**Examination Number**

**97547441**

**To Design A Working Model To Demonstrate**

**A Renewable Energy Source**

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**Design Brief**

On receipt of the design brief I began to think about the requirements to be fulfilled

i.e.

1. A means of varying speed
2. An energy converter
3. An electronic device for indicating output
4. All important operating features are clearly visible without dismantling.
5. The longest dimension of the model does not exceed 300mm
6. The electric power used must be less or equal to 9 volts.

**Analysis of Brief**

1. A means of varying speed

When talking about varying speed I had to decide what speed I needed to vary. If using wind I perceived varying speed to mean that of the wind. If talking about hydropower the speed of falling water could be varied.

Variable resistors and gates could be used to vary speed of motors and amounts of wind respectively.

A series of opening and closing values or funnels could vary the speed of falling water.

1. An energy converter

This could convert kinetic energy to electrical energy eg spinning a turbine to run a generator. It could also mean converting potential energy to electrical energy i.e. energy due to position e.g. water in funnel above turbine

The reason both must be converted into electrical energy is to satisfy condition 3.

1. An electronic device for indicating output

This could be a light bulb, an LED or a buzzer of some sort.

1. All important operating features are clearly visible without dismantling

To satisfy this, I must use clear perspex of a metal grid to protect vulnerable parts and yet retain visibility.

1. The longest dimension does not exceed 300mm

I knew I was going to have a problem with this as I considered a 300mm diameter wheel for a windmill too small to catch enough wind to produce enough speed.

**Investigation - Problems**

In solution to the design brief I investigated all the Renewable Energy Sources possible and solutions. These included

1. Solar Power
2. Wind Power
3. Hydro Power

I thought solar power would be complicated and unattractive so I tried Wind and Hydro power.

I researched windmills of all sorts. I toyed with the idea of a windmill turning a large gear wheel which in turn turned a small gear wheel attached to the generator. The problem here was trying to find a method of fulfilling requirement (1), i.e. to vary the speed. This was a vague term in itself. Did this mean vary the speed of the wings on the windmill or on the generator itself? I found it difficult to come up with an idea to vary the speed of the wings as this would have involved varying the pitch of the blade on the wing or a centrifugal breaking system inside the windmill.

I came up with the idea that I could produce my own wind source and from that vary the output è vary speed.

Two solutions came to mind

1. Produce wind with a motor, and use a variable resistor to vary the speed.
2. Have a motor at a fixed speed but using gates to vary the wind exiting the fan.

The advantages of this solution were that

1. I could vary the speed
2. I was converting wind (kinetic) energy into electrical
3. I could indicate output by having the wind rotate a windmill blade and run a generator - producing enough current to light an LED.

I realised now that I was going to have a severe problem in keeping my dimensions below 300mm as a large wheel would be needed to catch enough wind to rotate at high speed. I looked at a few types of wheel to see and test which was the best and most efficient method of catching the wind. I found that anemometers (used for measuring wind speed) use 3 cups for catching the wind. I considered this idea and found it to be the most practical sizewise and speedwise.

I also considered Hydro Electric Power (H.E.P.). I thought of placing a large 3 litre container (preferably funneled) above a turbine, letting the water out gradually or quickly through a tap and running a generator off the turbine.

**Criteria for Selecting Solution**

The problems were

1. The water would have to fall from a height. I only had 300mm
2. I may need a method of pumping the water back up to the tunnel.
3. I needed a large capacity tank, but like (a), I only had 300mm

I thought about pumping the water at high speeds at a turbine but the idea seemed difficult compared to wind power. I didn’t think I would get up enough speed with water as a medium.

I finally decided to use wind power as

1. I thought I could complete the project within the size limit
2. I thought I could develop enough speed to run a generator
3. I could vary the speed by producing my own wind using a motor and vary its speed using a variable resistor.

**Design Realisation**

Having chosen wind power I decided to build a model demonstrating how wind energy could be converted into electrical energy *(see diagram)*

I decided to produce my own wind and concentrate it on three air cups which, after gearing, would turn a generator spindle.

**Analysis of Parts - Air Funnel**

I commenced making the project and decided to start with the air funnel since I presumed this part would be the most time consuming. I chose it to be made from 1mm copper sheeting. I chose copper for its high metallic lustre which I had previously seen in copper piping.

I made a drawing on paper of the part and proceeded to cut out the copper. I then drilled it.

I would have wished to make the funnel at a more shallow angle to facilitate the air passing through it and not stopping it as I suspected it might do. But size restrictions prevented me from doing so. When I tested the funnel I found, as I had suspected that the funnel was preventing the air from passing through. Rather than scrap the piece or make a new one I decided to reverse the funnel so it would suck in through the small end and blow out the large end.

After rigorous time consuming tests of various materials, copper and perspex, I decided to make the air funnel support out of box iron and 2 parts of bright mild steel. These were cleaned, marked and drilled. They were then brazed together. We applied a thin coating of flux to the joints then we heated the steel to a dark red colour, then with a 2mm brass rod we brazed the parts together. This was cleaned with a series of files and finally emery paper before spraying.

Using bick formers I formed the funnel. This job was time consuming and laborious as the 1mm gauge was not as malleable as I needed.

I then soldered the two ends of the piece together.

I then cleaned the joint of its excess solder and oxides. After this preparation I spray painted the insides of the copped with undercoat and matt black. Finally I sprayed it with lacquer to give a good shine and protection from scratches

**Air Funnel Support**

On researching materials and methods I decided to use a section of box iron for the air funnel support. This would give it the rigidity need to prevent the air funnel rocking.

Previous to this I had tested a 1mm copper sheet support but this failed due to its lack of rigidity

Two pieces of bright ,mild steel could attach the box iron to the base and to the funnel. These were brazed on then spray painted with an undercoat, matt black and finally a lacquer.

**Fan Guard**

Safety played a very important role in my project. I ensured that nobody was injured by not exceeding the maximum voltage of 9 volts and by protecting any fast moving parts.

I considered it important to have the propellor well guarded as this was by far the most dangerous part.

The guard would have to be strong and impenetrable to any large object. This meant the bars ion the guard would have to be close together. I could see that this was going to make it extremely difficult to solder or braze. For this reason I decided to recycle the guard from a large sheet we had at home. I then cleaned off any dirt or grease and bent the wires in the appropriate positions. This was then undercoated and spray painted matt black yet again.

**Propellor Motor Support**

The options here were easy. I needed a metal that was malleable and that cleaned up well. I decided that aluminium would be the best choice. I chose the sheet metal, cut it out and cleaned up the edges. Then I marked it out and drilled it before commencing the bending. After bending I used wet and dry emery paper to clean up the piece.

**Generator Housing**

I needed a method of supporting the generator. I used 1” copper pipe which was as close as I could get to the generator diameter. I then proceeded to make two generator housing support legs. I drilled the holes before sweat-soldering the pieces together. This elevated the housing to the correct height so the large cog on the horizontal air cup support shaft met the small cog on the generator. The housing support legs were then bolted to a rectangular piece of copper *(see diagram)*, which in turn was bolted to the support legs.

It was then sanded down with wet and dry emery paper, then polished. Three coats of lacquer were then applied.

**Air Cup Support Shaft**

Using my research into anemometers for measuring wind speed, I decided to use three cups to catch the air.

I thought about using table tennis hemispheres to catch the air but this failed as the gearing I used was causing too much resistance.

I compromised by using larger hemispheres on 25mm shafts to give enough leverage to turn the large gear.

I chose brass for the three shafts because of its lustre. I threaded the outside for 10mm at one end of each.

I chose brass again for the horizontal shaft. It was 20mm shafting which I turned down to 9mm and the other end to 4 mm

**Air Cup Shaft Support**

I tested 5mm perspex for this part but found that it was far too brittle when bent. It was also time consuming to file parallel edges. It was also very difficult to prevent scratches on the parts.

I need a metal which was malleable enough to be bent at right angles and strong enough to fold up the rotating air cups. I chose 3mm aluminium for these reasons.

I marked out the positions for the holes and curves. I then filed and drilled the pieces.

**Battery Supports**

I intended on making a project which was fully portable. I did this by building in a battery which moved with the project. To hold this battery in place I used 20mm glass rod perspex. This was chosen mainly for appearance and strength. I threaded these after turning down one end to 10 mm for 25mm.

**Wiring**

I did my best to hide the wires

1. for safety
2. I felt that exposed wires made the project look untidy.

My efforts can be seen in the inside of the support and into the base. Also in the air funnel support where I drilled the air funnel and the base of the funnel support to enable me to place the wire on the inside of the box iron.

I soldered the wire onto the motor generator LEDs and switches. This gave good electricity. These gave good electrical contact and a strong joint not easily broken.

I used light wire to reduce to a minimum the current lost through the resistance of the wire.

**Cleaning**

All parts of the project were cleaned with wet and dry emery paper. Coarser paper was used on the air funnel support as it is made from steel. This gave me a very good surface finish and a good base for undercoat spray (if sprayed). The copper air funnel was cleaned with wet and dry then ‘Brasso’ to clean any grease or dirt. A lacquer was sprayed on all parts to prevent dirt or grease ruining surface finishes.

**The Base**

I required a heavy base as the project was heavy and I did not want it overturning. I chose 1 inch teak for its strength, weight and attractive grain structure. It also had high resistance to any current leaks which might have occurred due to wear and tear. This was edged by a router and then sanded. The holes were counter boarded at the back to accommodate the bolts.

**Electronics**

I had previously never used LEDs or variable resistors. Research into the operation of generators was also enlightening. This project enabled me to learn a lot more about the practical use, operation and function of these electronics components.

**General Assessment and Comments on Project**

Generally I liked the project. I found it very challenging. The research was interesting and fascinated me in the many ways in which energy can be generated in methods other than fuel burning.

Many of the parts, especially the air funnel were very challenging. I had not previously used copper so I feel I made the mistake of choosing copper of too high a gauge with which to make the part.

As well as this it was time consuming to find that I could not blow the air through the small end of the funnel. Because of this a new air funnel support had to be made when the deadline was very close. If I could have used more than 300mm I feel I could have made the funnel with a shallower angle and so concentrate the air on the cups but I was limited to 300mm so I could not do so.

It was a disappointment also to find that the air cups will only turn if the battery is new. The motor was very hard on the battery and used its charge very rapidly.

When the project worked I was pleased to see it lit the LEDs with ease. I had attempted to use a buzzer but the generator only produced enough current to run a buzzer when the battery was new.

I was challenged by the many processes I had used i.e. soldering and brazing. I enjoyed making the horizontal air cup support shaft and the air funnel.

I am glad I undertook to built this project and have learned a great deal from it.