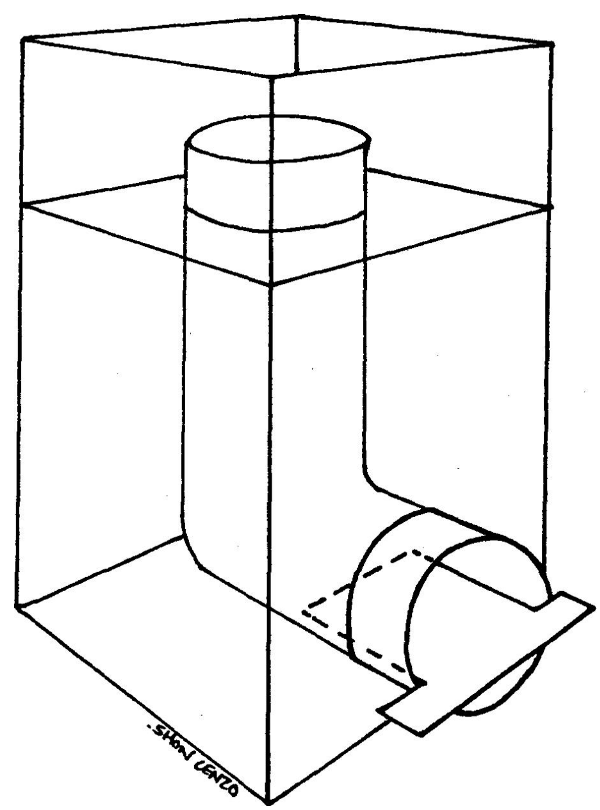
The Winiarski Rocket Stove (Estufa Rocky)

One pound of dry wood releases about 8,600 btu's of energy when burned. Gasoline is only about twice as concentrated. It took a long time for the tree to grow. The daily amount of sunlight was captured and changed into chemical energy. In fact, trees are very much like batteries, storing energy. Wood is like a battery that has been storing energy for decades. The energy is concentrated and ready for use at any rate, depending on need. Also, this "battery" does not lose its charge while sitting, cannot spill acid on your pants, and usually smells good!

Burning wood or any biomass also has a great advantage over burning petroleum products. Trees absorb carbon dioxide while growing and release the same amount when burned. The tree reduces the amount of C02 in the atmosphere and then replaces it. Burning fossil fuels, made from plants millions of years old, can only increase the amount of atmospheric C02, since absorption done by the plants happened so long ago. Burning biomass does not increase the amount of C02 in the atmosphere in the same way that burning petroleum can.

The 54" in diameter conical concentrator focuses about 10 square feet of sunlight at the pot. Each square foot of earth receives between 200 to 300 btu's per hour on a sunny day. So, the conical cooker delivers about two to three thousand btu's per hour to the pot. That's approximately equal to the amount of energy that's held in a small bit of 2 by 4 lumber only four inches long! The wood is very concentrated and we can burn it as quickly as we want. Direct solar energy is available **at a fixed rate and can disappear behind clouds. If you've got it, wood is a powerful, convenient source of fuel.**

By using wood efficiently, people can cook food using branches and twigs instead of split logs. Gathering fallen branches can bring people firewood without killing the trees, if the rate of use matches the resource. The branches are already a handy size so people can be spared the labor of splitting logs as well. The trees continue to grow while people cook with wood.



The low mass rocket stove.

Dr. Larry Winiarski's low mass Rocket stove has proven itself to be the most efficient cooking stove that we have used so far. It is far more efficient than high mass cooking stoves like the Lorena. We use Rocket type stoves now to cook, bake, heat water, warm houses, etc.

The Rocket stoves are based on an ingenious combination of principles:

The combustion chamber is insulated in order to keep the fire hot (above 1,100 F.) to burn the wood more completely, reducing smoke which is uncombusted fuel.

The cooking stoves are low mass, robbing less heat from the pot.

An insulated chimney creates a very strong draft which helps the wood to burn fiercely. It also makes the stove easier to light and to use. An insulated chimney has significantly more draft than an uninsulated chimney.

The wood is burned at the tips and is shoved in towards the fire which controls the rate of burn, reducing smoke.

The air/fuel mixture is regulated. A small opening is provided for incoming air. Too much air just cools the fire.

The incoming air is preheated, especially in a downdraft stove, which helps to keep the fire above 1,100 F. for complete combustion.

A skirt surrounds the pot on all sides. A small gap between the skirt and the pot allows hot flue gases to rise up near the pot, greatly increasing heat transfer. The flame hits the sides of the pot as well as the bottom.

An insulated skirt reduces heat loss.

Since the stove operates at very high temperatures, there is almost no smoke and it is possible to cook directly on top of the chimney. The flame, in contact with the pot, assures efficient heat transfer.

The "Guatamalan" Rocket stove is made up of six parts. Two of them are cut out of any five gallon metal container. This makes the external body of the stove. We've used soy sauce containers, paint buckets, etc. A short chimney (10"-12" is optimal) is made, in this example, from stove pipe. It's also possible to make the chimney from tin cans or more sturdy scrap metal. (A longer chimney will smoke less and may be preferable for that reason.)

How to Make the Stove

With a can opener or hatchet, etc. take off the lid of the can.

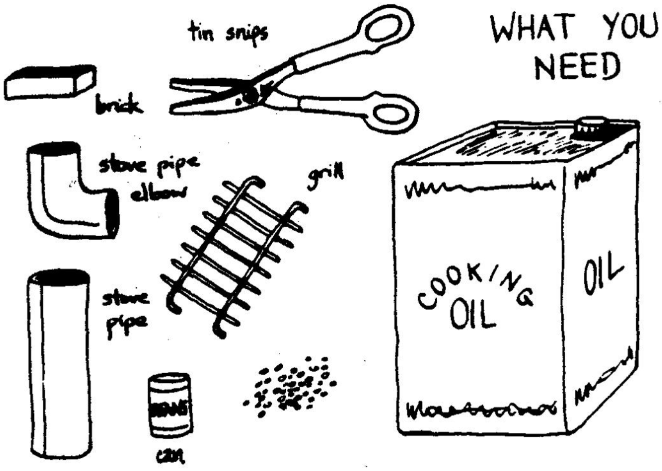
Then cut a 4" round hole in the middle of the lid and a 4" round hole in the lower front side of the can, about 1" up from the bottom of the 5 gallon can.

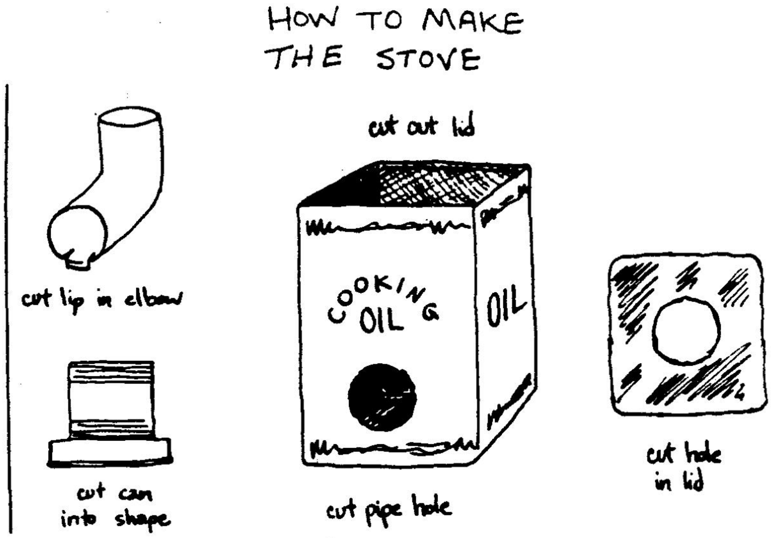
A 4" stove pipe elbow at 90 degrees is placed inside the can with the larger end protruding out the hole cut in front of the can.

Two parallel cuts, 1/2" apart, are made in this protruding section of elbow, on the lowest side of the pipe. This section is folded down, creating a lip so the elbow can't fall back into the container.

A straight section of 4" chimney pipe is then fitted to the other end of the elbow as a chimney. It is cut off 1" below the top of the can. (Remember that a short chimney is more efficient. A long chimney will keep flame from hitting the pot. Conversely, a taller chimney will produce less smoke.) The lid, with a hole in the middle, is fitted over the straight section of chimney pipe, after the space between the chimney and stove body is filled with lightweight insulation.

Insulation is small trapped pockets of air. It is this air that slows down heat transfer. Sand, brick, earth, cement, etc. do not contain many





The "Rocket" Cooking Stove

The "Rocket" stoves are based on the following combination of principles:

INSULATE AROUND THE FIRE:
A HOT FIRE WILL BURN MORE OF THE COMBUSTIBLE GASES RELEASED FROM THE WOOD

INSULATE AROUND THE CHIMNEY:
CREATES MORE DRAFT WHICH HELPS THE WOOD BURN FIERCELY AND KEEPS THE FIRE GOING

DON'T USE HIGH MASS MATERIALS:
HIGH MASS MATERIALS ROB HEAT FROM THE FIRE. WE WANT THE HEAT TO GO INTO THE FOOD, NOT INTO THE STOVE.

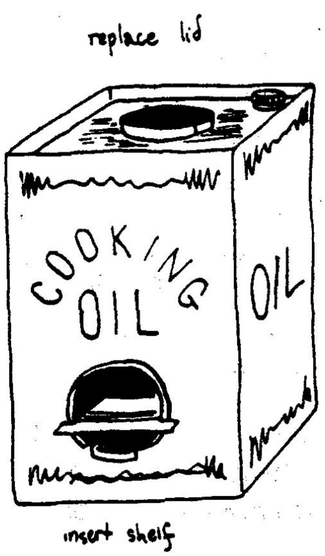
BURN THE WOOD AT THE TIP:
LESSENS THE SMOKE. SMOKE IS UNCOMBUSTED FUEL.

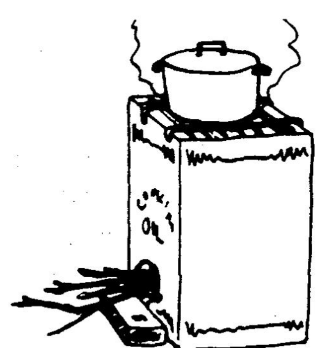
PREHEAT THE AIR/REGULATE THE AIR AND FUEL MIXTURE
TOO MUCH AIR ONLY COOLS THE FIRE.

MAKE A SKIRT AROUND THE POT:
ALLOWS THE HEAT TO CONTACT THE SIDES AS WELL AS THE BOTTOM OF THE POT. WITH A COVER IT'S EVEN MORE EFFICIENT

COOK ON TOP OF THE CHIMNEY:
SINCE "ROCKET" STOVES BURN MOST OF THE SMOKE, COOKING ON TOP OF THE CHIMNEY IS POSSIBLE

The fire chamber and chimney can be made out of tin cans, if desired. The tin cans will last about three months. The cans can be covered by as thin as possible a covering of clay/sand/straw mixture which will become a fired chimney.





trapped pockets of air and are poor insulators

Examples of good insulation include: pumice rock, vermiculite, perlite, wood ash, dead coral and aluminum foil, if it traps air.

Usually, we use wood ash. As long as it stays dry, wood ash is a great insulator and it is found near fires.

To finish the stove make a pot support, similar to a grill, out of heavy gauge fencing or wire and place it on top of the container. Alternatively, it's possible to rest the pot on top of the container itself. In this case, it's necessary to cut large holes in the top of the container so the air can flow unimpeded past the bottom of the pot. These holes should have the same cross sectional area as the chimney and firebox, in this case 4" in diameter.

Then, make the flat shelf that fits inside the fire chamber and helps to separate the sticks. The shelf can be made out of a flattened tin can and slides into the combustion chamber. The stove will be much more efficient if used with a skirt around the pot. The skirt is simply a sheet of metal that is as high as the pot. The skirt surrounds the pot, leaving an even gap of about 1/4" between the skirt and the pot, so the hot flue gases are directed to contact the pot sides. The skirt gap is equal to the cross sectional area of the chimney. An insulated skirt is double walled with insulation between the walls.

We use the Rocket stove at Aprovecho and we recommend it. It's much easier to use than an open fire and uses less firewood. Please let us know what you think of it. Help us to continue its evolution towards perfection!

Insulation and High Mass in Stoves **(and Houses)**

The Maria Telkes solar cooker gets very hot almost immediately if it's empty and aimed at the sun. But, full of beans and rice, it takes a while to reach higher temperatures. The mass of the food and water absorbs the heat initially. The old Lorena stove, which Aprovecho helped to design, is so heavy that a lot of the heat goes wastefully into the stove, instead of into the pot of food! Sand and clay and earth are not good insulators.

An earthen or cement Rocket stove takes a long time to heat a pot of water, when first started. All of the mass in the stove is "robbing" heat from the pot, where you really want the energy to go. That's why we use low mass insulation around the fire in our current designs.

With low mass insulation the heat can do its job with less waste. The small isolated pockets of air in the insulation do not absorb much heat, and heat passes very slowly through insulation. Sand, clay, earth, etc. do not insulate well because they do not contain many isolated pockets of air.

Remember it's the air in a material mat creates the insulation. The function of the material around the air is only to separate the air pockets. Usually the more the material weighs, the more it absorbs and diverts the heat. A Rocket heating stove uses high mass, heavy materials to capture heat that would otherwise flow up out of the chimney and out of the room. The high mass sucks up heat and stores it. In a heating stove, mass can play an important role. But, in the case of a cooking stove, mass just takes heat from the pot and lowers efficiency, especially when starting the cooking process.

Mass is necessary in solar buildings to absorb and store heat from the sun. An empty room, full of air, won't store very much heat. But a cement wall will get hot enough to keep the room toasty all night long.

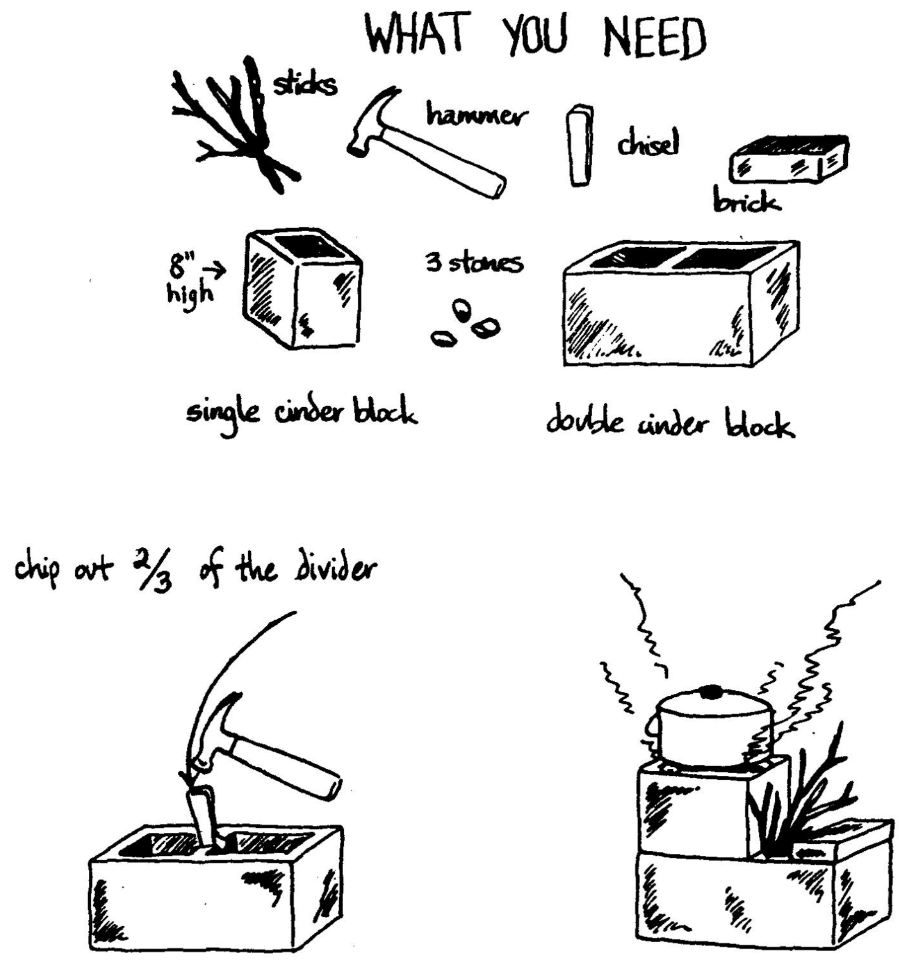
This room will stay warm for a much longer time, however, if it is insulated. In a good solar house, the mass is contained inside the building and is surrounded by insulation in the ceiling and walls. A high mass house, in which the walls are built out of earth or cement, will have troubles if it doesn't have insulation on the outside. The high mass in the walls will suck up a tremendous amount of heat and lose it to the outside.

You'd need to make an earthen wall four feet thick to equal the insulative value of 3.5 inches of fiberglass insulation (R-ll). Heat will easily pass through earthen or cement walls, and it will take a lot of energy to heat the house.

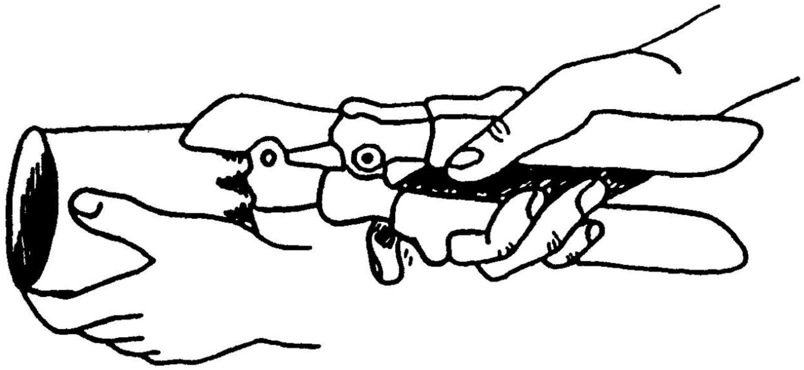
For this reason, the best adobe houses had double walls. The air space between the walls acted as insulation which blocked the flow of the heat from the inside to the outside. If a high mass house has external insulation, the heat that has been trapped in the interior mass will be contained. But without insulation, not only will it take a very long time to heat up the mass, but the heat will only be wastefully dissipated to the outside.

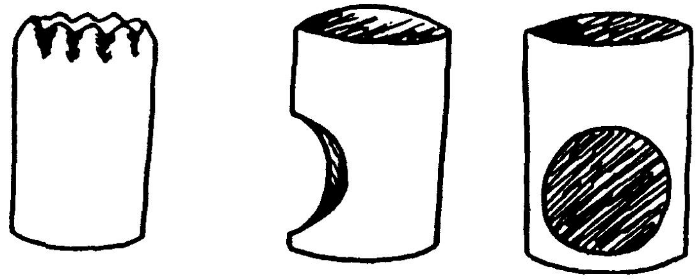
Of course, adobe houses in hot climates did not really need double walls. The major need in the desert was for cooling, and the mass helped in this regard. Uninsulated, shaded, high mass walls will stay at the day's average temperature. In the desert, the average temperature can be quite pleasant. But, in a cold cloudy climate, the average temperature is too low for comfort. An uninsulated, earthen-walled house in that type of climate ends up refrigerating its occupants.

High mass houses have also been buried underground. The benefit is that the house, in contact with the earth, will stay at the temperature of the earth, which is about 58 degrees F. However, this house too, if it doesn't have exterior insulation, will require heroic efforts to raise the interior temperature. Without insulation, the heat will, in effect, be trying to raise the temperature of the entire Earth.

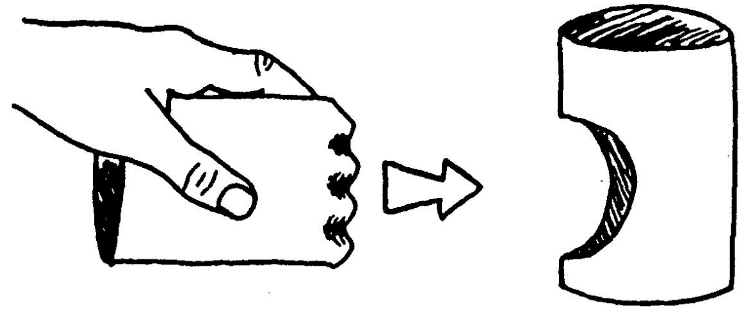


A rocket stove built from cement blocks: The stove can be placed inside of any kind of a form. Insulation can then fill the space between the stove and container, which helps the stove to burn hotter and smoke less.

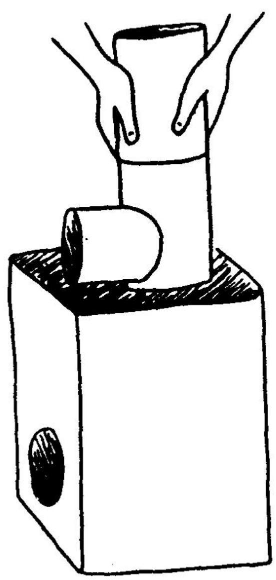




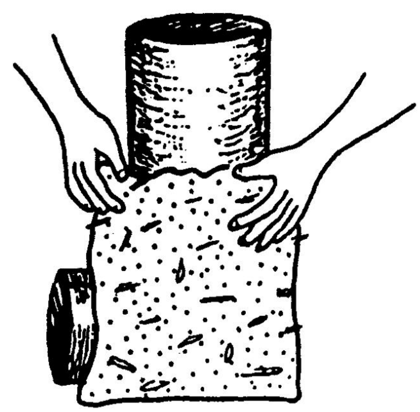
CRIMPING THE TIN CAN



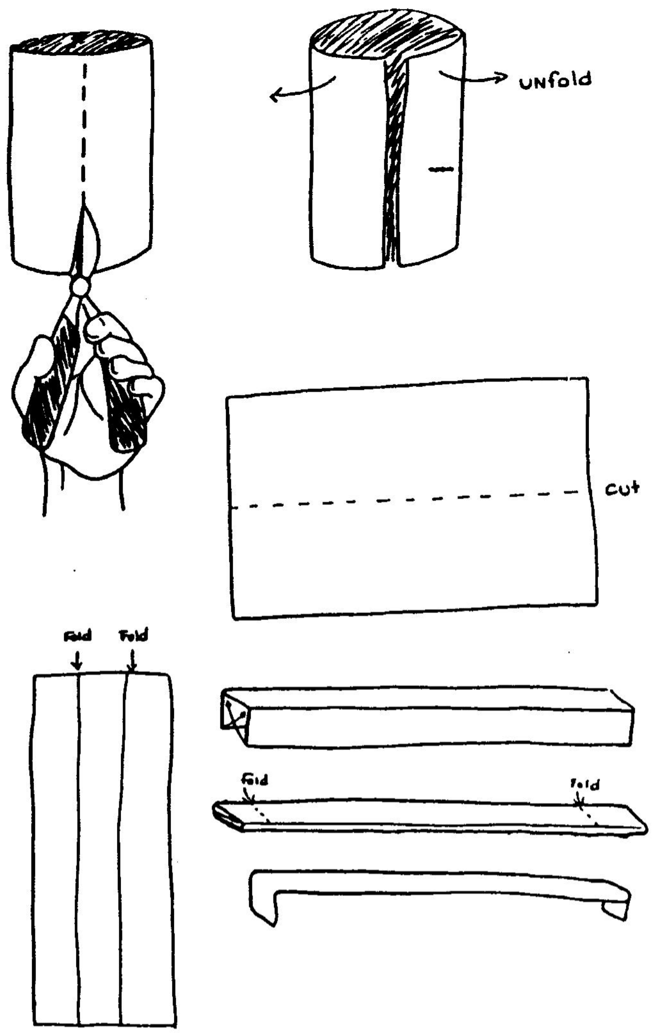
MAKING THE FIREBOX AND CHIMNEY

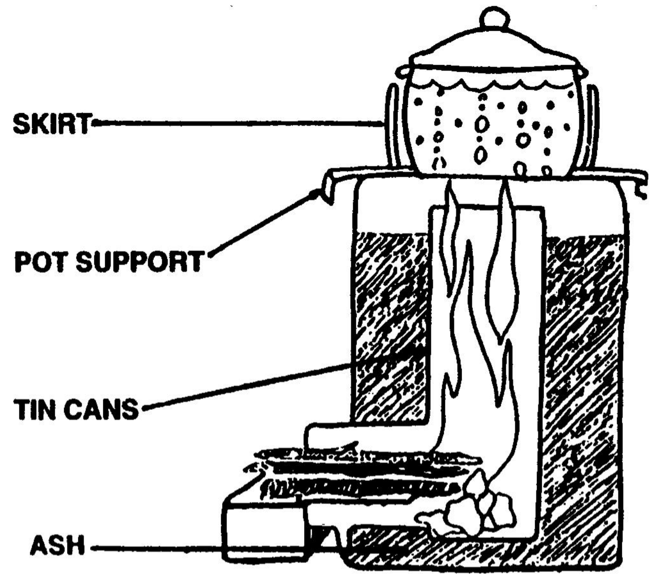


INSERTING THE FIREBOX AND CHIMNEY INTO THE EXTERNAL BODY OF THE STOVE



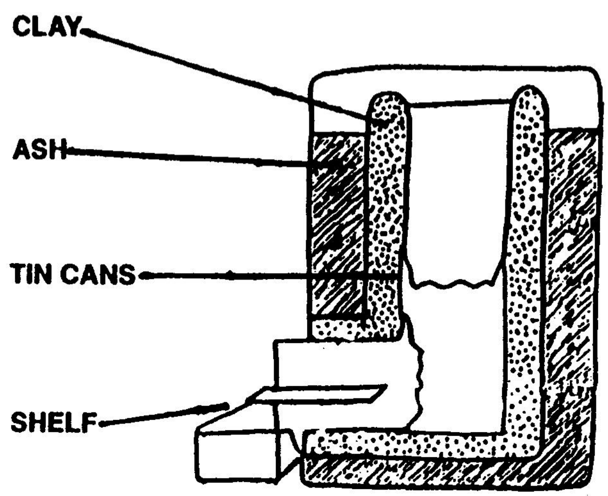
OPTIONAL USE OF CLAY/SAND





STOVE WITH POT SUPPORT AND SKIRT

MAKING THE POT SUPPORT



THE STOVE WITH CLAY/SAND AROUND THE TIN CANS

Mass and insulation, when combined, make for a perfectly lovely, easily heated solar home, or an effective stove. However, when mass is wrongly used, or is thought to be like insulation, mistakes in construction are made. An understanding of these two factors can help us all in our search for a bountiful, not sparse, simplicity.

Concerning Stove Efficiency

When Dr. Winiarski and I first walked around San Nicolas, the ranch in Mexico where I have a house, he surprised me by saying that the Rocket stove wouldn't save a tremendous amount of firewood. He saw how well the ranchers made fires and thought that a fuel efficient stove would save only 30% to 40% more firewood.

When people are careful and expert, the indoor open fire (or three stone fire, as it's sometimes called) is a relatively efficient cooking method.

Traditional methods can work very well. In fact, the indoor, open fire can be more efficient than higher mass, supposedly fuel efficient stoves. Of course, this probably plays a part in the cultural resistance to new methods of cooking. The introduced methods are not necessarily superior in every way.

God made fire, people made pots. The trick in improving efficiency is not so much to improve the efficiency of combustion, but to improve the transfer of heat into the pot. The skirt around the pot is very important. The stove body keeps wind away from the fire, keeping the fire hot enough for more complete combustion to occur. The stove "forces" users to feed wood more slowly, to make better fires. It can be tempting to build an overly large open fire, since a large fire won't go out as easily.

Fuel efficient stoves can save a lot of fuel compared to open fires outside in the wind. They can play a very important part in decreasing the need for large amounts of firewood for cooking.

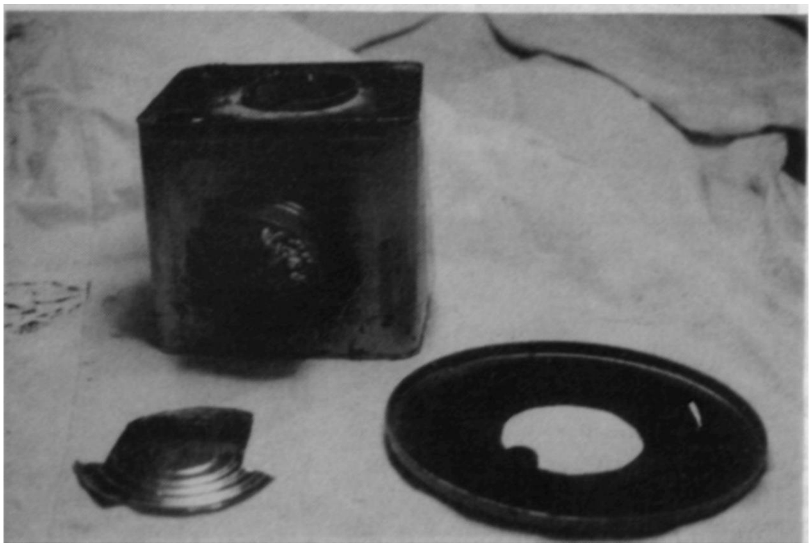
However, an indoor, open fire is not necessarily an inefficient cooking method. It takes a low mass stove with a skirt to improve upon it. A high mass stove can easily use more fuel than a simple indoor fire, especially when the stove isn't in constant use, which is frequently the case. It really all depends on how carefully people make fires.

How to Make a Rocket Stove with Tin Cans

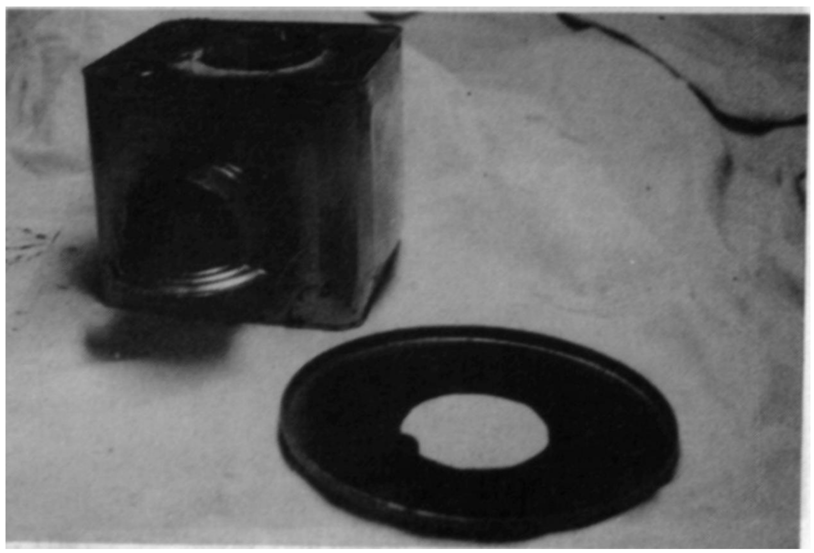
In many countries around the world it is advantageous to use tin cans to make a chimney. Tin cans are often available when there is no other chimney material. The cans will burn out in about a month. However, it's possible to replace the cans rather easily. (Of course, it's always possible to make a fired clay chimney and firebox, that will last much longer.)

You'll notice from the diagram that it is possible to cover the chimney with a mixture of clay and sand (60% sand mixed with 40% clay works well). When the tin can chimney burns out, the sand /clay chimney takes its place. The ash insulation, of course, is still used between the outside of the clay/sand chimney and the metal stove body.

In Zaire, many Rocket stoves were built for and by Rwandan refugees using the containers that had held relief supplies. The container was cut up to make the chimney and firebox. Pumice rock or wood ash filled the interior of the stove between the external body of the stove and the chimney. It is even possible to make the external stove body out of sand and clay as long as insulation surrounds the internal chimney. A chimney really helps to burn up smoke, to keep the fire going, and to direct flame at the pot.



The stove body, shelf, and skirt support.



The shelf is inserted into the firebox.

The skirt support rests on top of the stove body. The skirt is also shown.

Three pot supports an inch long sit on the skirt support.

The pot rests on the pot supports.

The skirt directs the heat around the pot.