SOLAR ENERGY INSTALLATION MANUAL

Barefoot College, Tilonia

PREFACE

"Greetings, O Sun God!
We have known you as the source of energy
and worshipped you as a God!"

We and our forefathers have used the energy of the sun in so many ways. The collection and use of this energy has always been a challenge to people. Human beings have to a great extent learnt to use this boundless energy and maximized its practical use. The Barefoot College also has taken the initiative to make its own contribution to the use of this energy.

The first effort of the Barefoot College was the experimental use of solar energy for its Health Centre in 1984. The workers of the organisation took the responsibility of maintenance after its installation. And from this was born the concept of the barefoot solar engineer.

On the basis of this experiment a seven kilowatt solar unit was installed. It was further extended to thirteen kilowatts. This gave the necessary encouragement to optimize the use of this capacity and to spread it further. In 1989 the Solar Workshop was set up. Then came the establishment in Jammu and Kashmir, Sikkim, Bihar, Uttaranchal, Madhya Pradesh, Rajasthan and Himachal Pradesh, of the 4,200 home lighting systems and 3000 lanterns. PCBs were designed, components assembled and the training of barefoot solar engineers began. This long experience with maintenance of solar units brought home the need and importance of the use of this energy. The result was the evolution of the system of maintenance and its methodology.

The Barefoot College had these experimental and demonstration units in the sub-Himalayan region and the plains of northern, eastern, western and central India. The results proved both the necessity as well as the need for the use of solar energy in these areas. Research potential has been established, as well as the need to collect and collate information to enrich this study. Solar units and other methods of use of solar energy should have long-term feasibility. In the future, we hope to bring together the results of our research and explore the possibilities of expansion of the use of this energy.

Bunker Roy
Director
Barefoot College
Tilonia

INTRODUCTION

In this manual the installation of solar equipment is explained in detail. This information enables them to function well and have a long life without requiring major repairs. Here, methods related to installation of solar panels, charge controllers, battery and fittings of lights is explained in as much detail as a barefoot solar engineer learns during her or his training. A careful following of these methods ensures life of the solar equipments and appliances.

This manual is an is an accumulation of knowledge about solar equipment gathered over several years at the Barefoot College, Tilonia.

MAIN POINTS IN INSTALLING A SOLAR UNIT

1. Ensure that the whole apparatus is installed where sunlight reaches.
2. First join the load wires and fit them.
3. Look for a suitable place to install the solar panel (module) keeping in mind the direction of the sunlight and the +ve and –ve while doing the wiring.
4. Place the battery at a suitable place and complete the other wiring.
5. Connect the charge controller to the load wires first and then connect the battery and lastly the module.

After the wiring is completed start the unit.

Precautions before commencing installation of a solar unit are:

a) ensure that all the instruments, equipment and relevant instructions are available and

b) since solar units are normally installed where grid electricity is not available, therefore even forgetting to carry a nail, tape or a screw can delay installation. Make a list of things needed for the installation and check it.

The steps for installing a solar unit are given in this manual. The precautions and processes explained must be kept in mind. Before the last step (i.e., connecting the module battery and controller) ensure that all the steps in the process are completed.

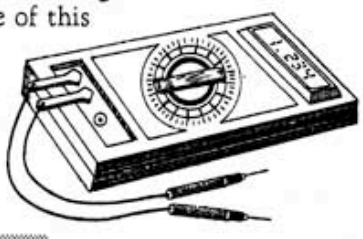
Get the entire work done by a trained solar engineer or at least have it done under his guidance. For each job, use the tools meant for it. Work should be done neatly and care taken that it is strong. One can make out good installations by the neat fittings of wires, correctly fixed lamps on the walls, quality of switches etc.

TOOLS AND OTHER MATERIALS

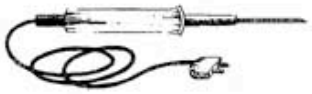
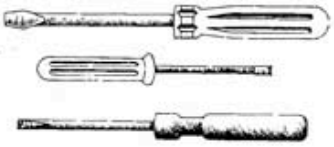
In remote areas tools and other materials required for installation may not be available. So, before leaving for the site of installation a thorough list of all tools and materials required should be prepared and cross-checked to see that everything is available in the toolkit. Some material like nails, screws, tape etc. should be taken in excess of requirement. Essential information – such as how to reach the site, and how to carry the equipment up to the site – should be collected beforehand.

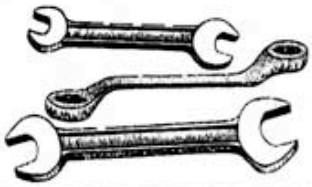
Unless you have access to 220-240 volts electricity do not carry a soldering iron and drill which require this voltage. Carry only those tools which work on a 12-volt current. In such conditions as soon as you reach the site fill up the batteries with 12.30 gravity acid and connect these to the module for getting charged. This will help in getting sufficient power for working electrical tools, as well as lighting to help in your installation work.

For installation, maintenance and repairing faults the voltmeter (multimeter) is an essential tool. This tool, helps locate faults such as broken wires as well in measuring the voltage. Before using the multimeter, sufficient knowledge about how it works is also necessary, since wrong use of this tool can confuse you and also put the equipment in danger of damage. Nowadays digital voltmeters are also available in the market (these make reading simpler). The power can also be measured by multimeters.



LIST OF TOOLS AND IMPLEMENTS

Instrument		Use
Crimp Tool		To join lugs to wires
12-volt DC Soldering Iron		To join wires to terminals, and for fixing other components
Hydrometer		To measure battery gravity and charge
Voltmeter (Multimeter)		To test connections, and to measure voltage and current
12-volt drill and drill bits		To drill holes in mounting boards (gitti) and frames
Measuring tape		To measure distances, e.g. how far the wire clips should be installed
Screwdriver set (star and flat blade)		To tighten screws and terminals
Paper and pencil		To write notes on measurements
Wire cutter and stripper		To cut and strip wires

Instrument		Use
Hack saw		To cut frames
Torch		To use for installing in the dark
Pliers		To tighten nuts and bolts
Spanner set		To tighten nuts and bolts of battery terminals and solar module stand
Hammer		To fix nails or gittis
Level		To measure the mount grade, and horizontality of wires
File		To smoothen surfaces after cutting
Compass		To determine directions for solar module
Manual		For guidance on installation

PRECAUTIONS FOR INSTALLATION

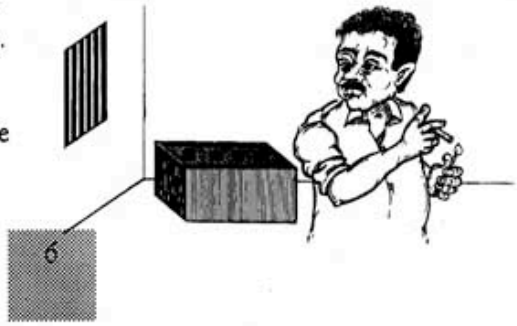
General Precautions

Normally, solar equipment has proved to be quite harmless. It however helps to know that you are working with a system where a powerful battery is involved and the flow of current between the +ve and –ve poles is intense. If care is not taken then a painful shock and sometimes even burns may occur. Normally if the following instructions are kept in mind, these hazards can be prevented.

- Do not wear rings and other jewelry while working.
- Use insulated tools or those with rubber handles.
- Keep the loose cables and metal tools away from the battery and panel, so that they do not accidentally come into contact with live wires, terminals or loads. Short circuits can also damage the battery.
- Well stocked first aid kits should be available at the installation site. Make sure someone knows how to use it.

Batteries need to be handled with special care and caution.

- Battery acid is extremely corrosive and can destroy clothes, burn skin or cause blindness if it comes into contact with the eyes. Wear protective clothing as well as glasses. Use a glass funnel to avoid splashing when filling cells.
- Never lift the batteries by their terminals. Batteries are heavy, so carry them upright from the bottom.
- Batteries should be kept in ventilated places.
- NO SMOKING should be allowed near the batteries.
- Beware of the electrical current in a battery. If the battery terminals are accidentally shorted, someone could get a bad shock.



Modules are expensive and potentially breakable too, therefore

- Transport modules with great care
- Beware of the shock while wiring or installing it. A 40 watt current cannot cause a dangerous, lethal shock, but still, several modules in a series are much more dangerous. Disconnect or cover the array with a blanket while wiring to avoid shock.

PANEL INSTALLATION ON ROOFS

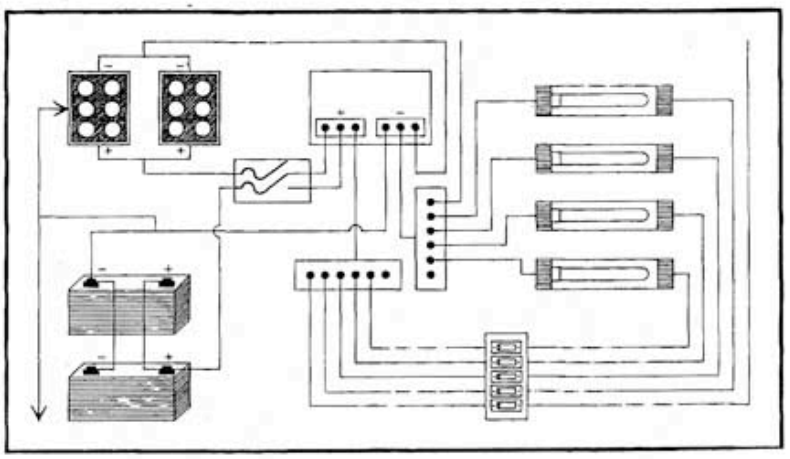
While doing the fittings on roofs use a stable ladder, and position it correctly. Have somebody hold the bottom of the ladder.

It is necessary to ground the modules (panels). A thick wire may be attached to the frame or stand and grounded, hence protecting the panel from lightning.

Wiring the load

The following precautions must be taken while wiring the load:

USE A CIRCUIT DIAGRAM
A circuit diagram is extremely useful during wiring the load, especially if the system is a complex one. If a lighting system has



to be expanded in future by a barefoot solar engineer, a circuit diagram will enable her/him to quickly understand how the system is wired, and accordingly how it can be expanded.

USE DIFFERENT COLOURED WIRES

Work and connection of each colored wire is specific and certain. It is called a colour code. Therefore while wiring the equipment, appropriate colour codes should be used by barefoot solar engineers (as explained in the training). Systems that do not use appropriate colour codes are dangerous as they will most likely confuse a barefoot solar engineer who has not installed the equipment but has to repair or maintain it.

LABEL CABLES

Pieces of labeled electrical tape fixed onto cables from connector strips, enables quick identification of the cable without wasting time. For example; if a wire to the panel labeled "panel +" or "panel –" gets cut or disconnected, it can be easily identified.

ALWAYS DOUBLE CHECK POLARITY BEFORE WIRING

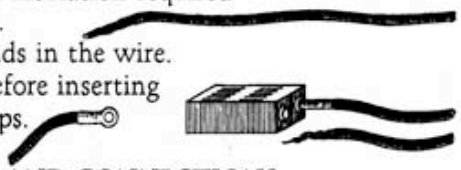
If the wrong cables are fixed to the wrong terminals by mistake the end result could be a damaged module, or ruined electrical appliance.

WHY DOES VOLTAGE DROP?

The voltage drops because of loose wire connections. Therefore all connections should be as tight and secure as possible. Good quality/ standard wire should be used in all voltage applications.

PREPARING A CABLE

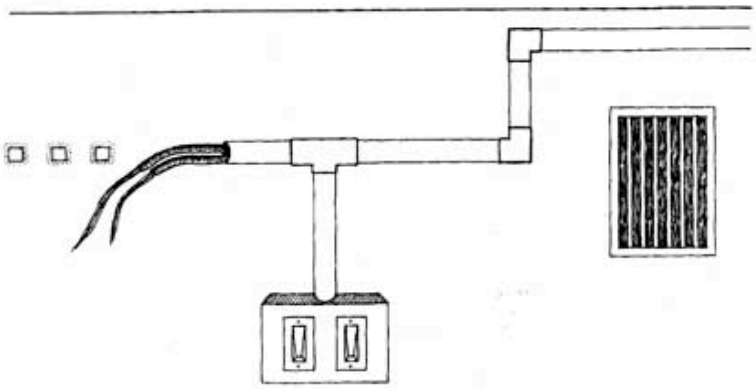
- Cut the exact amount of insulation required from the end of the wire.
- Avoid cutting small strands in the wire.
- Twist the wire strands before inserting them into connector strips.



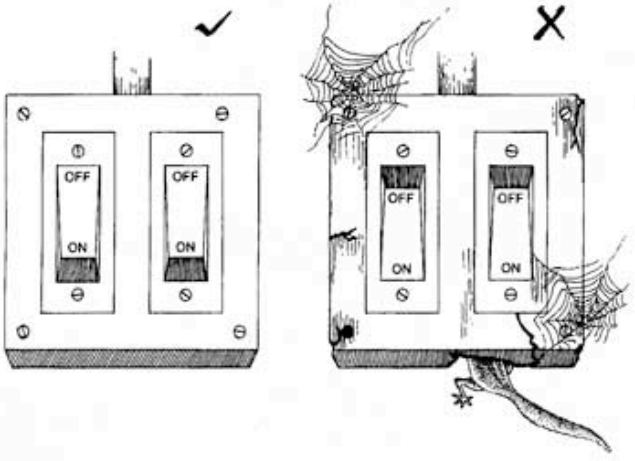
LAYING CABLES, WIRING AND CONNECTIONS

- Use a correctly sized connection strip.
- Do not use or twist wire connectors as they are likely to become loose, or break apart and cause a voltage drop.
- When tightening screws in connector strips and terminals, turn the screw until it is tight enough for a secure connection, but not so tight that it cuts the wire.
- Locate all connections so that they are easily accessible for reopening or tightening.
- A crimping tool is a special type of pliers used for making connections and pinching the connector collar tightly around the end of the wire. Therefore the crimping tool should be used to secure all electrical contacts.

- Cables are clipped on a small wooden board (gitti), and fixed into a wall by digging it. The barefoot solar engineer is trained for this work.
- Clip cables neatly to the wall, spacing the clips at regular intervals. If a conduit pipe is used, it should be properly fixed to the walls.
- All wires should be clipped so that they run exactly vertical or horizontal. If the wires have to be turned towards the clip-board, it should turn making an angle of 90 degrees.



- Place light switches and power sockets in well mounted boxes, tightly secured to the wall.
- Positioning of switches and sockets should be according to the needs of the users.
- Use standard OFF and ON positions – i.e. OFF is up and ON is always down – throughout the installation.
- When laying the conduit outside, make sure that it is within six centimetres of the electrical box.
- Controllers and junctions boxes have to be sealed properly so as to prevent the entry of lizards, spiders and other insects.



INSTALLING SOLAR MODULES

The solar module should be mounted in a place where it can receive maximum sunlight, and should not be over-heated.

A barefoot solar engineer should choose a proper location, plan the installation and collect all the necessary tools and accessories.

Modules should not be covered by shadow or dust. They should be placed as close to the batteries as possible and in a place that is safe from theft and beyond the reach of children.

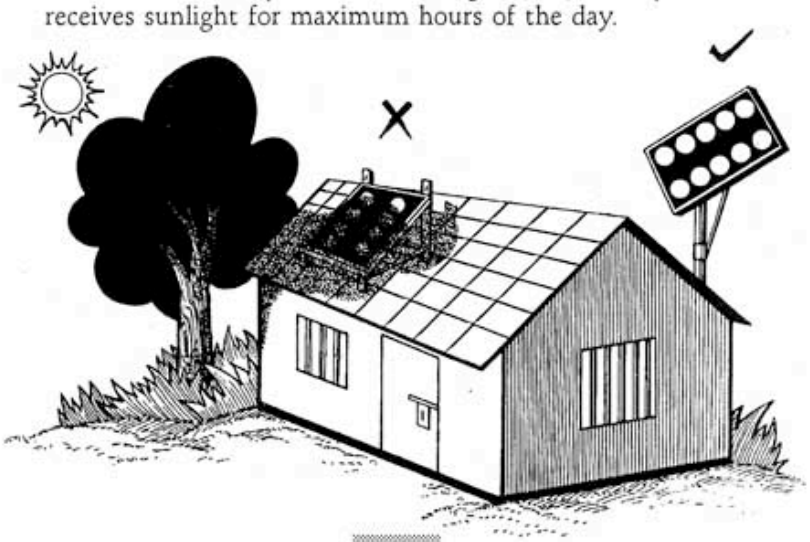
Handling Solar Modules

Solar module cells can break like glass, although the glass is strong, made to withstand the impact of storms and hail stones. The module can, however, break if it falls down or by rocks hitting it. There is no other alternative other than buying a new module in such circumstances.

During transport or work the back of the module should be especially protected, as this side is usually neglected. Hard, sharp objects can break the back of the module if they strike hard enough. Repairing a module is almost impossible. The module will be ruined even if one cell is broken. Modules should never be twisted, as this may break or damage the cells inside. Holes must be drilled carefully in a frame, so that the cell inside is safe. It is better to use the holes that are already drilled in the frame.

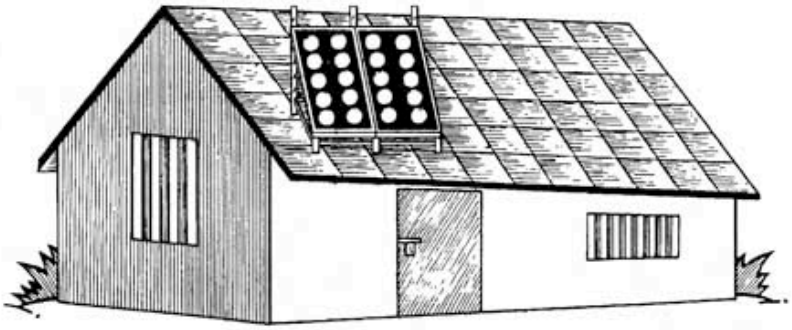
Choosing the Mounting Site

- The most suitable place for installing a module is a place that receives sunlight for maximum hours of the day.



- It should not be at ground level, so that it is out of dust and out of the way of animals and humans. It should not be mounted near a kitchen or a chimney lest it be covered with smoke.
- The module should be in a place where it will not be covered by shadows. Check the position of the sun during different times of the day, and during different seasons and determine whether shadows from trees or other objects will fall on the intended module location. Even if one cell is shaded, the output of the module falls considerably.
- The module should be in a place where it does not get overheated, such as tin rooftops. The module should be at least 10 cms off a tin rooftop, if fixed on it. The module should be located where it can be cooled by air.
- It should be ensured that the wire used to connect the battery and the module is thick enough to ensure that the voltage drop is less than 5%.
- Moreover the distance between the battery and the module should be as little as possible, to prevent loss or voltage drop.

Method of Mounting



After deciding on a suitable site, the next step is to mount the panel on the module. The module stand and frame known as "array" is supplied, along with solar electric equipment. The array is either "fixed/stationary" or "tracking/moving" type. Each type has its own advantages and disadvantages.

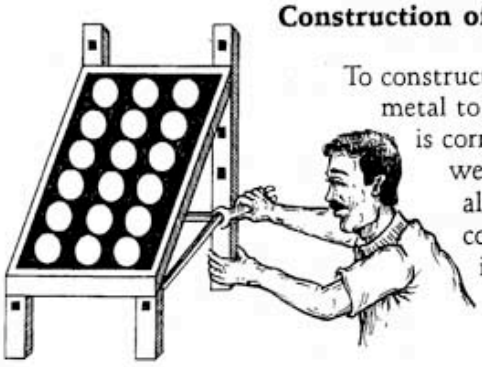
Tracking modules can be rotated in the direction, and position of the sun. Its output is 25% more than the fixed one. But throughout the day, often every two hours, it is necessary to change its direction to face the sun. This increases the work load. Tracking equipment can sometimes change direction by itself in storms because of strong winds thus turning away from the sun.

A fixed module is strong (if the quality is good) and can withstand strong winds and storms without bending or breaking.

A barefoot solar engineer must make a correct decision about the best possible mount for the panel/module. That is:

- Whether to use tracking equipment or a fixed one.
- Whether to mount it on a roof, or on the ground, on a stand or on a pole.
- Rooftop mounts use racks or brackets to fix the array to the roof structure. Brackets may be installed so that they pivot downwards for easy cleaning or so that their angle can be adjusted reasonably.
- Sometimes it is difficult to mount a stand as the roof structure is difficult or not congenial to it. In such circumstances the module may be mounted on a pole, firmly fixed to the ground. Pole mounts are usually expensive and difficult to clean. But it does keep the module off the ground and in a secure and highly visible place.
- If the roof is small, and the modules more in number, then the pole mounts are useful. Wire fencing may be done around the modules in this type of arrangement, so as to protect it from animals etc.
- The stand (array) should be positioned in such a way that rain-water does not accumulate on it but runs off the module. A barefoot solar engineer is trained in deciding direction and angle of the module.

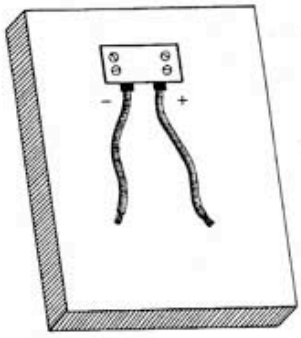
Construction of Metal Stands



To construct the stand or array, the metal to be used should be one that is corrosion resistant and weather proof such as aluminum. But aluminum is costly, so often iron is used instead. It is best coated with red oxide paint so to prevent corrosion.

Module Connections

Before attaching the module leads to the battery controller, ensure that the battery is fully charged, and producing at least 12 volts. Only after ensuring the above should the final connections be made.



POINTS TO BE KEPT IN MIND

- Use a proper sized cable.
- Ensure that the stand is well grounded and secure.
- The junction boxes should be well sealed to prevent corrosion.
- Soldering iron or crimp tool should be used to make sure the connections are good.

If there is more than one module in the array, then the modules must be wired in a configuration that matches the system voltage. See figure A and B for parallel and series connections. (Always consult a barefoot solar engineer for such connections.)

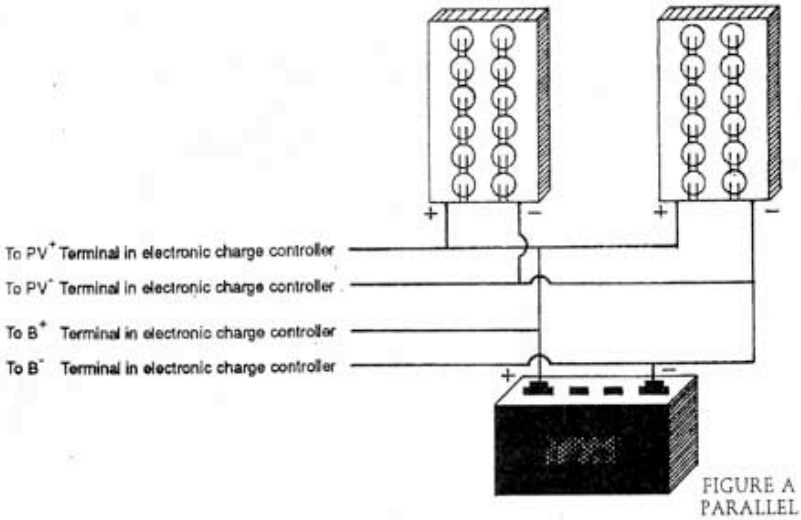


FIGURE A
PARALLEL

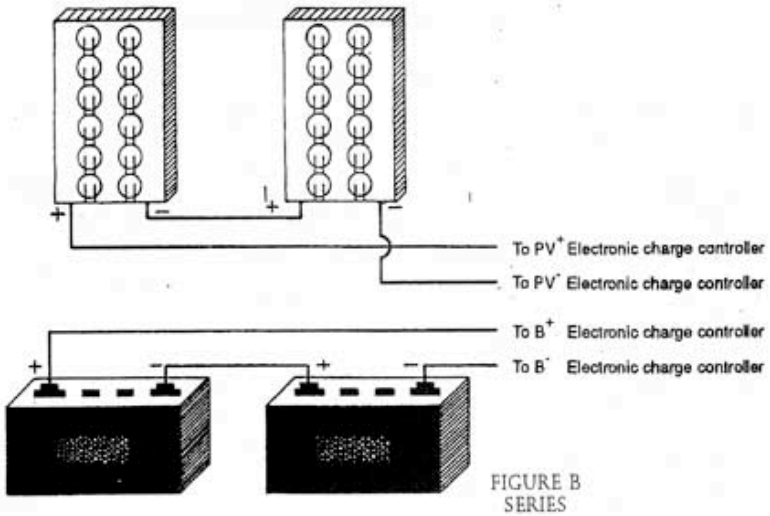


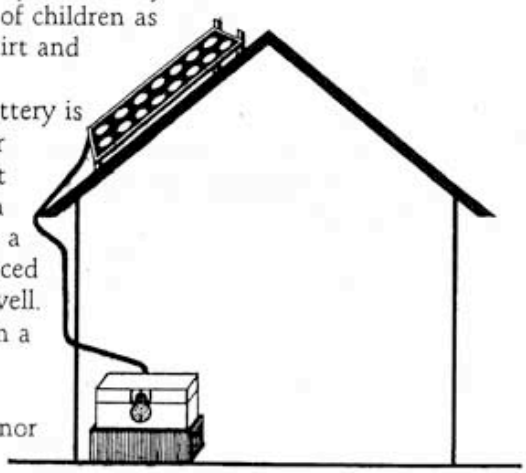
FIGURE B
SERIES

BATTERY AND CONTROLLER INSTALLATION

Choosing the Battery Location

The battery should be located in a cool, ventilated room, where there is minimum human and animal traffic. While locating the battery the following instructions must be followed:

- The battery should be located as close to the array as possible, to reduce voltage drop. The size of the cable should be large enough to carry the charge current from the module without more than 5% voltage drop.
- There should be no direct sunlight on the battery.
- The battery should be kept in battery boxes, out of the reach of children as well as sheltered from dirt and dust.
- The room where the battery is kept should have proper cross ventilation so that the explosive fumes can escape. There should be a NO SMOKING sign placed next to the battery as well.
- The battery should be in a closet or a room where children and animals cannot tamper with it, nor can it be easily stolen.



Transporting Batteries to Inaccessible Areas

Batteries that are commonly used are filled with acid electrolytes and they are likely to tip and spill during transport on rough roads. Batteries are always transported dry and acid is carried separately in sealed cans. After arrival at the site, acid is carefully poured into the batteries.

While filling the acid, plastic tubes, funnel and protective glasses should be used for safety. Any acid spilt on the clothes should be rinsed immediately. The equipment used while pouring the acid should be washed with water. Keep plenty of water while pouring the acid. It is better to wear old clothes while filling acid.

Batteries without acid are sent in a charged state by the manufacturers. As soon as they are filled with acid they provide current. Therefore, tools and cables should be kept away from terminals and posts as accidental short circuits are both expensive and dangerous.

Battery Wiring

As previously stated the distance of the module to the controls and the batteries should be as short as possible.

If a module is fixed to a pole, run the wire straight down the pole, then run it through the ground and attach it to the battery. This underground cable can be protected with conduit and the places where the cable is laid can be marked. In future if the ground is dug then the conduit will protect the cable.

If one battery of 12 volts is to be used, attach the battery to the cable. There are special types of connectors, in which cables are inserted in cable terminals, and tightly fastened. The terminals are finally coated with petroleum jelly.

If there is more than one 12-volt battery, they are arranged in series or parallel. For example, if we have four batteries and 24 volts needed for it, then two batteries should be in series and two in parallel. A barefoot solar engineer should be present while wiring the battery.

FINAL CONNECTIONS

A barefoot solar engineer, who is trained in solar electric systems, should make the final connections.

Before commencing the final connections, all the wires and cables should be properly installed, without being connected yet to the control terminal. Connections from the battery and the modules to the charge controller should also not be made before that. Before beginning the process, tube and lamps must be removed from the holders in order to check polarity of the holders.

Final connections should be done keeping four points in mind:

1. Connect battery to the charge controller

The terminal and connectors should be properly cleaned before connecting wires to the battery terminal. Clean inside surface of the connector and battery posts using sand-paper.

After this, to check polarity, touch both the terminals (positive and negative) to the connector posts of the battery. If there is any fault in the wiring it can be removed immediately. If there is no problem, the black wire should be connected to the (–) and the red wire to the (+) connector, put into the battery post and bolted.

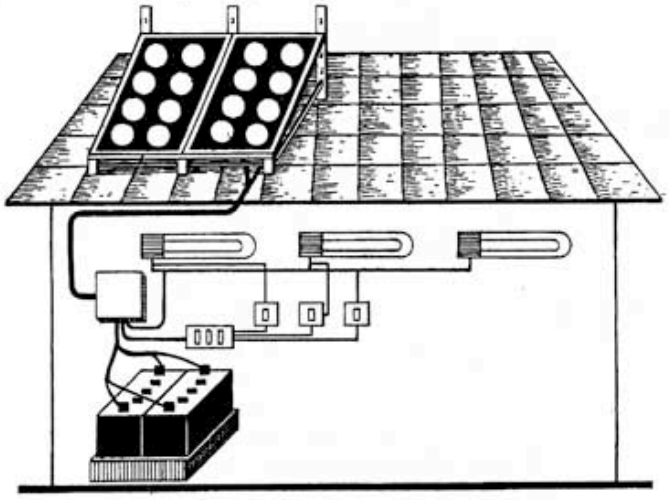
Tighten the black wire (–) to the negative terminal of the controller. Now, touch the red wire (+) to the positive terminal of

the battery controller very briefly. If it sparks, there may be some mistake in the controller. so recheck the connections. If there is no spark then connect positive red battery cable to the terminal and tighten

2. Connect and check the load

Now when the battery connections are complete we have power available to check the wiring of the tube (lamp) and sockets in the load. Before beginning this remove all the tubes from the holders.

Check the polarity of each lamp holder using a multimeter. If the polarity is right, fix the tube or lamp and switch on to see if it lights. This test should be repeated for each lamp. Check the wiring when voltage is low. If the positive and negative are attached in reverse the inverter can be damaged. If there are short circuits check the polarity of the sockets too.



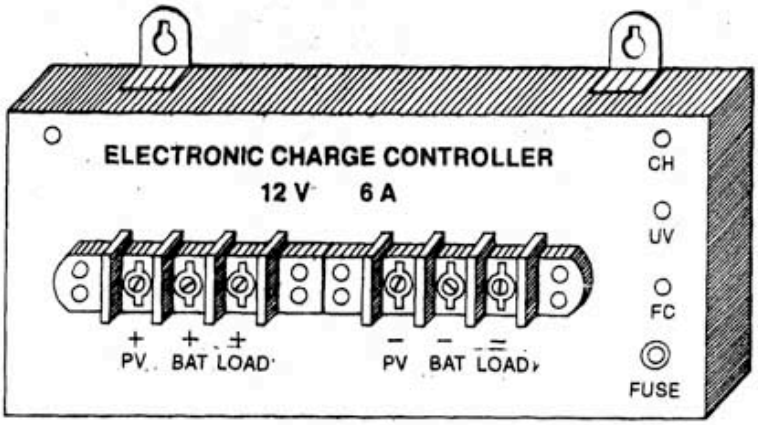
3. Tube Lamp

Fix the tubes and lamps to the holders. Now it is ready to use for lighting.

4. Connect the solar cell modules

Cover the module with some cloth, turning all switches OFF. Now connect the cable from the junction box of the module to the charge controller according to the colour code, after checking the polarity. Then remove the cloth.

The black wire should be tightly joined to (–) wire of controller, and touch the red charge wire to the terminal briefly. If there is a charge indicator, indicator light should come ON, and the battery should jump between 0.3 and 0.4 volts depending on the position of the sun.



If there is no problem it means that the solar equipment is ready for use.

It is the responsibility of the solar engineer to inform the users about cleaning the panel, security of battery, fuses etc. It should be best to visit the user's house for a day or two after the installation, and go through the exercise the solar engineer expects the users to do daily.

NOTES

Barefoot College
Social Work Research Centre
Tilonia 305816, District Ajmer, Rajasthan
Phones: (01463) 88204/88205/88210
Fax: (01463) 88206
E-mail: barefoot@jp1.dot.net.in