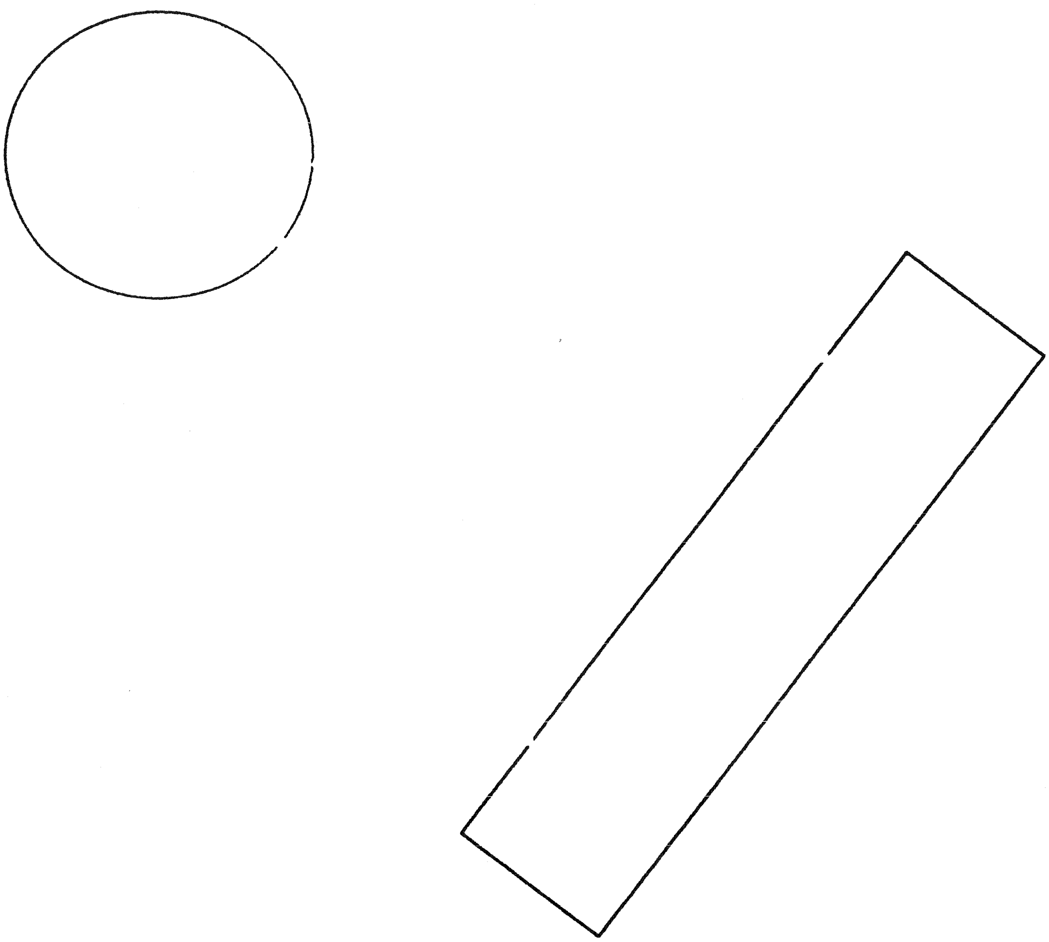
Active Air Solar Collector



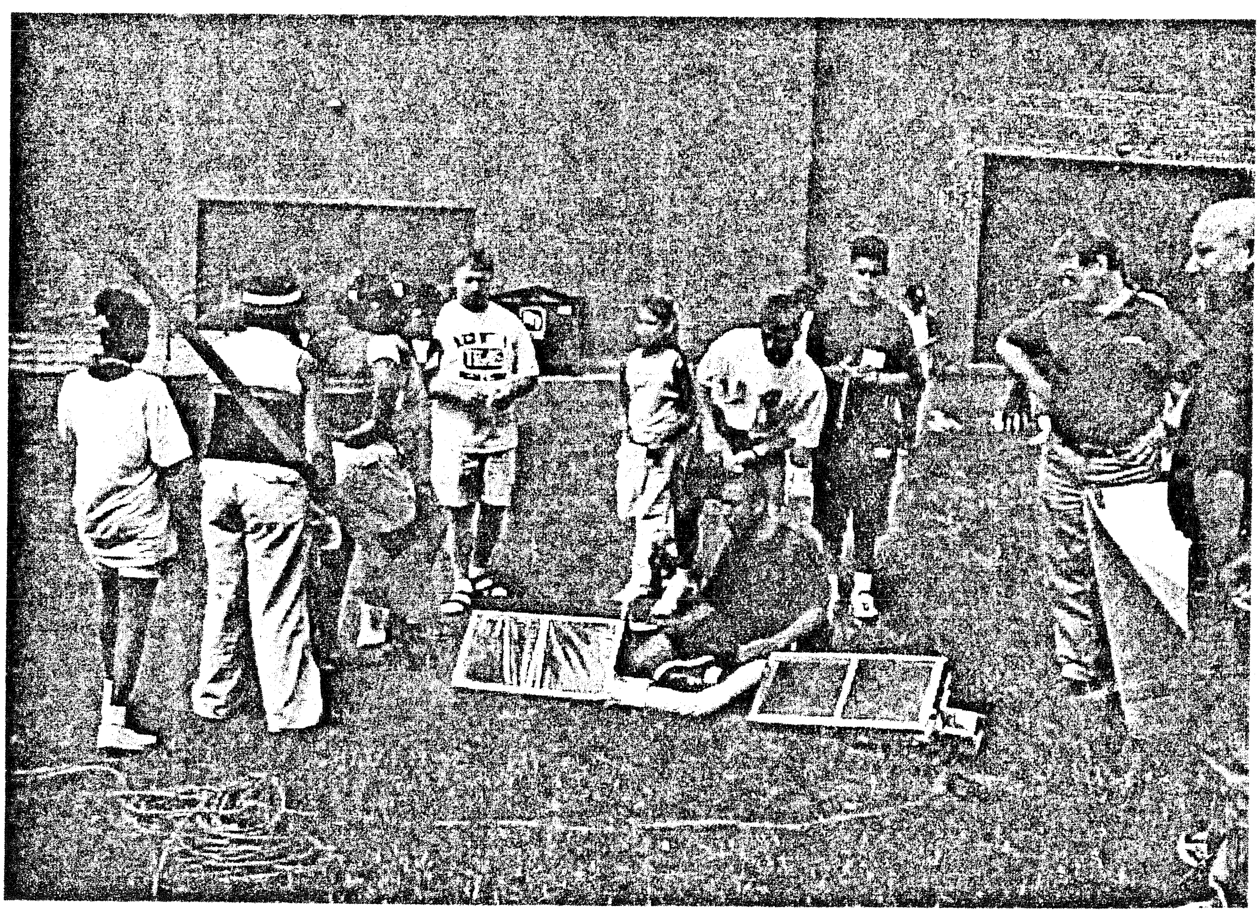
Energy Concepts
Curriculum Workshop
Dr.Kenneth Welty

Active solar collection

Alternative energy sources are important to all of us. They may replace or be added to non-renewable energy supplies to do work for us. Renewable energy sources will provide energy with far less damage to the environment than fossil fuel sources. The down side of renewable energy sources is the cost. They are not very economically efficient at this point in time. Solar energy is one example of alternative energy that researchers are studying.

The Amount of sunlight that hits the roof of a house, one day provides enough energy to heat that house for a full year. The problem that faces us is the collection of that energy. Solar heating systems for homes are one method of tackling this problem. These systems may be Passive or active in nature. Active solar heating systems use mechanical means to collect and transfer heat.

Active solar heating systems are more complex that passive systems. Solar energy is collected and moved mechanically to where it is needed. As you move around town start to look for shallow, dark boxes on the roofs of some homes. These are flat-plate collector, or solar panels. They use heat from the sun to heat air, water or an antifreeze solution. The heated air or solution is moved to a heat storage area. The heat is then circulated as needed through the living area.



ACTIVE SOLAR ENERGY

During your passive solar learning activities, you discovered the potential of collecting the sun's radiant energy. Eventhough the technology you used was very simple, you were able to convert solar energy to a more useful form of energy, heat. Contrary to popular beliefs, solar energy systems do not have to be complicated to work effectively.

Passive solar homes and buildings use architectural features to collect, convert, store, and distribute solar energy. Active solar energy systems use collectors to collect and convert the sun's radiant energy. Unlike passive solar energy systems, active systems use mechanical and electrical devices. These devices often need electrical energy to work.

There are two basic types of active solar systems: air systems and liquid systems. Air systems use air for a heat transfer fluid. Using a fan, cold air is pumped to the solar collector. Once inside, it is circulated through the absorber system. When the absorber system is exposed to solar energy, it becomes very hot. As the air circulates through the absorber system, it too becomes hot. When the air leaves the collector, the heat it carries can be stored or used to heat living space. To store the heat, the air is typically circulated through a bin filled with rocks. As the air travels through the bin, the rocks absorb the heat. When solar energy is not available, room air is circulated through the bin, heated by the rocks and returned to the living space. Air systems use heating ducts and fans to distribute the heat.

Air systems are usually simpler, cheaper, and require less maintenance than liquid systems. One major disadvantage of air systems is they are not very effective for heating water.

Liquid systems use water or an antifreeze solution as a heat transfer fluid. Like air systems, the heat transfer fluid is pumped through an absorber system where it becomes hot. After it has been heated, the heat transfer fluid can be circulated through radiators. The radiators, in turn, heat the air in the living space. Excess heat is typically stored in a tank of water. The hot water can be used for domestic purposes. Pipes and pumps are used for heat distribution. Preventing the heat transfer fluid from freezing is a major consideration when designing and installing liquid systems.

There are two basic types of solar collectors used in active solar systems. The most commonly used is a flat plate collector. The collector is comprised of a thin rectangular box with its top face covered with a glazing material. The glazing material can be glass or clear plastic. The rectangular box houses and insulates the absorber system. If the collector is designed for a liquid system, the absorber system is a network of pipes connected to a large sheet of metal. If the absorber system is designed for an air system, it is usually a corrugated or thin sheet of metal. In both cases, the absorber system is treated with a special flat black paint.

The second basic type of solar collector is called a concentrating collector. These collectors use a reflective surface to concentrate solar radiant energy onto an absorber system. These collectors can only be used in liquid systems. Because the solar energy is concentrated, these collectors can produce temperatures up to 1,000 degrees Fahrenheit. When the sun's position changes, concentrating collectors must be adjusted. This adjustment process is called tracking. In order for concentrating collectors to be efficient, they must be tracked with the sun throughout the day.

Most active solar systems require more than one collector. The collector area for a typical house can range between 1/4 and 1/3 of the floor area being heated.

The most popular application for active solar technology is heating water for domestic, industrial, and commercial use. These hot water applications range from heating swimming pools to producing steam for industrial applications. Both air and liquid systems can be used to heat residential homes. However, many experts feel that active solar heating is best suited for commercial and industrial applications. Lastly, solar energy systems can be used to provide air conditioning. However, active solar air conditioning systems are very expensive.

Active solar energy systems use collectors to convert the sun's radiant energy to useful thermal energy. Active systems use mechanical and electrical devices that require electrical energy. The two basic types of active systems are air systems and liquid systems. Air systems use ducts and fans for heat distribution, and use rocks for heat storage. Liquid systems use pipes and pumps for heat distribution, and use water for heat storage. The two basic types of solar collectors are flat plate collectors and concentrating collectors. Flat plate collectors enclose the absorber system in a rectangular box with glass on one face.

Concentrating collectors use a reflective surface to concentrate solar energy onto an absorber system. Active solar systems can be used to heat water, heat living space, and air condition living space.

Learning Activities:

Solar collectors are the most important element in an active solar system. They collect the sun's radiant energy and convert it to useful thermal energy. To use the thermal energy, a heat transfer fluid must be circulated through the collector. During the following lab activity, you will be building a simple parabolic collector. When your collector is finished, you will test it by linking it with other collectors and circulating water through the system. In addition, you will be collecting and interpreting input versus output temperature readings.

Building a Parabolic Solar Collector:

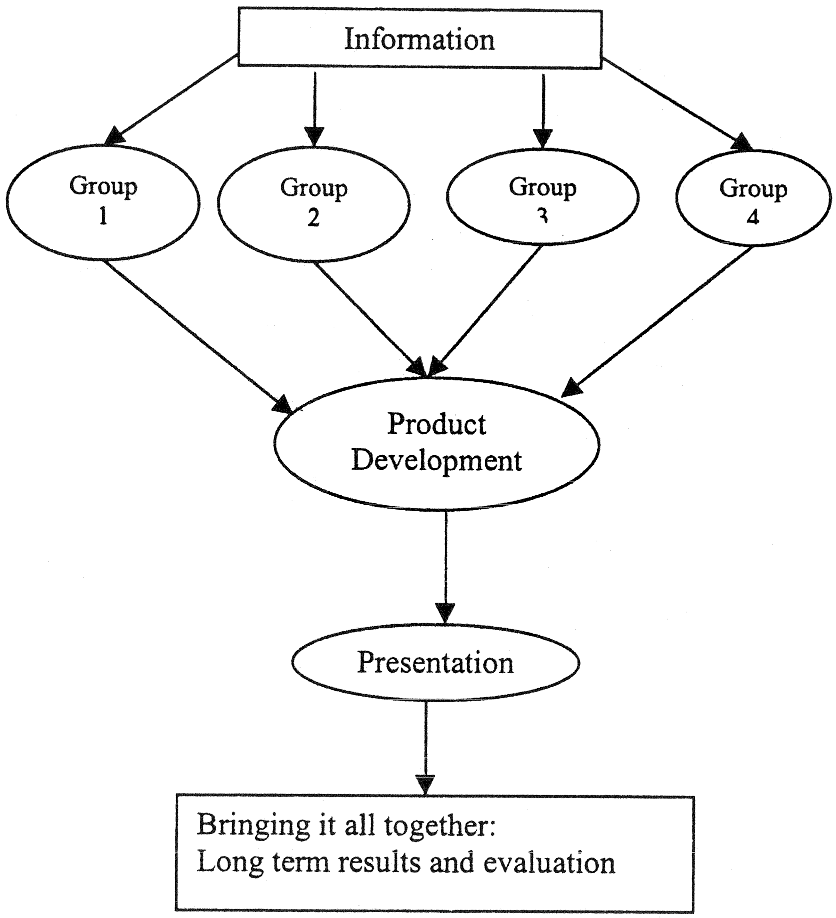
1. To build a simple parabolic collector, you will need the following materials:

   * one length of 1/2" copper pipe, 30 inches long
   * two pieces of 1 x 4 lumber, 2 feet long
   * two sheets of plywood, 3/4" thick, 8" wide, and 24" long
   * one sheet of 1/8" hardboard, approximately 28" wide and 24" long
   * spray adhesive
   * flat black paint
   * enough commercial grade aluminum foil or reflective mylar (aluminized) to cover the hardboard
   * 14 1/2" long #6 pan head screws
   * one 10 foot long of duct tape

2. Using the template provided by your instructor, lay out a parabolic curve and its focal point on both sheets of plywood. Using the band saw, cut along the outside of the parabolic curve. Using a drill press equipped with the appropriate drill bit, drill a hole through the focal point on each sheet of plywood. Make sure you follow all the safety rules when using power machines.

3. The next step is to glue aluminum foil to your piece of hardboard. Before using any glue, cover your working surface with newspaper. Position your hardboard and several strips of aluminum foil on the newspaper. Apply a thin coat of adhesive to the top of the hardboard and to the back of the aluminum foil. Allow the glue to dry. When the glue is dry, position one

Flat Plate Solar Collector
Flow Chart



Doug Barlow
Mark Gronley
Ron Haisler
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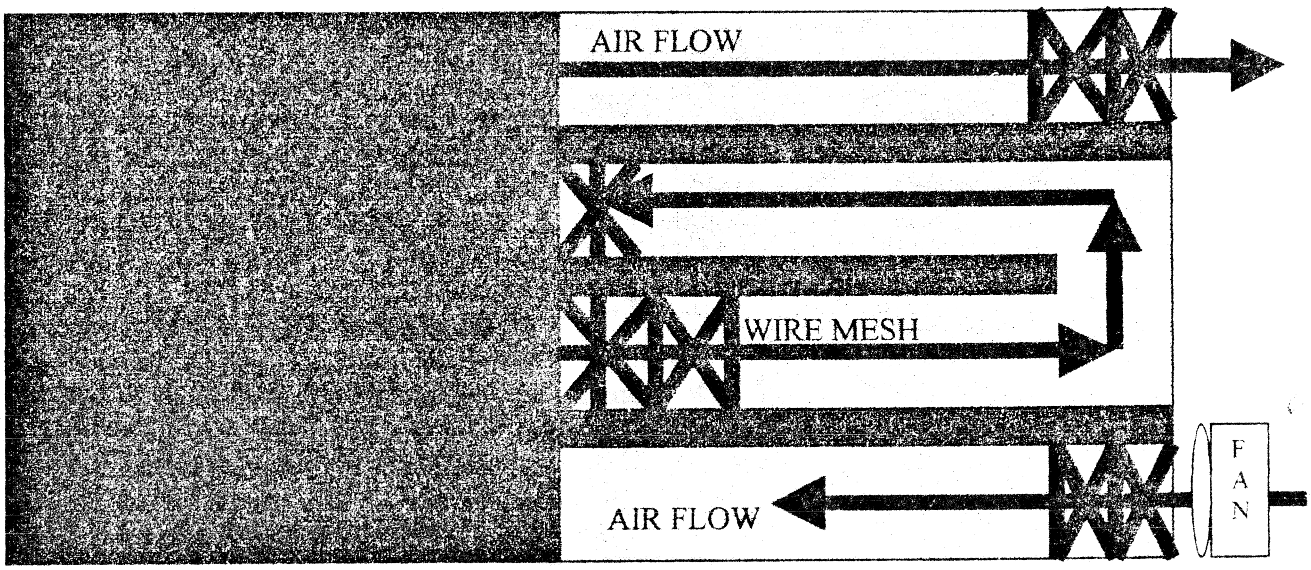
ACTIVE AIR SOLAR COLLECTOR
HOW IT WORKS



- The energy of the sun heats the black plate.
- The black plate in turn passes some of its heat to the wire mesh.
- Ambient air is forced into the chamber.
- The wire mesh disrupts the airflow.
- This disruption causes the air to be exposed to more heated surfaces thus increasing efficiency.
- The heated air is forced through the collector collecting heat as it moves.
- The heated air is then exhausted where in theory it heats a mass in order to store the energy for use at a later time.

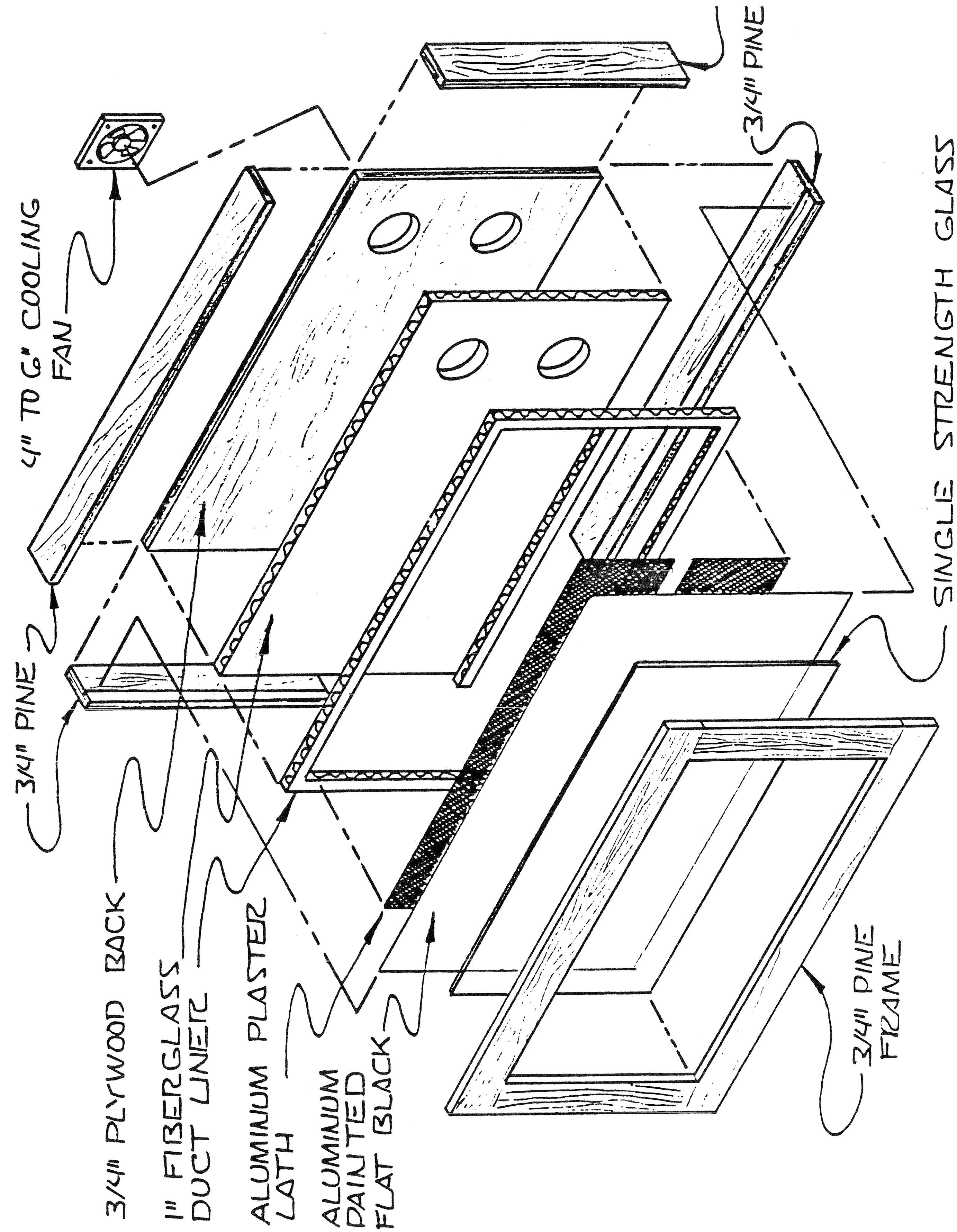


FIGURE 1
AIR COLLECTOR

Objectives:

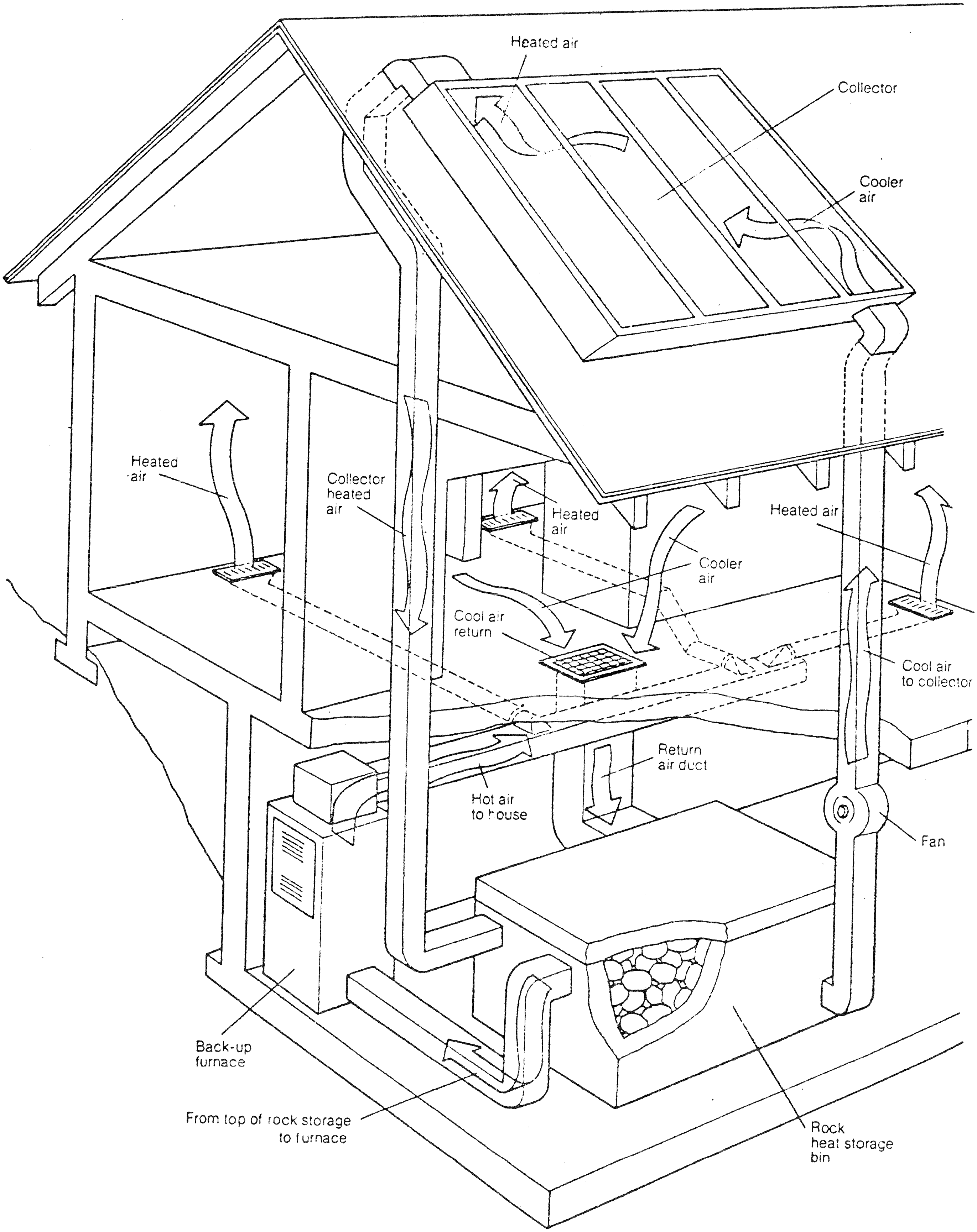
At the end this activity students will be able to

1. Identify the basic parts of a solar collector

2. Identify at least three (3) variables that affect the temperature produced by the solar collector

3. Explain how each variable effected either the temperature increase or decrease of the collector.

Air Heating System



Flat Plate Solar Collector

Classroom timing **40 – 50 min. class period**

• Setting the table	3 –4 days
• Assign area of study group's research	1 day
• Product development	3 – 4 days
• Testing, revision, documentation	2 days
• Class report – results to the class	2 days
• Evaluation	1 day
• Large scale system project	2 days
	15 days

Helpful Hints for Teaching Active Air Solar Collection

- Acquire ***all materials***
- Build a prototype for demonstration and for ***your*** general ***knowledge*** on assembly
- ***Pre-cut*** foam board for the students (this reduces waste)
- ***Paint one side*** of the 12 x 12 panels ***before*** starting project
- Stress the importance of having the ***shinny side*** of the foam board on the ***inside*** of the collector.
- Point out that the ***baffles must be staggered*** in order for the air to flow properly
- Make sure that the plastic wrap is ***stretched*** very tight and that it is well ***sealed***
- ***Caution*** the black plates become ***hot*** and stay ***hot***

Oh, By the Way….

The classroom management and the potential problems of your students will depend on how the project is handled. If you choose to have the entire class partake in this project there will be different and possibly more headaches than if small groups are cycled through the project. A few things to consider when doing this project are set-up, clean up, storage, safety, group sizes, and the students who work faster. Set-up is important to make sure the project gets off on the right foot. It might be easier and less time consuming if the pieces are cut for the students. If you are going to have the students research possible designs for the project then different problems could surface. It might cause problems with the amount of supplies needed because it will not be constant from group to group. Safety can be a concern if the students are to cut the pieces themselves using the utility knives. Wiring the power supply to the fan and the fan itself could also be a concern. We found with more than four students per group someone would be left out and not have anything to do. Because some students work faster it might be necessary to have something constructive for them to do if they finish early. Extra time should be left for clean up, especially if the students are cutting the pieces themselves.

To maximize the success of your students you might want to stick to pre-cut pieces for the collector. This way all the students should be able to get relatively the same results. Also having extra materials available in case of mishaps will help guarantee their success.

Materials Required:

Parts:

Quan.	Description	Size	Material
1	base	½"X12"X24"	foam core board
2	sides	½"X2"X24"	foam core board
2	ends	½"X2"X13	foam core board
3	baffels	½"x1½"X18"	foam core board
2	plates	23gaX12"X12"	sheet metal
4		6"X24"	chicken wire
1	cover sheet	18"X30"	visqueen (plastic sheeting)
1	can black spray paint		
1	3" dia. Computer fan		
1	3" dia. Dryer vent		
1	roll duct tape		
1	thermometer (the kind used to make cappuccino)		
1	light source (for indoor use)		
1	utility knife		

Directions:

1. Spray paint the sheet metal plates, black on one side. Set aside to dry.
2. Lay the sides and ends out in front of you with the shinny side up. Cut a slit ½" down from the top, extending to 3/8" in from either end. (This slit will accept the sheet metal plates when you assemble the collector).
3. Assemble the sides and ends to the base fastening them with the duct tape. **BE CERTAIN THAT THE SHINIE SIDE IS FACING INWARD AND THAT THE SLITS ARE UP!** See fig. 1
4. Insert the baffles into the box. Stagger the baffles in the box so as to make a maze for the air to flow through. See fig. 2. Fasten with duct tape.
5. Roll the chicken wire into cylinders and place them in the chambers formed by the baffles. Make certain that the wire

- Make predictions
- Develop convincing arguments
- Draw conclusions

Science

C.8.3 Design and safely conduct investigations that provide reliable quantitative or qualitative data, as appropriate, to answer their questions

C.8.10 Discuss the importance of their results and implications of their work with peers, teachers, and other adults

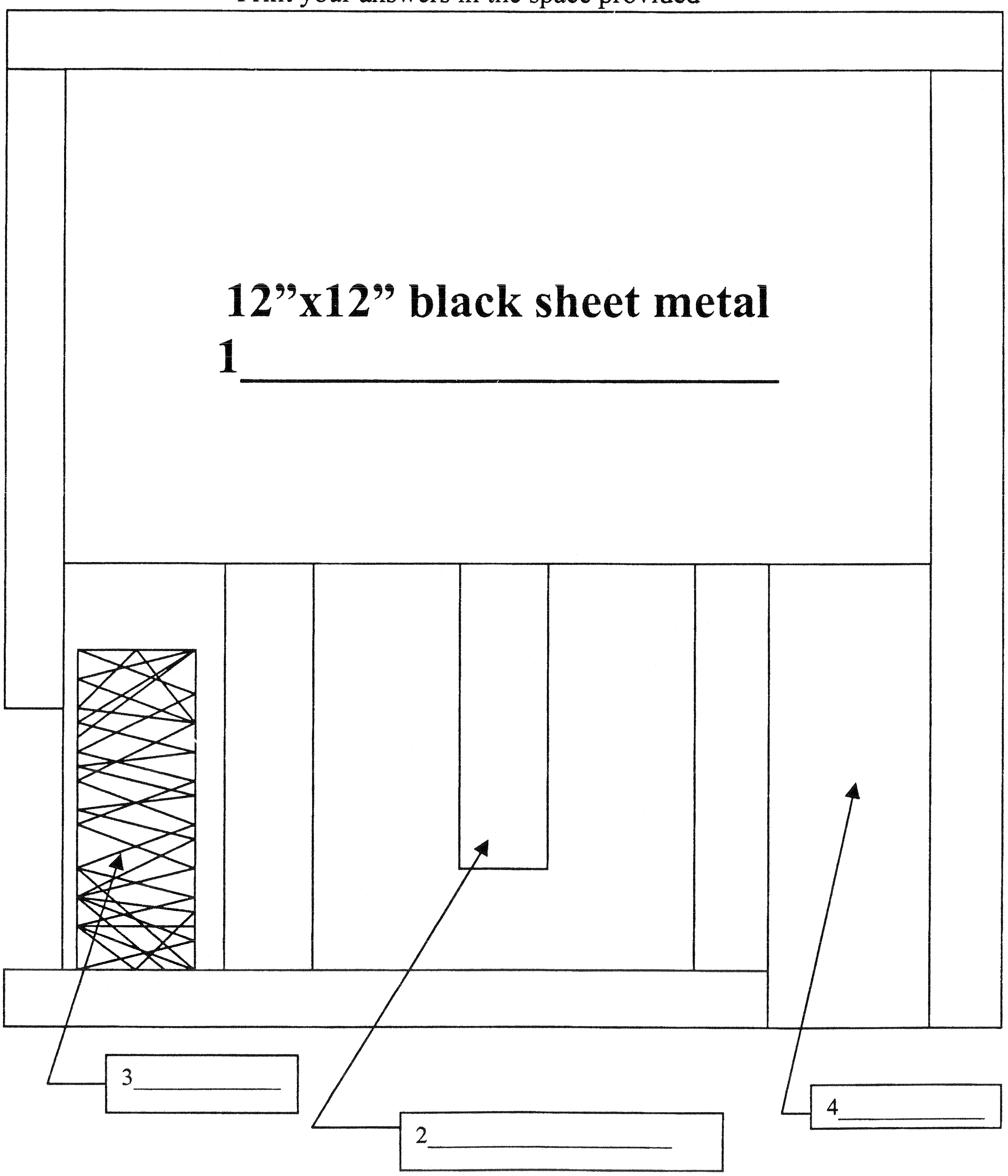
G.8.3 Illustrate the impact that science and technology have had, both good and bad, on careers, systems, society, environment, and quality of life

Name______________________
Date___________Period________

Alternate Energy

Active Solar Collector

Identify the parts of a solar collector
Print your answers in the space provided



Evaluation:

1. Given what you have been told in the lesson, why do you think that one side of the metal plates were painted black and the other side shinny?

2. What will happen to the temperature of the air as it exits the collector if the speed of the fan were increased?

3. What will happen to the temperature of the air as it exits the collector if the speed of the fan were decreased?

4. What do you think that the results on the outflow would be if the in coming air were cooled to 10 degrees, would it be higher or lower? Why?