CONSTRUCTION AND OPERATION OF A CHARCOAL OVEN*

By CALIXTO MABESA
College of Forestry
University of the Philippines

INTRODUCTION

Wood charcoal is a carbonized organic material in demand for ironing clothes, especially in localities where electricity is not available or where its price is high, and for cooking. It has the advantage over firewood in that the former emits no smoke. Industrially it is used as a filtering material, and certain grades are used for smelting iron ores, others are used by blacksmith and in the manufacture of steel. This paper, however, explains the construction and operation of an earthen oven for the manufacture of charcoal on commercial scale. This construction is a modification of a Japanese oven, with the advantage of shorter time in the drying of the dome. Ordinarily, the time required to dry a Japanese oven from the time it is finished to the time of firing, is about three months. But this modified oven may take from four to five weeks only. The writer had actually constructed one which dried in twenty-five days.

LOCATION OF CHARCOAL OVEN

It is easier to transport charcoal than green wood; hence, the choice of the location of the oven should be given first consideration. The oven should be accessible to raw materials, that is, the raw materials should be as near the oven as possible. Likewise, the oven should be readily accessible to the means of transportation to facilitate the marketing of the charcoal. Another factor which should govern the location is the availability of water supply. It is preferable to locate an oven where water is always available.

In case of highland species, the topography of the country from which the billets will be removed should be taken into account. It should be so located that the transportation of the billets would always be downhill. It is less difficult to transport charcoal than green billets uphill.

If the oven is to be built in a mangrove swamp, it is advisable to locate it along the bank of a navigable river, where the ground is high, and there is abundance of raw materials. Thus, the easy transportation of the raw materials as well as the finished products will be assured. The billets are stacked near some tributaries when the tide is low and are loaded in dugout or bancas and transported to the oven when the tide is high.

MATERIALS FOR CONSTRUCTION AND THEIR PREPARATION

Stones and clay are used to build the walls of the oven. Ordinary clay with low shrinkage upon drying is commonly used. The clay is prepared into balls of five to six inches in diameter. The number of these balls may vary with the size of the oven. An oven (egg-shape), 10 feet at its widest point 16 feet from the back of the

* This work was conducted when the writer was Wood Technologist, Bureau of Forestry.

entrance (inside measurements), and 6-1/2 feet at highest part of the dome will need from 1,500 to 2,000 balls (3 to 4 cubic meters) of clay.

Preparation of earthen materials. — These balls are placed in a circular stacked pile of firewood, with open center (figs. 1 and 2). The first layer of earth ball is placed when the firewood has been piled about two feet above the ground (fig. 3). Over the first layer of earth balls, firewood billets tier of earth balls is placed. The last tier of earth balls is topped with firewood billets of about the same thickness as the preceding ones. Fire is then started at different places around the circular stacked pile. If fire is started early in the morning the earth balls will be baked the following morning. Two or three days after, the burnt earth is ready for pounding. After pounding it is screened through an 8-mesh wire. The screening should be used for building up the wall. A part of the pounded burnt clay should be screened through a 16-mesh wire. This one will be used for the dome of the oven. About two-thirds of the burnt clay will be needed for the dome.

LAYOUT

The oven should be located on a rising ground. A slope of 15 to 20 degrees is preferable. The opening should be toward the prevailing wind. In case the location is along the river banks, the oven should be constructed on high ground where it could not be flooded.

As soon as the location is decided and the size determined, the stakes are placed. The first step in staking, of a size, say sixteen feet long and ten feet at the widest distance, is to locate the center of a semicircle which forms the rear portion of the oven. With a radius of six feet (one foot extra for thickness of the wall if the ground is not adobe) describe a semicircle and drive stakes at convenient distances along it. The line of the length should pass at the center of the semicircle dividing it into two equal parts. From each end of the arc, stakes are driven in a straight line converging towards the end so that the distance between the lines of stakes at the end of the oval is slightly over five feet (fig. 4).

CONSTRUCTION

Shed. — As soon as the stakes are driven, indicating the ground plan, a shed should be built over it. The width should extend two feet beyond each side of the proposed oven and the same distance from the rear. In front, the eaves should extend five or six feet from the entrance in order to give enough space for workers and protection for the unloaded charcoals in case it rains. The height of the roof from the highest part of the oven may be from 5 to 6 feet. In case a battery of ovens is to be set up, the width of the shed should be increased accordingly. The spacing between individual ovens may be three feet apart at its widest point depending upon the kind of soil and the topography of the ground. A battery of ovens is usually used in the mangrove swamps. In the highland species, the common practice, because of the topography of the ground, is to build one oven where all the billets can be carried down without much expense in transportation.

Excavation. — When the roof is up, digging and removing of the earth should be done until the floor is on level with the proposed entrance. If there is seepage of water, it is a good practice to have the floor inclined, say, with 8 inches drop towards the rear of the oven so that the entire floor inclines inward from the entrance. The idea is to let all the seepage water collect and drain in the small canal at the base of the wall, to the rear and where the drainage pipe terminates. This drainage pipe is usually made of anahaw from which the pith has been removed. It should be buried at least a foot and a half

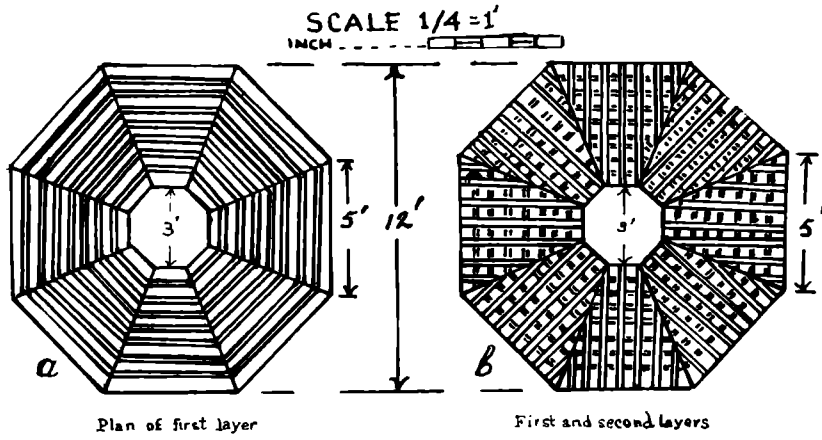


FIG. 1

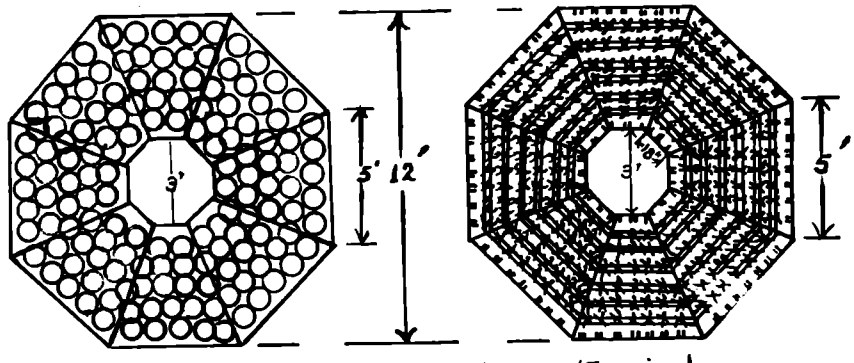


FIG. 2

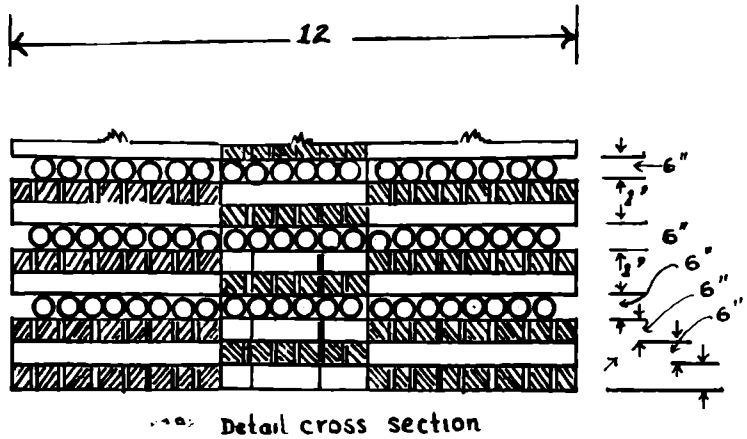


FIG. 3

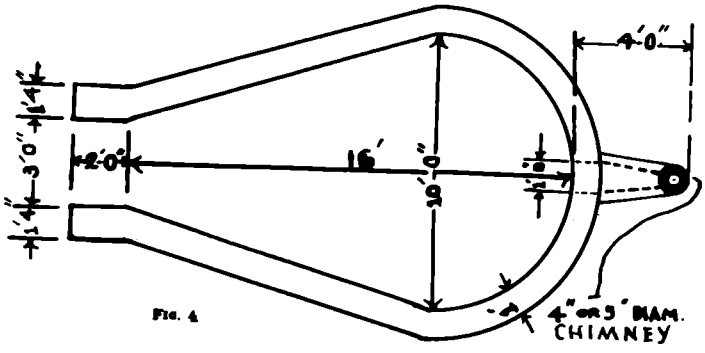
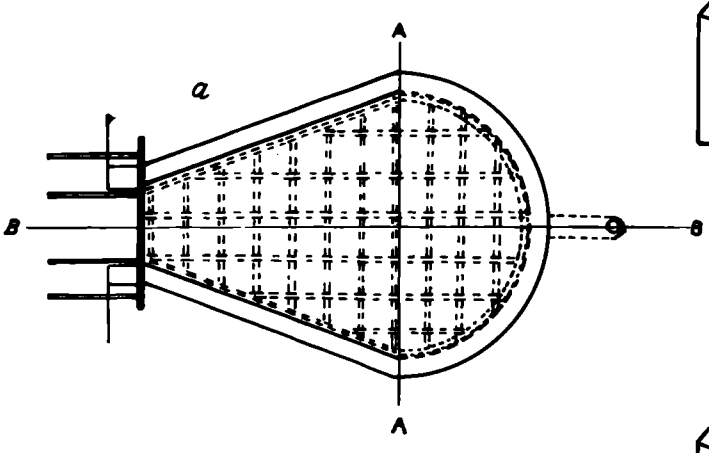
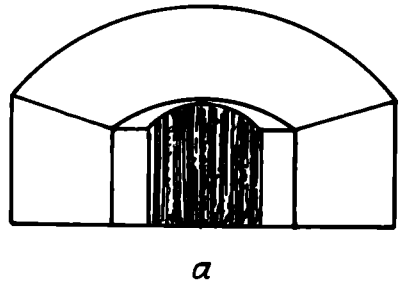
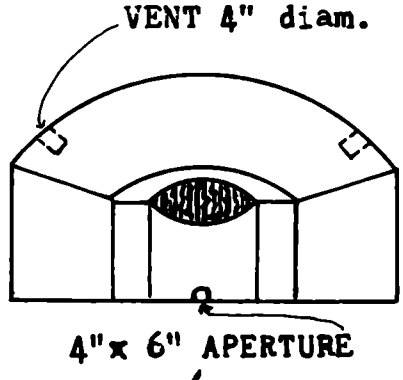


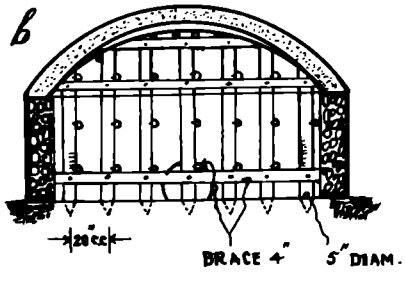
Fig. 4

GROUND PLAN

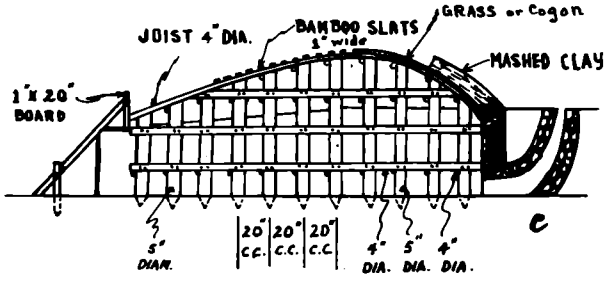








SECTION A-A



SECTION B-B

FIG. 5

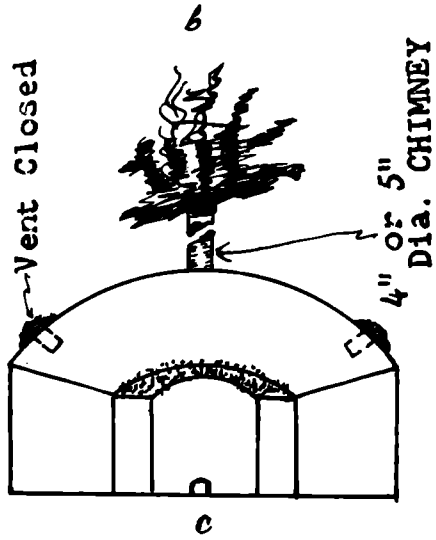


Fig. 6. Different steps in firing an oven

from the surface of the floor with inclination towards the outside usually passing beneath the entrance and extending out beyond where it would not interfere with the loading and unloading of the oven. The footing of the wall is one foot deep and one foot wide.

The chimney is located about 3 to 4 feet from the outer edge of the wall and should lie within the middle of the oven along the line of its length (fig. 4). It should have about a foot in diameter and gradually become smaller towards the top so that at the level of the wall, its inside diameter should be between 4 and 5 inches.

WALL

For building the wall, a 50-50 mixture of 8-mesh screening and raw clay added with water is prepared by stepping and shoveling until a thorough mixture is obtained. The water used should just be enough to wet the mixture. A good indication that enough water has been used is shown by the fact that when the mixture is heaped, its base has no tendency to spread. When the mixture is ready, stones are placed along the footing, say, at a foot interval. The prepared mixture is then placed until this first layer of stones is totally covered. Another layer of stones is again placed over, then covered with mixture. This process is continued until the right height of the wall is obtained. It should be borne in mind that none of these should be exposed along the inner side. A layer of a least 2-3 inches thick of the mixture should cover the stones. In order to have the wall at the rear almost in perfect semi-circle, it is a good practice to drive a cylindrical stick, say 1/2 inch in diameter, at the center of the arc. With this as center, get another stick, 5 feet long and describe a semi-circle at the different heights of the wall. This will help indicate protrusions or depressions along the height of the wall which should be filled or smoothed out.

The wall should be 4 feet high from the ground floor all along the arc of the oval while from each end of the arc to the entrance, the height should gradually decrease from four to three feet. The best way to determine the various heights of the wall to be constructed on the legs of the oval is to have a string tied, 3 feet high from the end of the leg at the entrance, and four feet high at the end of the arc. The wall is then built up to the string. When the wall is finished, the entrance would be three feet wide, the wall on each side being a foot thick. Wall extensions, 2 feet long from the entrance should be built having the same height as that of the entrance and 3 feet apart from its inner sides.

If the soil where the oven is constructed is either sticky clay or adobe, the building of the walls may be dispensed with. In the former case, the clay should be tamped daily for several days or until it dries up to make it more compact and to reduce the danger of cracking. The disadvantage of this, however, is that the wall may crack and crumble little by little subsequently after several operations which necessitate "repairing" every time the oven is unloaded. In the latter case, the adobe will not crack and crumble if it is a type that has not started disintegration.

The Dome.—The highest point of the dome is usually 62-1/2 per cent more than the height of the wall. For example, if the wall is 4 feet, the highest point of the dome from the ground floor will be 4 x 1.625 or 6.5 feet. This is usually about 6 feet from the back of the oven. With this point determined, the posts are placed in rows, one at the center and two rows on each side of the middle. The interval between posts on center, which are 4 to 5 inches in diameter of wood that are also to be used for charcoal, is usually twenty inches to two feet when using 3-4 inches crossers or beams. The beams should be nailed flushed with tops of the posts and cut so that the required curvature of the dome is followed.

This curvature may be determined by using bamboo splints bearing in mind that the shape of the dome resembles that of an egg on a larger scale. The height of the dome at the entrance is 4 feet from the ground. As soon as the beams are nailed to the posts, thick bamboo splints about one and one-half inches wide are nailed or tied across the beams, the spacing between splints being approximately one inch. When the splints are all placed over the dome a layer of cogon grass is spread over the dome (fig. 5). The purpose of this is to smooth the upper surface of the form. Then a thoroughly wet mixture of 95 per cent parts powdered burnt earth of 16-mesh screening and 5 parts unburnt clay are placed on the dome. When wood ash is available, the following proportion may also be used: 80 parts burnt powdered clay, 10 parts shifted wood ash, and 10 parts unburnt clay. The thickness of the dome varies at the different portions, being eight inches near the base and decreasing gradually to four inches at the top of the dome. At the entrance is placed 1-inch board about 20 inches wide and long enough so that when the mixture is placed on the dome at this portion it would prevent it (mixture) from falling. While the mixture is being placed it should be tamped to prevent any honeycombing. After the placing of the mixture, shifted wood ashes should be sprinkled uniformly. When the dome begins to harden, tamping should be stopped. In the meantime, fire should be built underneath the dome to hasten the drying of both wall and dome, care being taken that the form does not catch fire. It has been found that the charcoal instead of ordinary wood is much safer to use especially when the drying is under the care of inexperienced laborer. Every morning until it is dry the wall should be tamped before placing the fire. Any crack should be mended only after the wall is dry. Tamping of the mended portions is necessary immediately after mending. The ember should be evenly distributed underneath the dome and along the wall. In this way the wall as well as the dome becomes dry after four weeks' to a month's time.

Operation. — When the dome is dry, vents, one on each side and one at the rear (fig. 6), are made down to the form. The diameter of each orifice is about 4 inches. Then the billets are placed vertically inside until the whole oven is filled. The entrance then is covered with the same mixture as that of the wall, together with some stones until it is on the level with the height of the wall, but leaving an opening of 4" x 6" below, i.e., 4 inches wide and 6 inches high, the upper position of the opening being an arc. This is the entrance of the air during the burning (fig. 6, b). The fire is built at the upper opening. When it has worked its way inside and to the bottom of the opening as seen from the lower aperture, then the upper opening is ready to be closed, i.e., it is closed with the same mixture as that used at the lower part of the entrance, but without stone until the whole opening is entirely closed, so that the air enters only at the bottom aperture (fig. 6, c). In the meantime, the form at the bottom of the side openings as well as at those of the rear should be punctured with red hot iron so that the smoke can come out as soon as the fire has started. A tube about four feet high, 4 to 5 inches inside diameter, usually of iron, is placed over the opening for the chimney. When the dome becomes warm, the side openings should be closed. Like-wise, the rear one is to be closed when the fire has extended towards the rear end of the dome (fig. 6, c).

The burning may extend to the seventh day after the fire has started, if there is no trouble, at which time the smoke coming out from the chimney becomes bluish white and thin. When this stage of burning is reached, it is about time to plug all the openings. Remove the chimney and plug the opening, too, with the same mixture as

that used at the entrance, and also the aperture beneath the entrance.

All places where air is likely to leak through should be covered with a coating of a thick mixture of ash and water. After six or seven days, the dome is ready to be opened when it is slightly warm to the touch. If after this period, the dome is distinctly warm, it is likely that there are air-leaks and should be located and covered thickly with the ash and water mixture.

When the charcoal content of the oven is ready to be discharged, it is safe to have ready water, say, two five-gallon cans. The plug of the entrance is torn open beginning at the top downward, till the entire entrance is cleared. If the fire is out the discharging can proceed; usually it takes a day. But if burning embers are present it should be put out before discharging by pouring water. The fire develops fast when the entrance is clear open and may get out of control, in which case the charcoal may all turn into ashes.

After discharging the charcoal the floor of the oven is cleared of ashes and small pieces of charcoal. Any mending should be done after cleaning so that the following day the oven is ready to be loaded. Loading may be done by 5 men, 3 inside arranging the billets vertically and 2 men handling the billets inside. If the loading is started early in the morning, by evening it may be over, if the men are experienced; otherwise, it may take two days. It is a common practice to detail two of the men to prepare the mixture for plugging the entrance when the oven is nearly full, while the other three continue to load till it is full. Before the day is over the entrance is plugged to the height of the wall, ready to be fired the following day.

Cost. — The cost of building an oven of the size mentioned will vary with different localities, the proximity of the materials needed being an important determining factor.

Firewood:

1. Twenty-five cubic meters of firewood for burning the clay at ₱6 per cubic meter ..... ₱150.00
2. Ten men at ₱3 a day for 1 day to build up firewood pile for burning clay ..... ₱ 30.00

Clay:

1. Gathering of earth 8 cubic meters at ₱6 per cubic meter .....₱ 48.00
2. Balling 4 cubic meters and setting them in a pile of wood by 14 men at ₱3 a day .... ₱ 42.00

Other operation:

1. Setting fire by 4 men at ₱3 .. ₱ 12.00
2. Excavating the ground for the men by 5 men, 2 days at ₱3 a day ..... ₱ 30.00
3. Pounding and screening the burned earth at ₱10 a drum, for 18 drums of 53 gallons .. ₱180.00
4. Collection of stones for the sides, diameter not more than 12", 3 cubic meters at ₱15 ..₱ 45.00
5. Cost of construction of the wall, 10 men at ₱3 per day for 3 days .....₱ 90.00
6. Cost of collection of materials for the form of the dome and construction of same (Bamboo, wooden posts, girts and nails) .....₱120.00
7. Cost of placing the dome, 8 men at ₱3 .....₱ 24.00
8. Cost of tamping the dome, 1 man at ₱3 per day for 6 days ₱ 18.00
9. Cost of tamping the inside wall and firing underneath, 2 men at ₱3 a day for 28 days .....₱168.00
10. Loading, 5 men for 2 days at ₱3 per day .....₱ 30.00
11. Firing, 2 men for 1 day at ₱3 per day .....₱ 6.00
12. One man to watch firing at ₱3 a day for 6 days .....₱ 18.00

Total expenses .....₱1,011.00