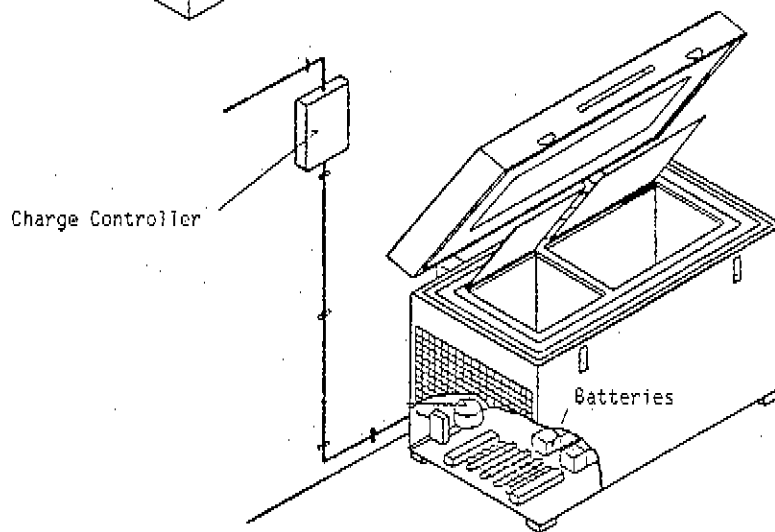
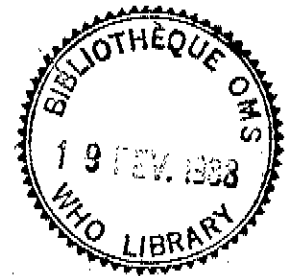
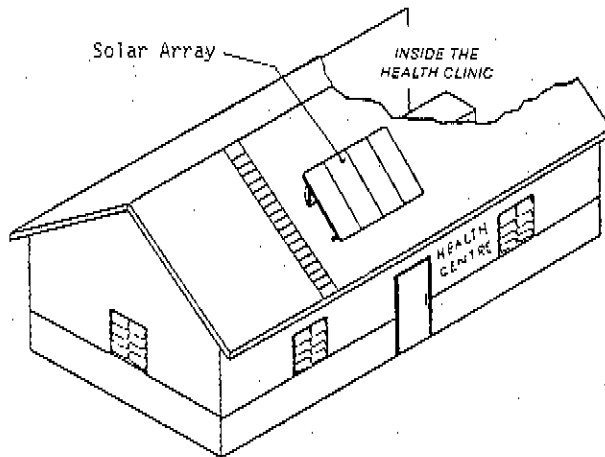


USER'S HANDBOOK FOR
" PHOTOVOLTAIC REFRIGERATORS "

26



A USERS HANDBOOK
FOR
PHOTOVOLTAIC POWERED REFRIGERATORS

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SCOPE

This handbook has been published by the World Health Organization Expanded Programme on Immunization.

It is a handbook for users of stand-alone, photovoltaic powered compression refrigerators operating at 12V or 24V DC in medical centres. These refrigerators are used for storing vaccines and medicine and for freezing icepacks. Stand-alone means here that the solar array does not power any other device (e.g. lights) and the refrigerator is powered only from the solar array.

This handbook should not be used for any other types of refrigerator.

1. ACTIONS ON HANDOVER

You should read this section before the installation technicians have left the health centre. There are some important questions that you must ask them before they go.

1.1 Getting to know your solar refrigerator

Your new solar refrigerator is an important part of the cold chain. You can store vaccine and medicine in it safely, and freeze icepacks in the freezer compartment. But for the refrigerator to operate properly, you must be familiar with its parts and understand how to use it.

A solar powered refrigerator is not the same as a refrigerator that burns kerosene or bottled gas. It is similar to a refrigerator that uses mains electricity but has a different power supply - solar energy converted into direct current electricity by solar cells.

Figure 1 shows the basic parts of your solar refrigerator

power supply. These parts are: the solar array, the charge regulator and the batteries. Together they provide the electricity for the refrigerator. The solar array can be roof-mounted, mounted on a pole or located at ground level with a protective fence around it. The batteries and charge regulator can be mounted in the refrigerator cabinet or placed nearby in suitably protected cases.

Figure 2 shows a typical solar refrigerator cabinet and the location of the parts.

Before the installation technicians leave, you should:

1. Ask them to provide you with the information listed in Table 1.
2. Fill in Table 2 and sign it.
3. Fill in the first entry in the Daily Record Sheet like the example shown in Table 3.
4. Check that the installation is **CORRECT** by answering the questions in Table 4.
5. Check that the refrigerator system is **OPERATING CORRECTLY** by answering the questions in Table 5.

Figure 1. SOLAR ELECTRICITY SUPPLY FOR A PHOTOVOLTAIC
REFRIGERATOR

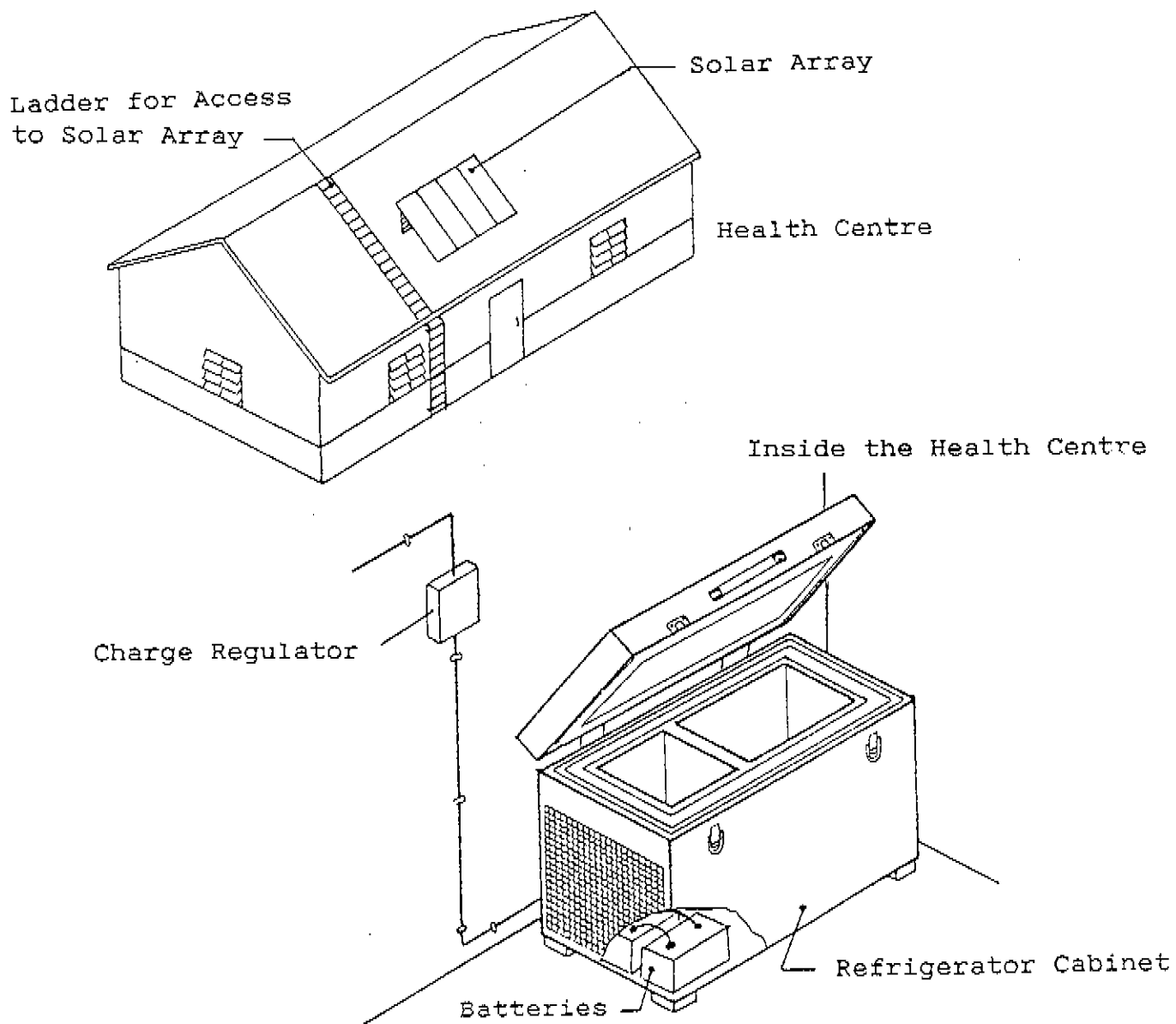
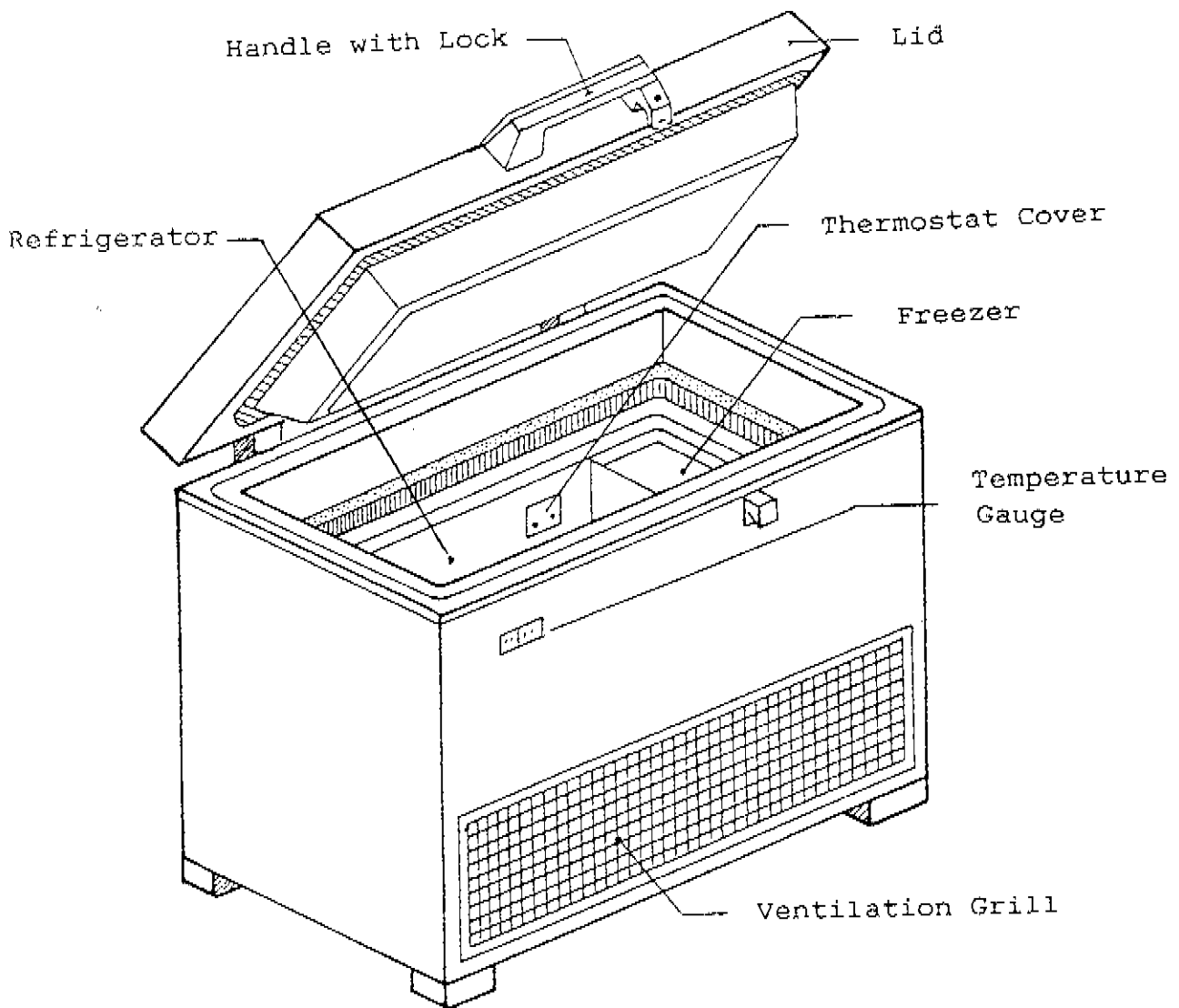


Figure 2. A TYPICAL REFRIGERATOR CABINET



**Table 1. ASK THE INSTALLATION TECHNICIAN TO PROVIDE
YOU WITH THE FOLLOWING INFORMATION AND
WRITE IT DOWN ON THIS PAGE.**

1. Maximum number of icepacks to be placed in the freezer in any one day:
2. Vaccine capacity of refrigerator compartment: litres
3. The model of the refrigerator
4. Where spare fuses for the Charge Regulator and Compressor Controller are kept:
5. The location of the refrigerator ON/OFF switch:
6. When to switch the refrigerator OFF and ON:
7. The location and colour of the Indicator Light 'REFRIGERATOR DISCONNECTED':
8. The location and colour of the Indicator Light 'DO NOT FREEZE ICEPACKS':
9. The location, colour and function of any other Indicator Lights:
10. The location and purpose of the Thermometers and any other Meters:
11. The Thermometer and Meter readings which indicate normal operation:

Table 2. SITE DATA SHEET
(TO BE COMPLETED AND SIGNED BY THE
TECHNICIAN AND USER)

1. Full Address of Health Centre:
2. Name and Rank of Person Responsible for Centre:
3. Names of Centre Staff trained to use and do user level maintenance on system:
4. Date solar refrigerator system installed:
5. Make and Model of refrigerator unit installed:
6. Make and Model of Charge Regulator installed:
7. Quantity and Type of Batteries installed:
8. Quantity and Type of Photovoltaic Modules installed:
9. Array Mounting Arrangement (Tick arrangement used):
 - Roof with means of safe access
 - Pole with possibility for cleaning array
 - Ground with protective fence

10. List of Tools, Manuals, Record Sheets and Supplies provided for user (Tick and indicate quantity if supplied):

- Daily Record Sheets
- 10 Fuses for each place
- Distilled water in closed container
- Talcum Powder
- Flat-bladed screwdriver
- Phillips screwdriver
- Soft Brush to clean Condensor
- Sponge to clean Array
- Padlocks and Keys
- Petroleum Jelly
- Battery refill bottle with spout
- Thermometer to measure room temperature
- Thermometer to measure refrigerator compartment temperature
- USER HANDBOOK for PHOTOVOLTAIC REFRIGERATORS
- Manufacturer's Manual

11. Name and Address of Solar Refrigerator Technician responsible for maintenance of system:

12. How to contact Solar Refrigerator Technician:

VERIFIED AND APPROVED BY:

Person responsible
for Centre

Chief Installation
Technician

Table 3. EXAMPLE OF DAILY RECORD SHEET

DAILY RECORD SHEET

WEEK FROM _____ TO _____

	TIME	TEMPERATURE IN REFRIGERATOR COMPARTMENT	AMBIENT TEMPERATURE	QUANTITIES LOADED		INDICATORS ON	SIGNATURE
				ICEPACKS	VACCINES		
MONDAY	MORNING						
	AFTERNOON						
TUESDAY	MORNING						
	AFTERNOON						
WEDNESDAY	MORNING						
	AFTERNOON						
THURSDAY	MORNING						
	AFTERNOON						
FRIDAY	MORNING						
	AFTERNOON						
SATURDAY	MORNING						
	AFTERNOON						
SUNDAY	MORNING						
	AFTERNOON						

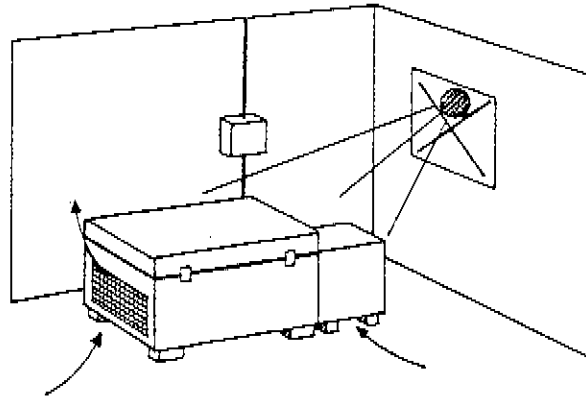
Table 4. IS THE INSTALLATION CORRECT ?

The Solar Array:

- Can you reach it easily and safely to clean it?
- Is it protected so that unauthorised persons cannot damage it?
- Are the cables which are connected to the array firmly attached or hidden?

The Refrigerator Cabinet:

- Is there good air circulation around all sides and on top of the refrigerator cabinet especially in front of the ventilation grill?



- Is the refrigerator cabinet placed so that it is NEVER in direct sunlight?
- Is the refrigerator cabinet raised off the floor so that it can readily be cleaned around and will not be damaged by water used to wash the floor?
- Can you reach the doors and locks easily?

The Charge Regulator and Batteries:

- Are the Charge Regulator and Batteries mounted in protective cases?
- Are the Cases attached to the wall, floor or refrigerator cabinet?
- Are all the cables firmly attached or hidden?

IF THE ANSWER TO ALL QUESTIONS IS YES,
THE INSTALLATION IS CORRECT

2. HOW TO OPERATE YOUR SYSTEM

2.1 General Remarks

- (a) The refrigerator must always be turned on during normal use.
- (b) Only open the refrigerator cabinet when it is necessary. Make sure that you close it quickly and securely.
- (c) Always lock the refrigerator cabinet immediately after use.
- (d) Only turn the refrigerator OFF when:
 - o you need to defrost the evaporator
 - o you need to change a fuse
- (e) Keep all vaccines in the refrigerator and in accordance with EPI recommendations. The correct temperature for vaccine storage is more than 0°C and less than 8°C. **NEVER PUT DPT OR TETANUS TOXOID IN THE FREEZER COMPARTMENT.**

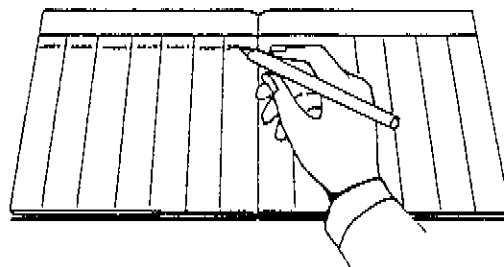
2.2 Loading the Refrigerator

- (a) Do not LOAD icepacks if the "DO NOT FREEZE ICE PACK" indicator light is on.
- (b) LOAD the freezer compartment with ICE PACKS IN THE MORNING ONLY.
- (c) Do not put more than the recommended number of icepacks in the freezer compartment in any one day.
- (d) Do not put more than the recommended amount of vaccine in the refrigerator compartment.
- (e) You should leave about 5 cm (2 inches) between the cartons of vaccines. This allows the cold air to move around the refrigerator compartment
- (f) Always keep the same type of vaccine together and store your vaccines neatly.
- (g) You must use all the old vaccines before the new ones. So you should put new vaccines underneath or behind old vaccines. Before use, make sure that vaccine has not expired.
- (h) DO NOT KEEP FOOD OR DRINK IN THE REFRIGERATOR OR ANY OTHER NON-MEDICAL ITEM. The solar array can only produce a certain amount of electricity each day. If food or drink is placed in the refrigerator there will not be enough electricity to cool the vaccine.

2.3 Filling in the DAILY RECORD SHEET

- (a) Look at the **TIME** and write this down in the correct row in your **DAILY RECORD SHEET**. The record sheet shows the day of the week and whether the entry you are making is a morning or afternoon recording. Choose the correct row to make your entry.
- (b) Check the **TEMPERATURE INSIDE THE REFRIGERATOR COMPARTMENT** and record it on your **DAILY RECORD SHEET**.

If the temperature is NOT between 0°C and 8°C, go to Section 4 of this handbook "WHAT TO DO IF A FAULT OCCURS" for the action you must take.
- (c) Check the **ROOM TEMPERATURE** and record it on your **DAILY RECORD SHEET**.
- (d) Count the **NUMBER OF ICE PACKS** loaded into the freezer compartment each morning, and record it on your **DAILY RECORD SHEET**.
- (e) Count or estimate the **QUANTITY OF VACCINE AND MEDICINE** loaded into the refrigerator compartment since the last time the **DAILY RECORD SHEET** was filled in and enter this quantity on the sheet.
- (f) Look at the **INDICATOR LIGHTS** and enter in your **DAILY RECORD SHEET** which **COLOURS** are illuminated.
- (g) Check that you have **CORRECTLY** filled in the **DAILY RECORD SHEET** and **SIGN IT**.



FILL IN RECORD SHEET TWICE A DAY

3. USER MAINTENANCE

3.1 Daily Tasks

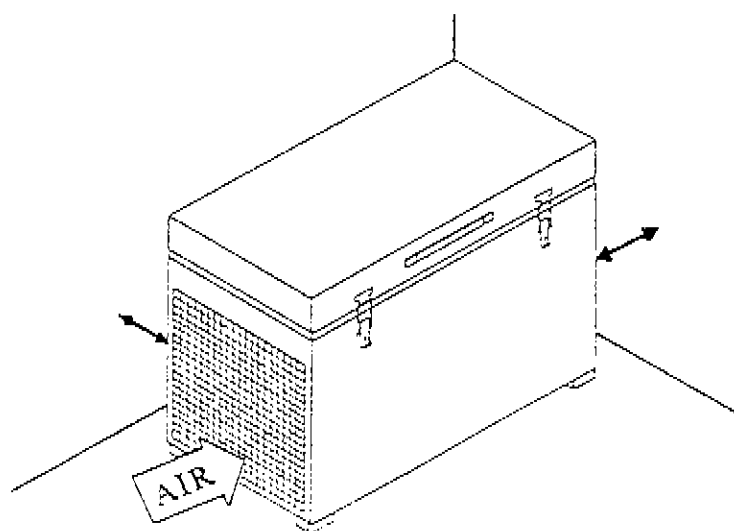
- (a) Fill in the **DAILY RECORD SHEET** each morning and afternoon.

The refrigerator compartment temperature must be more than 0°C and less than 8°C. If the temperature is not correct, then go Section 4 of this handbook "WHAT TO DO IF A FAULT OCCURS" for the action you must take.

- (b) Check the **INDICATOR LIGHTS** and any other **METERS**. If **ANY** of them indicates that the refrigerator system is not operating normally then:

- **MOVE ALL VACCINE TO ANOTHER PLACE** if the **FRIDGE DISCONNECTED** indicator light is **LIT**
- **REMOVE UNFROZEN ICE PACKS** from the freezer compartment if the **"DO NOT FREEZE ICE PACKS"** indicator light is **LIT**

- (c) Make sure that the refrigerator ventilation grill (if fitted) is not blocked or obstructed and that there is free air circulation all around and underneath the refrigerator cabinet.



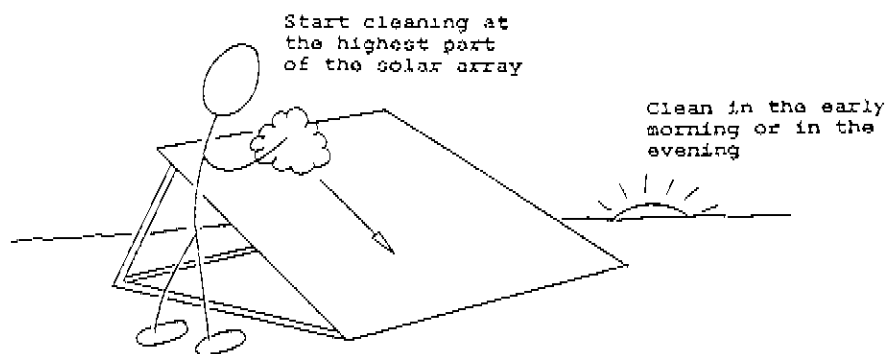
FREE AIR CIRCULATION

3.2 Weekly tasks

- (a) Check the amount of ice forming around the freezer compartment. It is normal for a little ice to form in the freezer, but if the ice is thicker than 5mm (1/4 inch), then move the vaccine to another refrigerator or store it in a cold box with ice packs. The refrigerator must be switched off, and the refrigerator cabinet defrosted. The proper steps for DEFROSTING THE REFRIGERATOR CABINET are as follows:
- (i) Move the vaccine to another refrigerator or store it in a cold box with frozen icepacks.
 - (ii) Switch the refrigerator OFF.
 - (iii) Open the lid/door of the refrigerator and freezer compartment, and remove separator if possible.
 - (iv) As soon as it is possible to remove ice with your fingers, do so. Do not remove ice with knives or any other sharp objects.
 - (v) Wipe the freezer compartment dry after all the ice has melted.
 - (vi) Clean the refrigerator inside with soap and water, then dry it carefully. Never use scouring powder, steel wool or abrasive cleaners. Remember to clean the lid/door sealing gasket and put some talcum powder on it to prevent it sticking to the door frame.
 - (vii) Switch the refrigerator back ON.
 - (viii) Wait until the inside temperature in the refrigerator compartment is less than 8°C.
 - (ix) Return the vaccine to the refrigerator and close the door/lid.

If defrosting is necessary every week, the lid is probably not sealing properly. See CHECKING THE LID OR DOOR SEALING GASKET described later in this section under Six-Monthly Tasks.

- (b) Clean the solar array. Dust and dirt on the solar array reduces its capacity to produce electricity. It should always be kept clean. The proper steps for CLEANING THE SOLAR ARRAY are as follows:



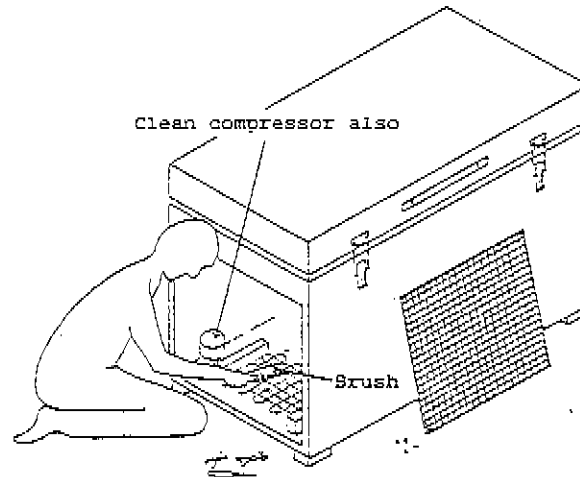
CLEANING THE SOLAR ARRAY

- (i) Remember - always clean in the early morning or evening when the solar array is not in strong sunlight to avoid risk of damage.
- (ii) Wash the array using plenty of clean water and a clean soft cloth or sponge. Do not scratch the surface of the array.
- (iii) Wipe the surface of the solar array gently, starting at the highest point and working down to the lowest point. Make sure that all the dust and dirt is removed.
- (iv) Do not stand on the solar array, or lean heavily on it, as this may break it.

Access to the solar array should be easy and safe. Ask the service or installation technician to provide a better method of access if you think the present arrangement is unsafe or if you do not feel comfortable about cleaning the array.

3.3 Monthly tasks

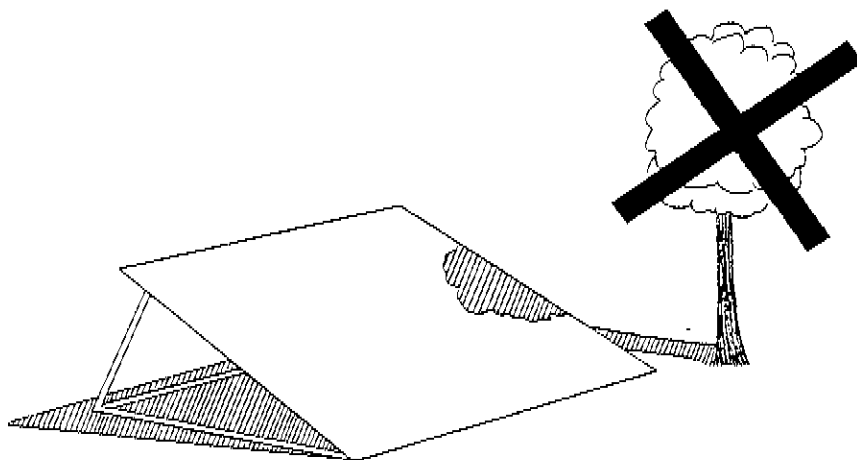
- (a) Clean the parts of the refrigerator cabinet. To operate correctly and reliably, the refrigerator cabinet and the parts inside it must remain clean. The proper steps for **CLEANING THE PARTS OF THE REFRIGERATOR CABINET** are as follows:



CLEANING THE PARTS OF THE REFRIGERATOR CABINET

- (i) Switch OFF the refrigerator.
- (ii) Remove or open the cover which provides access to the compressor, condensor and fan (if fitted) of the refrigerator cabinet.
- (iii) Use the soft brush provided with your refrigerator to remove any dust and dirt from the condensor and compressor.
- (iv) If the condensor is fitted with a fan, make sure that the fan rotates freely, and brush dirt and dust away from the fan and fanmotor.
- (v) Switch the refrigerator ON again.
- (vi) Wipe clean the outside of the refrigerator using soap and water.

- (b) Check for shadowing of the array. Shading of the array, even partly, will reduce the amount of electricity produced for the refrigerator. Check that the solar array is not shaded during the hours of sunlight. This should be checked at approximately 8 am, 12 noon and 4 pm. The following action is necessary if you find that any part of the array is shaded during normal sunlight hours:



CUT BACK TREES OR BUSHES WHICH
SHADE THE ARRAY

- (i) Cut back bushes and trees that may have started to shade the solar array between 8 am and 4 pm. Trees and bushes which only cause shading in early morning (before 8am) or late afternoon (after 4pm) do not need to be cut. Do not cut down more bushes or trees than necessary and always seek the permission of the person responsible for them by explaining why it is necessary.
- (ii) Make sure that nobody has put anything in front of the solar array that may block the sunshine falling on it.
- (iii) If new buildings cause shadows to fall on the array, it may be necessary to move the array to an unshaded place. Ask your technician to check and if necessary, move the array.

3.4 Six-monthly tasks

- (a) Check the level of acid in all types of batteries which are not sealed. If the level of electrolyte (acid mixture) in any of the cells in the batteries drops sufficiently to expose the plates of the battery, then the battery will be damaged and the refrigerator will not operate properly. Checks are necessary, but following safety regulations MUST be observed.

WARNINGS:



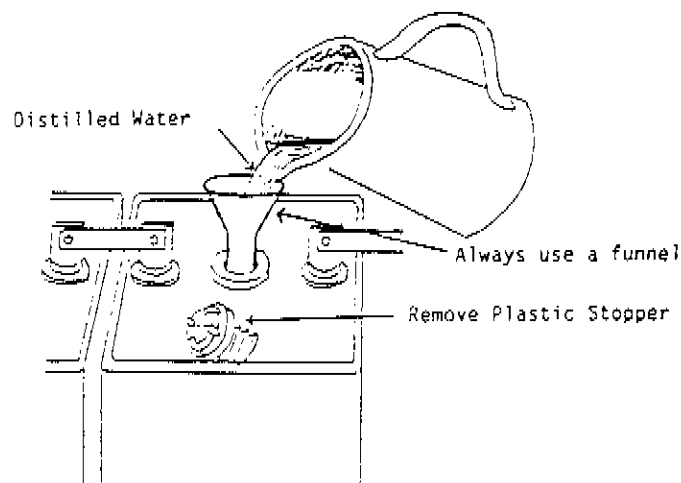
- o KEEP NAKED LIGHTS, SPARKS AND HEAT AWAY FROM BATTERIES AS EXPLOSIVE GASES MAY BE PRESENT.



- o LIQUID (ELECTROLYTE) IN BATTERIES IS CORROSIVE. KEEP OFF SKIN AND AWAY FROM EYES. AVOID CONTACT WITH CLOTHES.

If the batteries are sealed they will NEVER need topping up.

NEVER ADD ACID



ADDING WATER TO THE BATTERIES

(i) If the batteries are not of the sealed type, then they will have plastic stoppers or a plastic lid on the top. Remove each stopper or each lid one by one and see if the metal plates inside are covered by liquid. There is often a mark or indicator which shows the correct level.

(ii) Add **DISTILLED WATER** if necessary to each cell until it is filled up to the correct level indicated or until the metal plates are well covered. **DO NOT** fill the battery up until it overflows. Use the plastic bottle with a spout or a clean funnel to put in the water.

(iii) Replace each stopper or lid.

(iv) Do this for all of the compartments in each battery.

It is important that **ONLY DISTILLED WATER** is used.

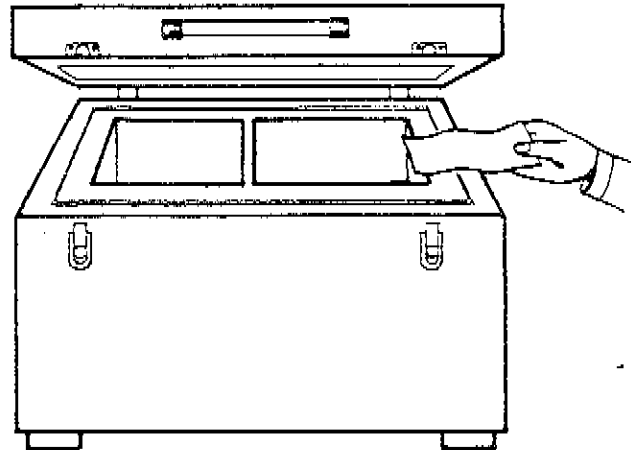
(b) Check that:

- the array is firmly mounted,
- all cables or electrical wiring connecting the different parts of the system together are firmly attached and not damaged,
- the battery and charge regulator cases are firmly attached to the wall or floor if they are not inside the refrigerator cabinet, and finally,
- no parts of the refrigerator cabinet are loose or dangerous to the people who use the refrigerator system.

If **ANY** of the parts checked above are **NOT** satisfactory, then

CONTACT THE MAINTENANCE TECHNICIAN IMMEDIATELY.

- (c) Check the lid/door seal. If the seal does not prevent the cold inside the refrigerator and freezer compartments from escaping into the room when the door/lid is closed, then your refrigerator will require more electricity to run and the refrigerator system will not operate correctly. The seal MUST make good contact all the way around the joint between the door/lid and the compartments in order for it to seal properly. To check this, do the following:



CHECKING THE LID/DOOR SEAL

- (i) Open the refrigerator and place a thin paper strip over the place where the seal of the refrigerator cabinet comes into contact with the lid/door.
- (ii) Close the lid/door.
- (iii) Pull the paper strip. If it moves easily the door/lid needs adjustment or the seal needs replacing.
- (iv) Try the paper strip all around the the lid/door in this way, paying special attention to the corners.
- (v) Check all the way around the lid/door in this way, paying particular attention to the corners.
- (vi) If the seal is coming loose, glue it back on. If this is not possible, request a replacement seal.

If you are unable to make the seal fit CORRECTLY, all of the way around the joint, CALL THE MAINTENANCE TECHNICIAN.

4. WHAT TO DO IF A FAULT OCCURS.

Do the following:

First, identify the symptoms of the fault by finding out if:

- (a) The refrigerator is too warm (above 8°C.) and the compressor is NOT running. You may determine if the compressor is running by;
 - listening for the motor noise from the compressor,
 - or
 - touching the compressor to see if it is vibrating,
 - or
 - touching the compressor to see if it is warm..
- (b) The refrigerator is too warm (above 8°C.) and the compressor is running at times.
- (c) The refrigerator is too cold.

Next, do the CHECKS and ACTIONS which correspond with the symptoms of the fault you have found out above. These CHECKS and ACTIONS are explained in the page of this manual. It is IMPORTANT that:

- (a) You be sure your choice of symptom is correct.
- (b) You always start with the first step listed on each page and proceed in order through all the steps.
- (c) If, after doing ALL the CHECKS and ACTIONS, the refrigerator is still not working properly, you start at the beginning and check everything again.
- (d) If, after checking all the faults twice, the refrigerator is still not working properly, you move the vaccine into another refrigerator or a cold box and call the technician immediately.
- (e) You note in the DAILY RECORD SHEET the CHECKS you made and the ACTIONS taken. This will help the solar fridge technician to identify the fault with your refrigerator.

4.1 The refrigerator is too warm (above 8°C.) and the compressor is NOT running

- (a) Check that it is switched ON. If not, then switch it ON.
- (b) Do ALL the user maintenance tasks defined in Section 3 of this manual.
- (c) Check that the thermostat setting has NOT been changed if the model fitted to your refrigerator can be adjusted. Reset it at the initial position.
- (d) Check that the fuse has not blown. If it has, replace it. If the fuse blows for a second time call the solar fridge technician.

4.2 The Refrigerator is too warm (above 8°C.) and the compressor is running at times.

- (a) Do ALL the user maintenance tasks defined in Section 3 of this manual.
- (b) Check that the thermostat setting has NOT been changed if the model fitted to your refrigerator can be adjusted.

Reset it at the initial position.
- (c) If the refrigerator compartment temperature is still more than 8°C., call the solar refrigeration technician.

4.3 The refrigerator is too cold.

Remember: NEVER FREEZE VACCINE. If the refrigerator is too cold and the vaccine is in danger of being frozen remove the vaccine to another refrigerator or cold box until the refrigerator temperature is again above 0°C.

- (a) Some refrigerators have a removable separator between the freezer compartment and the refrigerator compartment. If this has been removed, incorrectly positioned, or is partly broken, replace or repair it.
- (b) Check that the thermostat setting has NOT been changed if the setting of thermostat fitted to your refrigerator can be adjusted.

Reset it at the initial position. It will take some time for the temperature to rise, but if after 1 hour the temperature has not risen noticeably, transfer the vaccine to another refrigerator or cold box and call the solar refrigerator technician.