Solar Water Heater

with Solar Energy Concentrator

A thesis submitted to

Prof. Josette T. Biyo

In Fulfillment of the

Requirements in Technology Research II

Submitted by:

Jasper M. de Leon

Jimmy John G. Ganancial

Jono Ivil V. Ibardolasa

Philippine Science High School

WVC

Brgy. Bito-on, Jaro, Iloilo City

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ABSTRACT

Technology Research Paper is an account of how a solar water heater was created to heat water by the use of sunlight. The principle of convection current to heat water was the main principle of the research.

This solar water heater is made up of GI sheets, cork and glass. Water was placed inside the heater pipes to act as the heat transfer medium of the water heater.

Data from the results of tests of the solar water heater were taken and the data showed that the solar water heater was operational.

APPROVAL SHEET

This research paper entitled *"Solar Water Heater with Solar Energy Concentrator"* submitted by Jimmy John G. Ganancial, Jasper M. de Leon and Jono Ivil V. Ibardolasa in partial fulfillment of their requirements in Technology Research II, has been examined and is recommended for acceptance and approval.

_____ _____

Date Prof. Josette T.Biyo

Tech. Res. II Consulatnt

This research paper is accepted and approved in partial fullfilment of the requirements inTechnology Research II.

_____ _____

Date Prof. Rebecca V. Yandog

PSHS-WV Director

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CHAPTER 1

INTRODUCTION

A. RATIONALE OF THE STUDY

Since the beginning of time, man has been finding ways to improve his way of living. Because of this, he was able to develop technology. Technology is the main factor of improvement in our living, but the main factor of getting this technology going is energy. Because of that, energy also became the main factor in the life of man.

In modern times, we get energy from the fossil fuels. These fossil fuels burn and create intoxicating fumes, which harms our environment. This fossil fuel also causes pollution in the cities. Because of this, man is now trying to save the world by finding ways to have energy that will not pollute the earth.

One of the ways to have energy is by harnessing the energy from the sun or solar energy. Solar energy became increasingly attractive as an energy source owing to its free and inexhaustible supply and non-polluting character, which is in stark contrast to such fossil fuels as coal and petroleum (Encyclopedia Britannica). Solar energy is also advantageous because it cannot be monopolized and it can be used in decentralized manner.

B. STATEMENT OF THE PROBLEM

1) Is it possible to come up with a solar water heater that is using a solar energy concentrator?
2) Is it possible or practical to come up with a solar water heater that is using solar energy concentrator in commercial scale?

C. OBJECTIVES OF THE STUDY

This study was conducted with the following objectives:

1) To make a prototype of a low-cost solar water heater which is very efficient and can effect faster heat transfer.
2) To make a solar water heater using heater tubes/pipes with a volatile heat transfer medium which transfers heat to the water to be heated thereby raising the temperature in much shorter time.
3) To create a solar water heater with solar energy concentrator to hasten the speed of heating the water.

D. SIGNIFICANCE OF THE STUDY

This study is significant it can use the energy given off by the sun as a simpler source of heating water for personal and home use. This study will also lessen the pollution in our air as well as the community where we live by not using exhaustible fuel like coal, which produces vast amount of smoke and fumes, but by using the sun's energy. This study may also help other Filipino inventors as a patent or a model to be improved and later be used commercially in large scale.

E. SCOPE AND LIMITATIONS

The study was conducted in the campus of the Philippine Science High School Western Visayas, specifically near the Boy's Dormitory. Some parts of the prototype were constructed in workshops and in our houses.

To create the prototype, we used glass, mirrors and sheet metal for the concentrator; sheet metal for the tank; water and metal pipes for the conductors; cork for insulators; cork for insulators; and sheet metal painted black for the light absorbing material.

The capacity of the tank was approximately three liters and the heater could heat three liters of water in 30 minutes.

E. DEFINITION OF TERMS

Coal - is a rock derived from wood and other plant tissues that flourished several hundreds of years ago.

Petroleum - an oily liquid mixture of complex hydrocarbons occurring naturally in the pores and fissures of sedimentary rocks, usually in association with its gaseous form, natural gas.

Solar energy - radiation from the sun capable of producing heat, causing chemical reaction or directly generating electricity.

Solar energy concentrator - a device that is capable of producing high temperature from the sun by focusing the sun's light at a point.

Solar water heater - a device that collects solar energy through solar panels to water heater.

CHAPTER II

REVIEW OF RELATED LITERATURE

The world needs a source of power that is clean, inexpensive, predictable, readily available, and free to all those that have the equipment to use it. We already have such power source - the SUN. The sun is an extremely powerful energy source. The fossil fuels upon which we rely are ultimately derived from the sun's energy, which is used by plants.

The radiation from the sun is capable of producing heat, causing chemical reactions or directly generating electricity. The solar radiation is by far the largest source of energy received by the earth, but its intensity at the earth's surface is quite low. This is partly because the earth's atmosphere and it's clouds absorb or scatter as much as 54% of all incoming sunlight. Despite this, in the 20th century, solar energy became increasingly attractive as an energy source owing to it's free and inexhaustible supply and it's non- polluting character, which are in stark contrast to such fossil fuels' sources as coal and petroleum (Encyclopedia Britannica, 1993).

The idea of using the sun's energy is not new. It is said that the ancient Greek philosopher Archimedes used the energy of the sun's rays to set fire to an invading fleet. He is intensified the heat by using mirrors. In France, several experiments with solar powered engines were carried out during the 19th century.

Among these experiments was a one-horse power solar steam engine, invented by Agustine Mouchot in 1866, and solar press demonstrated in Paris in 1882.

Until recently, solar-power engine were brought or thought of a scientific curiosity. They were still not very economical. However, since the 1970's, when the depressing status of energy source were revealed, solar power has received growing attention as a possible fossil fuel alternative (Popular Science, 1990).

Before we can use the sun's energy, we need to transfer it into usable forms.

Energy from the sun reaches the earth in the form of radiation. This radiant energy is distributed over a wide range of wavelength. Most of the energy lies in the visible region that is it produces light. Surfaces that are black absorbs the radiation and convert it to heat (Collier's Encyclopedia, 1995). These are the two main ways of using this form of conversation. The first is the solar collector.

Solar collector is the name given to a device that uses the greenhouse effect to concentrate the heat of the sun's rays. The rays are falling with the same intensity, for example, on every part of your house during the daytime to heat up a whole room using the greenhouse effect is very inefficient, unless the glass area is very great in proportion of the room. But if you make a small box with a glass on top to let the sun's rays through and insulate to keep the heat inside the box to a very high temperature. Most solar collectors work on this principle (World of Science Energy from the Sun and Atom).

Solar collectors are generally consisted of black plate of metal or plastic to which attached tubes through which liquid or gas is pumped. The solar radiation heats the plate, the fluid carries away the heat, and either to storage or to some device that uses heat. One or more transparent covers of glass or plastic are often used to reduce friction, radiation and convection losses from the collector plate, thereby enabling the higher temperature to be obtained. In addition, some collector plates are coated with paint or chemical film that will absorb nearly all wavelengths of the solar energy but emit only a part of the heat wavelengths (Collier's Encyclopedia, 1995).

The second scheme is the mirror device, which involves the concentration of sunlight by mirrors. These devices reflect sunlight from a wide area and concentrate it on to small-blackened receiver, thereby greatly increasing the light's intensity in order to produce high temperature. Different combinations are possible, ranging from tubular to spherical receivers, used with parabolic or other curved mirror surfaces, to flat receivers, used with flat mirrors (Collier's Encyclopedia, 1995). The arrays of carefully aligned mirrors used in so-called solar furnaces can focus enough sunlight to heat target temperatures not less than 3600 Fahrenheit or 2000 Celsius. This heat can be used to study the properties of materials at high temperature, or can be used to operate a boiler, which in turn generates steam for a steam driven generator power plant. The solar furnace has become an important tool in high-temperature research. For producing steam, the movable mirrors are arranged to concentrate large amounts of solar radiation

upon blackened pipes through which water is circulated and thereby heated (Encyclopedia Britannica, 1993).

HEAT . . .

Heat is energy characterized by the ability to produce an effect manifest itself in many forms which heat is more important. In strict technical sense, heat is defined as energy in transition; hence it represents a state of non-equilibrium. Transfer of energy as heat occurs in three mechanisms of radiation, conduction and conviction. In less restricted sense, heat is frequently thought of as any kind of thermal energy whether in transition or in storage (Encyclopedia Americana, 1968).

HEAT TRANSFER . . .

Heat transfer concerns the flow of heat energy in matter resulting from temperature differences. Heat whether in the form of molecule motion or electromagnet radiation, obeys certain natural law of heat transfer in flowing from one body to another. Transfer takes place through conduction, convection or radiation. The science of thermodynamics relates the rates of heat flows to temperature differences and material properties. The efficient operation of any device that uses energy is likely to depend on reducing certain rates of heat transfer and increasing others. For example, a home heating system operates most efficiently when the heat loss through the building's walls is minimized and the

heat transfer rate from burning fuel to the room air is minimized (Grolier Encyclopedia, 1991).

One of the most striking things about heat is that it is constantly in motion. People spend much of their time in trying to control the movement of heat so that they can go into places where it is needed and keep it out of their control when it is not needed. They introduce heat into their dwellings in cold whether and seek to prevent in hot weather.

Winter clothes are designed to prevent heat from escaping the body, summer clothes are designed to promote its flow from the body. Effective methods of transferring heat from one place to another in hundreds of industrial operations such as the transporting steal, the molding, and curing of plastics and rubbers, the processing of glass and pottery, the preparation of chemicals, have been devised (The New Book of Popular Science, 1990).

What we call convection is really a combination of conduction through a fixed medium and convection proper, in which heat is transported by means of moving medium. When flowing water, say, it comes in contact with a hot surface, some of the fluids are heated by conduction and the heat is carried along with fluid later comes in contact with a cold surface, again through conduction.

Sometimes a stationary body of water or air can be set moving by being heated. Supposed there is a quantity of water in a rectangular tank. If heated, or heat is applied at the bottom of the tank at one end, the water at the end will

become warm by conduction. It will expand in all directions and will become less dense than before. It will not be able to move along the bottom of the tank since the cold water it encounters will be denser by comparison and will resist its passage.

The cold water above the heated area will also be comparatively dense. But it will not offer the same resistance to the warm water since the pressure of the water decreases as the depth decreases. The warm water will rise, therefore, and will heat the area above it by convection. When the warm water comes into the surface, it will flow along the top until it reaches the other end of the tank. In the meantime, the cold water at the bottom has moved toward the warm end, where the water is warmer and less dense. In this way a complete circuit of moving water is set up. Circulatory movements of this kind are called convection currents (The New Book of Popular Science, 1990).

TRANSFERING THE HEAT . . .

The air that is warmed up inside the solar collector can be used to heat water. This is done in several ways. One of them is the simplest method, which is known as the Tricycling System. In this system a sheet of corrugated metal is placed inside the box and water is fed through a pipe at the top. The pipe has small holes at the bottom of the corrugations. The metals warmed up by the heated air and sunlight; the water trickles slowly down the corrugations and gets warm. The warmed water goes into a pipe into the storage tank. By circulating

over the corrugated metal throughout the day, the water becomes hot enough to provide most of family's usual need (World of Science Energy from Sun to Atom, 1992).

A more efficient system uses metal tubes, such as copper to circulate the water inside the solar collector box. Instead of corrugated metal, a flat sheet of metal lies at the bottom of the box and a copper pipe is bent in a series of U-curves to the sheet metal. Water comes in at the top, flows around the inside of the copper pipe and passes out at the bottom. The heat absorbed by the metal plate passes through the copper and heats the water (World of Science Energy from the Sun and Atom, 1992).

HEATING THE HOUSE . . .

Water heated by the sun during the day can also be used to heat the house at night. This is best done by having a concrete floor which water pipes are embedded. At night, the hot water from the storage tank is circulated through the pipes in the floor. Heat from the hot water is transferred to the concrete and radiates up into the room.

Another way of using the sun's energy for heating is to heat in a solar collector and let it circulate inside the house. This is not as sufficient as using heated water because the earth does not hold its heat long as water but when a house is specially designed as a solar house air heating becomes more efficient (World of Science Energy from Sun to Atom, 1992).

Thermal Insulation

Thermal insulation is a method of insulating or separating one conducting body from another by means of non-conductors to prevent or reduce the transfer of the heat; also called heat insulation. Thermal insulation is needed in this project so as to reduce the heat loss along the heater pipes and the storage tank. Heat insulation or thermal insulation is available in a number of shapes or structures, many of which are designed to serve a specific use. In this project we are going to use two forms of insulation. The first is Loose-fill insulation.

Loose-fill insulation usually is poured or packed in bulk between confining structural members. Loose-fill compositions used for specific temperature requirements are asbestos powder, cork granules, diatomaceous earth powder, powdered gypsum, mineral wool-pellets, shredded paper, magnesia powder, shredded wood fibers, pumice and light-weight slag's.

The second is the pipe insulation. Pipe insulation are preformed into rigid half cylinders to fit specific pipes and tubing diameters or, for large pipes, are furnished in segments and flexible form. Some prefabricated pipes employ loose-fill insulation packed in between the pipes surface and the exterior protective jacket (Colliers Encyclopedia, 1995).

Heat Pipes or Heater Pipes

Heat pipes is a heat exchanger which transfer or transport energy over relatively large distances with the temperature differences kept as small as

possible. The heat pipe consists of a hollow tube closed at both ends and is partially filled with a liquid that boils at a desired temperature. One end tube is immersed in the warm region and the other in the cold region. The objective is to transfer heat from warmer to the colder region. The process may be visualized by assuming that the tube is in vertical position with the lower end immersed in the warm region. The liquid fills the lower end of the tube and starts boiling when the temperature of the warmer region exceeds the evaporation (or boiling) temperature of the liquid. The accumulation of the vapor increases the pressure at the lower end of the tube. These forces the vapor upward, where it condenses since the temperature of the colder region is below the evaporation temperature. Gravity causes the condensed liquid to run down along the inner surface of the tube. In this way a steady circulation of fluid is maintained. Heat is required to evaporate the liquid. In boiling process this heat of vaporization is removed from the hot region. The same amount of heat is released when the fluid is transferred to the cold region. Consequently, circulation of the fluid causes transport of heat from warm to the cold region (Encyclopedia Britannica, 1993).

Solar Energy Concentrator

This energy concentrator is a multifocal solar energy concentrator comprising a plurality of horizontally and laterally disposed narrow strips each having predetermined angle or inclination with reflective surfaces adapted to reflect multi focally solar energy to an area of concentration spaced upwardly of said inclined strips, which could be used or adapted to all types of solar devices.

According to A. M. Anos, inventor of solar energy concentrator, this invention relates generally to devices used for effectively utilizing solar energy which could be manufactured at costs lower than the present solar energy concentrators(Anos, 1982).

Solar Water Heater

Solar water heaters are water heaters that utilizes the sun' energy to heat water for air conditioning your homes as well as in the use of hot water bath. Solar water heater generally consists of a solar collector, a supplementary storage tank and a circulating pump and controls. To heat a domestic water supply, the storage tank is placed in a series with an ordinary fuel powered water heater. Cold water entering the system flows into the water tank and then into normal heater unit (Collier's Encyclopedia, 1995).

The precursor of solar water heater is the hot water heater, which utilizes the heat from fuel-generated boilers. The early hot water heating system depended on gravity action for circulation of the water and hence referred to as gravity hot water systems. The heated supply of water in the boiler was less dense than the cooler water in the radiators; the resulting small difference in density is sufficient to cause a flow of water through relatively large pipes. In normal operation a continuous circulation of water was maintained, and the temperature of hot water leaving the boiler was increased as the outdoor temperature decreased. This increase in temperature caused a large flow of hot water to take place.

In spite of good performance features, the gravity circulation system has become largely outmoded and replaced by forced-circulation system, which utilizes the pump to move the water through the pipes. Changes in radiation styles also occurred. During the 1930's large column type radiation were replaced by small tube radiators. Still later, convection were developed which provided a metal shield in front of the radiator to increase the flow of room air over the heat transfer surfaces. About 1940 the baseboard radiator was developed which greatly increased comfort produced by hot water system, as well as the aesthetic of the system (Encyclopedia Americana, 1968).

Present solar water heaters consists essentially of a heater pipe usually disposed horizontally and plurality of smaller heating pipes normally disposed in inclined manner with the upper ends and is provided with a cold water inlet and warm water outlet. The lower ends of the heating pipes are closed and the heater pipe is preferably insulated. The said solar water heater is rather slow in the transfer of heat. The maintenance of that type of solar water heater is rather difficult and costly.

Victor S. Korionoff Jr. with his solar water heater with heat transfer medium improved this type of solar water heater. This invention of a solar water heater consists essentially of an insulated horizontal tank having a water inlet at the lower portion thereof and a hot water outlet at the upper portion thereof. Connected to the lower portion of the horizontal tank are several partially evacuated and sealed heater pipes, which are disposed in parallel relation and

inclined upwardly toward the horizontal tank. The upper ends of said heater pipes protrude substantially into the horizontal tank. Within each heater pipe is a small amount of water, which vaporizes ands transfers heat to the cold water in the horizontal tank.

The invention relates in general to a device for heating water and more particular to a solar water heater evacuated tubes or pipes having lower portions exposed to solar radiation and upper portion protruding into a tank storing the water to be heated. The evacuated pipes contain a small amount of water, sodium chloride solution, mercury and any suitable of heat transfer medium which vaporizes when subjected to radiant heat and which instantaneously gives up its heat to the water to be heated (Korionoff, 1982).

With this invention, heat transfer is effected faster than the conventional water heater, which requires the heating of pipes. In this invention, when the heater pipe is heated, the small amount of water therein being in the partial vacuum is converted to steam or vaporized in a very short time. This steam or vaporized medium goes immediately to the upper end of the heater pipe. At this position of the steam, the heat thereof is instantaneously transferred to the water in the horizontal tank which affects the immediate condensation of the steam and the condense flows down to the body of the heater pipe. With the disparity of temperature between the water and small amount of steam in the heater pipe, continuous heat exchange takes place until the temperature is equalized.

The amount of heat transfer depends on the length and size of the heater pipes and also the kind of heat and transfer medium (Korionoff, 1982).

CHAPTER III

METHODOLOGY

I. MATERIALS

1. Glass
2. G.I. sheets
3. Black paint
4. Cork board
5. Cork
6. Sealant
7. Rugby
8. Water
9. Salt

II. METHODS

A. Collection of Materials

Most of the materials were bought from the hardware with the exception of glass, which was bought from the glassware or glass centers.

The galvanized iron (GI) sheets were used as heater pipes and were also used as the body of the solar collector and tank. The glass was used in the solar panel and must be clear enough to let the light in. The black paint helps in absorbing the light and turn it to heat. The corkboard was used to insulate the main water tank

to prevent heat loss as well as in the solar collector. The seal used to close every unnecessary opening especially on the solar collector and last but not the least the silicon glue was used to assemble some parts of the water heater.

B. Description of the prototype

The prototype of the solar water heater with a solar energy concentrator has a width of 28.5 cm. and a length of 64 cm. and a height of 27 cm. and is already functional.

The prototype of the solar water heater with solar energy collector consists of a main water storage tank, twenty-four heater pipes, and two solar energy collector.

The storage tank is where the water was heated through the heater pipes. The storage tank consists of two cylinders, separated by two-centimeter thick cork for insulation. It has an inlet and an outlet. The cork was used as a stopper to stop the leak of water in the outlet and inlet. Secured on both sides of the storage tank were holes drilled one centimeter apart with a centimeter of diameter. These holes serve as the point of connection for the heater pipes.

The heater pipes were inclined upward to the water tank at an angle. Each of said pipes were partially evacuated and sealed in a conventional manner. The heater pipes contain small amount of heat transfer medium, which vaporizes when subjected to solar heat.

The solar collector on the other hand is composed of the heater pipes, black GI sheets, cork, and glass. The body of the solar collector is made of GI sheets and is insulated using the cork. The glass covering lets in the light but does not let heat escape. The black sheets of galvanized iron absorb the light and turn them into heat, heating the heater pipes and causing the water inside to evaporate.

This water heater works on the principles of heat transfer but the main principle is the convection current. The heated water in the heater pipes evaporates and the water vapor moves to the upper end of the heater pipe inside the water tank and transfer the heat to tank and condenses and then returns to the lower end. In this manner heat transfer is utilized to heat or boil the water in the tank.

C. Making the Prototype

C. 1 Creation of the Parts

Most parts of the prototype of the solar water heater was made at different workshops in Kalibo, Aklan. A craftsman at their respective workshops made the solar water heater collector and the storage tank. The sealed GI pipes with NaCl solution was also prepared by the workers.

C. 2 Assembly of Parts

The different parts of the solar water heater were assembled also at Kalibo, Aklan in a workshop. The solar collectors were first attached to the heater pipes by soldering lead and in turn the heater pipes were inserted to the holes at the sides of the water tank.

C. 3 Making and Testing the Set Up

The set up that we put up was used to determine the efficiency of the heater pipes to heat the water. In making the set up, we looked for a can with a cover and drill a hole at its side and inserted a heater pipe to that hole forming an angle. We sealed the opening using metal epoxy and let it dry for six hours. After that, we pour in one liter of water in the can and cover it and drill a hole again in the cover of the can so that we can insert a thermometer to find the change in temperature of the water inside. We heated the heater pipe by using a hot plate. We then recorded the change in temperature every two minutes.

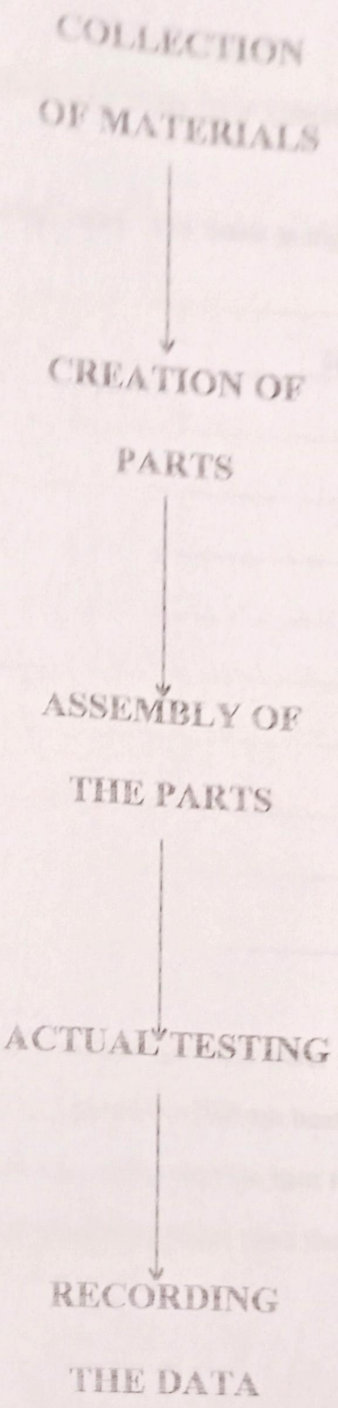

Figure 1. FLOWCHART OF THE METHODOLOGY

CHAPTER IV

RESULTS AND DISCUSSIONS

Set-up: One (1) Heater pipe heating 1000 ml of water at high temperature (110 C)

Table 1.1

Time (minutes)	Temperature (C) of Water
0	30
4	30
8	31
12	32
16	33.5
20	35
24	35.5
28	36
32	37

As shown in Table 1.1, the temperature of the water in the set-up rises as the heater pipe is heated through the hot plate. This shows that our heater pipe is functional and is effective in heating the water. This also shows that the heat transfer medium, salt solution, inside the heater pipe is capable of transferring heat from the hot plate to the water inside the set-up.

ACTUAL TESTING OF THE PROTOTYPE

Day 1 (November 24, 1998) – Clear sky, temperature is 32 degrees Celsius

Table 1.2

Time(Minutes)	Temperature of Water(Celsius)
0	31
4	31
8	31.5
12	32
16	33
20	35
24	36
28	38
32	40.5
36	42
40	43
44	46
48	48.5
52	52
56	54.5
60	58

As shown in Table 1.2 the temperature of water inside the water tank increases as the time the Solar Water Heater that is exposed to sunlight increases. This shows that our prototype is functional. The increase in temperature is only minimal probably because the heater pipe and the solar collector were not fully evacuated as planned.

Day 2 (November 26,1998)- Sky is clear, temperature is 30 degrees Celsius

Table 1.3

Time(Minutes)	Temperature of Water(Celsius)
0	30
4	30
8	31
12	32
16	34
20	35
24	36.5
28	38
32	40
36	42
40	43.5
44	46
48	48.5
52	53
56	55.5
60	59

The results are almost the same as of that of the results in Day 1.

CHAPTER V

SUMMARY, CONCLUSION and RECOMMENDATION

SUMMARY

Based on the tests that we conducted we found out that the heater pipe is effective in heating water. The salt solution that we used as the heat transfer medium inside the heater pipe is capable of transferring the heat from the solar collector to the water tank. We have also found out that the minimal increase in the temperature of the water inside the water tank was caused by the partially evacuated heater pipes and solar collector.

CONCLUSION

We conclude that the solar water heater is functional for the heater was able to heat the water inside the water tank. But we can say that the solar water heater is not efficient. We say that the water heater is not efficient because it will need at least two minutes under sunlight to raise the temperature of water to approximately one degree Celsius.

We also conclude that the heater pipes are effective. We say that they are effective because one heater pipe, with a hot plate as its source of heat, could heat one liter of water to 40 degrees Celsius after 50 minutes.

RECOMMENDATION

We recommend that the heater pipes should be sealed well so that the water inside the pipes would not escape. The glass covering the solar collectors must also be sealed well to the collectors so that water would not enter the solar collector. The water tank should be soldered well so that the tank would not let water escape. We also recommend that a better heat absorbing material than the GI sheets should be used for the solar collector for a better absorbing ability. A better heat transfer medium than salt solution must be used in order to get a better result.

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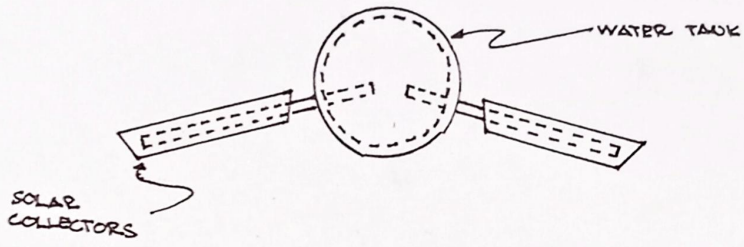
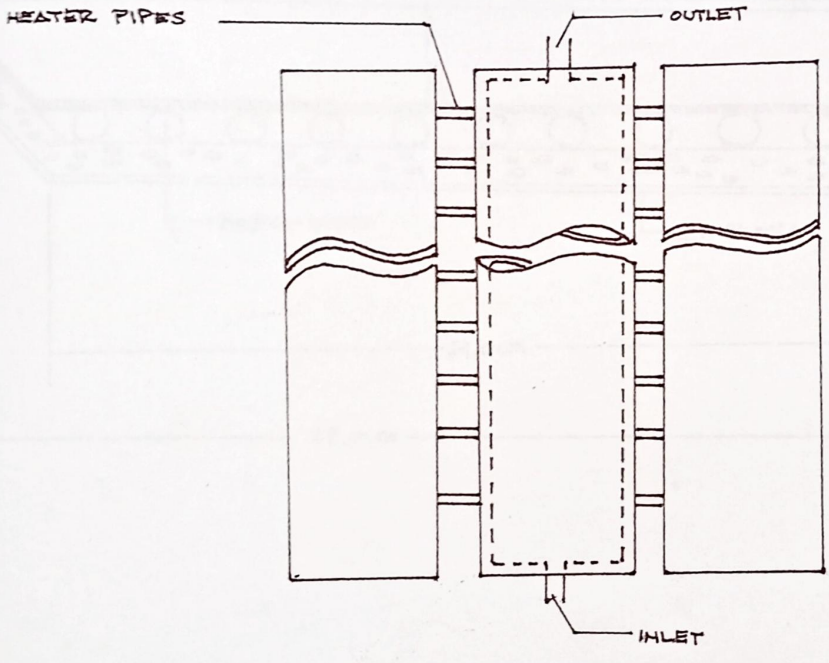


A.



B.

Figure 3. Schematic diagram of the solar water heater.

A. Side View; B. Top View

SOLAR ENERGY COLLECTOR

A.

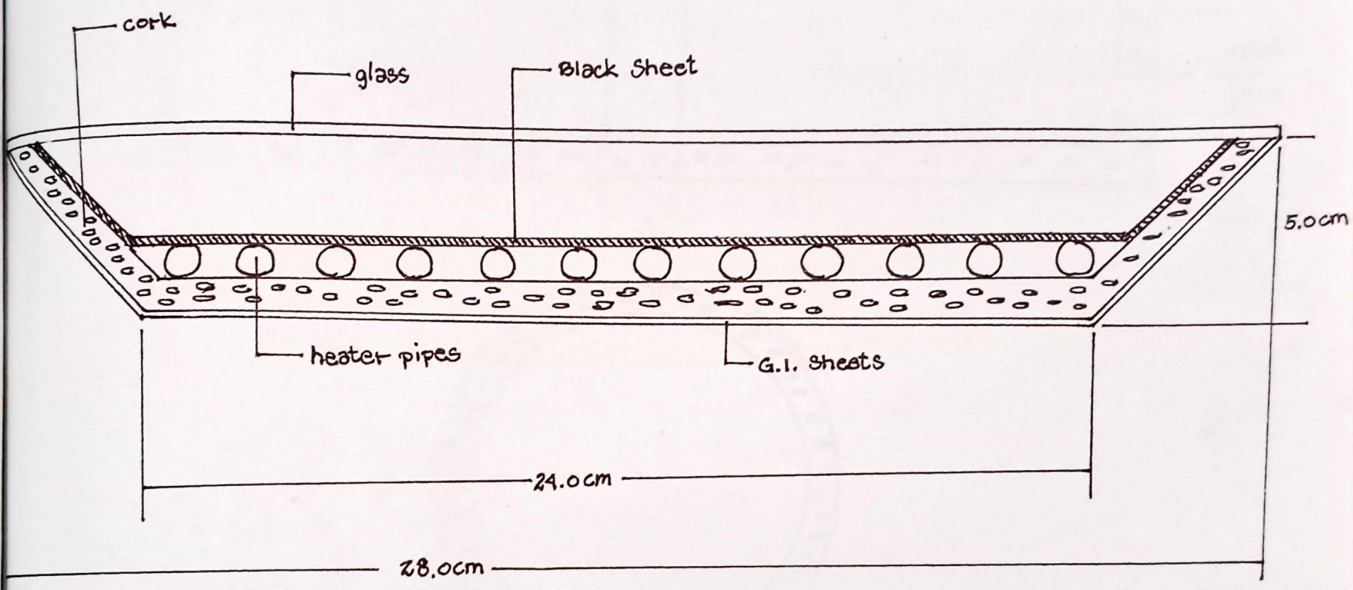


Figure 2. Schematic diagram of the solar energy collector

A. Side view; B. Top View

Figure 4. Schematic diagram of the water tank

A. Side view, B. Top view

HEATER PIPES

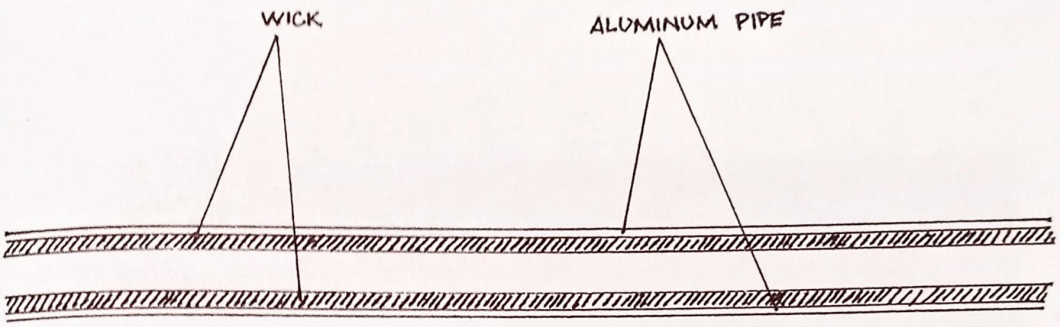


Figure 5. Schematic diagram of the heater pipe

APPENDIX A
PLATES

PLATE NO. 1.THE INSIDE OF THE WATER TANK.

PLATE NO. 2. EXTERIOR OF THE WATER TANK.

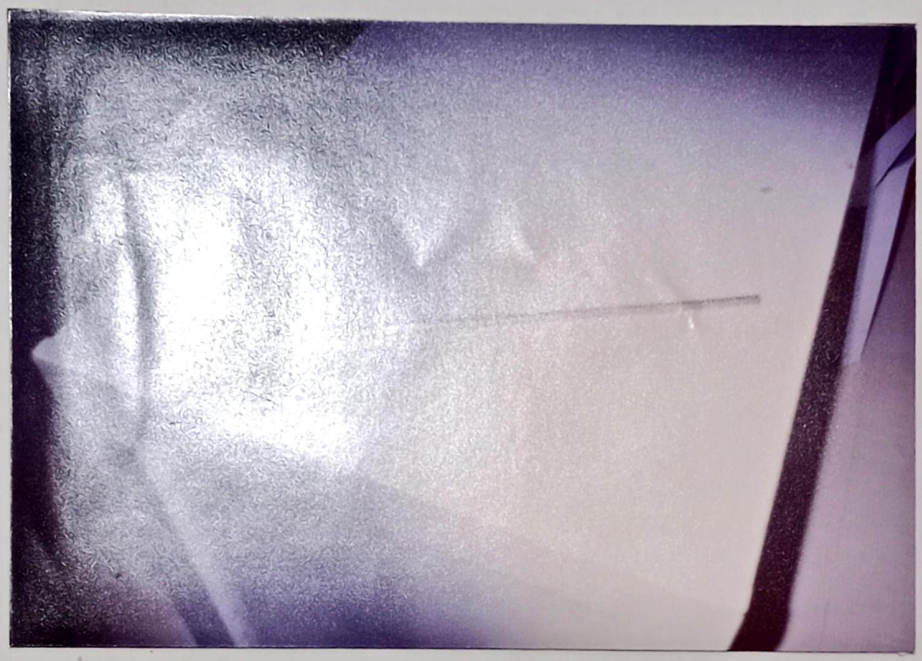


PLATE NO. 3. THE HEATER PIPE.

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PLATE NO.4. SOLDERING THE WATER TANK.

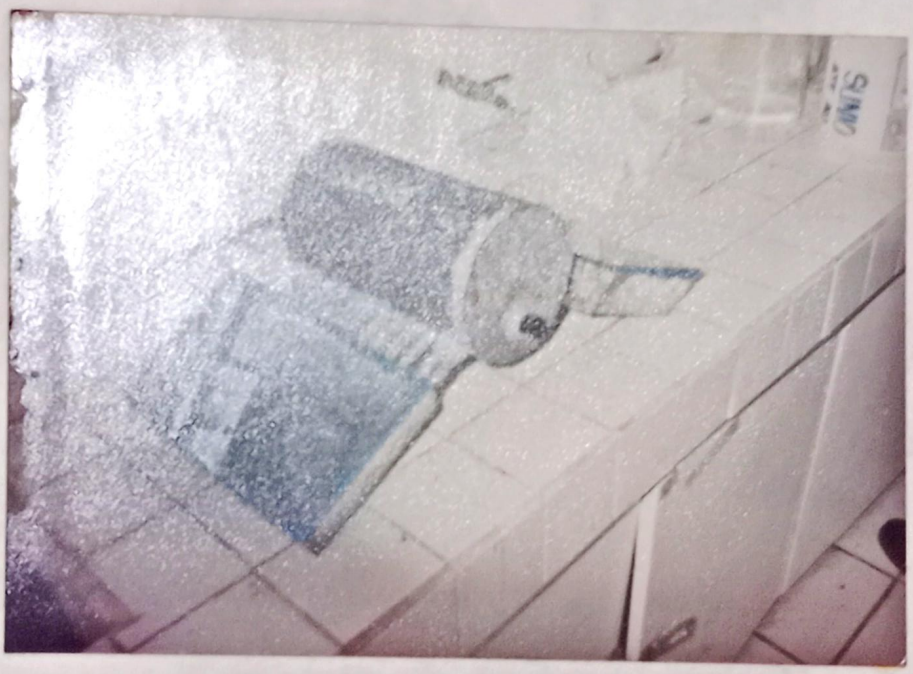

PLATE NO. 5. THE SOLAR WATER HEATER PROTOTYPE.

PLATE NO. 6. THE PROTOTYPE BEING TESTED.