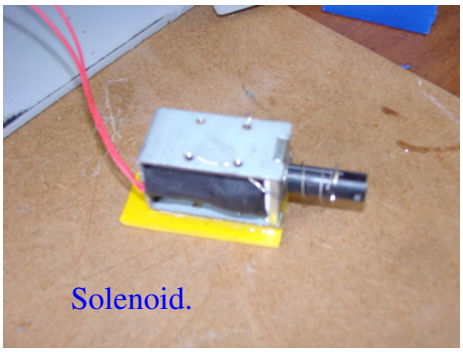


The circuit.

The circuit is controlled by a picaxe 28 A and is used by a keypad and solenoid lock. The intial working of the circuit is controlled by the picaxe which is further controlled by the programming. The Programming tells the picaxe what to do and how the components should react. Also components correctly chose so as able to work with the picaxe and to achieve the desired result.

The keypad that is connected to the picaxe is done in two parts. The first part is the inputs these are the vertical rows on the keypad. Because they are inputs they are set each with a 10k pull down resistor bringing the voltage down to zero. This means they are pulled low are all 0.
The next part is outputs these are the horizontal rows of the circuit. These are all so set to zero. If all the outputs are off and a switch is pushed nothing will happen because the inputs are at zero. This is because nothing is on there is no high anywhere on the circuit. But if an output is switched high and a button is pressed on the corresponding row that button will be active high. So with this a pin number can be found. If each time the keypad is scanned it is able to pick up these highs and eventually the correct pin can be programmed.

With the correct keypad entered it activates a Solenoid lock. This solenoid is powered by a 12v power supply and because of this is set on a different positive but shares the negative. Solenoid lock is connected to the picaxe with a 10k pull down resistor connected to an IRF 530 n type power mosfet. A mosfet is similar to a transistor that it acts as an electronic switch. This is an n type mosfet meaning a negative channel mosfet. The mosfet works by applying a voltage to the gate lead. The gate controls the output drain current and the source works with the drain which is connected to the negative. So when the picaxe takes the correct pin it sends a voltage to the gate of the mosfet which activates the solenoid. Because the mosfet can take high currents and the gate can control the drain current the mosfet was chosen so the 12 v battery can be used.


Solenoid.

An over ride device that will be used is an electronic key switch that will be connected to the solenoid with a separate 9 volt power supply. This is in case the battery goes flat or something else goes wrong with the circuit.

In safeguarding for long term use we found that through the construction and use of the components and circuit that the positive and negative rails came apart at times. Cause of the problem maybe due to the type of battery the large 12v cannot be taken by the circuit. So a more durable board may need to be used in the future.
Also may be a connection in the keypad wire, clips could be added so the clips could just be removed instead of moving the circuit which moves the joints on the board which can cause them to break.