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Drying Equipment for Cereal Grains & Other  
Agricultural Produce

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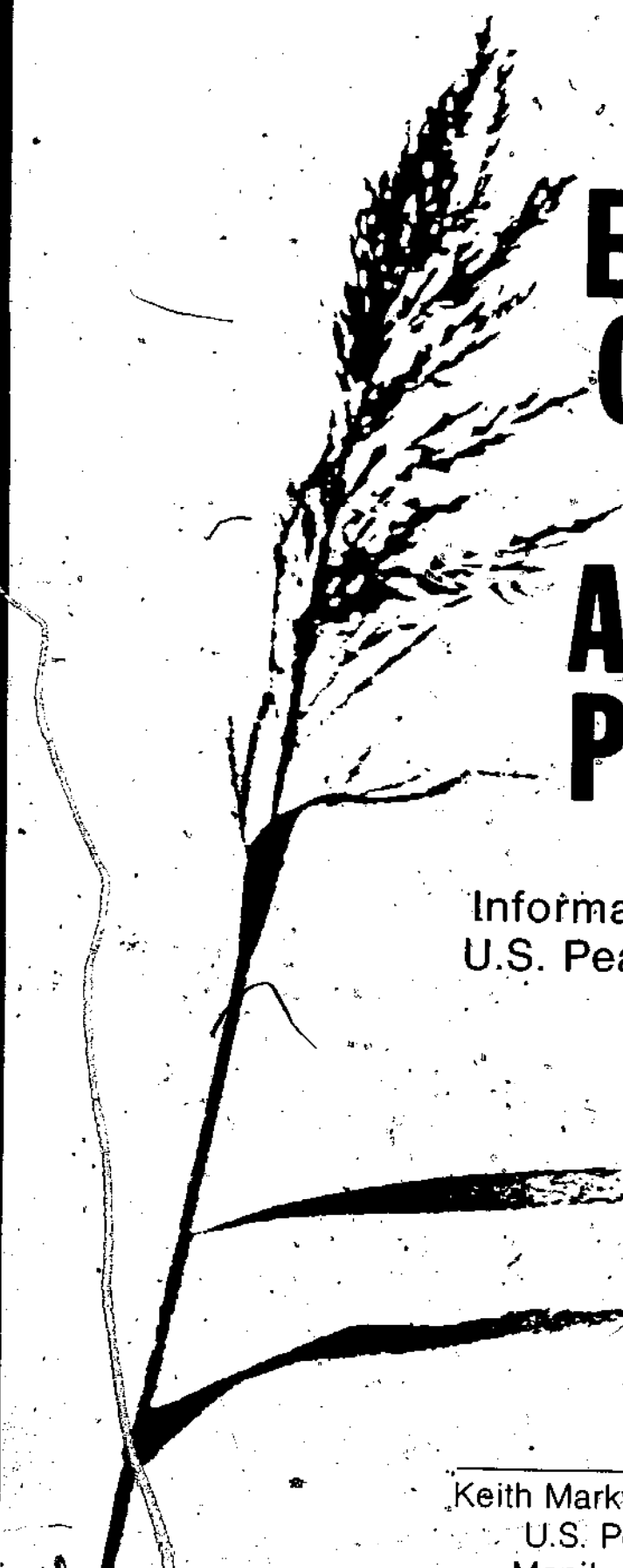
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# Drying Equipment for Cereal Grains and Other Agricultural Produce

Information and Illustrations  
U.S. Peace Corps-Philippines

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Keith Markwardt, Volunteer  
U.S. Peace Corps  
Manila, Philippines

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# CREDITS

The information in this booklet is adapted from projects completed by PCV Keith Markwardt during his two year service in the Bicol Region, Philippines.

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# INTRODUCTION

## A. Background

Grain-drying in the Philippines has traditionally followed the simple practice of spreading newly harvested produce on mats or concreted areas where the sun can draw out excess moisture. For decades, producers and traders have relied on this method and year after year they have accepted the losses that are inevitable. When the produce is spread out in this manner, it is susceptible to losses caused by sudden rains, wind squalls, birds and rodents, infestation, and thru handling spillage. On the national average, 15 to 20 percent of all grain produced is lost or destroyed before it is placed on the family table. In certain regions, the harvest season coincides with the months of nearly continuous rainfall. In these areas losses incurred can be phenomenal—40 percent or more. Such heavy losses certainly cannot be sustained by countries where population growth is greater than the growth of available staple commodities. Of course, the lack of drying facilities is not the only cause of these losses: every stage of harvest and post harvest processing contributes to the total loss; drying however is usually the prime cause.

## B. Daily Capacity

The flat bed dryer is most practical when constructed to hold 40 to 60 cavans of grain rice per batch; however, a smaller or somewhat greater holding capability could conceivably be used. When designed to allow for continuous operation, the dryer can easily complete two drying cycles, or batches, in one day. The drying time for each batch will depend primarily on two variables; first, the MC (moisture content) of the produce, and second, the relative humidity of the ambient air. With these two variables in mind, the drying time will usually be six to eight hours. Thus, in a 50 cavan batch drier, two batches (100 cavans) can be completely dried in 12 to 16 hours. Since daily maintenance on the various components is required, it is not practical to operate a full 24 hours. Therefore, two batches is usually the maximum amount that can be dried in one day.

## C. Annual Capacity

The annual capacity of the drier will of course depend on the number of days per year the drier is utilized. This capacity should be estimated so that expenses incurred on an annual basis can be computed into a cost per cavan rate. A common example can be illustrated as follows:

The drier is located in a rice producing area which has, on an annual basis, two harvest seasons. The length of each season is approximately 30 days, or 60 days per year. Assuming that the drier is used at the capacity of 100 cavans per day for the entire 60 days of harvest, the annual capacity would be 6,000 cavans.



# THE COMPONENTS— ALTERNATIVES AND ADVANTAGES

## A. The Rice Hull Furnace

The rice hull furnace illustrated here was adapted for use in drying grains from the established practice of burning rice hulls in a similar type of furnace used for food preparation in restaurants. Also, several ideas for designing this furnace were derived from the work done at International Rice Research Institute (IRRI), Los Baños and from a large scale furnace used to produce steam for a steam turbine electric plant located in Tacunong, Cotabato. The use of the furnace is the instrumental factor in keeping the drying cost low enough so that the produce can be profitably dried. By referring to the cost analysis, the reader can easily discern that nearly 50 percent of the drying cost can be saved when a rice hull furnace is used in place of the more conventional kerosene burner. Some other advantages of the rice hull furnace are:

- Rice hulls are a nuisance to millers; most will be pleased to have them taken away. The hulls are lightweight, easy to handle, available year-around and in most locations. The hulls flow freely in a gravity-fed system; this provides for an easy and low cost method of fueling the furnace.

- The operation is a safe and efficient method of burning organic fuel.

- When operating, the furnace usually requires attention for only three to four minutes out of fifteen. This allows the operator to assist with bagging grain, etc.

- Constructing the furnace is reasonable in both time and capital. Furthermore, the life of the furnace should be several decades because it is made primarily of a cement and lime concrete which is resilient to heat and aging.

## B. The Petroleum Burner

The kerosene or oil burner is by far the most common unit used for drying grain, but with the ever-increasing price of these two products the use of the burner has become economically undesirable. The owners of these units are realizing that nearly one half of their operating expense can be directly attributed to 1.5 to 2.5 liters per hour of fuel used by the burner. However, the burner does offer several advantages:

- The unit is commercially available in Manila and other cities.

- The convenience of using petroleum fuel and lack of fuel ash.

- Considerably easier to control temperature. By setting the flow rate of the fuel, the operator will usually have a continuous heat within the desired range.

- The unit is portable.

## C. Blower/Engine Assembly

A variety of locally or commercially made blowers may be used. The function of the blower is to draw the heated air from the furnace or burner and force it into the plenum chamber of the drying bed. The blower must be capable of providing a constant pressure in the plenum equal to a reading of one inch displacement in a manometer connected directly to the plenum. The reading of one inch displacement is valid for palay but not necessarily with other grains as the smoothness of the seed coat and the physical size and shape of the grain will affect this reading. The most common blower is the vane-axial type. Its advantages are:

- Low cost and ease of fabrication.

- Materials are fairly common and can be located in most provinces.

- Provides a strong negative pressure to draw the air from the furnace. Also, it provides a high volume of air (30 to 40 cubic meters per minute per cubic meter grain) at a steady pressure.

Another type of blower is the centrifugal type. The centrifugal blower is

more costly to fabricate and it does not have the ability to hold a high pressure in the plenum. However, the unit does have certain advantages:

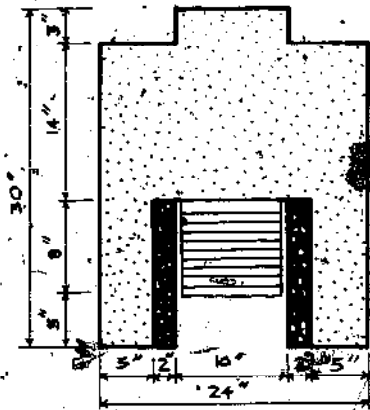
- The unit operates with little noise and vibration. When powered by electric motor the whole drying operation is surprisingly quiet.

- Requires a lower starting torque therefore a longer life for drive motor can be expected.

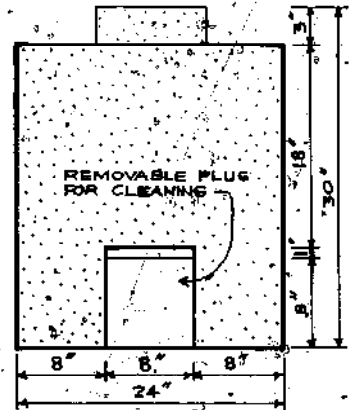
- Slide adjusters can be fitted at both ends of the blower to provide quick adjustment of the air inlets. This has merit because it allows operator to control the amount of ambient air supplementing the heated air from the furnace.

To power the blower a choice is available between either a gasoline, diesel or an electric motor. Some of the factors to consider when deciding the type of power to use are: availability of replacement parts, current in the local area, possible alternative uses for the power plant, local preferences. Diesels are more expensive but more economical to operate. If a gasoline engine is used it should be a heavy duty model capable of running for extended period of time. The blower will require a six to eight horsepower engine. The electric motors should be from three to five horsepower and, if possible, should be run from a three-phase power supply.

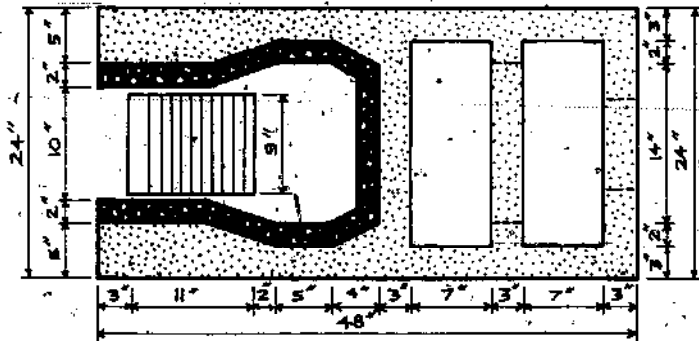
# rice hull furnace



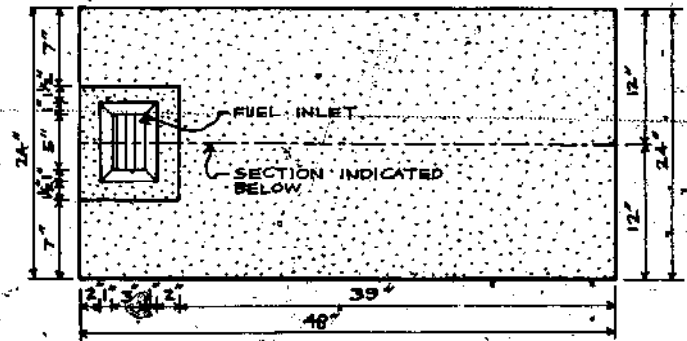
FRONT VIEW



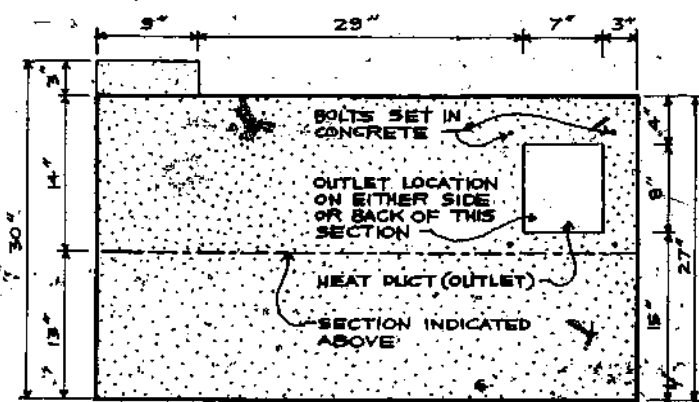
BACK VIEW



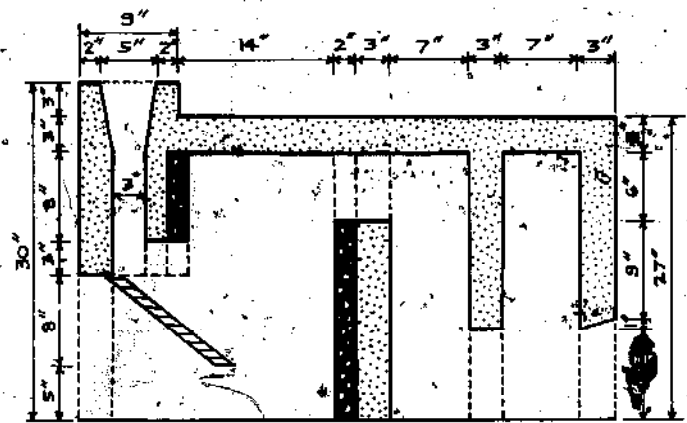
PLAN



TOP VIEW





SIDE VIEW



SECTION

KEY.:

-  POURED CONCRETE
-  FIREBRICKS

Section III:

# RECOMMENDED DRYING TEMPERATURE, °C

TYPE OF PRODUCE	MC OR USE	TEMPERATURE °C
Seed corn	over 25%	35 to 38
Seed corn	under 25%	43 to 48
Feed corn	over 25%	60 to 66
Feed corn	under 25%	62 to 70
Soy beans	seed	40 to 43
Soy beans	commercial	71 to 75
Palay	milling	42 to 44
Palay	seed	35 to 37
Copra	commercial	65 to 75
Fish	commercial	not available

NOTE: To generate heat in the various temperature ranges, the furnace will consume rice hulls at the following rates: one third sack per hour at 35° to 48°, one sack per hour at 49° to 60°, one and one fourth sack per hour at 61° to 75°.

Section IV:

## COST ANALYSIS

### A. Construction Costs

A detailed item by item report should be completed to determine the exact cost of constructing the drier. Some of the materials will be bought in Manila but the majority can be bought locally. (See attached listing.) An estimate of the purchasing components, materials, and construction costs can reasonably be placed at not more than P4,000.

### B-1. Operating Costs for Rice Hull Furnace

Because of the simplicity of the design, the unit requires little mechanical energy and has few moving parts that require maintenance. Therefore the operating costs are not too dependent on the rising price of fuel and oil. The key factor in keeping the cost low is that the thermal energy, normally produced by burning kerosene or oil, is produced in this drier by burning rice hulls—abundant and free unlike the

petroleum products it replaces. The drier does require one small gasoline or diesel engine in the 6 to 8 hp range to power the blower component. The factors or inputs to consider when determining the operating cost are:

- (1) Fuel—one liter per hour
- (2) Oil and maintenance—10% of fuel cost
- (3) Operator—one peso per hour
- (4) Depreciation of engine—15% per year

Based on a maximum operating time per batch of 8 hours, the inputs/50 cavan batch will equal:

- (1) P12.00
- (2) P 1.20
- (3) P 8.00
- (4) P 2.25 (Based on an annual capacity of 6,000.)
- (5) P 23.45 Total cost per 50 cavan batch
- (6) P 47 Total cost per cavan

### B-2. Operating Costs for Kerosene Burner:

When using the burner, all of the inputs (1 thru 4) will remain unchanged. The key difference is that the cost of the kerosene is an additional input and must be computed into the cost per cavan:

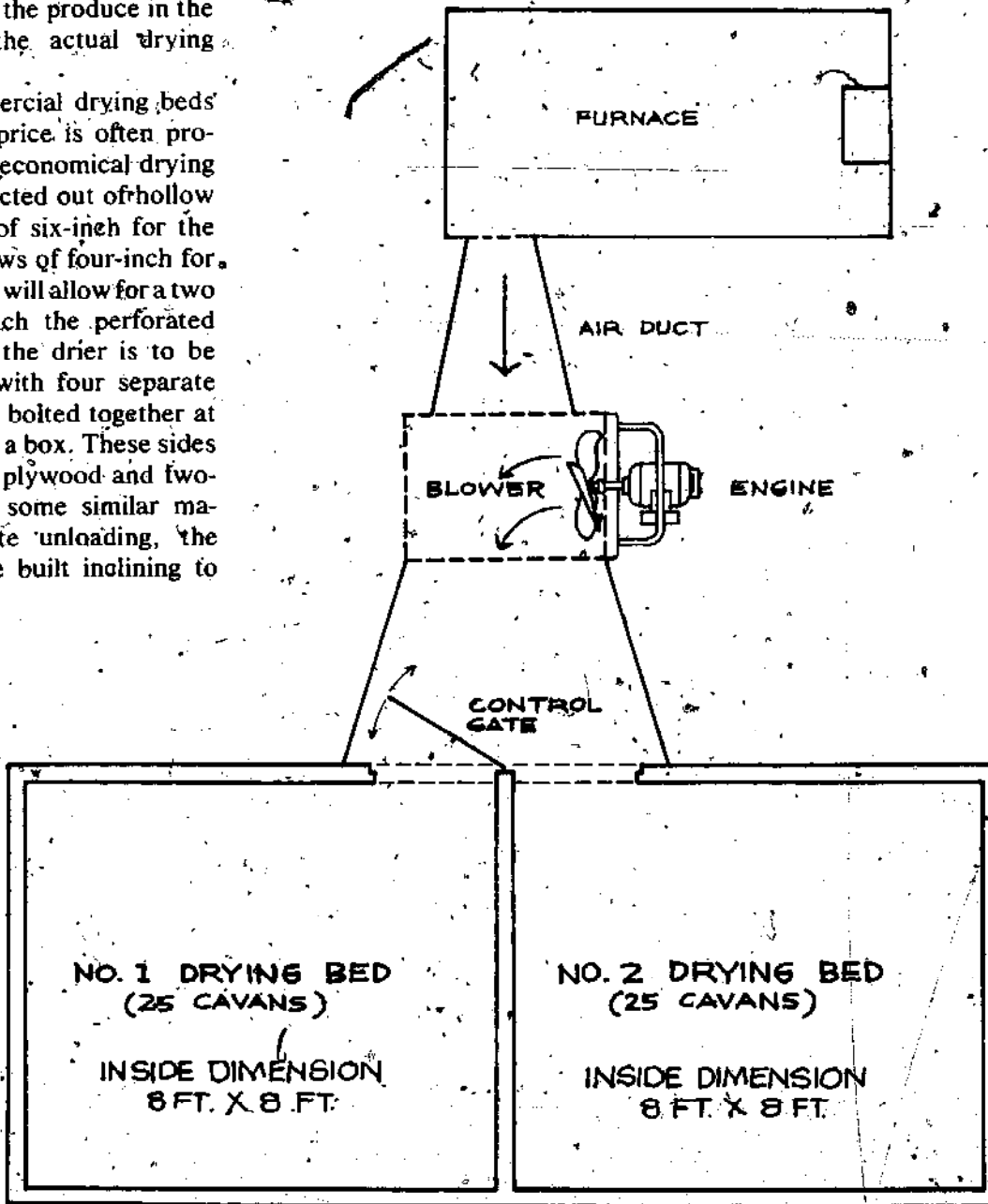
- (1) P12.00
- (2) P 1.20
- (3) P 8.00
- (4) P 2.25
- (5) P 18.00 (kerosene)
- (6) P 41.45 Total cost per batch
- (7) P 83 Total cost per cavan

**D. Drying Bed (see note)**

The drying bed is a box-like structure which contains the produce to be dried, on a perforated floor located horizontally at about mid-height in the structure. The perforated floor separates the upper section, the container, from the lower section, the plenum chamber. The perforations allow the heated, pressurized air in the plenum to rise upward thru the produce in the container where the actual drying takes place.

There are commercial drying beds available, but the price is often prohibitive. The most economical drying bed can be constructed out of hollow blocks: two rows of six-inch for the plenum and two rows of four-inch for the container. (This will allow for a two inch ledge on which the perforated floor can rest.) If the drier is to be portable, build it with four separate sides which can be bolted together at the corners to form a box. These sides can be made from plywood and two-by-two lumber or some similar material. To facilitate unloading, the container could be built inclining to one end.

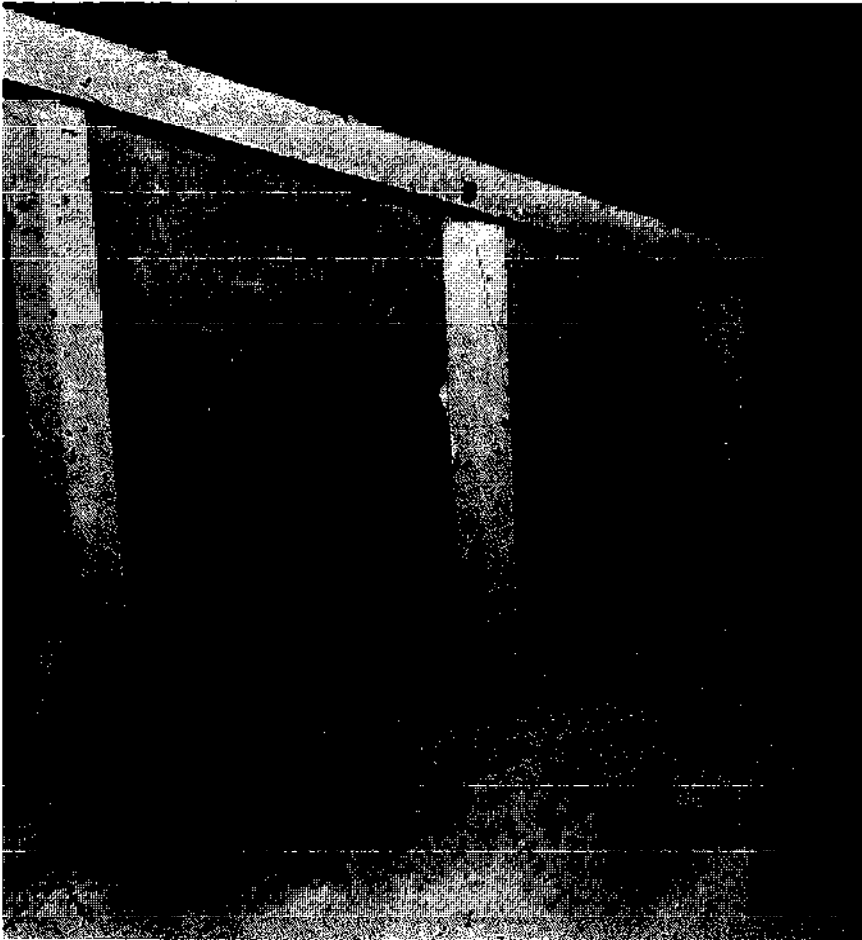
*NOTE: As stated in Section I-B, the drying bed may be constructed to allow for continuous operation. This can be accomplished by dividing the bed into two sections and, with the addition of a gate in the duct between the blower and the bed, the air can be directed to one or both of the two sections. During operation, one section can be emptied and reloaded without interrupting the drying process in the other section. (See illustration.)*



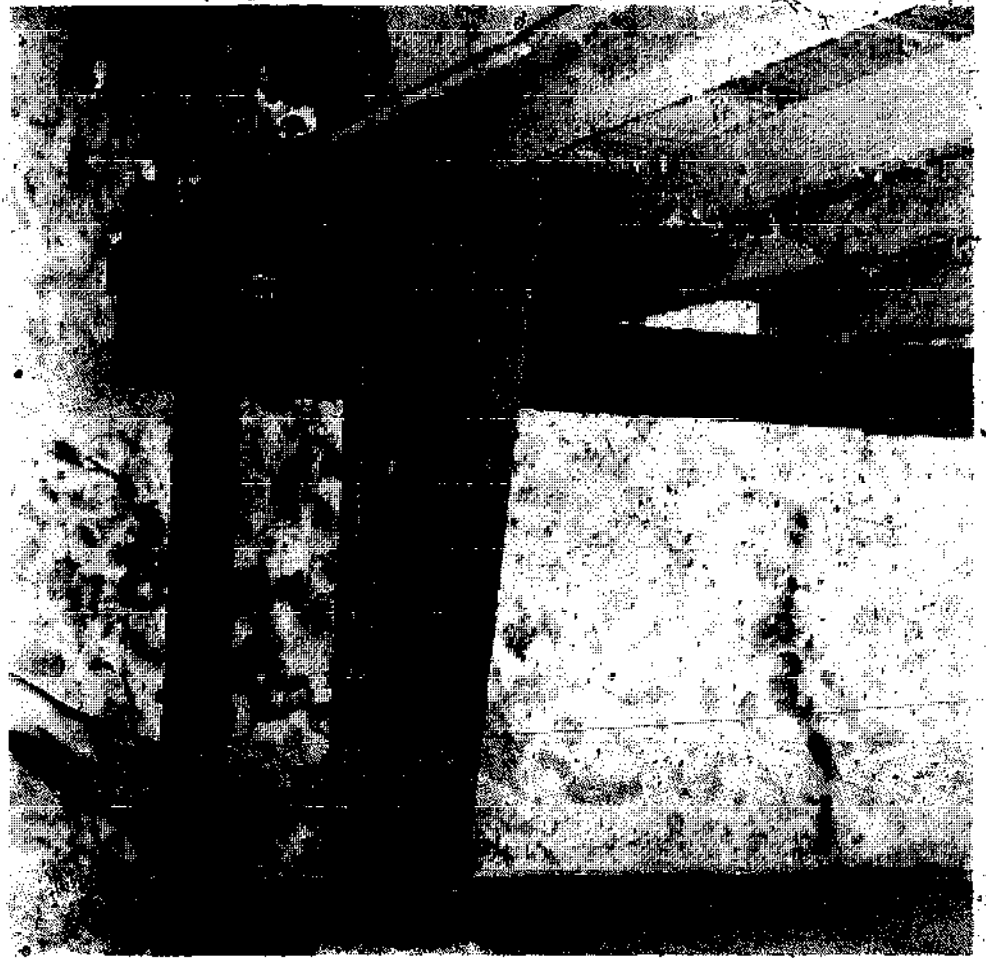




A drying facility built specifically for copra. The bed is inclined from the mezzanine floor to an area at ground level where the dried copra is bagged. The bed is made from one-by-two slats and is inclined to make emptying easier. The mezzanine floor is used for loading the drier from a convenient position and allows the workers to do so without walking on the dried copra.



The plenum chamber is made from hollow blocks. The drier has two by-three bed supports which span the two walls and the sides are made from plywood and two-by-two lumber.



*A simple slide device can be used to control the flow-rate from the tapered gravity-flow container for rice hulls.*



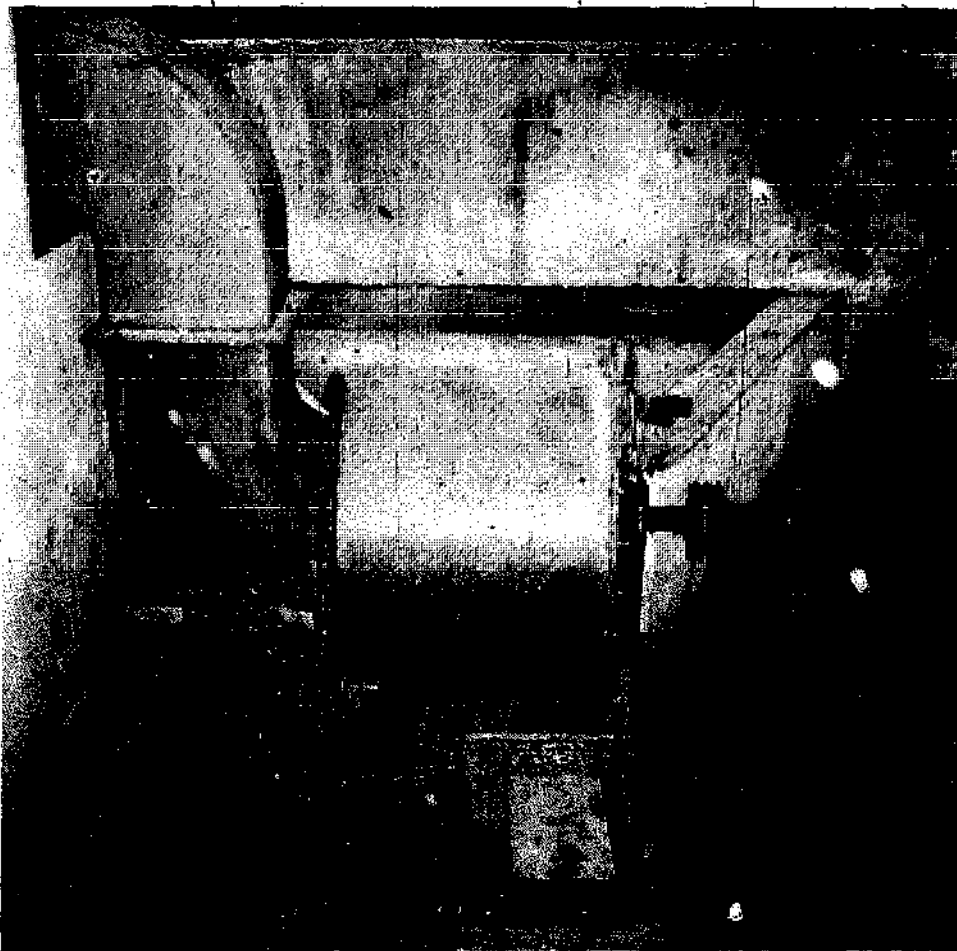
*The furnace, at right, is connected to the centrifugal blower by a duct. The control switch in the upper left-hand corner should be located near the control for the rice hulls.*



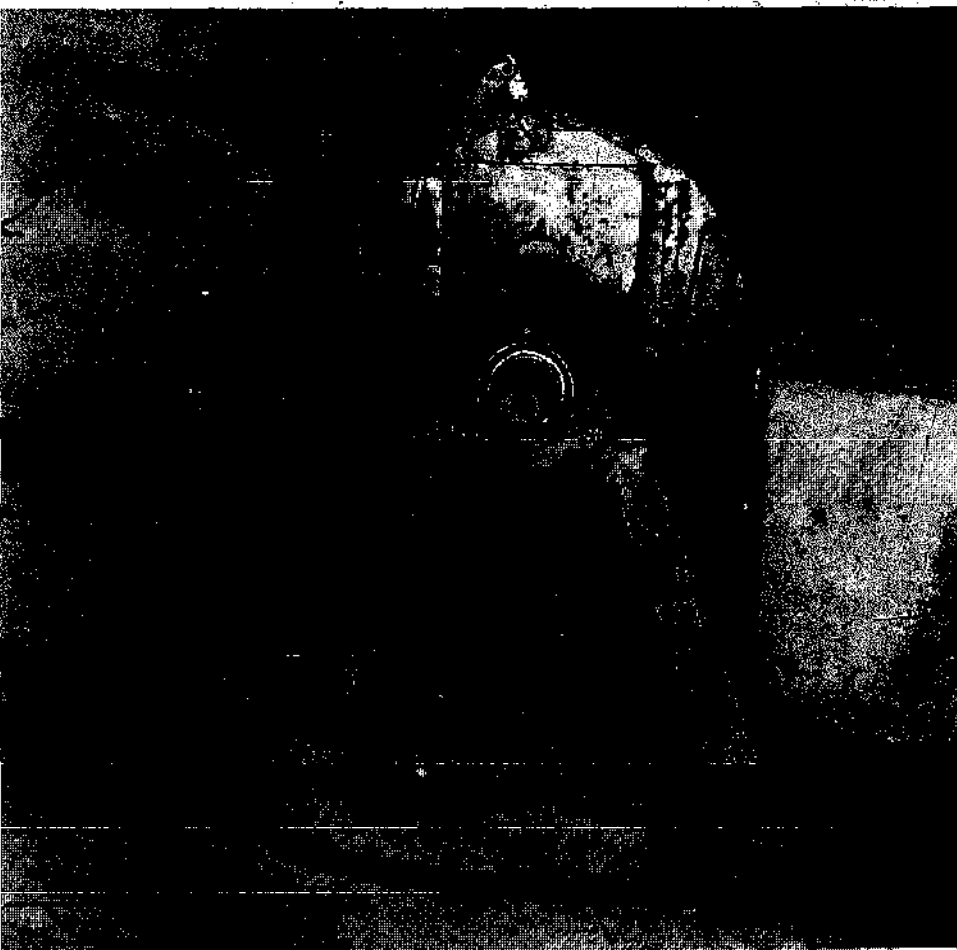
*The removable plug is used for cleaning the ash trap.*

*An end view of the fire box section of the furnace. During operation an iron grille holds the burning hulls inside the fire box and allows incoming air to pass through the hulls to provide for efficient burning. The white hulls are completely spent of all thermal energy while the darker hulls are not totally burned.*

*The centrifugal blower is positioned between the furnace and the drier. The bed is not completed; lacking are the divider and the control gate necessary for continuous operation. Also, the duct from the blower to the drier is not sealed. The duct between the furnace and the blower is a good example of metal ducts.*



*An end view of the same blower. Notice the lever control for the slide adjustment. The slide on this end controls the ambient air flow; the other end controls the heated air.*



# TEMPERED MATERIALS

## MATERIALS NEEDED FOR 50 CAVAN DRYING BED

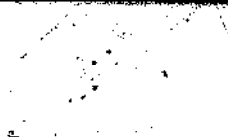
Quality	Size	Type	Price	Location
4	1" x 2" x 10'	Lumber		
18	2" x 2" x 10'	Lumber		
2	2" x 4" x 10'	Lumber		
120	four inch	Hollow Blocks	.85	Manila price
85	six inch	Hollow Blocks	.95	Manila price
5	Bags	Cement	14.20	Manila price
8	2' x 8' gauge 24	Expanded steel Sheets	44.60	General Hardware Cubao, Manila
12	1/4" x 2"	Bolts		
1	20° to 80° (approximate)	Centigrade Thermometer		

## MATERIALS NEEDED FOR RICE HULL FURNACE

3 3/8" x 4' x 8' (or) 1/4"	Tempered Lawanit Plywood
60 feet 2" x 2"	Lumber
60 feet 1" x 2"	Lumber
1 9" x 13"	Iron grid (iron grille)
2 Bags	Cement
2 Bags	Lime
1 Kilo 3 inch	Nails
1 Kilo 2 inch	Nails
1 Kilo 1 inch	Nails
equal to 700 inches of surface area	Fire Bricks
4 - 5/16 x 3	bolts

NOTE: The Lawanit, or plywood, and the lumber will be used to make frames for pouring the walls of the furnace. The entire set of frames should be constructed and well braced so that the pouring of concrete can be

completed without interruption. Allow one week for curing; then use at low temperatures for the first several hours. This will limit cracking.



# NOTES