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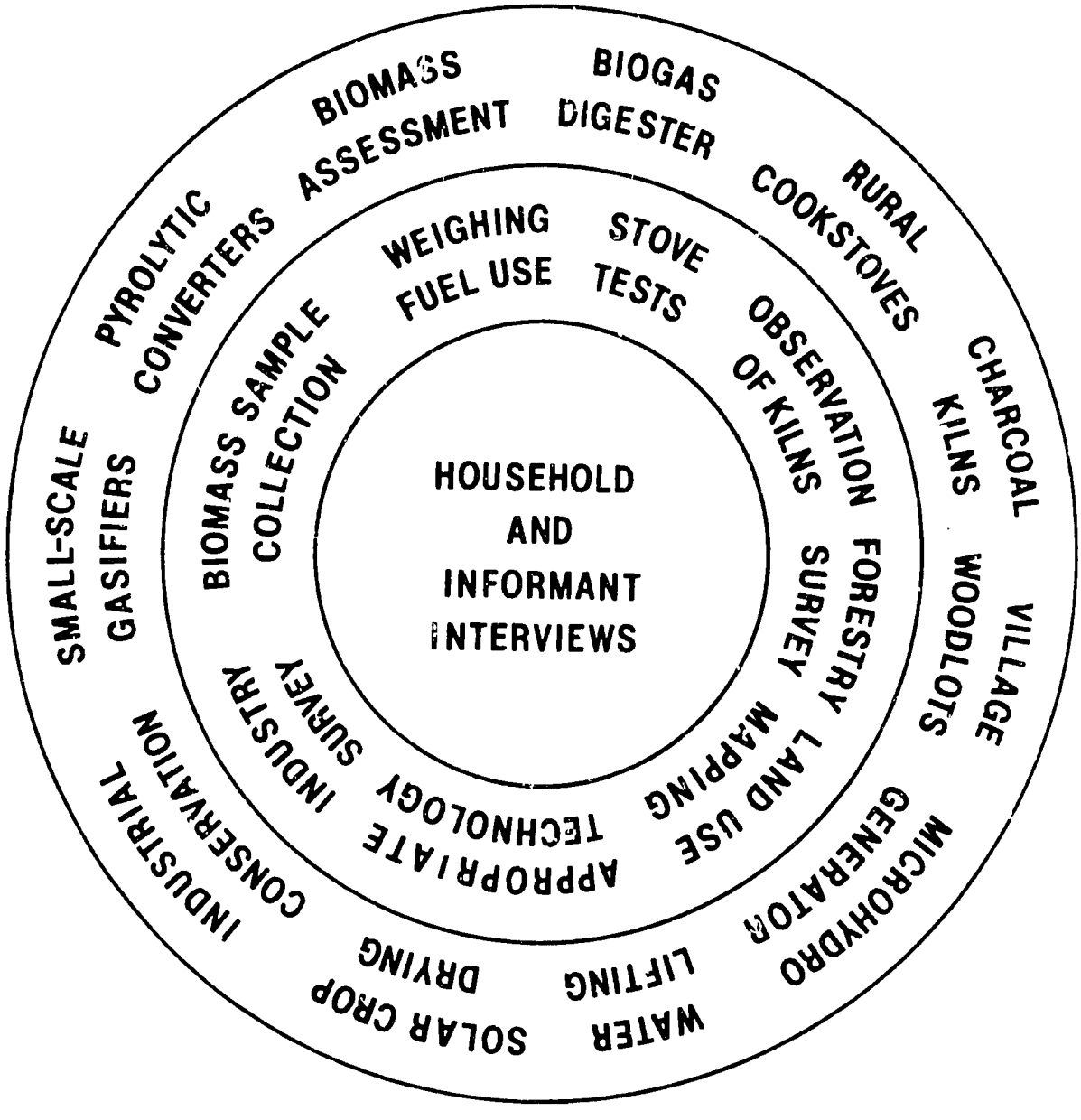

RURAL INDUSTRY

META SYSTEMS INC THAI GROUP

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RURAL INDUSTRY: SURVEY RESULTS

SOMPONG AIEMJOY

JOHN ARNOLD, JR.

Acknowledgement

This series of reports was produced through the joint effort of professors and students from four of Thailand's leading universities, Chulalongkorn University Social Research Institute, Chiang Mai University Social Research Institute, Khon Kaen University Faculty of Agricultural Economics, and Kassetsart University Faculty of Forestry and research personnel from Meta Systems, Inc. Together they were responsible for the design, execution and analysis of the baseline survey.

This report was prepared by Sompong Aiemjoy and John Arnold. Technical assistance was provided by Supot Pakyoo. The graphics were drawn by Jakrit Charoenpant. The text was typed by Watcharee Chalorkunwat. Report production was supervised by Patricia Ferguson. The dedication, patience, long hours and unflagging sense of humor of all participants is gratefully acknowledged.

Author's Warning

This report is meant for use by researchers working on the Renewable Non-Conventional Energy Project. Approval should be obtained from U.S. Agency for International Development, Bangkok (Rod MacDonald) or Asia Bureau, Washington (Robert Ichord) before quoting any part of this report.

The more taboos there are in the empire
The poorer the people;
The more sharpened tools the people have
The more benighted the state;
The more skills the people have
The further novelties multiply;
The better known the laws and edicts
The more thieves and robbers there are.

Lao Tzu

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Errata Sheet

LIST OF CHANGWAT OF THAILAND

In this report a variety of spellings have been used for the survey Changwat and village. The correct spelling and some of the variants are shown below.

Changwat

Buri Ram: Buriram, Burirum

Chanthaburi: Chantaburi

Chiang Mai: Chiangmai, Chaing Mai, Cheing Mai

Chon Buri: Chonburi

Kamphaeng Phet: Kampangphet, Kampaengpet, Kamphangphet, Kampangphet

Khon Kaen

Lampang

Nakhon Ratchisima: Korat

Nan

Phetchaburi: Petburi, Petchbura, Petchaburi

Roi et: Roi-et, Roi-Et

Si Sa Ket: Srisaket, Sisaket

Udon Thani: Udorn Thani, Udornthani

Villages

Bang Rahong: Bangrahong

Maikan Sangkan: Mailand Sangan

Pa Bhu: Pabhu

Wang Chapou: Wangchapoo

Klong Bon: Klongbon

Nong Wangyao: Nongvangyao

Pa Woe: Paver, Pawer

Pa Han: Pahan

Pa Nai: Panai

Si Chiengmai: Srichiengmai, Srichaiangmai

San Pa Tong: San Pa Toung

Samkhasantisuk: Sam Kha San Tisuk

Mai Ho Phra: Mae Ho Pra

Nong Buaeng: Nongbuadeang

OTHER TERMS

Household - Related individuals living in a house and eating together

House compound - Area around the house which is owned by members of the household and is often demarcated by a fence

Head of household - Male or female leader of the members of the household, usually the owner of the house

Head of village - Phuyaiban

Head of sub-district - Kamnan

Village - Muban

District - Amphoe

Province - Changwat

Errata Sheet (continued)

Phase I - Survey in Petchaburi, Korat, Srisaket, Kampangphet, and Lampang

Phase II - Survey in Songkla, Chantaburi, Roe-et, Udorn Thani, and Chiang Mai

Phase III - Survey in Nan, Burirum, and Chiang Mai

Delivered heat - The amount of energy content in the fuel burned

Captured heat - In cooking the amount of heat which is transferred to the cooking vessel

Moisture content - On a wet basis, weight of water as percentage of total sample weight

Heat or energy content - The high heat content of a substance at 0% moisture as measured in a bomb calorimeter

1 Unit of electricity - 1 kilowatt-hour, a billing unit used by the Provincial Electric Authority

6 1/4 rai = 2 1/2 acres = 1 hectare

jar lamp - small wick lamps

wick lamp - chimney or hurricane lamps

Rice Products - Straw residue in field,
- Stalk residue from threshing,
- Husk shell residue from milling
- Bran edible residue from milling

NEA - National Energy Administration of Thailand

NSO - National Statistics Organizationof Thailand

PEA - Provincial Electricity Authority

1. Rural Industries

This report has been prepared to provide background data and some research findings to the project participants involved in the monitoring and improvement of industrial use of energy.

1.1 Survey Methodology

The operators of various rural industries were interviewed by survey co-ordinators using a structured interview schedule which concentrated on the use of resources, especially labor, fuel and raw materials, and the level of production. This interview was supplemented by observation of the production process and physical measurements of the quantities of fuel used and product produced. For those industries using biomass fuels, samples were collected and tested for moisture content.

The major difficulty with this survey effort was the reduced sample size due to the time limitations on survey personnel. Since the survey sample size was limited to 47, a comparative analysis was made with data collected by the Regulatory Division of the National Energy Administration. Their raw data was examined and a subset of 84 small enterprises was selected. Another difficulty was measuring the amounts of fuel and raw material used and of product produced. Since the quantities of fuel, material and product were too great to be weighed in their entirety, estimates had to be made.

In addition to the rural industries, home industries were surveyed as part of the household interviews. A total of 162 home industries were surveyed of which only 24 used biomass fuels. The home industry interview schedule was a two page questionnaire concerning the uses and sources of fuel, raw materials and labor.

1.2 Industries Surveyed

The types of industry surveyed by the project staff and the NEA can be grouped into three classes; building materials, crop processing and household materials. Building materials include bricks, limestone, and timber. Crop processing includes the milling of rice, cassava and sugar, the drying of rubber and salt, and the weaving of jute. Household goods include glazed and unglazed ceramics and metal-work. The raw materials for these industries are obtained almost exclusively from the rural areas. They include clay, limestone, wood, rice, sugar cane, cassava, latex, salt water, and scrap metal. The technologies used in the rural industries are relatively simple with the exception of the larger scale units such as cassava flour, sugar and jute mills. Bricks are fired in simple clamps. Limestone and ceramics are fired in rectangular kilns. Rubber is dried over wood fires. Rice is milled using belt driven grinders and separators.

Most of the industries surveyed were selected based on their rural locations and size of their production and labor force. The number of employees was less than 75 for all establishments except the mills for cassava flour, sugar cane and jute.

1.3 Use of Fuel

The relationship between the volume of production and the quantity of fuel consumed was analyzed by computing the ratio of product to fuel on a weight basis. The results are presented in table 1 in terms of kilograms of product per kilogram of solid fuel, liters of liquid fuel or kilowatt hours of electricity. There were similarities between the survey data and the NEA data for brick and limestone kilns but dissimilar results for rice mills and ceramics. The discrepancies have to do with how the data was collected. The NEA data was based on interviews* concerning annual production and fuel consumption. The baseline survey personnel attempted to directly measure or estimate fuel consumption for a single production run. The NEA data was recorded in the units specified by the owners whereas the baseline survey used weight measures only. Where the NEA data was not in weight, a conversion factor had to be designed to make the data comparable. The final estimates of average fuel consumption for each industry were prepared using the available data and the judgment of the authors' regarding the reliability of the data.

Limestone

For the limestone kilns the NEA data is lower than the survey data but neither is necessarily more accurate because of the difficulties in measuring the large quantities of fuel used per firing. The survey sample included two operations for which crude estimates of fuel use had to be made, but the larger NEA sample had a wide variance (figure 1). A linear regression of the combined data indicated a marginal fuel consumption of 1 kilogram of wood per kilogram of limestone, but the correlation was only .82 and the constant in the equation was too large. If it is assumed that the lignite consumption data is more accurate than the firewood users and that the efficiency of the kilns using these two fuels is similar then the average firewood consumption would be close to 1.2 kilograms per kilogram of limestone produced.+

Given the variation in moisture and energy content of wood and lignite, the fuel consumption should vary by ± 15%. If the variation in kiln efficiencies is taken into account the range should be ± 35%. The expected range in fuel consumption, assuming a 1 kilogram average, would be 2/3 to 1 1/3 kilograms of firewood per kilogram of product.

Brick

For rice-husk-fired brick clamps there is a strong similarity between survey and NEA data (table 1). Also there is good correlation for the power curve regressions on the combined sets of data (figure 2). The quantity of rice husk required per kilogram of fired brick is .6 kilograms. There is a slight increase in efficiency as scale increases. The power factor for the combined data is .98, which implies a reduction in fuel consumption to .55 kilograms of rice husk per kilogram of fired brick for the larger clamps.

The sample for wood-fired permanent kilns is smaller than for rice

* NEA data was collected through mailed questionnaires. In some cases follow-up interviews were conducted.

\+ lignite heat content per kg is about 175% that of wood

Table 1

Fuel Consumption for Rural Industries

PRODUCT	TECHNOLOGY/FUEL	FUEL CONSUMPTION (PRODUCT/FUEL)					
		SURVEY DATA			NEA DATA		
		SAMPLE SIZE	AVERAGE	RANGE	SAMPLE SIZE	AVERAGE	RANGE
Limestone	Rectangular Kiln/ Firewood (1)	2	1.07	1-1.13	28	0.90	0.42-1.67
	Rectangular Kiln/ Lignite (1)	-			3	0.66	0.56-0.74
Brick	Clamp/Rice Husk (1)	10	1.64	1.27-1.83	12	1.62	1.46-1.74
	Rectangular Kiln/ Firewood (1)	2	0.76	0.75-0.76	3	0.81	0.75-0.86
Blacksmith	Simple Forge/Charcoal (1)	2	0.33	0.17-0.49	-		
Rubber	Wood Fired Drying Tower/Firewood (1)	2	1.13	1.05-1.21	-		
Ice	Salt Water Coolant Electric Power Compressor (2)	3	11.3	3.33-21.86	-		
Rice Mill	Small Diesel Motor (4)	4	55	40-60	5	25	19-36
	Large Diesel Motor (4)	-			4	40	10-55
	Rice Husk Fired Boiler (4)	-			9	11.25	3.4-37.7
	Electric Motor (5)	2	15.6	10.7-20.5	-	-	-
Glazed Ceramics	Round or Rectangular Kiln/Firewood (1)	-			3	0.47	0.35-0.65
	Tunnel Kiln/Firewood (1)	-			5	0.24	0.11-0.44
	Dragon Kiln/Firewood (1)	-			2	0.33	0.27-0.39
Non-Glazed Ceramics (Stoves, Pottery)	Round or Rectangular Kiln/Firewood (1)	4	0.52	0.31-0.84	1	.65	-
	Open Kiln/Rice Husk (1) (Stove)	2	0.62	0.40-0.83	-		
Cassava	Chipper/Diesel (3)	5	3.3	2.5-4.1	-		
	Pelletizer/Diesel (4)	2	115	80-150	-		
	Flour Mill/ Furnace Oil (4)	2	16	13.3-20.0	-		
	Electricity (2)	-	4.7	4-5.3	-		

1. kg/kg or ton/ton
2. kg /Kwhr
3. ton/lit
4. kg/lit
5. ton/Kwhr

PRODUCT	TECHNOLOGY/FUEL	FUEL CONSUMPTION (PRODUCT-FUEL) - Cont.					
		SURVEY DATA			NEA DATA		
		SAMPLE SIZE	AVERAGE	RANGE	SAMPLE SIZE	AVERAGE	RANGE
Salt	Metal stove/Sawdust (1)	1	0.37	-	-		
Foundry	Sand casting/Charcoal (1)	1	1.03	-	-		
Sugar	Stove/Bagasse (1)	1	2.6	-	-		
Jute	Textile machines						
	Diesel (4)	1	83	-	-		
	Electricity (2)	1	2.5	-	-		

Notes on Selection of Sample Data

1. The NEA data was initially screened to select small industries based on size of production
2. Where fuel consumption figures were unreasonably low (less then 30% of the average) they were eliminated
3. The samples removed according to criteria # 2 were for the rice mills.

NEA data-small	diesel	3 (≤ 20 H.P.)
large	diesel	2
rice husk	fired	4
	electric	1
Survey data-small	diesel	1

FIGURE 1

FUELWOOD CONSUMPTION FOR LIMESTONE MANUFACTURE

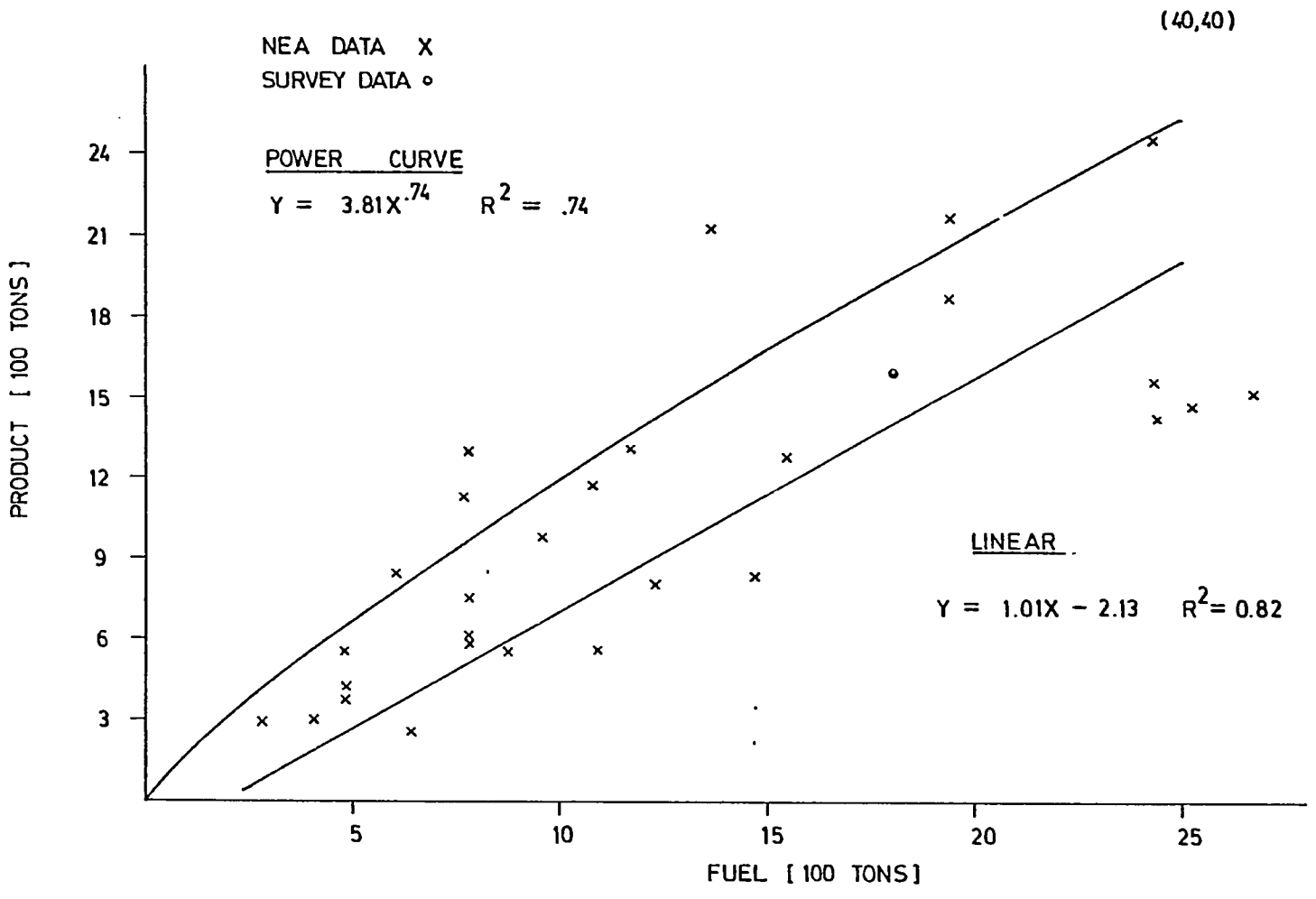
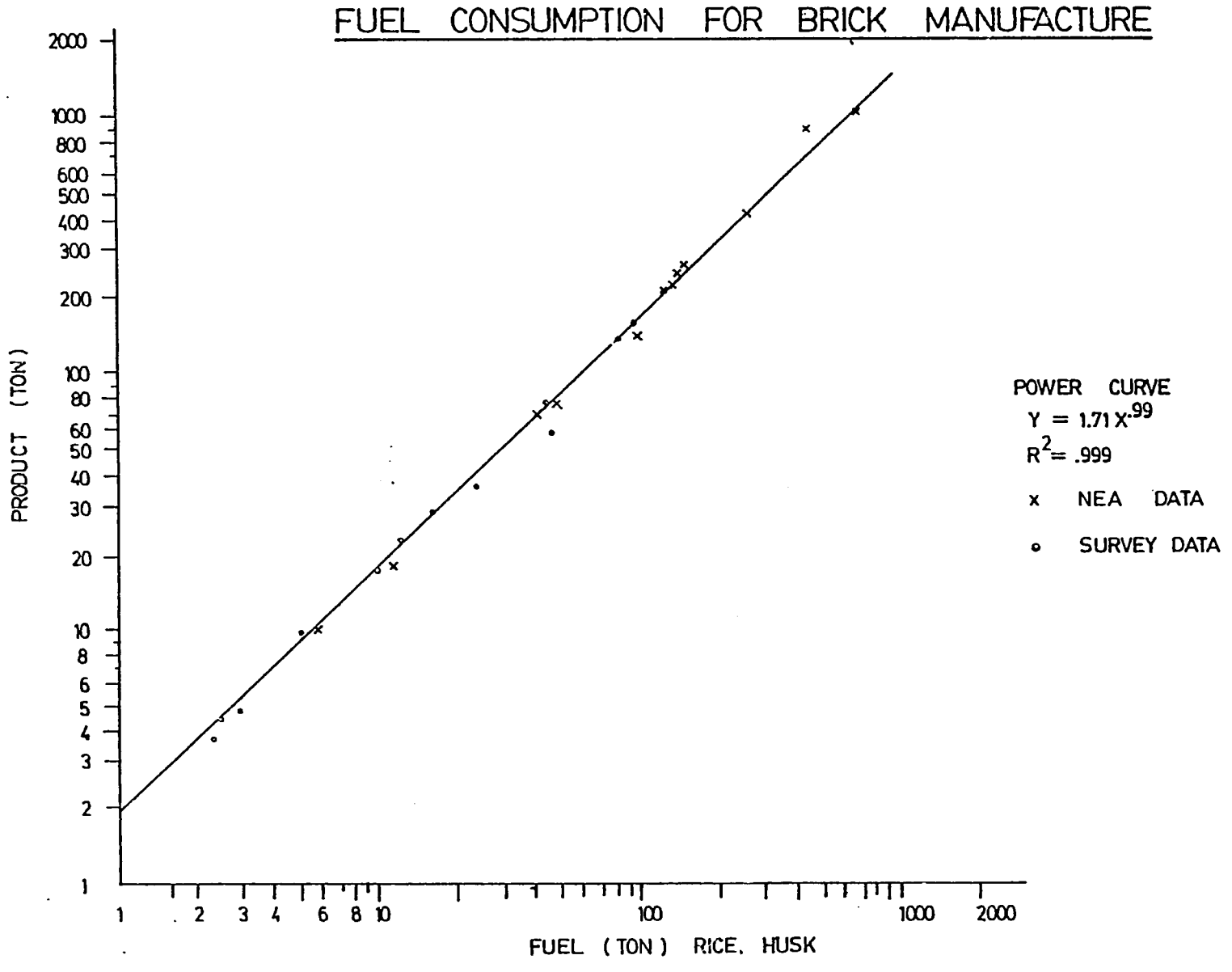


FIGURE 2


FUEL CONSUMPTION FOR BRICK MANUFACTURE
PRODUCT (TON)
2000
1000
800
600
500
400
300
200
100
80
60
50
40
30
20
10
8
6
5
4
3
2
1
1
2
3
4
6
8
10
100
1000
2000
FUEL (TON) RICE, HUSK
POWER CURVE
Y = 1.71 X^.99
R^2 = .999
x NEA DATA
o SURVEY DATA

husk fired clamps but again the agreement between survey and NEA data is good and the range in observations small. The average fuel consumption is 1.3 kilograms of wood per kilogram of brick. As with limestone kilns the variation in energy and moisture content of fuels should lead to a wide variance, however most of these kilns use rubberwood, so the range in fuel consumption is not especially large. For a bigger sample it is expected that fuel consumption would range between 1.0 and 1.6 kilograms of wood per kilogram of fired brick. A comparison of the two types of brickmaking indicate that the wood fired permanent kiln is about .4 times as efficient as a rice-husk fired clamp on the basis of heat content of fuels consumed. If the losses due to incomplete firing are included, assuming 25% for rice husk and 5% for wood, the permanent kiln is still only .5 times as efficient. However these calculations do not take into account differences in brick quality.

Rice Mills

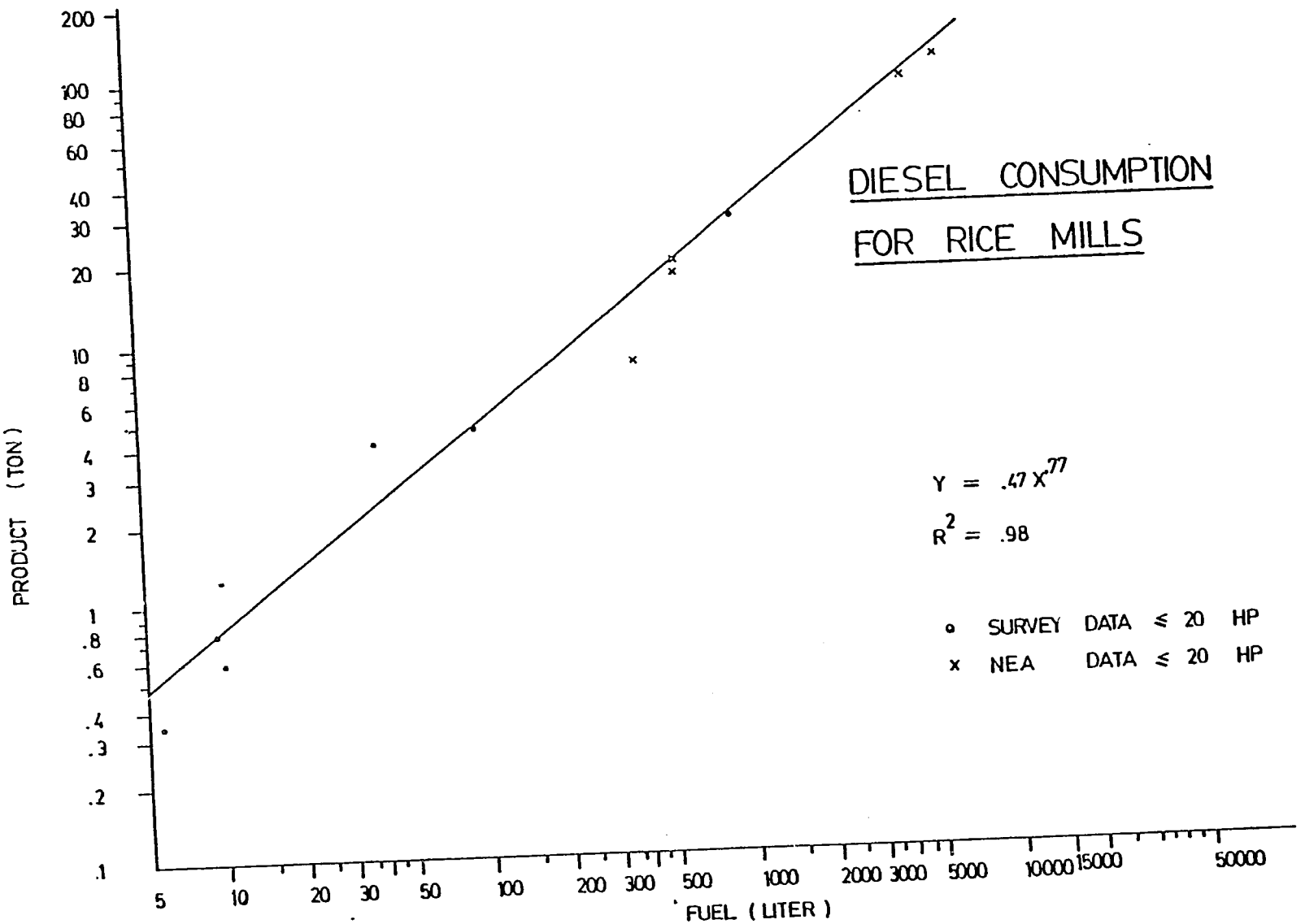
For rice mills three types of units were observed, diesel engine, steam engine and electric motor units. The steam engines were driven by rice-husk fueled boilers. Although a large number of these were surveyed by the NEA the results are not reliable. The difficulty in measuring the fuel consumption for rice-husk fired boilers is that they are fed automatically by a chute which draws off some of the flow of husk being ejected from the mill. The fuel consumption is well below 100% of the residue generated, but it is not possible to estimate what percentage is used. Since many of the boilers are quite old, their efficiencies are very low. Without direct measurement or knowledge of the boiler efficiencies reliable estimates of fuel consumption cannot be made.

The diesel engine mills created less problems in measuring fuel consumption but the range of results was considerable. The NEA data was consistently higher than the survey data for small scale mills.* This difference is difficult to explain since most of the units tested in the survey were traditional mills using large grinders and crude mechanical linkages for shaking the material through the various processes. These mills are elegant in appearance and are a well developed local technology but their energy efficiency leaves much to be desired. Modern milling units, especially integrated units with rubber rollers rather than grinding stones, are more fuel efficient but less efficient in converting padi to milled rice. It is likely that the NEA data includes these latter mills since they are located in the larger, more prosperous villages and towns; however, this information was not in the analysis. 19 liters of diesel is consumed per ton of rice milled, while for the NEA sample an average of 33 liters was consumed per ton. For both samples, differences in mill equipment and age created variation of $\pm$ 30%.

For the electric mills only two units were sampled. The average power requirements were 60 kilowatt-hours per ton of rice milled. Assuming a motor efficiency of 90% this implies an output of 70 horsepower-hours. For small diesels the fuel consumption is .23-.25 liters

* A subset of the NEA data was chosen to include small mills. Because of problems with record keeping and taxes, these mills would be the least likely to respond accurately to a mailed questionnaire.

FIGURE 3


DIESEL CONSUMPTION
FOR RICE MILLS
Y = .47 X^.77
R^2 = .98
o SURVEY DATA ≤ 20 HP
x NEA DATA ≤ 20 HP
PRODUCT (TON)
FUEL (LITER)
200
100
80
60
40
30
20
10
8
6
4
3
2
1
.8
.6
.4
.3
.2
.1
5
10
20
30
50
100
200
300
500
1000
2000
3000
5000
10000
15000
50000

per horsepower-hour. For the diesel-fueled mill, this implies an average power requirement of 76-82 horsepower-hours for the survey sample and 133-143 horsepower-hours for the NEA sample. The similarity between diesel and electric mill power requirements in the survey results suggests that this data be used in preference to the NEA data. If the 76-82 horsepower-hour is assumed to also apply for steam-powered mills and it is assumed that the boiler and steam engine have a combined efficiency of less than 10%, then the fuel consumption should be greater than 1/6 kilogram of husk per kilogram of milled rice. The NEA data averaged 1/11 kilogram which is probably an underestimate.

Pottery

Two types of ceramic production activities were examined. The first, the production of unglazed pottery, including stoves, was examined by both the baseline survey and the NEA. The sample size was relatively small and the range was considerable. The survey and NEA data are sufficiently close for the wood-fired pottery kilns that the average for the combined sample, 1.8 kilograms of firewood per kilogram of fired product, can be used. Based upon the range of species, moisture content and energy content for the fuel as well as the range of kiln efficiencies it is expected that the range in fuel consumption would be ± 30 or from 1¼ to 2 1/3 kilograms. In fact the data showed a wider range.

The traditional Thai bucket stoves are made using not only wood-fired kilns but also rice-husk mound kilns. Two of the latter were observed. The average fuel consumption was 1.6 kilograms of rice per kilogram of fired product. This number appears low because the rice-husk mound kilns should be less efficient+ than the wood-fired permanent kilns and rice has about 80% of the heat content of wood per kilogram of fuel. One possible explanation is that the firing temperature and time are less for the stoves than other pottery.*

The facilities for firing glazed pottery were surveyed by the NEA only. These facilities used a higher level of technology and consumed electricity as well as biomass fuels. The NEA data on firewood consumption presents some problems. The theoretical kiln efficiency decreases from the tunnel kiln to the dragon kiln and rectangular kiln, but in the NEA data the fuel consumption is highest for tunnel kilns and lowest for rectangular kilns. Also according to the data, the manufacture of glazed ceramics requires less fuel than unglazed ceramics. A comparison of all the fuel consumption data for ceramic manufactureres is shown in figure 4. The fuel consumption as a function of size is approximated for the glazed and non-glazed ceramics by power curves.

The glazed ceramic manufacturers use electricity in their production activities primarily for operating the glazing ovens. A linear regression of the NEA data indicated a marginal energy use of 7.3 kw-hr per ton of product, see figure 5.

+ The mound kilns have no structure to contain heat, and the burned husk acts as an insulation.

* Another possibility is that the wood fuel has a high moisture content.

FIGURE 4

FIREWOOD CONSUMPTION IN CERAMICS INDUSTRY

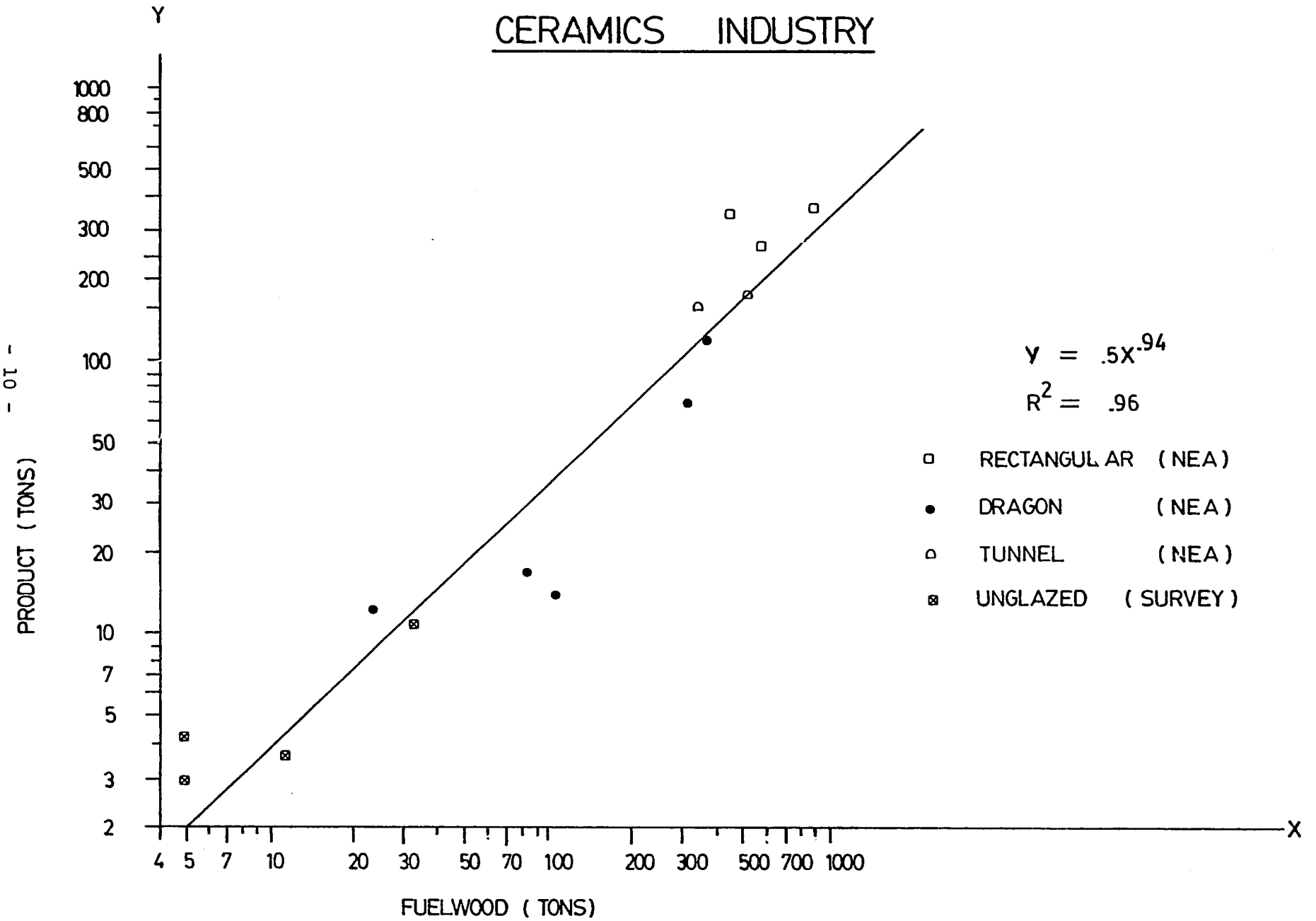
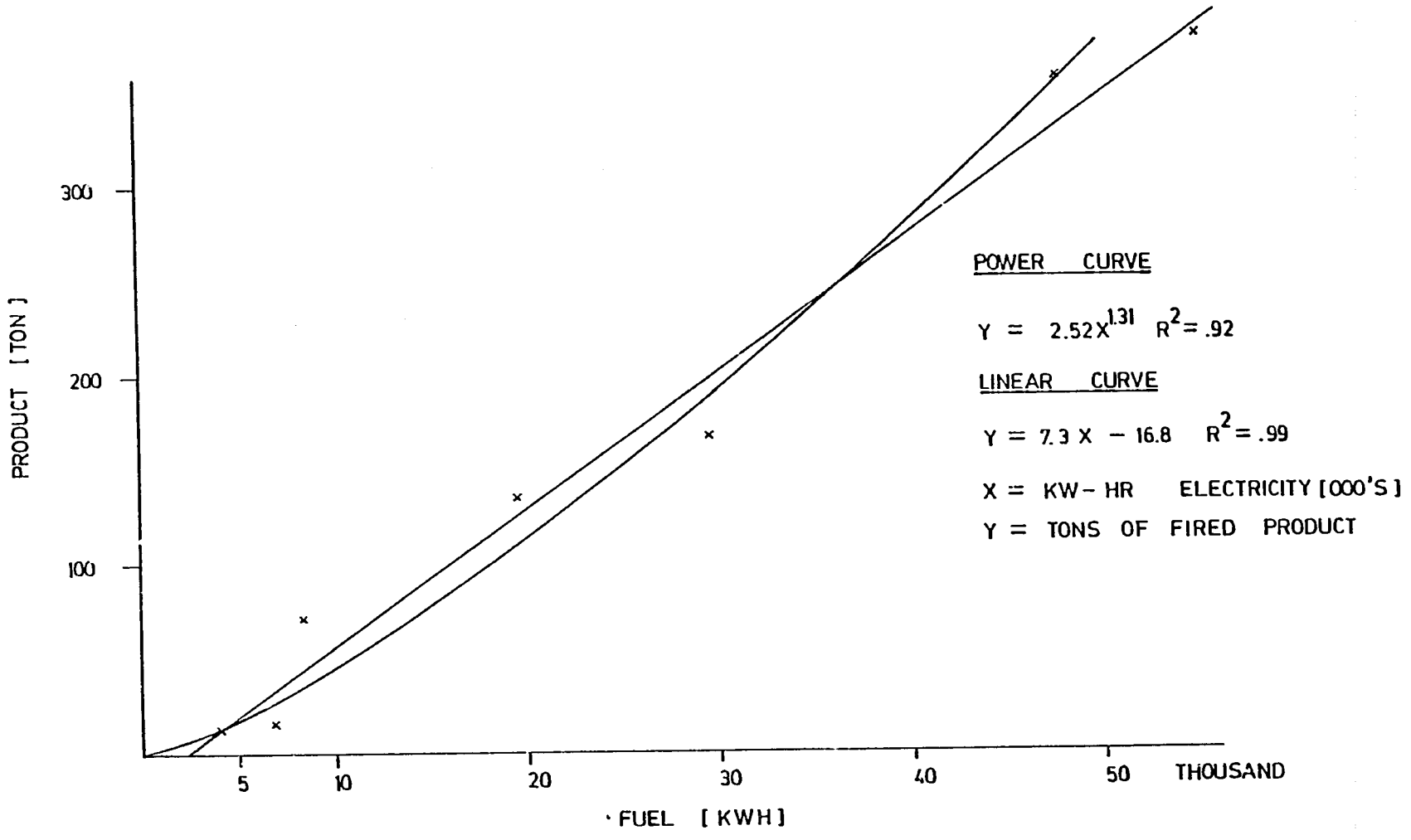


FIGURE 5

ELECTRICITY CONSUMPTION IN CERAMIC INDUSTRY



Cassava

Cassava is processed into chips, pellets or flour. The chipping units are either small, portable, hand-fed, diesel-powered units or large, stationary, belt-fed, diesel-powered units. The pelletizing machinery is generally diesel-powered with a chipping unit included in the first production stage. The flour mills include chipping units, milling units, centrifuges and furnaces. They consume electricity, furnace oil and diesel.

The chipping units which were surveyed used an average of 1/3 liter of diesel per ton of chips. The range of values was ± 25% which is not unreasonable given the variety of equipment, configurations and engines used. The pelletizing facilities surveyed used an average of 9 liters of diesel per ton of pellets. Again the range of values was about ± 25%.

The flour mills surveyed used small portable chippers which presumably have a diesel consumption rate which is equal to or greater than that for the chipping plants. The furnaces used to dry the flour consumed an average of 63 liters of furnace oil per ton of flour produced. The other equipment is electrically powered and the total consumption averaged ½ kilowatt hours per ton of flour. Since only two flour mills and two pelletizing facilities were surveyed and the data was based on managers' estimates, these averages are more indicative than accurate.

Ice

Three ice-making factories were visited by project personnel. All three used a standard technology with ammonia as the primary refrigerant and salt water as the secondary refrigerant. The factories differed in their sources of water and the amount of processing done to purify the water. These differences together with differences in age of plant partly explain the wide range in electricity consumption, from .05 to .3 kilowatt-hours per ton of ice. Inaccuracy of managers' estimates also account for some of this variation. Given the energy-intensiveness of pumping water, it is difficult to specify an average value of electricity consumption for a plant. However for the ice making operation a preliminary estimate of .2 kwhr per ton with a range of ± 25% can be used.

Other

Other crop processing activities which were surveyed included a jute mill, a sugar factory, rubber drying towers, and stoves for boiling salt water. The jute mill was a very large facility which used furnace oil for generating steam to clean the fiber and electricity for operating the processing and weaving machines. An average of 12 liters of fuel and .4 kilowatt hours were used per ton of kenaf processed. For the sugar mill an average of ¼ kilogram of bagasse was burned to produce a kilogram of sugar. For the rubber drying towers, an average of .9 kilograms of firewood were burned to dry one kilogram of rubber. The salt-water stoves were used to boil down salt water to obtain the salt. These long rectangular stoves were fueled through a chute with sawdust. For one kilogram of salt, 2.7 kilograms of sawdust was burned in the stove.

Two types of metal processing activities were observed. The first was blacksmiths using simple charcoal-fired forges, manually operated tube bellows, a small anvil and simple tools. These blacksmiths made parts for farm tools from sheet and scrap metal. They used an average of 3 kilograms of charcoal per kilogram of finished products. The second metal working activity surveyed was a foundry using cylindrical forges to melt down scrap iron for sand casting of machine parts to be used in rice mills. The forges used charcoal for fuel. The fires were fanned by diesel engine of electric motor-driven fans. The foundry used an average of 1 kilogram of charcoal per kilogram of cast material.

1.4 Use of Raw Materials

In this report, the ratio of the weight of the final product to the weight of the principal raw material is referred to as the yield. The reduction in weight from input material to output project (assuming no other materials are added) occurs due to: a reduction in moisture content, chemical reactions removing unusable substances, and/or mechanical separation of unusable substances. The data on yields for different rural industries are shown in table 2. The agreement between the project survey and the NEA data is reasonable. The range of observations is narrower than for fuel consumption. Since all the industries involve the processing of a single raw material rather than combination of two or more materials, the yields are all less than or equal to 1.

The chemical reduction of limstone produces an average weight loss of 22%, though it appears that this figure can be as high as 33% or as low as 15% depending on the kiln. The reduction in moisture content of clay and the chemical alteration to produce pottery resulted in a weight loss of between 8% and 29% for the different kilns and fuels. The average loss for wood-fired kilns was 19% versus 20% for rice husk-fired kilns. For glazed pottery with its higher firing temperatures, the weight loss averaged 24%. This figure is relatively constant for the different kiln types.

Bricks were similar to pottery and average 24% weight loss in rice husk-fired clamps versus 23% for wood-fired kilns. The resulting yield of 76-77% refers only to the weight ratio between a sun-dried brick and a fired brick. There are additional losses associated with underfired, burned and cracked bricks. This loss rate can range from 3% in well-constructed wood-fired kilns to 30% in poorly arranged rice husk-fired clamps. The higher loss rate is due to the insulation of rice husk ash around the lower courses of bricks so that they must be fired a second time. Various geometries can reduce this loss as can a procedure for removing the ash during firing. A similar loss is experienced in pottery making through under and over firing as well as breakage during loading and unloading. These types of losses were not examined explicitly in the survey.

The separation of sugar from molasses in heating the cane juice produced a 25% loss in weight. Mechanical separation of the husk from the rice produced a yield for between 40% and 70% according to the survey and NEA data. The large variation is probably due to inaccurate reporting by mill owners. The overall average yield of 57% seems low. If only the survey data is used the average yield is 61% with a range from 55% to 70%. The variation is caused by differences in type, age and condition of the equipment.

Table 2

PRODUCT	TECHNOLOGY/FUEL	RAW MATERIAL CONSUMPTION (PRODUCT/RAW MAT.)*					
		SURVEY DATA			NEA DATA		
		SAMPLE SIZE	AVERAGE	RANGE	SAMPLE SIZE	AVERAGE	RANGE
Limestone	Rectangular Kiln/ Firewood	2	0.71	0.67-0.75	28	0.78	.68-.85
	Rectangular Kiln/ Lignite	-			3	0.80	.69-.85
Brick	Clamp/Rice Husk	10	0.77	0.69-0.90	12	0.75	0.67-0.80
	Rectangular Kiln/ Firewood -	2	0.76	0.75-0.76	3	0.78	0.77-0.80
Blacksmith	Simple Forge/Charcoal	2	0.80	0.68-0.92	-		
Rubber	Wood Fired Drying Tower	2	0.92	0.91-0.92	-		
Ice	Salt Water Coolant Electric Power Compressor	3	1.00	(1.00)	-		
Rice Mill	Small Diesel Motor/ Diesel	5	0.61	0.55-0.65	7	0.51	0.29-0.70
	Large Diesel Motor/ Diesel	-			6	0.59	0.50-0.63
	Rice Husk Fired Boiler/ Rice Husk	-			13	0.58	0.40-0.65
	Electric Motor/ Electricity	2	0.63	0.56-0.69	1	0.43	-
Glazed Ceramics	Round or Rectangular Kiln/Firewood	-			5	0.77	0.75-0.80
	Tunnel Kiln/Firewood	-			6	0.75	(0.75)
	Dargon Kiln/Firewood	-			2	0.75	(0.75)
Non-Glazed Ceramics (Stoves, Pottery)	Round or Rectangular Kiln/Firewood	4	0.84	0.74-0.92	2	0.77	0.75-0.80
	Open Kiln/Rice Husk	2	0.80	0.71-0.89	-		
Cassava	Chipper/Diesel	5	0.65	0.60-0.72	-		
	Pelletizer/Diesel	2	1.00	(1.00)	-		
	Flour Mill/Furnace Oil	2	0.19	0.17-0.20	-		
Sugar	Stove/Bagasse	1	0.75	-	-		

ton/ton or kg/kg otherwise ton/unit noted

The cassava chippers not only slice the cassava root but remove unusable parts of the root. Afterwards the product is dried. The average yield is only 65% with a range of 60% to 72%. The cassava flour mill processes the cassava by chipping, drying, milling and centrifuging. The yield averaged 19% from the initial weight of the cassava to the final weight of the flour. About 35% of the weight loss occurred through chipping and drying. Another 41% was lost in the separation of less desirable products such as the mill residue (no alternative use) and the centrifuge residue (used as a pellet binder).

For drying of rubber the weight loss from lowering the moisture content averaged 8% of the initial rubber weight.

For blacksmithing the weight loss was due to waste in metalworking and the oxidation of the product during heating. The two blacksmiths interviewed gave widely differing values for weight loss, due to differences in processes, products and equipment, as well as inaccurate estimates. For a preliminary value the average has been discarded, and a number closer to the lower value, 10%, has been used.

In most of the industries surveyed, an improvement in yield or quality of product can be obtained through more capital-intensive technology or higher energy inputs. What is perhaps more interesting for the present study is how the current technology can be modified with minimum investment to increase fuel efficiency while maintaining or improving yield and product quality.

1.5 Use of Labor

For most industries in Thailand it is difficult to obtain accurate information on level of production or use of labor. Both can be used to determine the level of taxation and the latter is subject to minimum wage regulation. For rural industries this information is less accurate because of the intermittent nature of production, the use of casual labor, and the paucity of records. For this type of data the project survey results are considered less accurate than the NEA survey data, because the survey data was for a single production cycle and the annual production had to be computed by extrapolation.

Given these constraints any estimation of labor productivity must be viewed as tentative with a range of -50% to +100%. The principal value of the data presented in table 3 is that it gives an idea of the relative labor intensity of the different industries and the different production technologies. Productivity is stated in terms of tons per year per man. Given the casualness of labor it is not accurate to translate this into tons per man-year.

For rice mills the productivity of labor increases with the size of the mill. Large steam or electric powered mills use less labor per ton of rice milled than small diesel powered mills according to the NEA data. The project survey data tends to contradict this finding for small units because only 1 or two casual employees can operate a small diesel mill having a capacity of only 1 or 2 tons per day. In larger mills, there will be a large permanent work force which operates not only the mill but also the mill's transport fleet.

For pottery making the rice-husk-fired open kilns appear to require the least labor, one worker per 10 tons annual production. Firewood fueled permanent kilns such as the rectangular and Dragon kilns require

Table 3

LABOR UTILIZATION IN RURAL INDUSTRY

		LABOR CONSUMPTION (PRODUCT IN TONS/NUMBER OF EMPLOYES)					
		SURVEY DATA*			NEA DATA		
PRODUCT	TECHNOLOGY/FUEL	AVERAGE	RANGE	SAMPLE SIZE	AVERAGE	RANGE	SAMPLE SIZE
Limestone	Rectangular Kiln/ Firewood	45	31-60	2	182	27-350	18
	Rectangular Kiln/ Lignite			-	193	161-243	3
Brick	Clamp/Rice Husk -	45	14-110	7	32	5-75	12
	Rectangular Kiln/ Firewood	34	-	1	52	27-75	3
Blacksmith	Simple Forge/Charcoal	6	4-8	2			-
Rubber	Wood Fired Drying Tower	.25	.25-.27	2			-
Ice	Salt Water Coolant Electric Powered Compressor	25	2.7-66.6	3			-
Rice Mill	Small Diesel Motor	24	11-35	5	11	2.6-22.5	7
	Large Diesel Motor Diesel			-	4	0.8-27.4	6
	Rice Husk Fired Boiler			-	7	13-42	13
	Electric Motor	12	5.6-18.7	2	19	-	1
Glazed Ceramics	Round or Rectangular Kiln/Firewood			-	4.0	0.3-8.6	5
	Tunnel Kiln/Firewood			-	2.4	0.6-4.8	6
	Dragon Kiln/Firewood			-	4.6	3.9-5.2	2
Non-Glazed Ceramics (Stove, pottery)	Round or Rectangular Kiln/Firewood	5.3	2.5-7.0	4	2.8	0.3-5.3	2
	Open Kiln/Rice Husk	10	6.3-14.0	2			-
Cassava	Chipper/Diesel	293	205-375	3			-
	Pelletizer/Diesel	332	235-429	2			-
	Flour Mill/Furnace	95	57-133	2			-

* Annual production estimated from time for single production activity intermittent activities produce under estimates of labor requirement as in Rubber Drying

the same labor per unit product and the tunnel kilns approximately twice as much labor. Perhaps more labor is required for fueling the tunnel kilns relative to the other kilns. The simplicity of an open kiln using rice husk extends to the loading/unloading activity as well as the fueling.

For brick-making the labor productivity (in terms of annual weight production) is about 10 times that of pottery due to the larger scale production activity and simplicity in handling.* The rectangular kiln is easier to load and possibly to fuel but the clamp is easier to unload. The results of the project survey and NEA data are contradictory on which technology has higher labor productivity. Since the range of responses is considerable, no attempt can be made to resolve this contradiction.

For limestone kilns the labor productivity depends on how inclusive is the definition of labor. The loading and unloading activities are labor-intensive and some operations provide their own transport labor. Since labor requirements are fixed for loading and unloading, labor productivity is very much affected by the utilization of kilns. Older or poorly made units require considerable maintenance and the production activity may be limited to once a month or less if raw materials are limited. Better constructed units can be fired two or three times per month. The two units surveyed for the project were of the former type. The higher productivity figures in the NEA data may mean that those kilns were of the latter type or that they were capable of parallel operations with two or more kilns. The range of the NEA data is excessive but a tentative value of 160 tons per worker has been chosen with a range of 60 to 300 tons/worker.

In cassava processing the primary labor requirement is for material handling. The productivity of labor varies markedly with the use of diesel or gasoline-powered material-handling equipment. The average productivity observed was high, on the order of 300 tons per man, for chipping and pelletizing. The average productivity dropped by 2/3 for flour mills due to the additional processing and low yield of final product.

For ice factories the sample was too small and the data too varied to permit a reasonable estimate on productivity. For blacksmithing the average productivity of 6 tons per man is reasonable although variations with type of raw material, type of product and scale of production can be considerable. For rubber drying the labor requirements were quite high , but this activity occurs intermittently.

1.6 Markets

The rural industries obtained their raw material through a number of marketing channels. Sixty percent of the respondents purchased some or all of their raw material from traders, local markets or retail facilities. The building material industries collected some of their raw materials such as biomass fuels and inputs (46%), other materials were ordered as required (40%), or direct purchased (33%). Because of the intermittent nature of this industry, large quantities of raw materials were ordered as required rather than contracted, but smaller quantities

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* as well as the higher density of bricks.

of inputs such as diesel were purchased as available in local markets. For the collected material a wide range of sources were used.

For the crop processing industries the agricultural inputs were mostly purchased as available in the regional markets or directly from the villagers. Purchasing as available was mentioned by 76% of the respondents while only 16% mentioned direct collection and 8% ordering as required. The major source was farmgate purchase which was mentioned by 65% of the respondents. Traders were an important source of material for 20% of those surveyed. A variety of other sources were also used but these were less important.

The household goods industries, specifically metal and ceramic goods, purchased their inputs as available (55%). As with the building materials industries, different types of inputs were obtained from different sources with the result that the full range of sources, except craftsmen, were utilized. The details on the sources of raw materials are presented in table 4.

The marketing of the output of rural industries was done using ex-factory, retail and wholesale outlets. The crop processing industries tended to favor the wholesale outlet, 41% mentioned this channel while only 14% mentioned ex-factory orders and 18% retail sales. The building materials industries mentioned wholesale, direct-order and retail marketing with nearly equal frequencies. The household goods industries also mentioned these three. The three principal groups to whom the products were sold were traders, customers who ordered direct from the factory and purchasers at the factory. Local and regional markets and shops did not have a significant role in distribution of these commodities, the breakdown of marketing channels is shown in table 5.

1.7 Sources of Capital

The sources of capital used by rural entrepreneurs to establish their industries included formal bank loans, various sources of informal credit and personal savings. The larger industries such as the cassava flour mills, jute mill, rice mills, and plywood factory used bank loans or funds from partners and parent companies. The smaller factories used mostly personal savings. This source was mentioned by 3/4 of the small factory owners versus bank loans and loans from partners which were mentioned by only 1/6 of these owners. Informal credit sources such as money lenders, friends, suppliers and customers were used but much less than personal savings. No more than 1/5 of the small factory owner mentioned any one of these sources. One interesting source of credit was the profits from previous production activities which was mentioned by 16% of all the owners. The choice of source of credit by type of industry is shown in table 6.

The response rate of the rural entrepreneurs dropped to 75% when questions were asked concerning plans for expansion of production. The constraints on expansion are considerable in rural areas where factories are often too small to achieve significant economies of scale and where there are no significant barriers to entry. For those who responded, 28% mentioned lack of sources of finance for expansion, 20% mentioned a lack of additional demand and, interestingly, 17% mentioned a lack of

Rural Industries

Table 4

Sources of Raw Materials

Types of industries	Types of factors of productions		Method of obtaining raw material				From whom obtained ?								
	raw material	fuel	contract	order as required	purchase as available	collect	1. collect with hired labor	2. village market	3. regional market	4. traders	5. craftsmen	6. order from outside region	7. agriculture	8. collect own labor, other	respondents
1. Building Materials include bricks, limestone, cement and plywood.	clay, limestone, wood, rock, sand	fire wood rice husk diesel electricity	1	6	5	7*	4		1	3		3	2	10*	15
2. Crop Processing : a) rice	rice paddy	diesel electricity			8					1			7		8
b) cassava & sugar	cassava sugar cane	diesel bagasse electricity			8	2						1	9		10
c) rubber & jute	rubber kenaf	fire wood electricity		1	2					2				1	3
d) salt, banana and ice	banana water	electricity diesel gasoline		1	1	2				2				2	4
3. Household Goods : a) ceramic (stove & pottery)	clay	firewood	2	1	2	1	2					2		2	6
b) metal (foundry & blacksmith)	iron	charcoal gasoline			3				1	1				1	3
Total			3	9	29	12	6	0	2	9	0	6	18	16	

*Some collected and obtained by other means.

Table 5

Marketing Channel for Products

RURAL INDUSTRY GROUPS	Sample Size		How is the product sold ? (a)				To whom ? (b)						
			1	2	3	4	1	2	3	4	5	6	7
1. Building Materials:	10	Bricks		5	6	5	6	1		1		4	
	2	Stone	1	1	1	1	4	1	2		1	1	1
	1	Cement		2		1	1						
	1	Plywood		1			1						
	1	Sawmill		1	1	1	1	1				1	
	15	Total	1	10	8	8	13	3	2	1	1	6	1
2. Crop Processing	7	Rice		1	3	1		2	1			1	5
	9	Cassava, Sugar		1	4	1		2				1	3
	3	Rubber, Jute	1	1	1					1		1	2
	3	Salt, ice			1	2	1					1	2
	22	Total	1	3	9	4	1	4	1	1	-	4	12
3. Household goods	6	Ceramic, Stoves		2	2	1	3	1	1		1	3	1
	3	Foundry, Blacksmith		1	2	2	2	1				1	
	9	Total	-	3	4	3	5	2	1	-	1	4	1
4. GROSS TOTAL			2	16	21	15	19	9	4	2	2	14	14.

Code (A)
1. Contract
2. Direct order
3. Wholesale
4. Retail

Code (b)
1. Direct order, customer
2. Sold at factory
3. Sold at local market
4. Sold at regional market
5. Sold in shops
6. Bought by traders
7. Other

Rural Industries

Table 6

Initial Sources of Capital

Types of industries	1. profits from production	2. loans from friends and relatives	3. loans from bank	4. loans from money lender	5. money from partners	6. credit from suppliers	7. advances from customers	8. personel resources	9. others	Total responses
1. Building Materials include bricks, limestone, cement and plywood.	3	1	2	2	2		1	15		15
2. Crop Processing : a) rice	1	2	1					2	1	6
b) cassava & sugar		1	3	1	-	1	1	3		10
c) rubber & jute					1		1	2		4
d) salt and ice								4		4
3. Household Goods : a) ceramic (stove & pottery)	1		1	1				5		5
b) metal (foundry & blacksmith)	1							3		3
Total	6	4	7	4	3	1	3	34	1	47

suitable labor. In the building materials industry about 50% mentioned lack of finance while another 42% mentioned legal and bureaucratic constraints or general lack of interest. For the crop processing industries, lack of demand was mentioned by 44% of those responding while another 22% mentioned lack of finances. For the household goods industries lack of finance, raw material and labor were all mentioned. The responses by industry are shown in table 7.

Only 1/3 of the rural industries responded to the question about what source of finance would be used to finance expansion. Profits from production and personal resources were mentioned most frequently (38% for each source). Loans from banks were mentioned only half as often as is shown in table 8.

Table 7

Rural Industries — Constraints on Expansion

Types of industries	1. finances for investment	2. operating capital	3. raw material	4. labor	5. transport	6. demand	7. ability to manage larger operation	8. willingness to accept risk	9. others, legal, govnt regs, no interest	10. total respondents
1. Building Materials include bricks, limestone, cement and plywood.	6	1	-	2	-	-	-	-	5	12
2. Crop Processing : a) rice	2	-	-	2	-	2	2	-	-	5
b) cassava & sugar	1	1	-	-	-	4	-	-	2	8
c) rubber & jute	1	-	1	-	-	-	-	-	-	2
d) salt and ice	-	-	-	1	-	2	-	-	-	3
3. Household Goods : a) ceramic (stove & pottery)	1	-	-	1	-	-	-	-	1	3
b) metal (foundry & blacksmith)	-	-	1	1	-	-	-	-	1	2
Total	11	2	2	7	-	8	2	-	9	35

Rural Industries

Table 8

Sources of Capital for Expansion

Types of Industries	1. profits from production	2. loans from bank	3. money from partners	4. personel resources	5. others	10. total respondents
1. Building Materials include bricks, limestone, cement and plywood.	3	1	1	5		7
2. Crop Processing : a) rice	1				1	2
b) cassava & sugar				1		1
c) rubber & jute	1	2				2
d) salt, banana and ice				1		1
3. Household Goods : a) ceramic (stove & pottery)	2				2	2
b) metal (foundry & blacksmith)	1					1
Total	6	3	1	6	3	16

*Not cited were loans from friends, money lenders, suppliers or customers.

1.8 Production Processes

The production activities for the different industries vary in complexity. These activities are outlined in the flow charts in figures 6 to 12 by indicating either the equipment or the process at each stage of production. For ice making, the production process is standard with ammonia used in a primary refrigeration cycle and salt water used in a secondary refrigeration cycle. The chilled salt water is circulated through the ice tray storage area to freeze the water in the trays. Bubblers are attached to the trays to make the ice clear. The water for the ice is pumped from its source to the plant and may be chlorinated, filtered and otherwise conditioned as required. The salt water coolant is pumped through heat exchange units prior to being chilled by the ammonia refrigerent. The contents of the ice trays are cut into blocks using electric saws. The trays are moved between the storage area and the loading/unloading area by means of an electric winch. The equipment used in an ice factory is shown in photo sequence I.

The making of limestone is also a straight-forward process. The limestone rock is loaded into a large kiln, the kiln is sealed and then fired. The firing lasts about 7 days after which the limestone is removed. If it is to be used as a filtering material, then it is loaded directly onto trucks. If it is to be used for cement it it combined with water and ground into powdered form. This sequence is diagrammed in figure 7 and typical kiln operations are shown in photo sequence II.

The making of bricks is done in a number of ways. The basic methods observed during the survey are shown in figure 8. The bricks are made from a mixture of clay and either rice husk or ash. They are either manually formed by slop molding or mechanically formed by a diesel powered extruder and wire cutter. The bricks are sun dried and then either loaded into a wood fueled permanent kiln or stacked in the form of a clamp which is fueled by loading rice husk from the top of the kiln. The rice-husk-fired clamps are fired for about 20 days whereas the wood-fueled kilns are fired for about 5 days. Examples of the different kilns and brick-making processes are shown in photo sequence III.

The making of ceramics is similar to brickmaking as shown in figure 9. The preparation of the clay is presented in more detail on this flow chart. The clay is formed by grinding the clay and manually shaping in a mold, by mixing the clay into liquid form and pouring into a mold or by forming the clay using a mold and jigger. Not included in this chart are hand thrown pottery which are usually made by home industries. In the larger factories, electric powered equipment may be used to prepare and shape the clay. The pottery is fired in permanent kilns using firewood or in mound kilns using mostly rice husk. If the pottery is to be glazed a second firing is done in a wood-fueled kiln . The different kilns are shown in photo sequence IV.

The manufacturing of clay stoves is similar to ceramics but is shown in more detail in figure 10. The grate and clay stoves are formed separately using molds, jigger and wheels. The air-dried pieces are

Figure 6

ICE

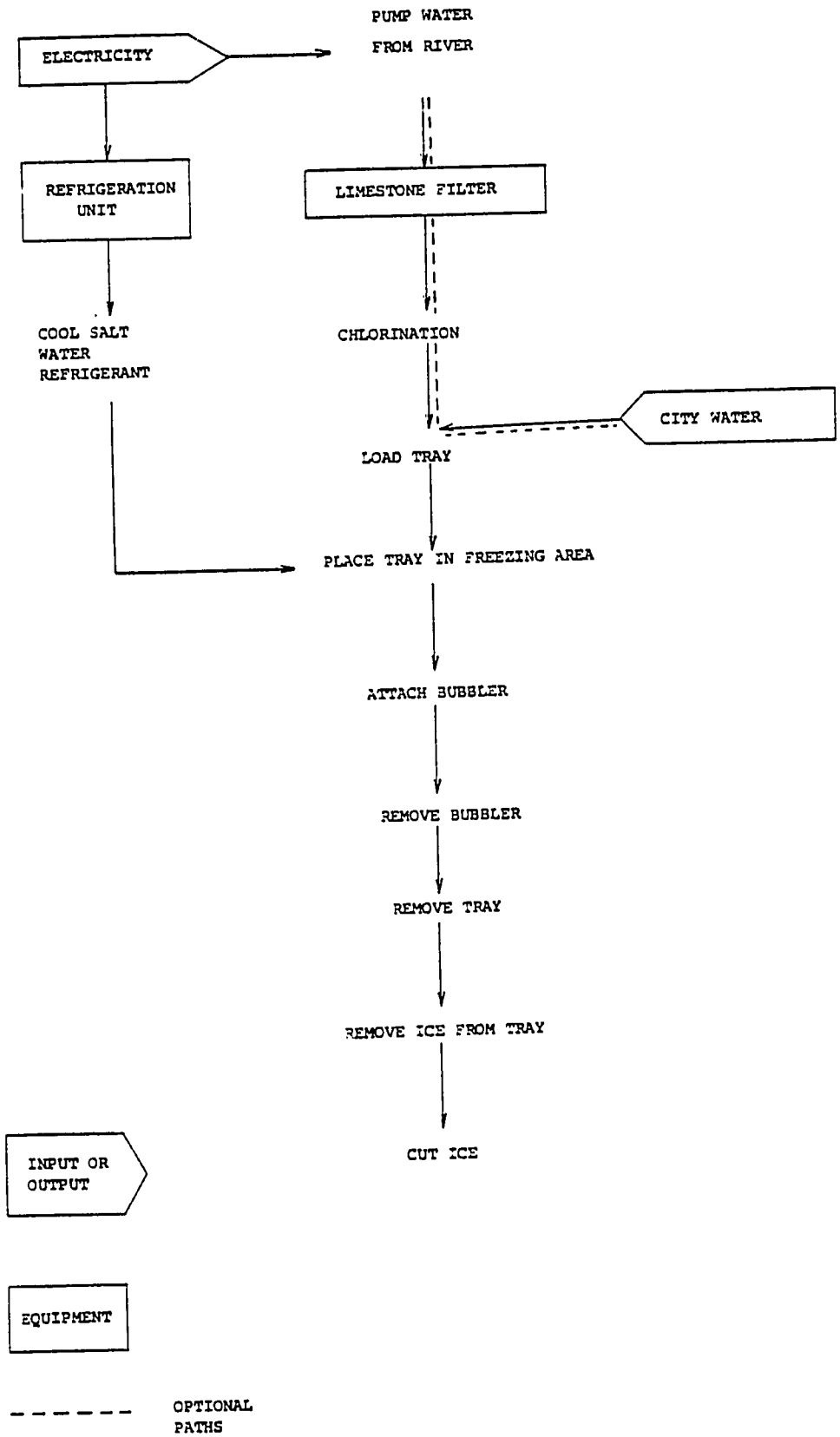

ELECTRICITY
PUMP WATER FROM RIVER
REFRIGERATION UNIT
LIMESTONE FILTER
COOL SALT WATER REFRIGERANT
CHLORINATION
CITY WATER
LOAD TRAY
PLACE TRAY IN FREEZING AREA
ATTACH BUBBLER
REMOVE BUBBLER
REMOVE TRAY
REMOVE ICE FROM TRAY
CUT ICE
INPUT OR OUTPUT
EQUIPMENT
OPTIONAL PATHS

Figure 7

LIMESTONE

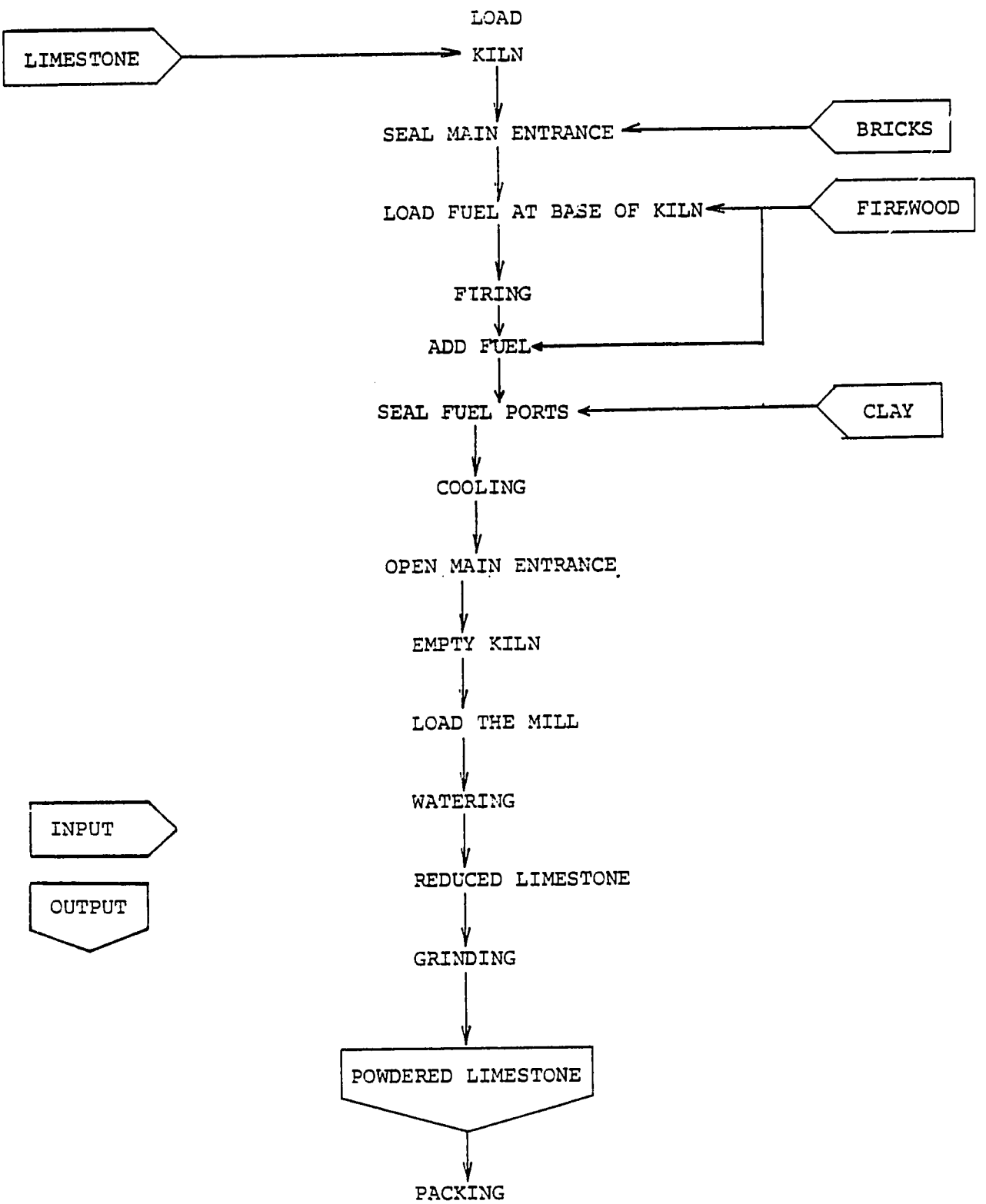


Figure 8

BRICK

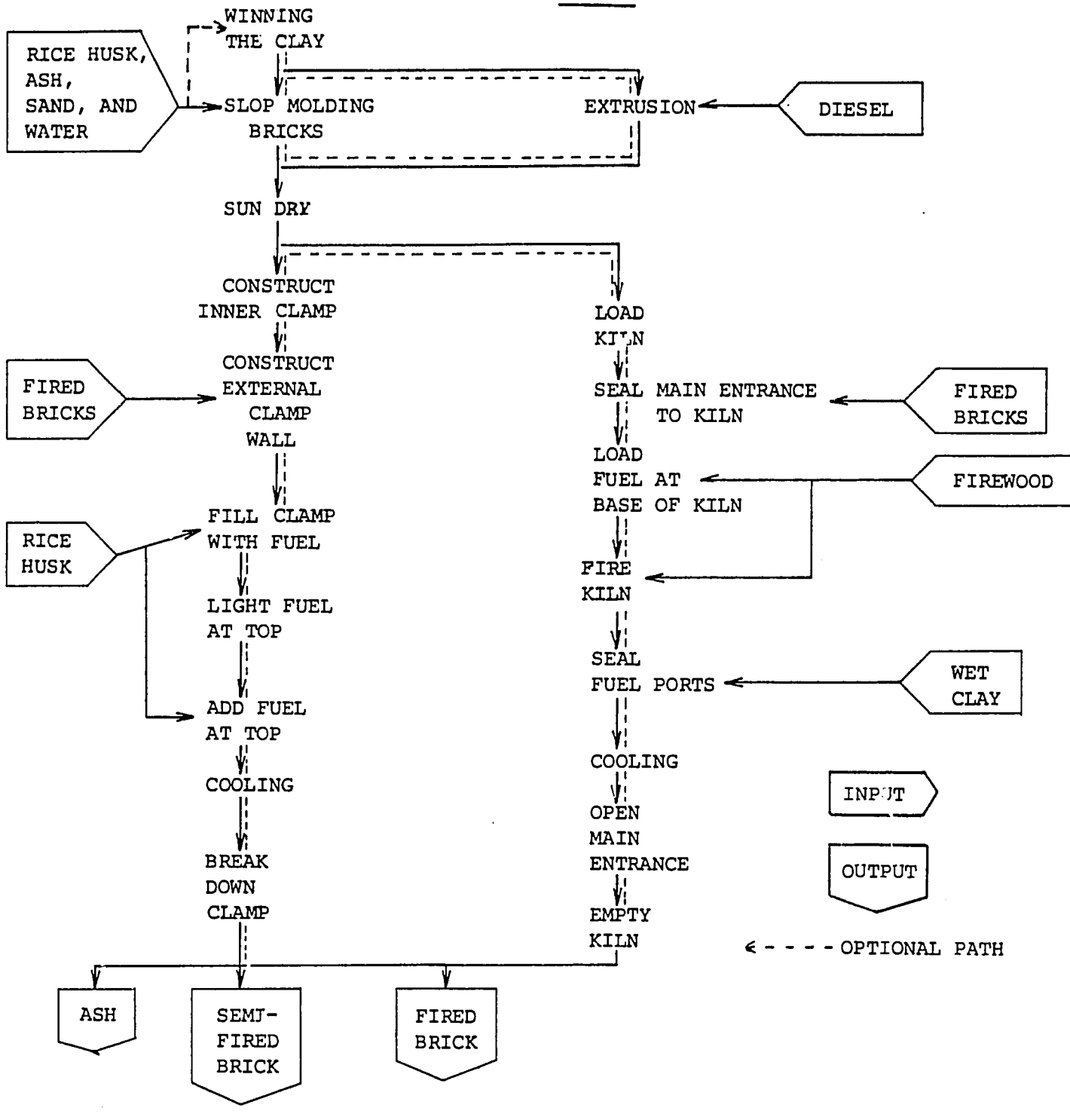


Figure 9

CERAMICS

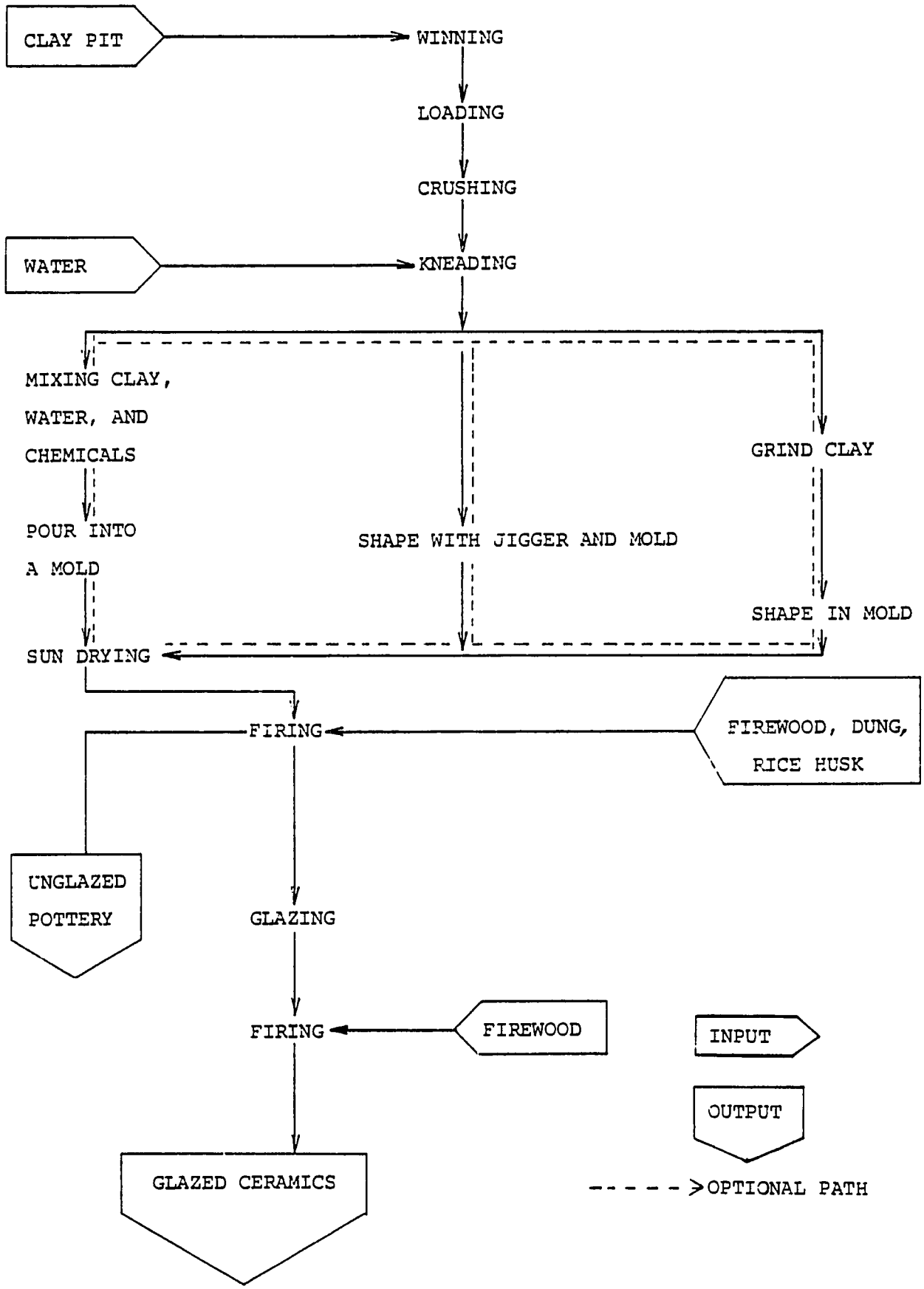
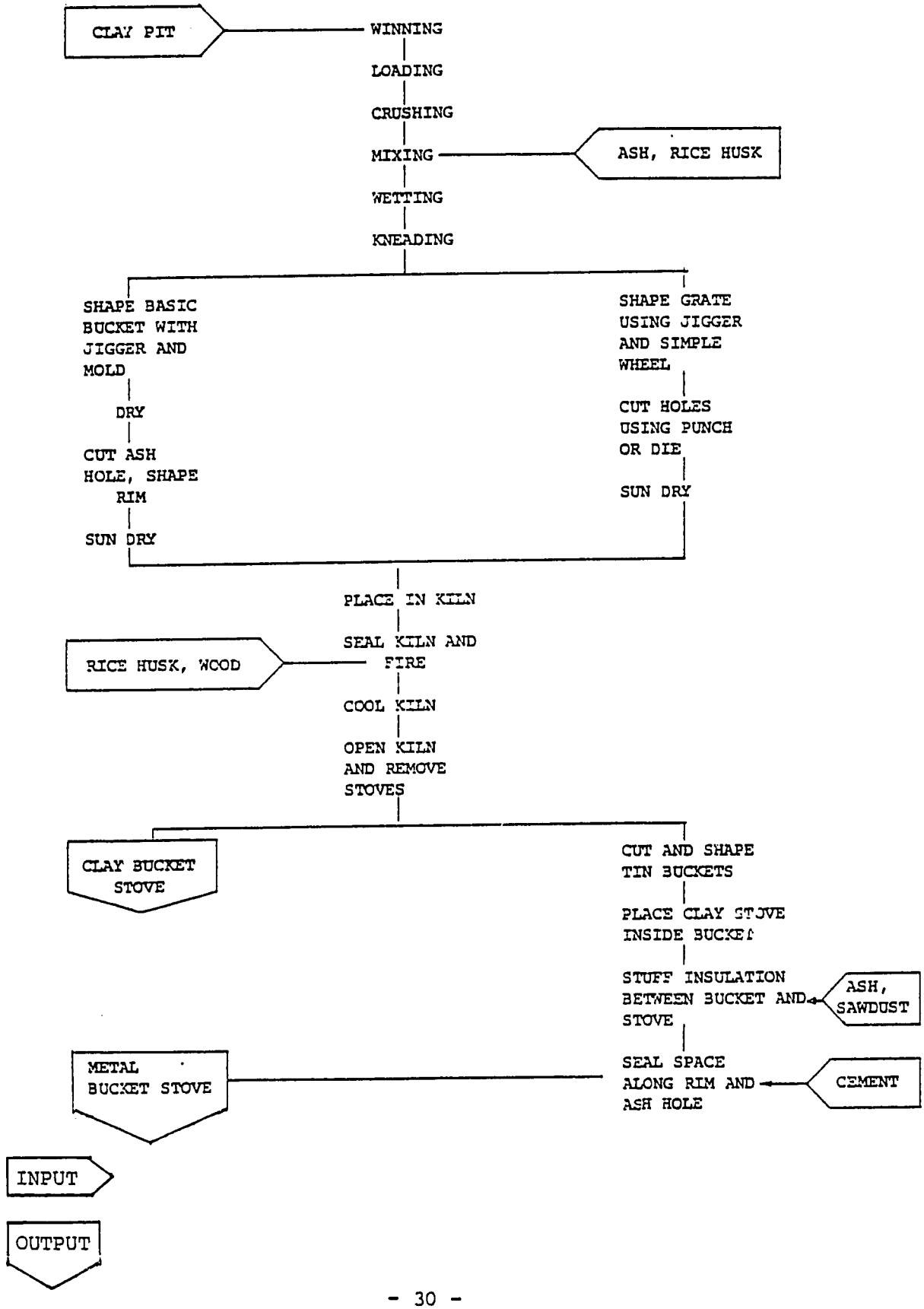


Figure 10

STOVES



cut and shaped using knives, punches and dies and then sun-dried for a few days before being placed in the kiln. Firing lasts from 3 to 5 days depending on the kiln and fuel. After firing, the clay stoves are either sold or made into metal bucket stoves. The latter are produced by forming buckets from tin sheets (bad printing runs of beverage can stock), placing the clay stove in the bucket and insulating the space between the clay and metal with ash or sawdust. The insulation is then sealed using a grouting material and a wire handle is added. The stove making activities and different kilns are shown in photo sequence V.

The processing of cassava has different activities depending on the end product. Three products are shown in the flow chart in figure 11, chips, pellets and flour. For all three the cassava root is chipped using a diesel-powered chipper. The chips are placed in a milling unit and an extruder if pellets are to be produced. If flour is desired, a centrifuge, extractor and dryer are used in addition to the milling unit. For the flour mill the production of residues is considerable. The waste products from the chipping activity have no use while those from the centrifuge can be used as a pellet binder. The equipment used in a cassava flour mill is shown in photo sequence VI.

The activities in a jute mill are typical of those in most textile mills. The kenaf and jute are obtained in the form of bales. The material is debaled and steam cleaned. The fibers are then carded, drawn and spun to produce a thread. The thread is put on a beam and then used for weaving (see figure 12). The various machines are shown in photo sequence VII.

The rural sugar industries which were observed grind the cane and boil the cane juice for about one day in a bagasse-fueled stove to produce raw sugar which is then sent to larger sugar mills for further processing and refining. The production process for these small industries is shown in figure 13 and scenes from a typical factory are presented in photo sequence VIII.

Other industries whose processes were observed but whose production sequence have not been diagrammed are rubber drying, salt making, metal foundry and concrete form work. The sequence of production is highlighted in the photo sequences IX to XII.

Rice milling is an important rural industry. The process is simple so no flow chart has been prepared. However, the flow of materials and related activities can be relatively complex. The flow chart in figure 14 describes a mill in Udorn Thani which combines pig raising and fish farming whith rice milling in order to improve the efficiency of resource utilization.

Figure 11

CASSAVA CHIP, PELLET OR FLOUR MILL

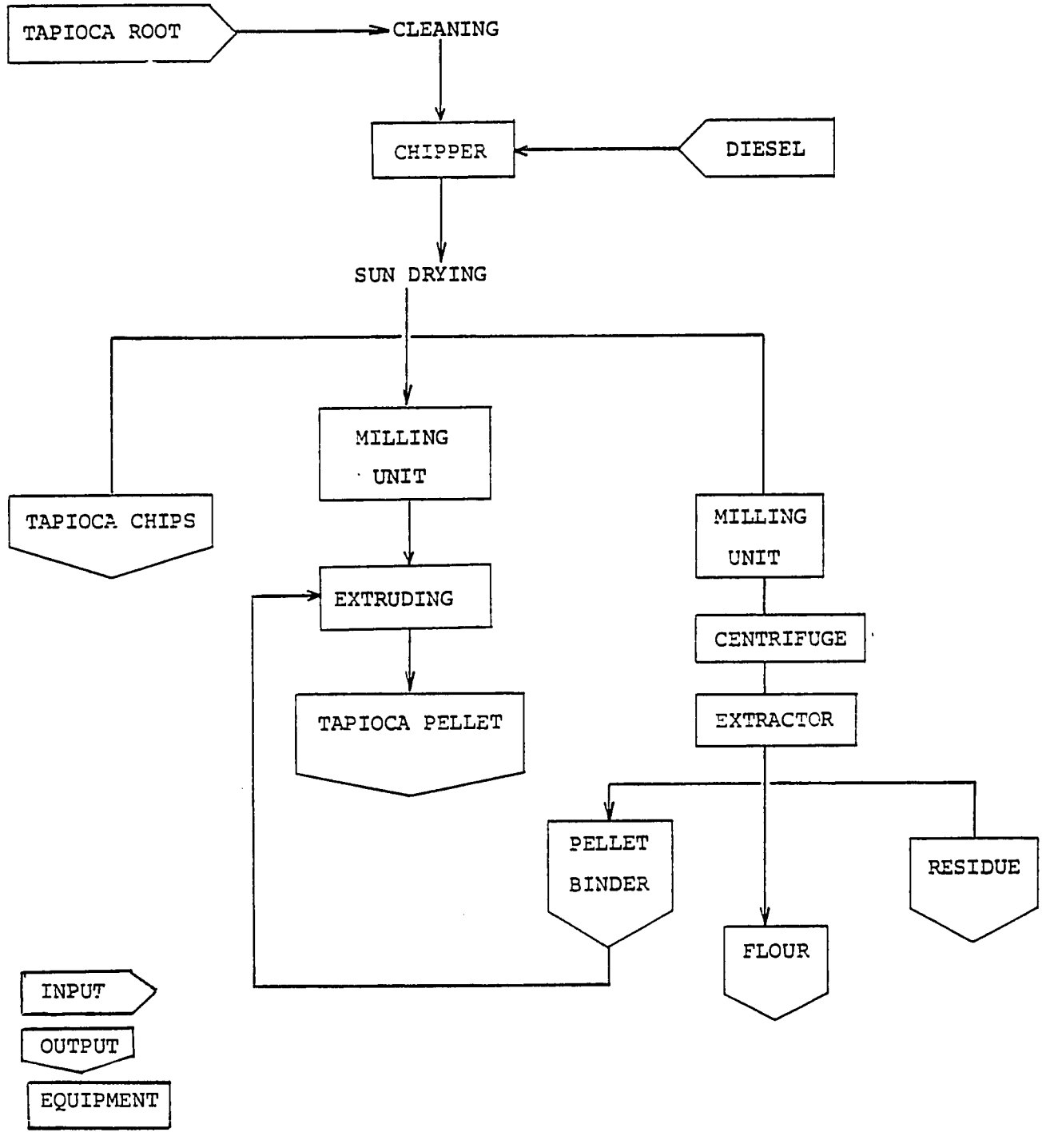


Figure 12

JUTE MILL

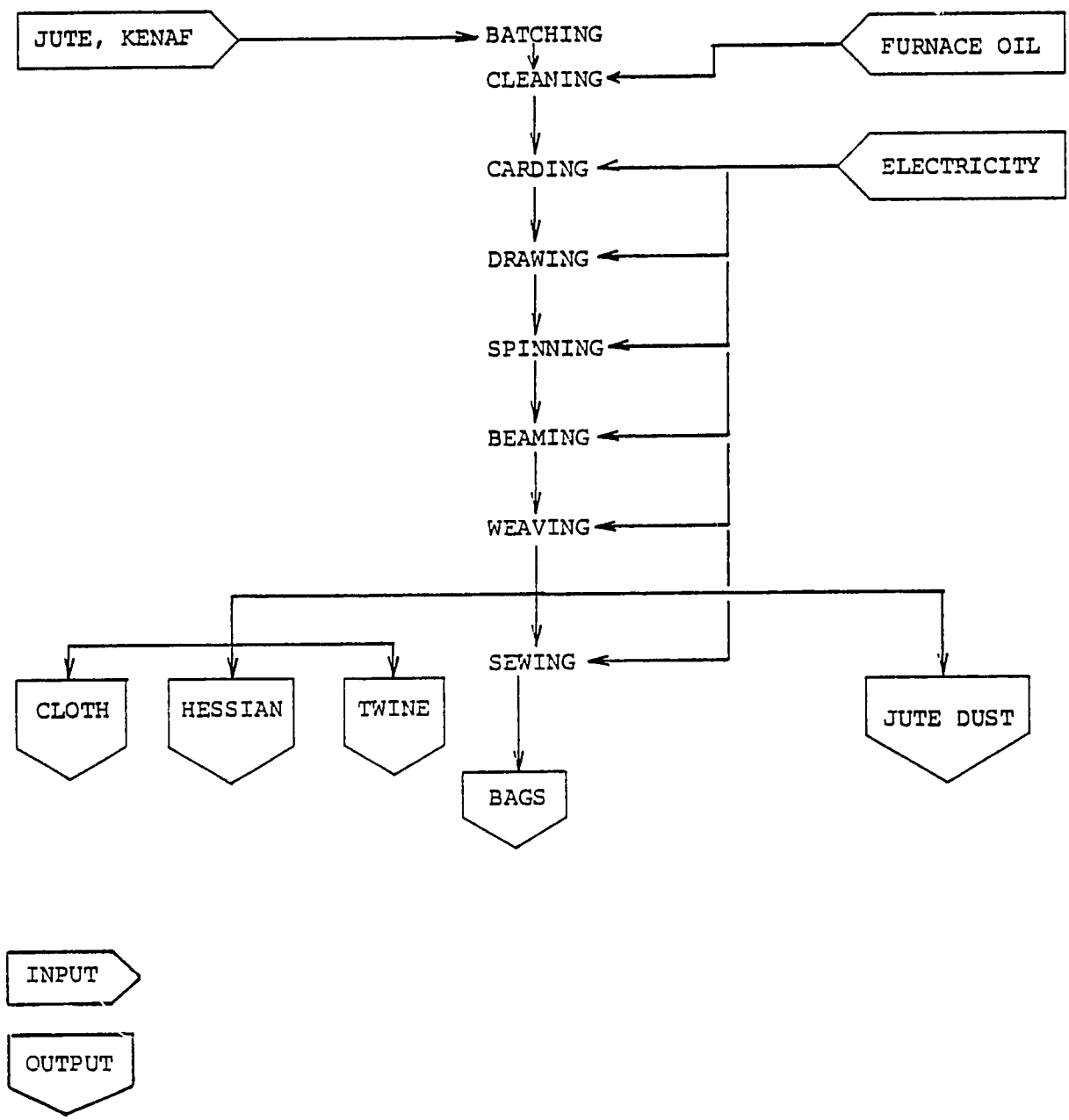
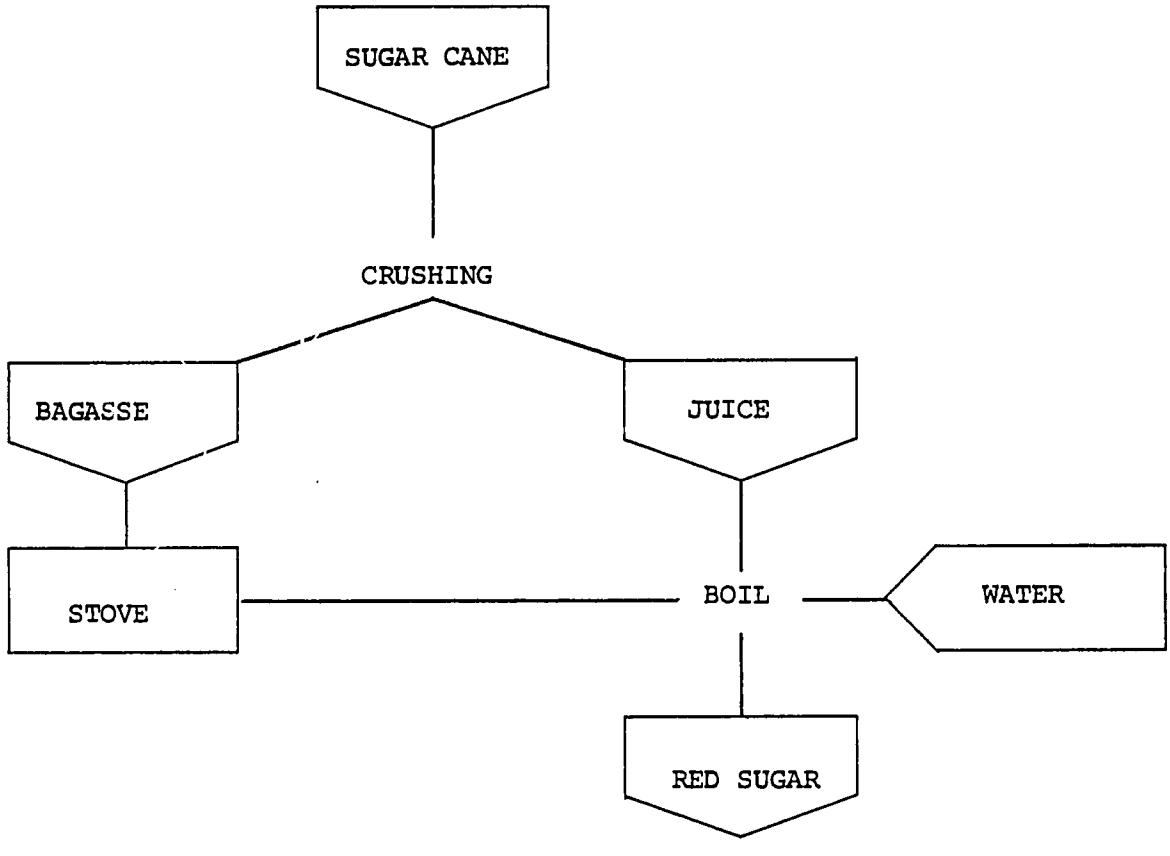


Figure 13

RED SUGAR



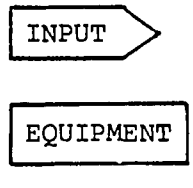
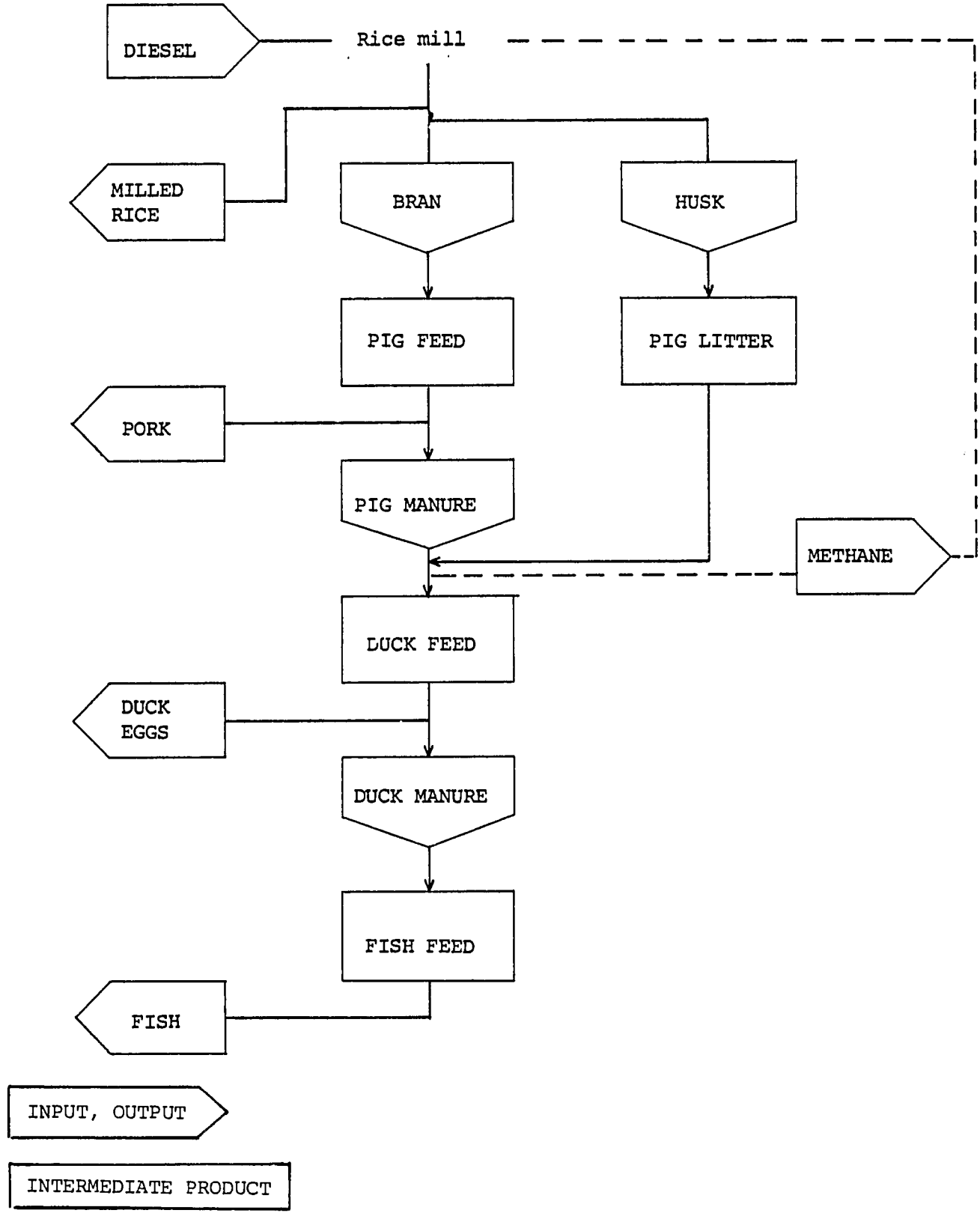


Figure 14

Integrated Rice Mill



Home Industries

2.1 Methodology

The definition of home industries as distinct from rural industries is not always clear. For the purposes of this survey a rural industry was defined as one whose production facilities were located away from the house and which employed a work force other than family members. The rural industries were surveyed directly by the survey co-ordinators and supervisors using a questionnaire designed specifically for these industries. In contrast, the home industries were surveyed by the survey enumerators as part of the household survey. Only a few questions regarding production, fuel consumption, raw materials and labor were asked and no measurements were made.

2.2 Findings

A suprising number of home industries were found in Udorn Thani, Lampang, Roi-et and Korat, where 22%, 15%, 15% and 12%, respectively of the survey households, had home industries. In Srisaket and Chiang Mai only 8% of the survey household has home industries, and in the other survey changwat the response rate was less than 3%.

The variety of home industries was considerable (see table 9). Most of them produced either food products or household goods such as clothes, woven products, and simple wood and metal products. The technologies were traditional, except for those doing cement form work, rice milling and metal sheet work. All production activities were labor-intensive.

Most of the home industries did not use fuel in their production activities. The principal exceptions were those industries producing food. Attempts were made to determine the amount of fuel consumed in food production activities but most respondents did not know. Those respondents who purchased rather than collected fuels were more frequently able to estimate fuel consumption. Some of these estimates are presented in table 10. The fuel consumption for the rice mills, brick kilns and blacksmiths is similar to the rates in the larger rural industries.

Table 9

Type of Home Industries Surveyed

Changwat	Number	Types
Petchaburi	3	Food (1), woven goods (2)
Korat	24	Food (18), broom (1), woven goods (2), metal container (1), rice mill (2)
Srisaket	15	Silk (3), woven basket (1), woven clothes (12)
Kampangphet	6	Charcoal (1), woven goods (2), thatch roofing (2), rice mill (1)
Lampang	30	Charcoal (1), woven goods (1), food (3), thatch roofing (25)
Songkla	1	Cement rings
Chantaburi	4	Food (2), woven goods (2)
Roi-et	25	Woven goods (23), blacksmithing (2)
Udorn Thani	40	Woven goods (7), blacksmithing (1), woven clothes (7), red sugar (22), bamboo drum (1), rice mill (2)
Chiang Mai	14	Woven goods (9), brick (2), wooden goods (3)

Table 10

FUEL CONSUMING HOME INDUSTRIES SURVEYED

Area	Number	Product	Technology	Raw Material	Fuel	Fuel Consumption Product/Fuel
Petchburi	1	Fried Banana	Stove	Banana	Wood	NA
Korat	2	Rice	Rice mill	Padi	Diesel	330kg/lit
Korat	2	Sweets (sticky rice)	Stove	Banana, rice	Wood	2.3kg/kg
Korat	1	Chinese Noodles	Stove	Rice	Wood	NA
Korat	1	Noodle Strainer	Simple forge	Lead, zinc	Charcoal	NA
Kampangphet	1	Rice	Rice mill	Padi	Diesel	62kg/lit
Kampangphet	1	Charcoal	Kiln	Wood	Grass, Wood	NA
Lampang	1	Charcoal	Kiln	Wood	Wood	NA
Lampang	3	Thai Spaghetti	Stove	Rice flour	Wood	NA
Chantaburi	1	Sweet rice in bamboo	Stove, saw	Sticky rice, sugar, coconut	Coconut frond	¼ lit/leaf
Udorn Thani	2	Rice	Rice mill	Padi	Diesel	2.5 sacks/lit
Udorn Thani	1	Knives, spades	Forge, tube bellows	Iron sheet	Charcoal	1 knife/kg
Udorn Thani	2	Red sugar	Stove	Sugar cane	Bagasse, wood	NA
Chiang Mai	2	Brick	Kiln, mold	Clay	Rice husk	500 bricks/m^3
Chiang Mai	3	Wooden bowls	Motorized lathe	Teak	Electricity	5 piece/kwhr

3. Comparison of Results

Data on consumption of fuels by rural industries is relatively scarce. In the previous sections the baseline survey data has been compared with the results of the National Energy Administration's own survey. Some data is also available from publications in other countries, however, the variations in fuels, technologies, raw materials and quality of products is so wide as to make direct comparison somewhat difficult. Nevertheless an attempt has been made to make such a comparison in tables 11 through 13. In the first, the data from the baseline survey on fuel consumption has been converted to energy consumption by computing the heat content of the fuels used. This conversion was made using the data on moisture content of the fuels collected during the rural industry survey and the standard heat content values derived in the "Biomass" volume. An extended sample was computed by including industries for which no sample was collected and using standard measures for both the heat and moisture content of the fuels. The most intensive energy use was in the blacksmith industry which consumed about 21 megacalories per kilogram of product. Foundries and ceramic factories were the next most energy intensive consuming about 6 megacalories per kilogram. Brickmaking, rubber drying and limestone reduction required between 2½ and 3 megacalories of wood fuel per kilogram of product. When rice husk was used the brick industry's energy consumption dropped to 1.7 megacalories. The least fuel intensive were the evaporation stoves for raw sugar and salt, which consumed 1 megacalorie or less per kilogram.

Data for energy consumption in other parts of the world has been collected for brickmaking as shown in table 10. The range is considerable, .3 to 6 megacalories, for the different fuels, kiln designs, and brick quality. For wood fired clamps the range narrows to .6-6 megacalories. The survey data average was in the middle of this range. Energy consumption for other industries is shown in table 13, however most of the information is for commercial non-biomass fuels. The pottery data has a wide-range depending largely on the type and quality of product. The range is similar to that found in the survey. For the textiles the survey data about 1/10 the amount mentioned in an Indian source, but for rice milling the survey data is 10 times as large as the value in the same source.

This discussion is not meant to reduce confidence in the survey data, but rather to point out the paucity of data on energy use for rural industry.* Only where a careful analysis has been made of the process, technology, level of energization and product quality can a comparison be made between different countries or even different regions of one country. At present, brickmaking is the only rural industry which has been studied in depth, but even in this industry the energy use is not well understood.**

* It is also necessary to exercise care in the collection of data. The Indian data may be aggregate values taken from industries using different fuels and having different levels of energization.

** A recent study of rural industry in Nepal by Deanna Donovan indicated much higher fuel consumption. The reasons for the differences were thought to be due to differences in technology.

Table 11

ENERGY CONSUMPTION BY INDUSTRY - SURVEY DATA
(MEGACALORIES PER KILOGRAM)

TYPE OF PRODUCT	MOISTURE MEASURED			MOISTURE ESTIMATED		
	SAMPLE SIZE	AVERAGE	RANGE	SAMPLE SIZE	AVERAGE	RANGE
Brick - wood	4	2.9	1.5-4.8	-	1.7	1.6-1.9
- rice husk	-	-	-	7	-	-
Rubber	1	2.6	-	2	2.8	2.6-3.0
Limestone	1	2.9	-	2	4.0	2.9-5.2
Ceramics, Stoves	4	6.4	1.5-12.0	6	7.2	1.5-12.0
Blacksmith	2	21.4	10.1-32.6	-	-	-
Foundry	1	5.9	-	-	-	-
Salt	1	1.0	-	-	-	-
Sugar cane	1	.3	-	-	-	-
Rice mills	4	.2	1.8-2.6	-	-	-
Cassava flour Mills	2	.8	-	-	-	-
Jute mills	1	.5	-	-	-	-

* standard calorific values used for energy content calculation

Table 12

FUEL CONSUMPTION FOR BRICKMAKING - NON-SURVEY DATA

TYPE	FUEL	Mcal/kg
Clamp (E. Africa)	wood	1.6-2.1
(India, Turkey)	coal	.9-1.2
Large scove kiln[1] with outside skin of fired bricks	coconut husks;	.5
	heavy fuel oil	.3-.9
Clamp (Indonesia)[3]	wood	1.0-4.3
Clamp[4]	wood	1.3-6.0
Downdraft kiln[5]	gas	1.3-1.8
Hoffman kiln[2] (minimum)	wood	.3
(normal)	wood	.6-.8
Ring Tunnel barrel arch kiln[6]		1.6-3.5
Continuous chamber kiln		2.1-2.9
Modern tunnel kiln[2]	gas, coal	1.5-2.3

Sources:

1. Brickmaking in Developing Countries assume 1 brick = 1.8-2.4 kg. (D-7).
2. Brickmaking Plant: an Industrial Profile (D-4).
3. Author's survey
4. Brick Manufacturing in Developing Countries. Case Study: Brick and Tile (D-3)
5. U.S. Bureau of Labor Statistics (D-1)
6. The Firing of Bricks, E. Rowden, Brick Development Assoc. 1964, London.

Table 13

FUEL CONSUMPTION FOR OTHER INDUSTRIES - NON-SURVEY DATA

(MEGACALORIES PER KILOGRAM)

PRODUCT	FUEL TYPE	TECHNOLOGY	FUEL CONSUMPTION Megacalories/ kg	ASSUMPTIONS	SOURCE
Floor tiles	no data	modern kiln	2.56	-	1
Pottery	coal	intermittent	1.3	-	1
		continuous	5.0	1	2
		downdraft	12.4-21.7	1	2
Cotton	Coal, Fuel oil	-	3.35	1	2
Wool (Carding)	diesel	-	6.4	2	3
Rice Milling	electricity	-	.03	3	3
Sugar Milling	wood, coal	-	1.82	3.4	3
Rice Flour milling	diesel	-	1.83	2	3

Sources

1. Energy For Industry, O' Callaghan
2. Project Report and Feasibility Study of an Appropriate Technology for Carg and Singh
3. Perspective Plan for Rural Electrification in The Telagana Region of Andhra Pradesh, India, National Council of Applied Economic Research, India

Assumptions

1. 6200 kcalories/kilogram for coal
2. 10,500 kilocalories/liter for diesel oil
3. per kilogram of padi
4. 3600 kilocalories/kilogram for wood

4. Conclusions

4.1 Survey Methodology

The rural industry survey effort reinforced the authors' belief that such surveys are among the most difficult to perform. Interviews with managers or operators are generally unsatisfactory unless a personal relationship already exists with the interviewer. Therefore, during the second phase of the survey, the original goal of surveying rural industries within the village survey area was changed to surveying rural industries in which the interviewer knew the manager or had a personal basis on which to approach him. The ability to analyze the relationships between technology, production process, fuel, material, labor and final product requires an engineering background preferably in industrial or mechanical engineering.* The industry survey team was made up of survey co-ordinators and supervisors who were social scientists not engineers.

The physical measurements for industries which use biomass fuels are difficult to perform because of the quantities involved. Simple procedures for weighing the contents of different size trucks and carts need to be developed. It is important that the survey personnel be present at the beginning and end of a production run to measure input and output. A two-person team made up of an engineer and an assistant is probably the most suitable strategy. The former would survey the technology while the latter would spend several days observing procedures and measuring materials. This strategy assumes that the basic goal is to analyze the production process from the viewpoint of introducing changes in technology and fuel use. A static analysis of fuel consumption would require a much simpler strategy.

4.2 Rural Industry

Those rural industries which use biomass fuels use relatively simple technologies and large quantities of fuel. Fuelwood consumption ranges from an average of about 1 kilogram per kilogram of limestone and 1½ kilograms per kilogram of brick to 2 kilograms per kilogram of pottery. Charcoal consumption for metalworking ranges from 1 kilogram per kilogram of product for foundries to 3 kilograms per kilogram of product for blacksmiths. Rice husk is used in brick-making, rice milling, and to a limited extent for pottery making. Average consumption figures are .6 kilograms per kilogram of fired brick and 1.6 kilogram per kilogram of fired pottery. The value for rice mills could not be determined accurately, but the average consumption reported was .09 kilogram per kilogram of rice milled. Engineering estimates indicate that the average fuel consumption should be closer to .12 kilograms of husk per kilogram of milled rice.

The production activities of rural industries are usually seasonal or intermittent. Therefore labor is often hired on a casual basis. Production is frequently based on orders rather than continuous activity. The output is further limited by shortages of fuels and raw materials and by competition from other production facilities. As a result the rural industries are operated at 50% or less of capacity. Technologies are

* Large sample size can provide some insights, but accurate data collection requires that the interviewer have some understanding of the production technology.

simple. Where diesel or electric power has been introduced the technical capabilities of the work force are limited to operating the equipment and possibly maintaining it but not repairing. These industries use a variety of marketing channels to sell their products and to obtain raw materials. This diversity is associated with the uncertainties of supply and demand rather than aggressive marketing. The source of finance for capital investment for rural industries is limited and heavily reliant on personal savings.

Any modifications in technology or production processes which reduce fuel consumption or use substitute fuels would be difficult to introduce because of the difficultmarket in which rural industries operate. One strategy for fuel conservation would be to modify traditional technologies rather than introduce new ones. This would minimize the capital cost and the retraining of labor. A second strategy would be to introduce new technologies through subcontracting arrangements from larger urban industries.

One of the major findings of this survey is the relative paucity of village industries. Most of the industries that were surveyed were located near main roads or in the amphoe centers. It appears that the ubiquitous road network in Thailand has reduced the competitiveness of village industries in favor of district industries. However, the regional concentration of these enterprises does not imply a concentration in the number of firms. The rural industries exist in a relatively competitive environment with few barriers to entry other than bureaucratic controls.

4.3 Home Industries

Home industries are not significant consumers of fuels except in the production of food products. The fuel consumption in food production is related to the efficiency of stove design which is addressed elsewhere in the project. Most home industries are labor-intensive activities requiring a minimum amount of equipment. Products are sold within a village or to traders from outside. Family labor is used. The production is limited by the availability of this labor, the family's income requirement and the potential demand. It is difficult to imagine any rural industry developing from these activities.

4.4 Future Surveys

The Renewable Non-Conventional Energy Project includes as one of its components an effort on industrial conservation. It was in support of this component that the rural industry survey was undertaken. The traditional efforts at industrial conservation have tended to focus on large industries where major reductions in fuel consumption can be achieved through sophisticated technical diagnosis and capital investment. Since the corporations concerned are relatively large and have an understanding of their costs as well as access to commercial credit, it is easier to convince them to reduce their fuel consumption.

Rural industries present a quite different problem. Their technologies are relatively simple, their operations are relatively small,

and their knowledge of costs and access to credit are limited. The approach to these industries must be completely different with more emphasis on technical design and less on monitoring technology. Before summarizing this approach it is worth considering the reason why such an effort is required:

1. Rural industries are more dependent on non-petroleum fuels, especially fuelwood.
2. Though individual factories are not major users of biomass fuels, the total fuel consumption of the factories is significant. For brickmaking alone, the fuel consumption nationally is probably on the order of ½ to 2 million tons of fuelwood and rice husks.
3. The rural industries not only contribute to the depletion of the national wood supply, they are also victims of this depletion. As supplies diminish they must use more expensive and often illegal sources of fuel thus increasing their production costs and reducing competitiveness.
4. The rural industries are a vital part of the Thai economy. They help to reduce the rural-to-urban migration, develop local entrepreneurship, and distribute wealth to the rural areas.
5. Decentralized rural industries reduce transport costs and fuel consumption.
6. Rural industries generally produce a product quality and price which better reflects needs in the local market.

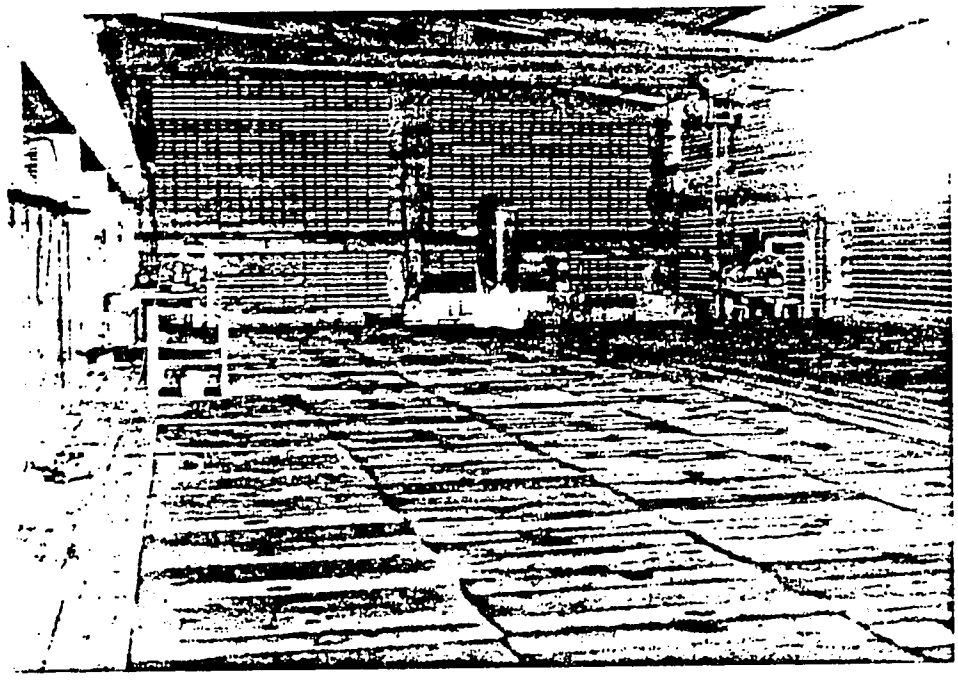
Future surveys should concentrate on the production technologies, especially as they relate to fuel use. Two significant problems for rural industry are the lack of access to finance and to technical information. More than once, the surveyors were asked about technical alternatives to permit fuel substitution or reduction in fuel consumption. Many of these alternatives have already been introduced in Thailand but have not been disseminated. The implications for future work are:

1. Rural industry surveys should concentrate on identifying the different production processes and technologies and their effects on
   - product quality
   - fuel consumption
   - labor skills
   - investment costs
   - operating costs and profits
2. Mechanical and industrial engineers should be involved in the planning and execution of the survey.
3. Simple technical drawings and photographs should be used for cataloging observations.
4. Unstructured interviews should be held with factory owners to identify problems in introducing technical change for their production activities.
5. Where possible the scientific reasons for improved fuel or production efficiency should be determined, possibly through consultation with university researchers or other experts.

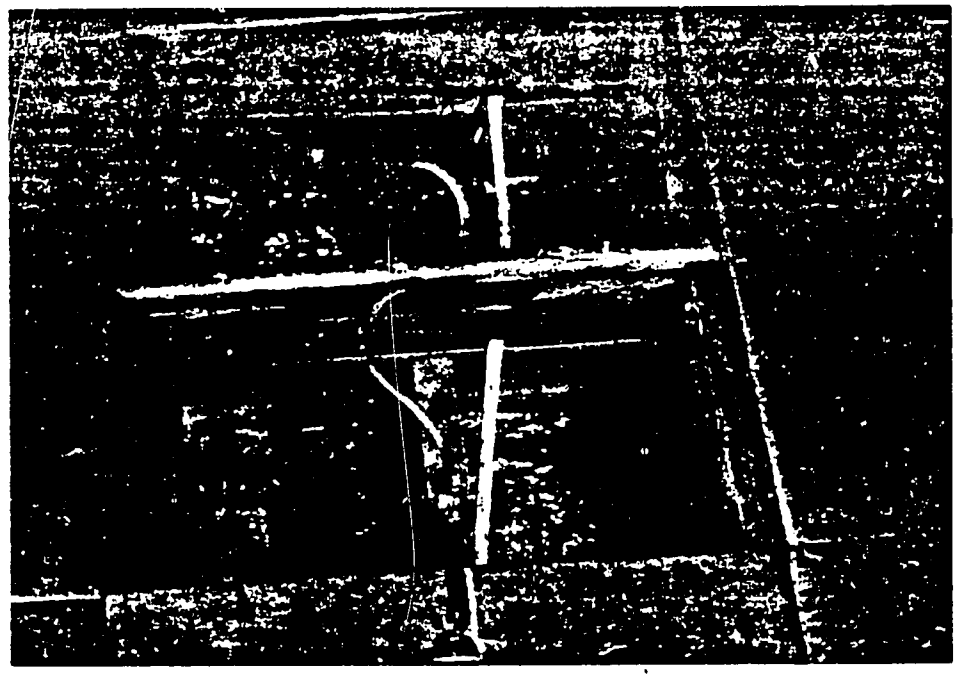
6. The survey results should be prepared in two reports; one directed at policy officials containing the statistical analysis and the implied demand for fuel, the other directed at factory owners and designed as a simple technical brochure on improved technologies and processes.

SEQUENCE I

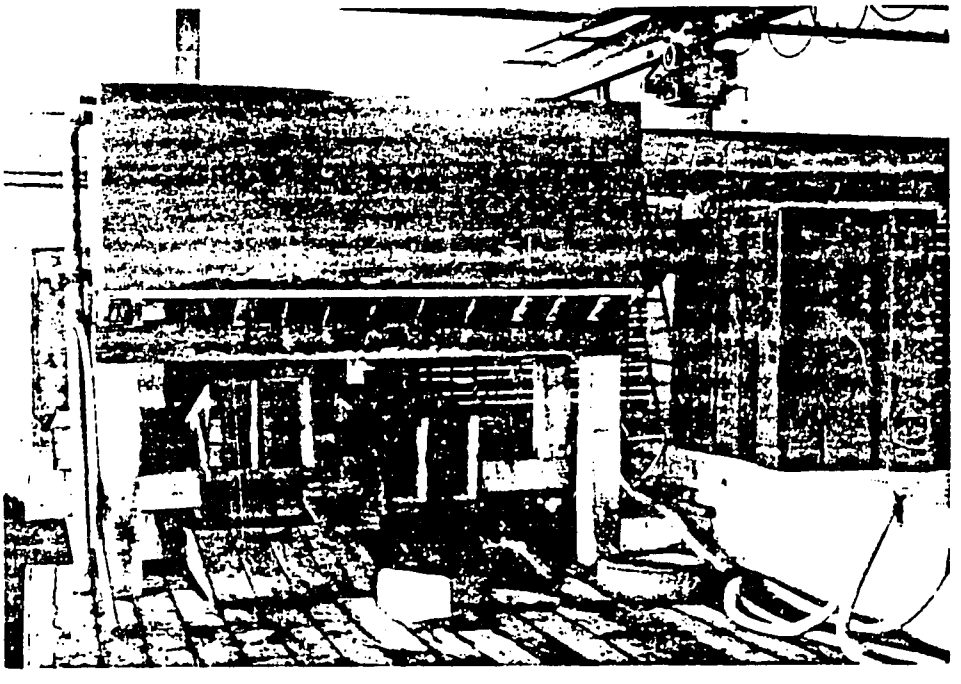
ICE



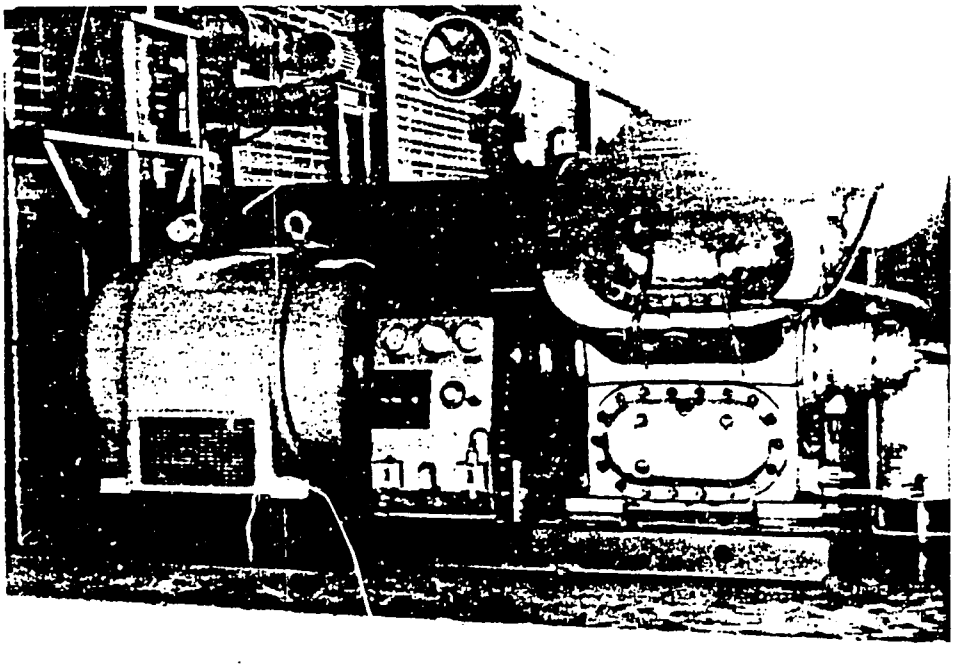
Freezing area with hoist for lifting ice trays - Udorn Thani



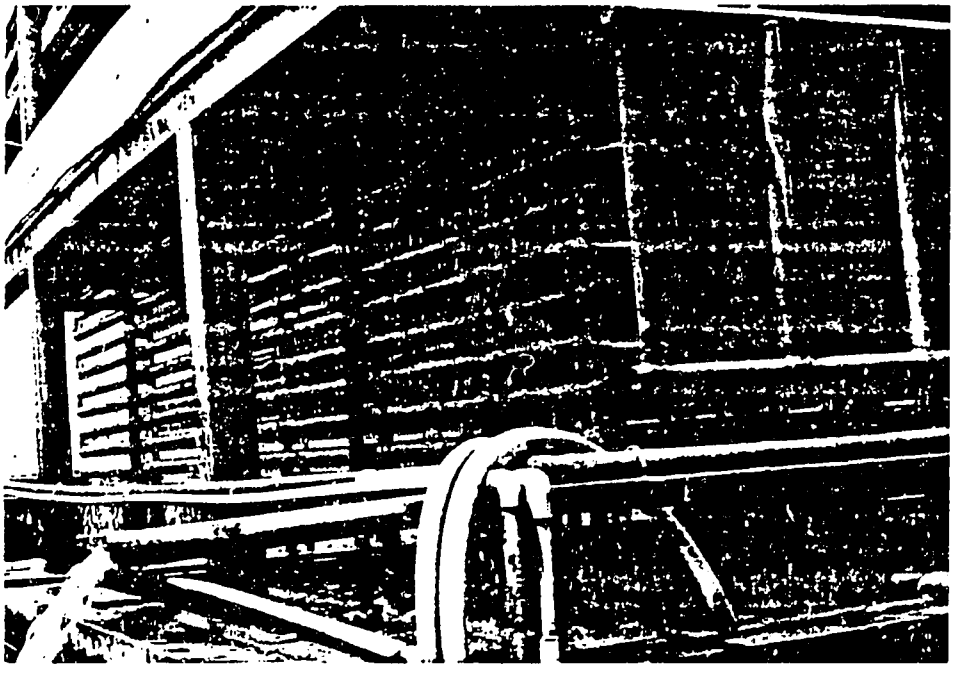
Bubbling tubes in ice trays



Ice tray unloading tippers



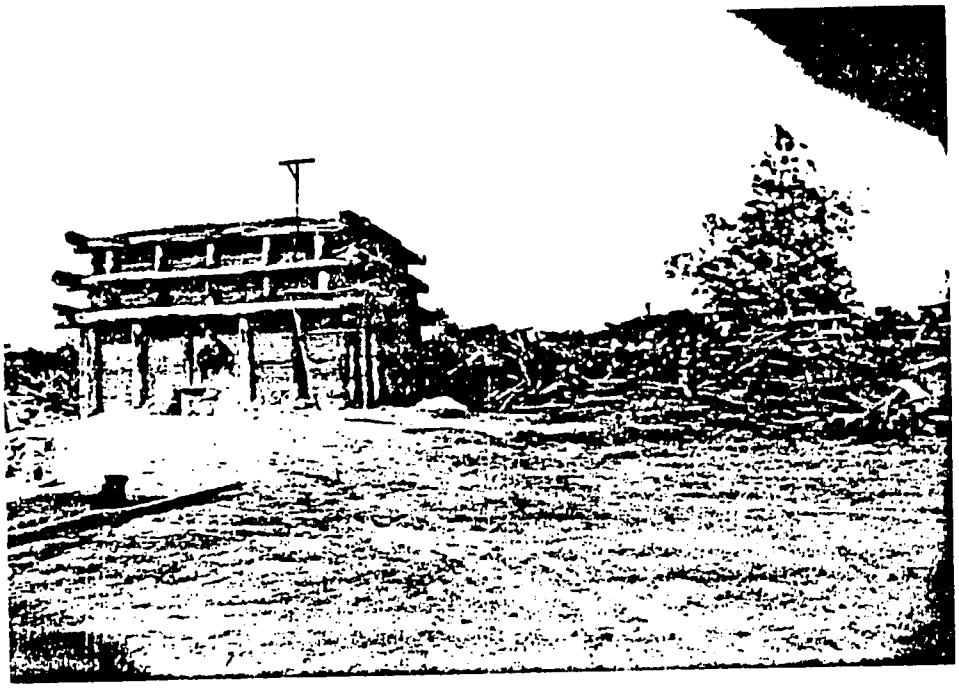
Compressor driven by electric motor



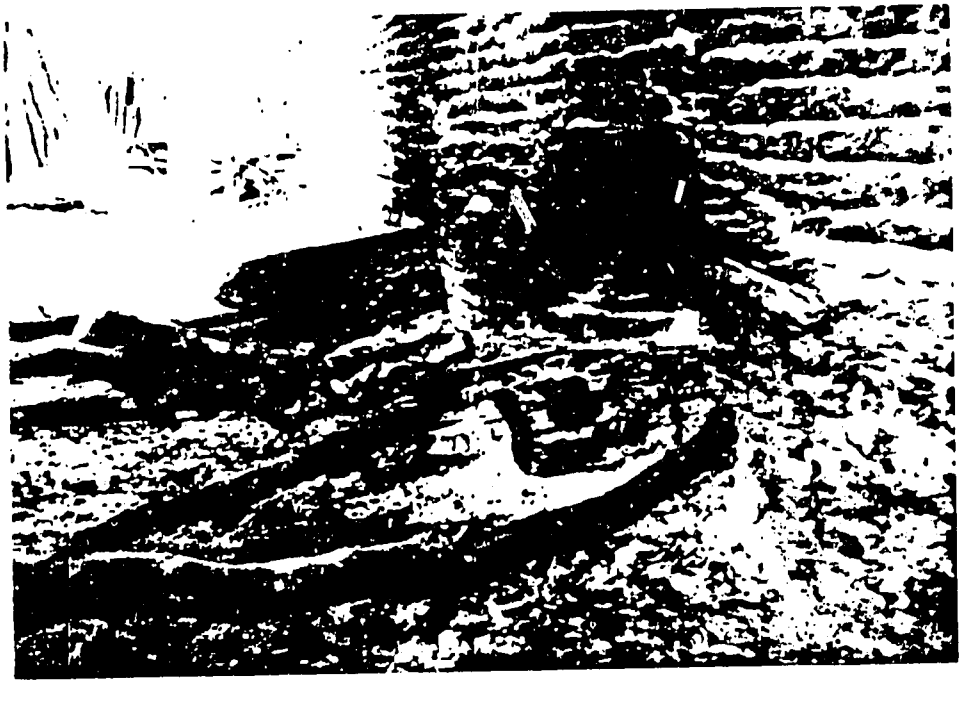
Evaporative cooling unit for salt water coolant

SEQUENCE II

LIMESTONE



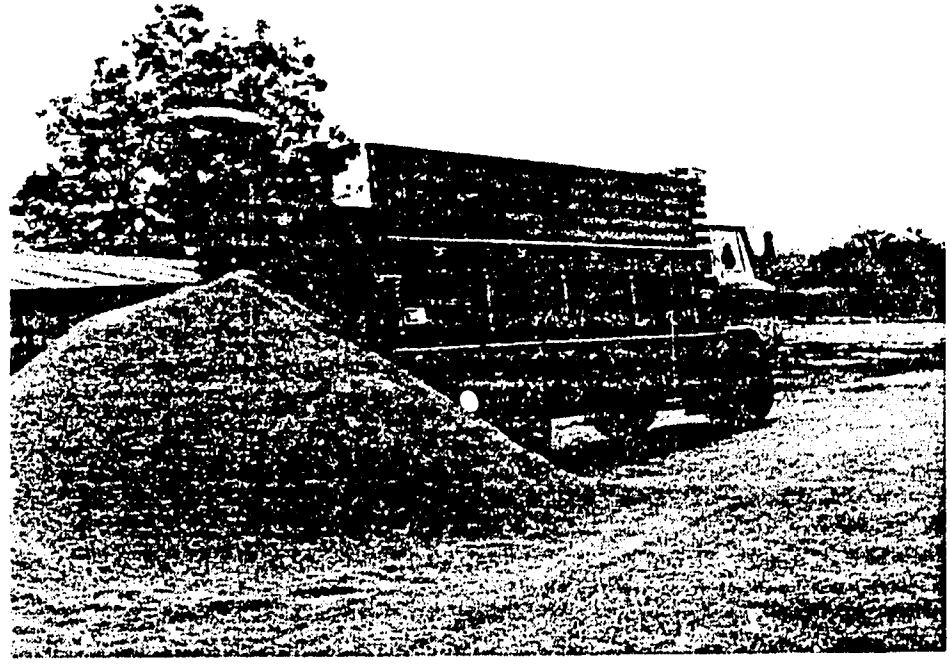
Kiln with fuel



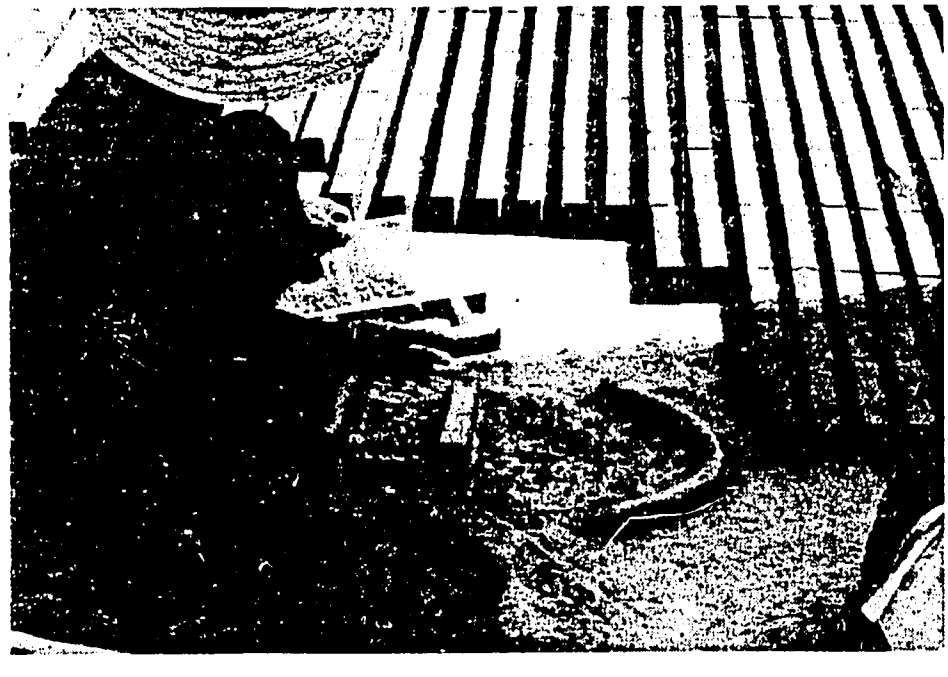
Burning fuel in kiln

SEQUENCE III

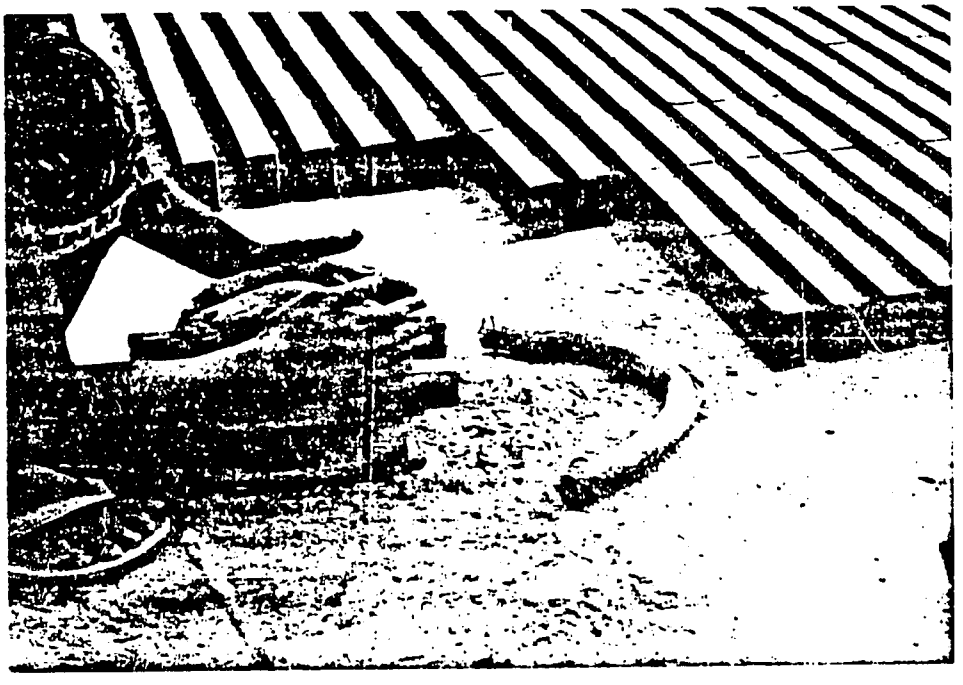
BRICKS



Rice husk fuel - Udorn Thani

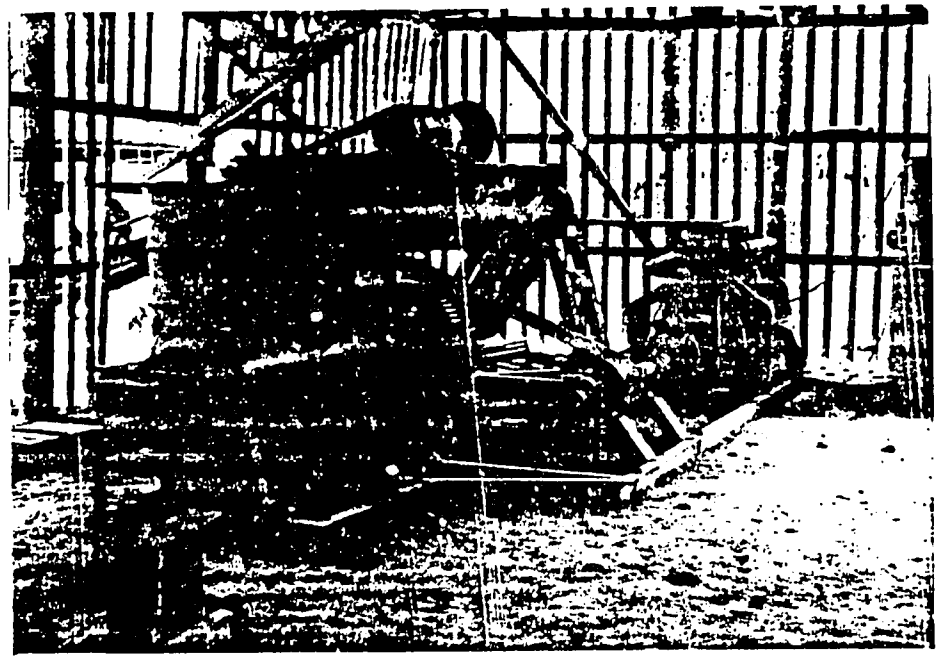


Slop molding, sanding the mold - Udorn Thani



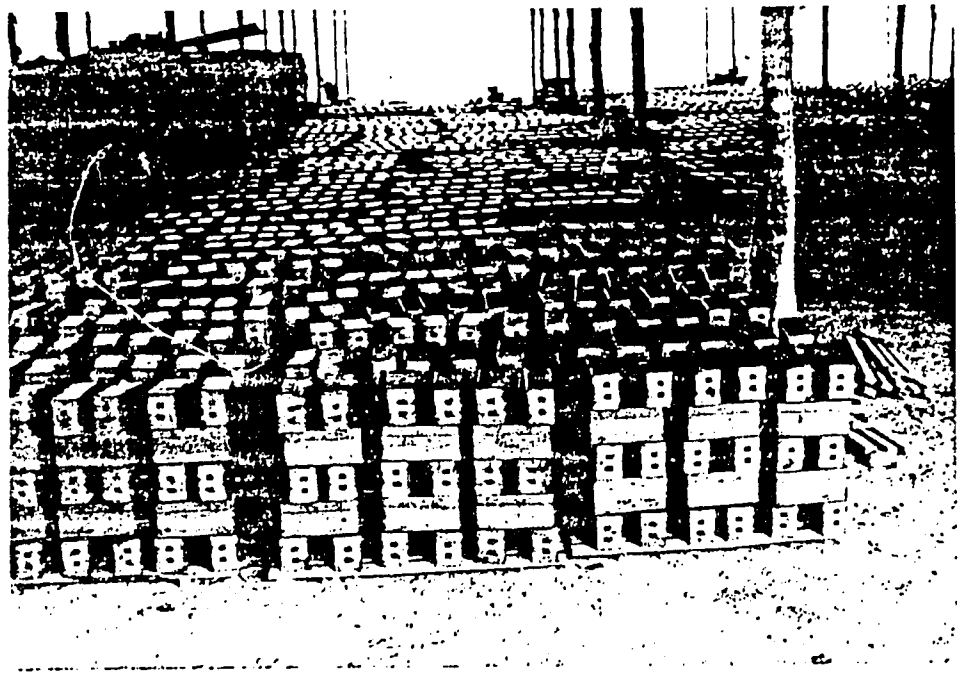
Slop molding, loading the clay

Slop molding, trimming the mold

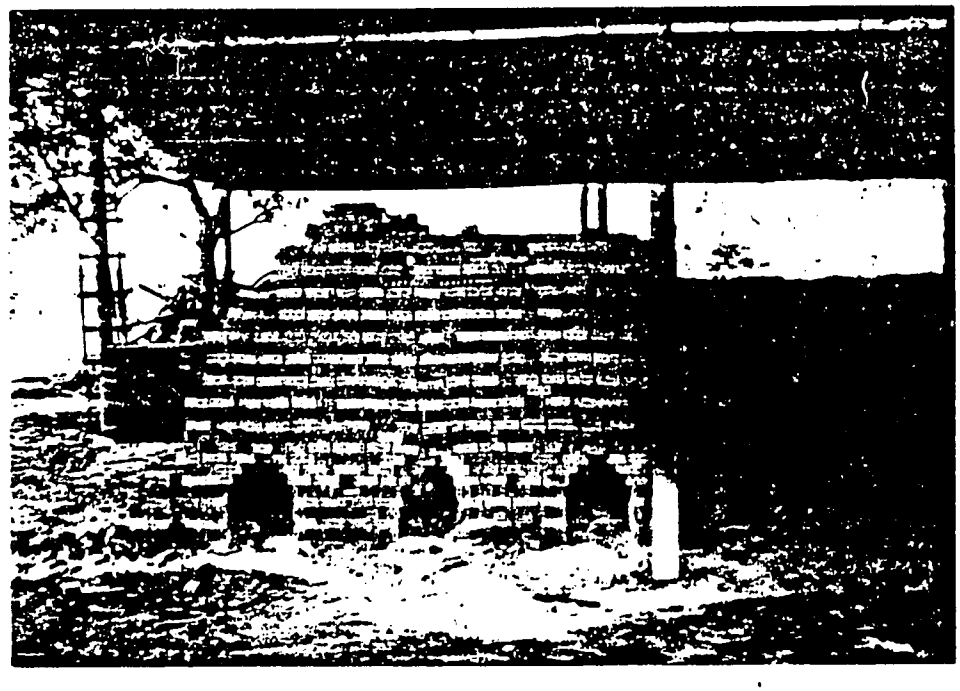


Brick extruder - Songkla

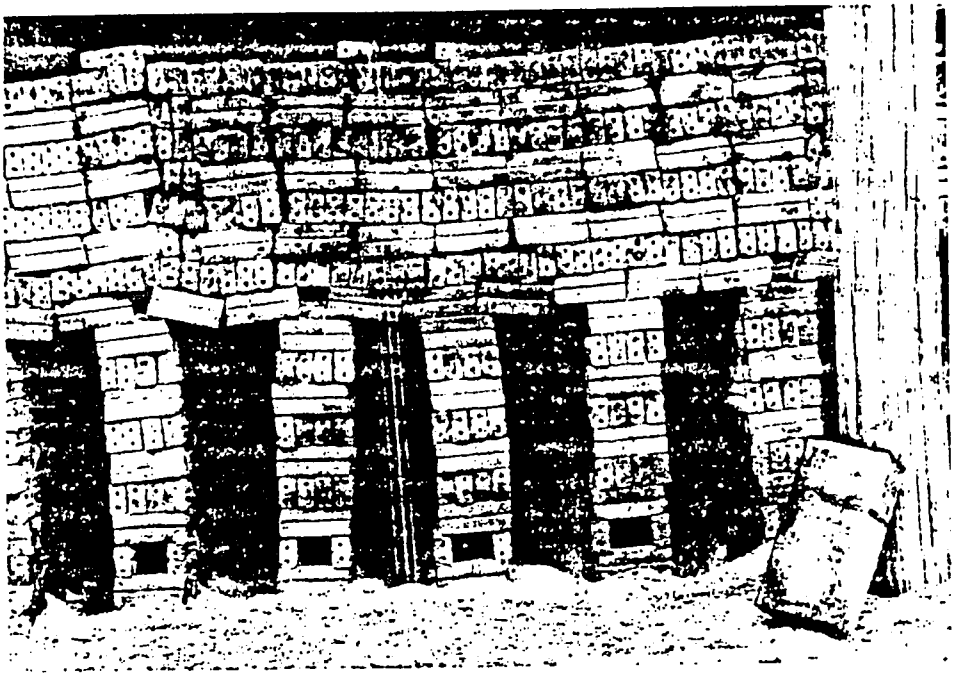
Clay mixer - Roi-et



Drying bricks - Songkla



Brick-making clamp - Chantaburi



Clamp detail - Roi-et

Loading rice husk into clamp - Chonburi

Detail of clamp after firing - Udorn Thani

Wood-fired brick kiln - Songkla

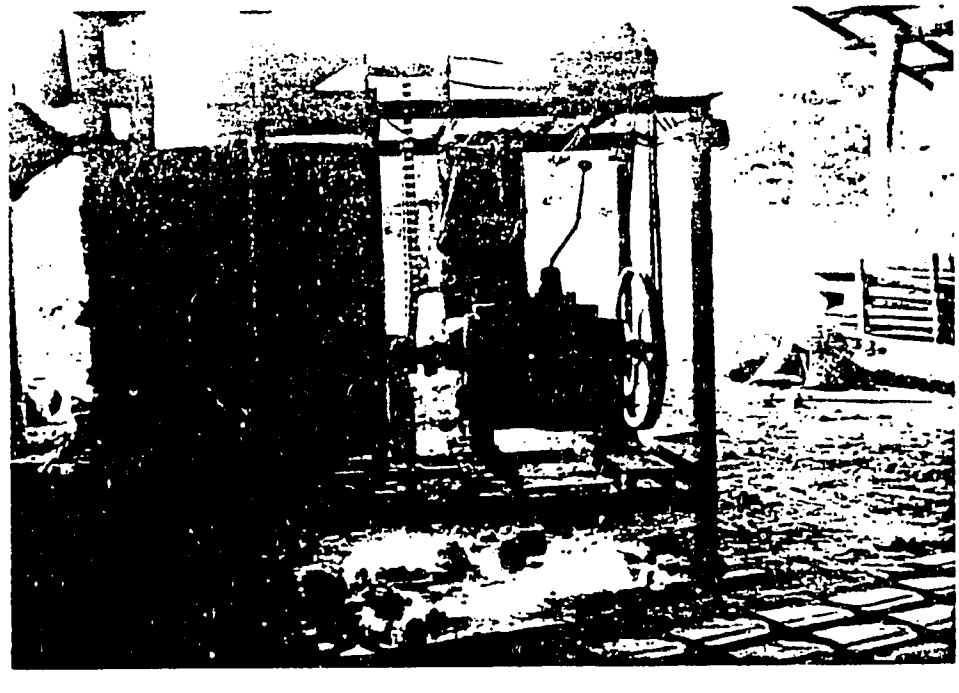
Wood fuel in kiln - Songkla

Beehive brick kiln - Chantaburi

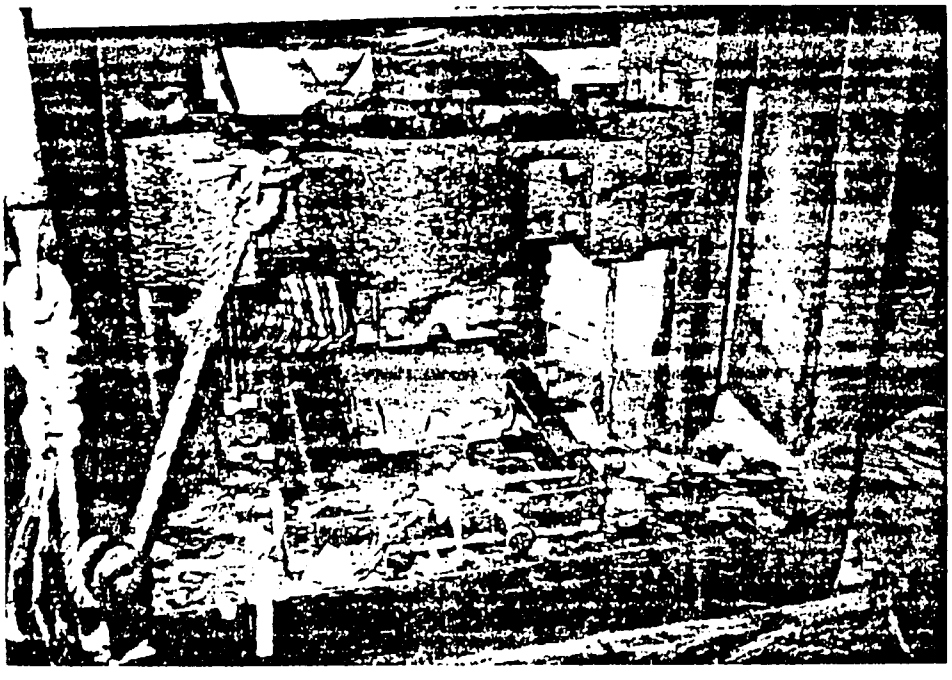
SEQUENCE IV

CERAMICS

Fuel for ceramic kiln

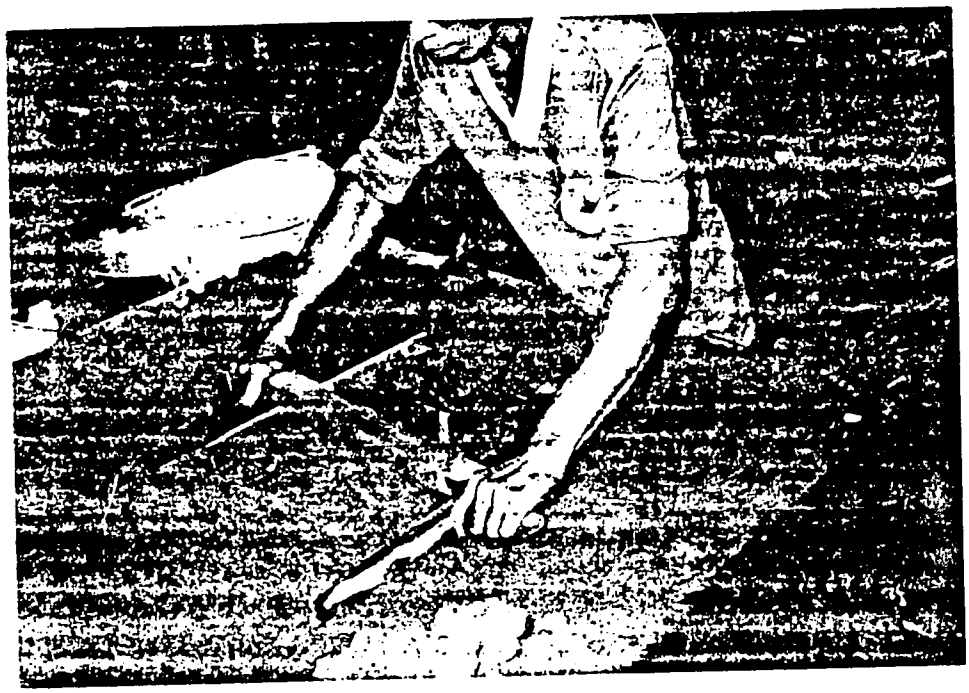


Clay mixer

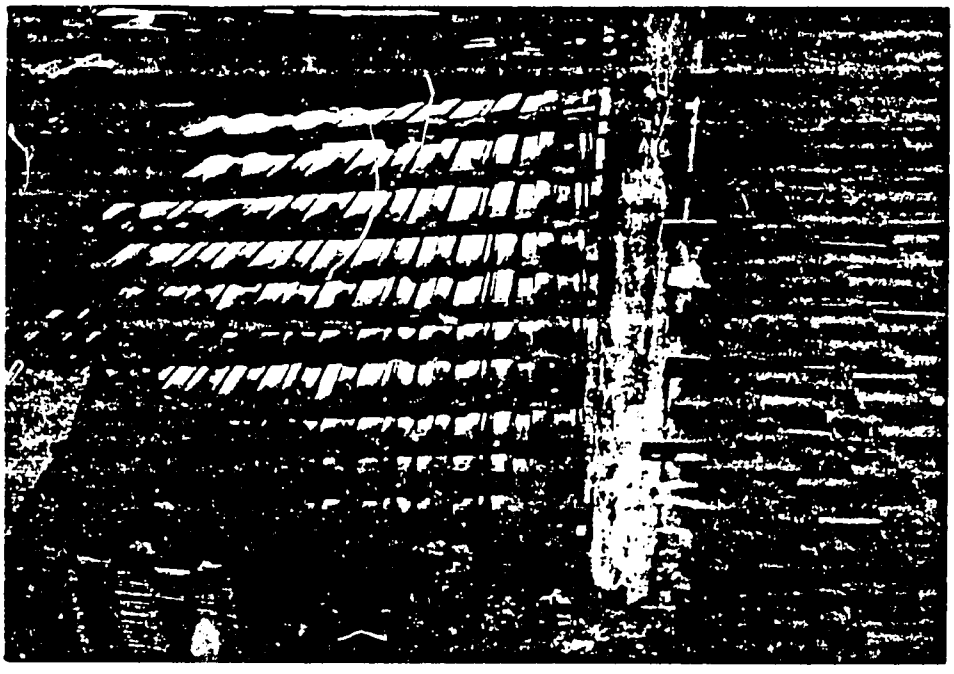


Detail of press - Chantaburi

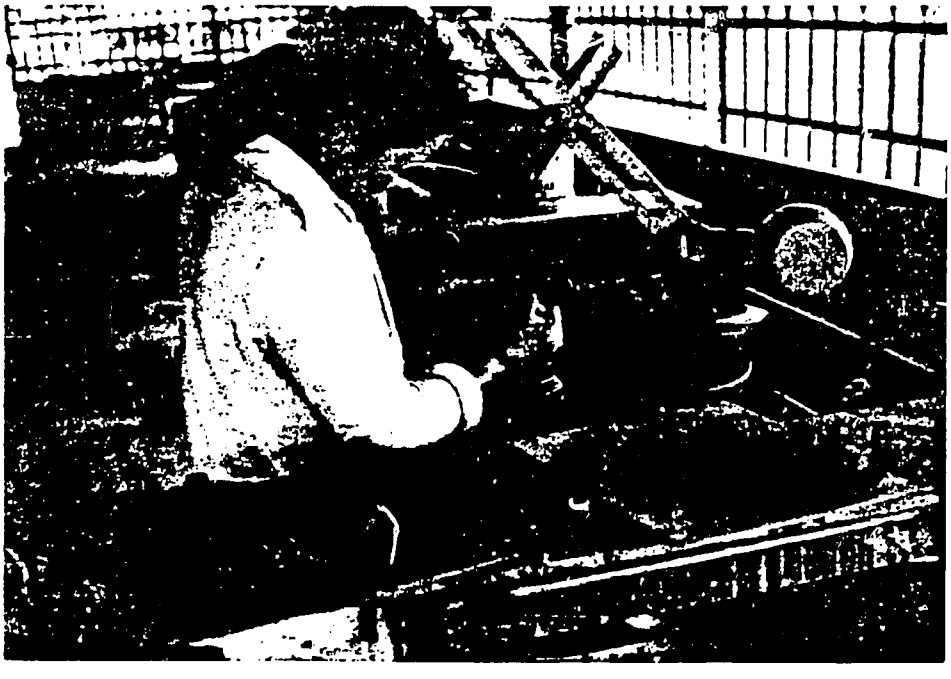
Shaping clay tile in a form - Chaing Mai



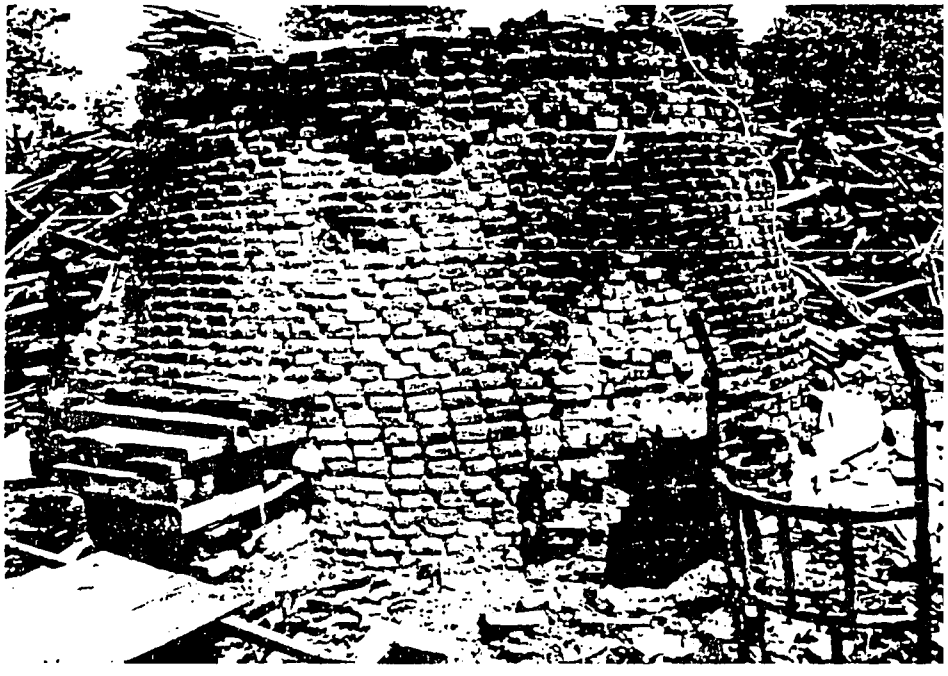
Shaping clay tiles in a form-Chaing Mai



Drying clay tiles



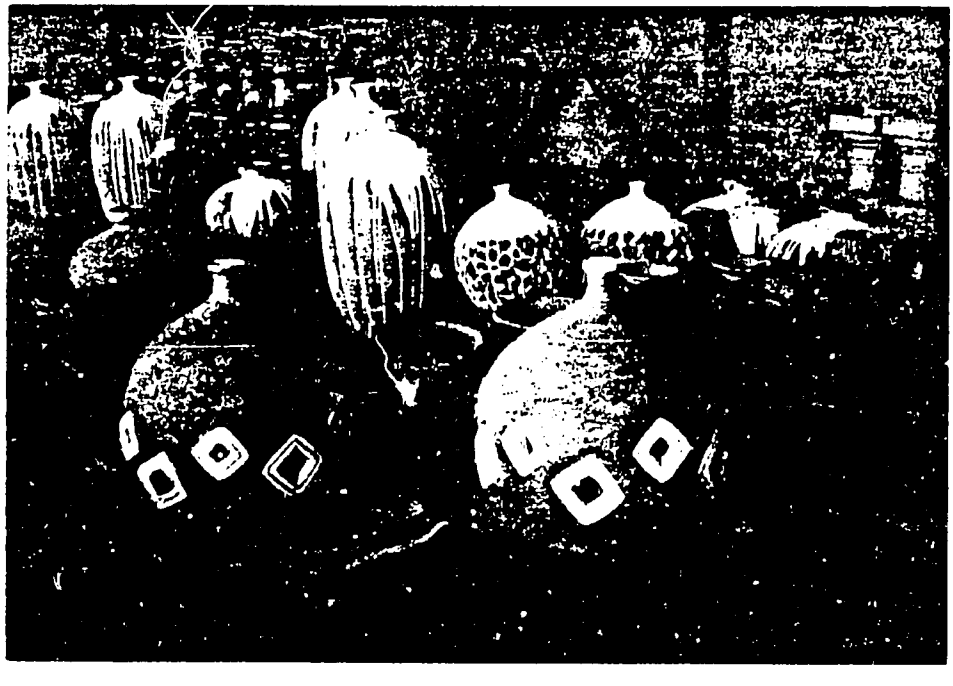
Working with a jig on a pottery wheel



Ceramic kiln - Chaing Mai

Ceramic kiln being fired - Chaing Mai

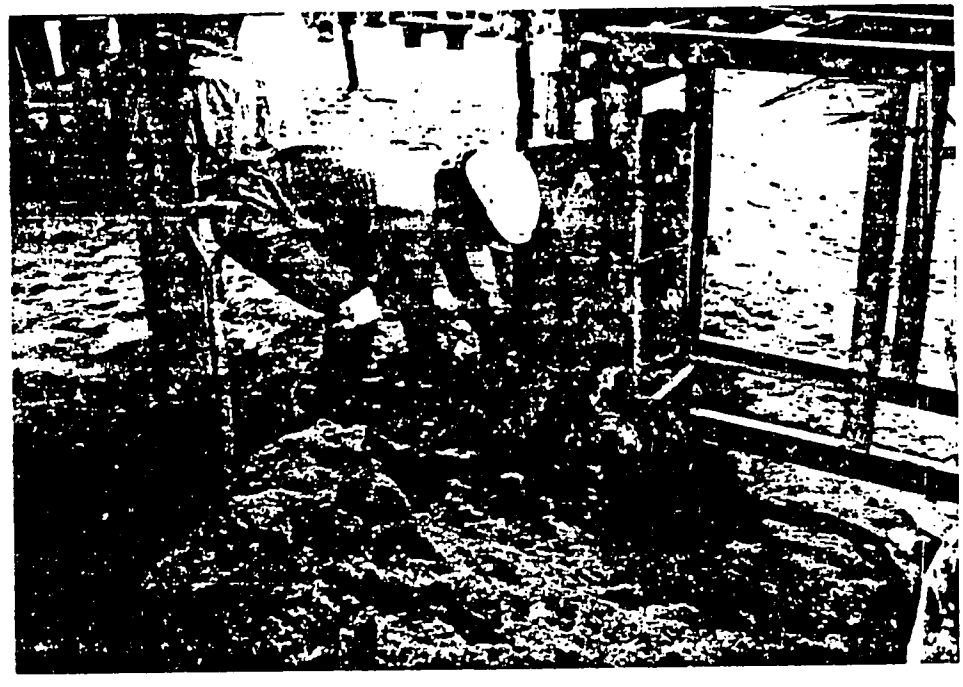
Fired ceramics - Chaing Mai



Pots with glaze ready for firing - Chaing Mai

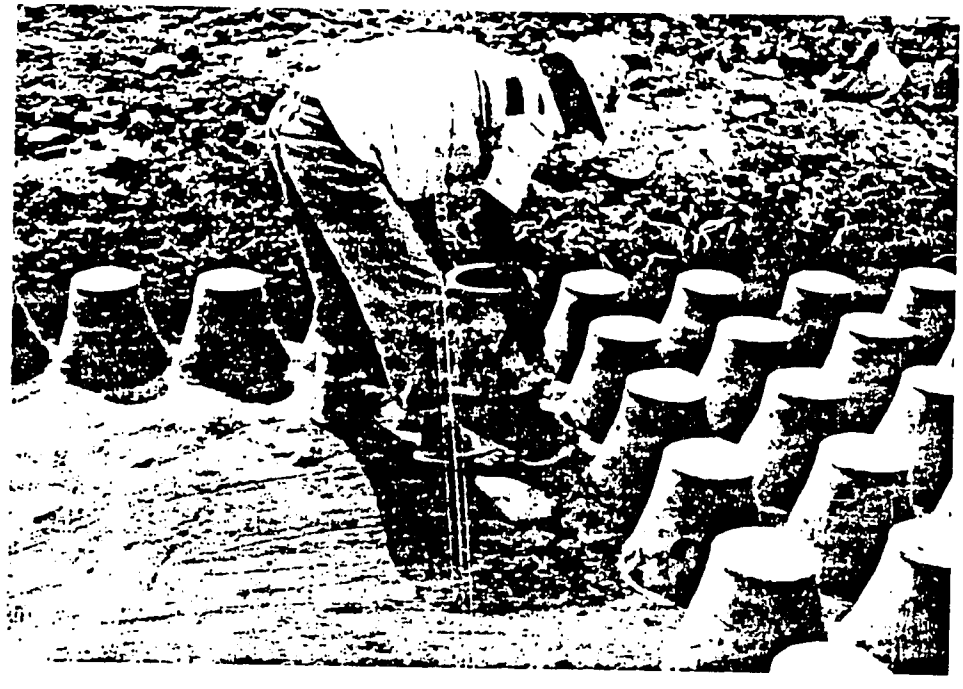
SEQUENCE V

STOVES



Preparing clay

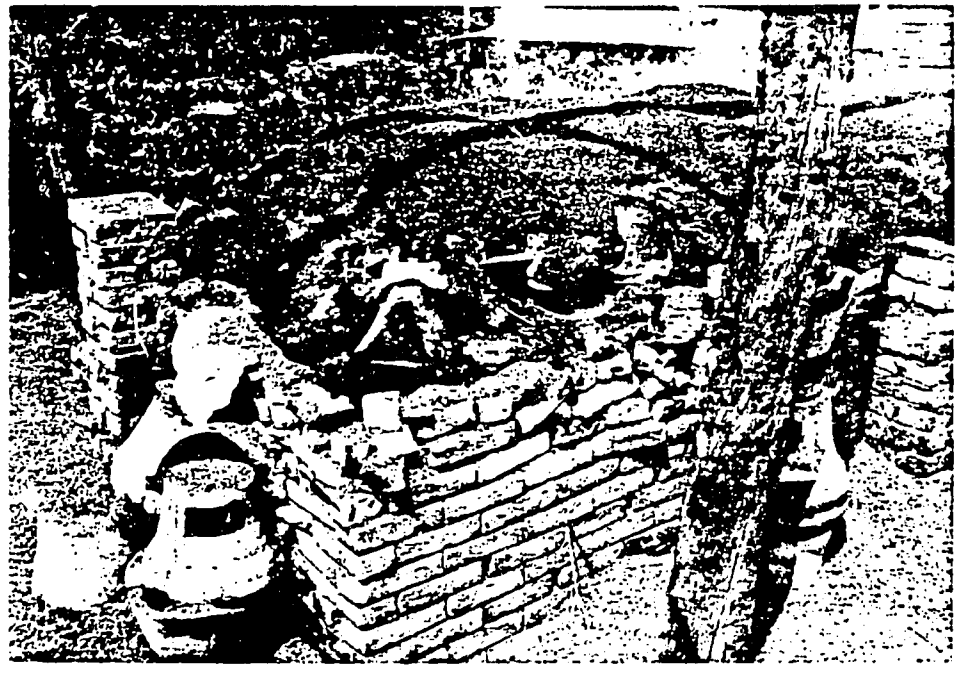
Forming clay in a
wood mold - Chonburi



Drying basic clay forms in the sun - Udorn Thani

Cutting rim in clay form after drying - Udorn Thani

Cutting wood fuel hole
in clay form - Chonburi



Rice husk fueled stove kiln - Udorn Thani

Wood-fueled vaulted roof kiln for stoves - Chonburi

Stoves ready to be unloaded

Metal buckets used for finishing stoves - Udorn Thani

Placing insulation between clay stove and metal bucket - Chonburi

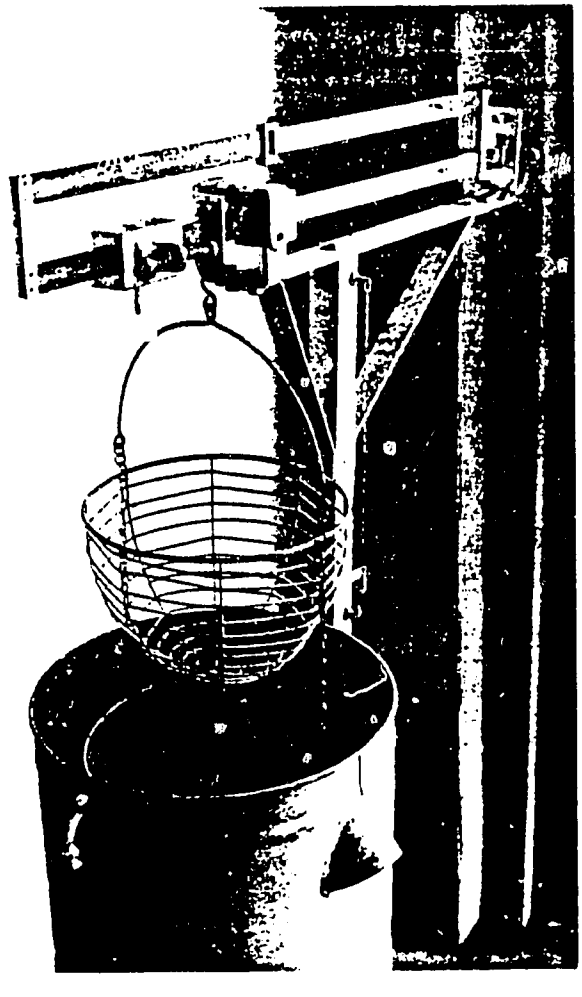
Preparing stove grate - Chonburi

Final product - Udorn Thani

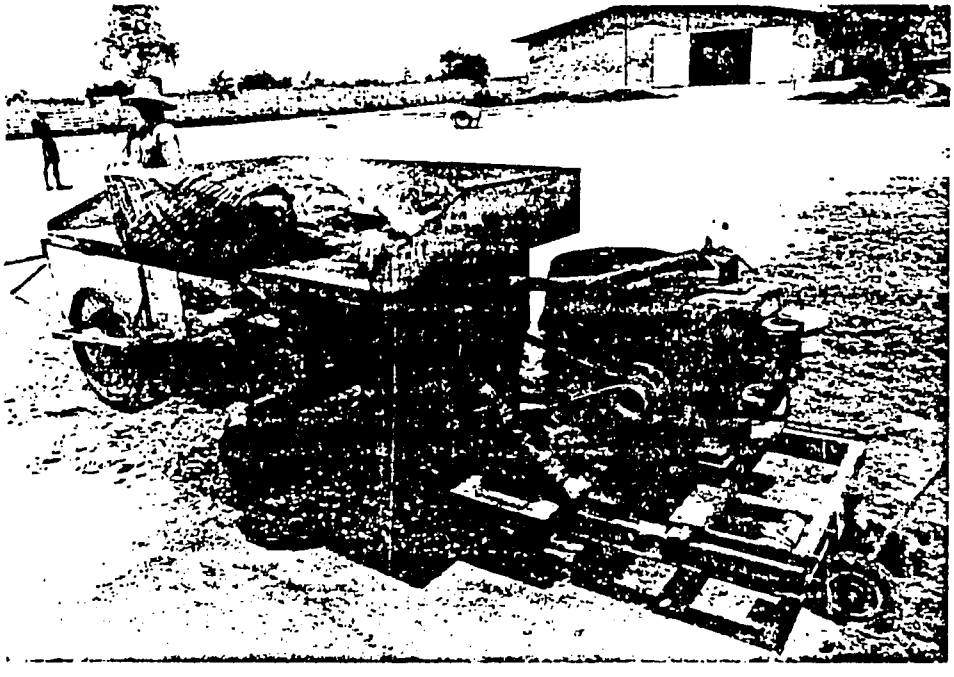
SEQUENCE VI

CASSAVA

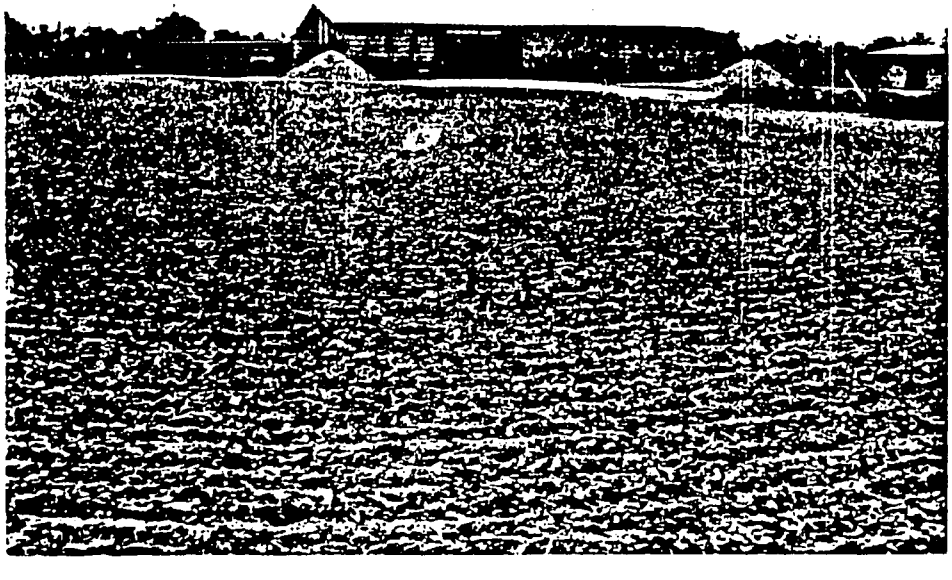
Cassava roots - Korat



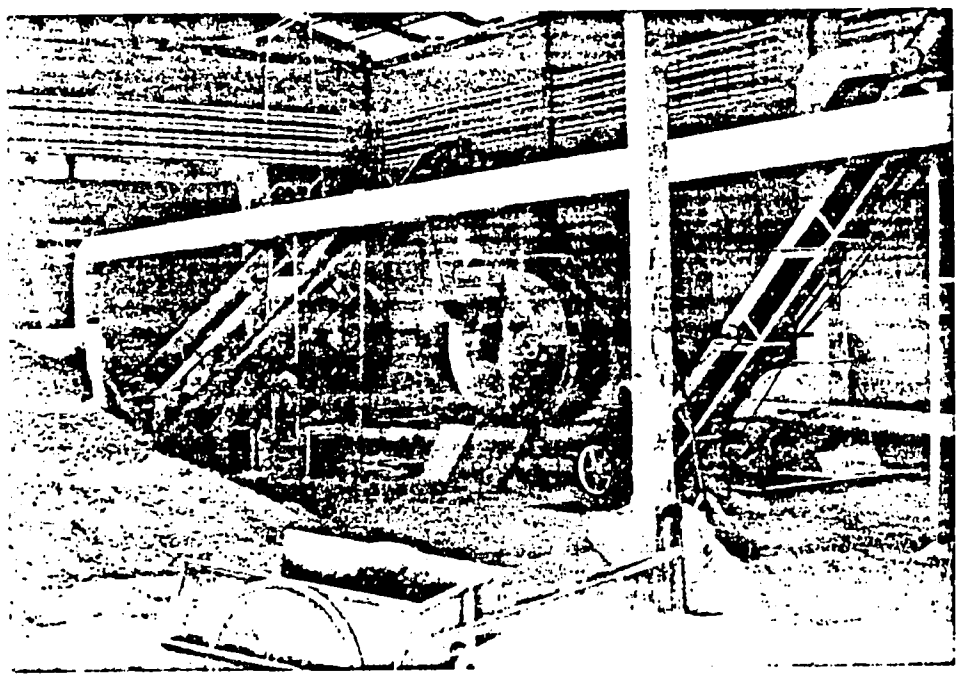
Moisture gauge for cassava - Kampangphet



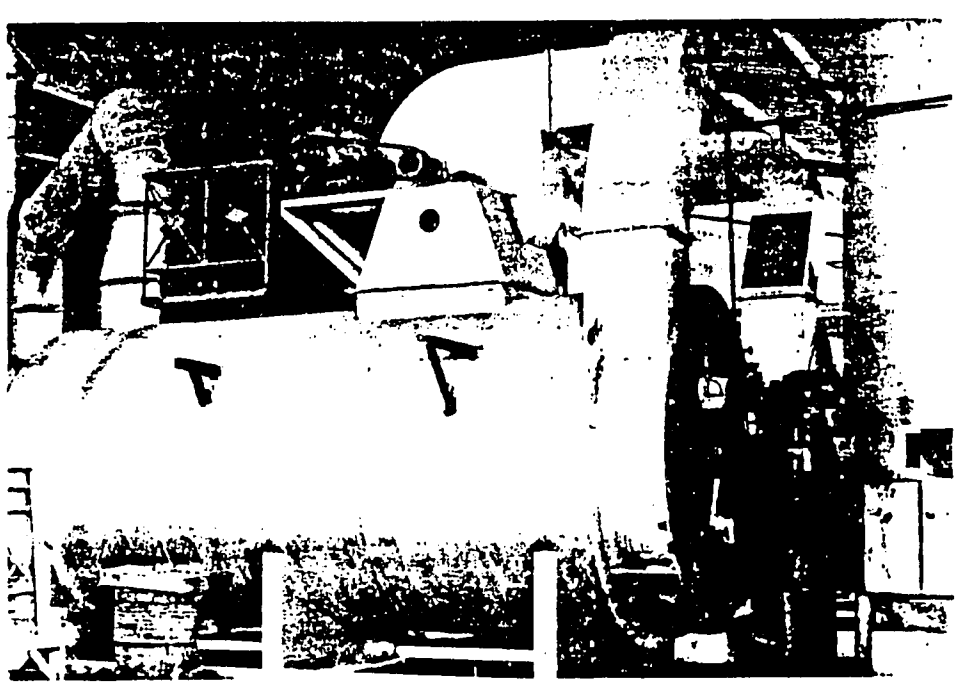
Portable cassava chipping unit - Kampangphet



Drying cassava chips - Korat

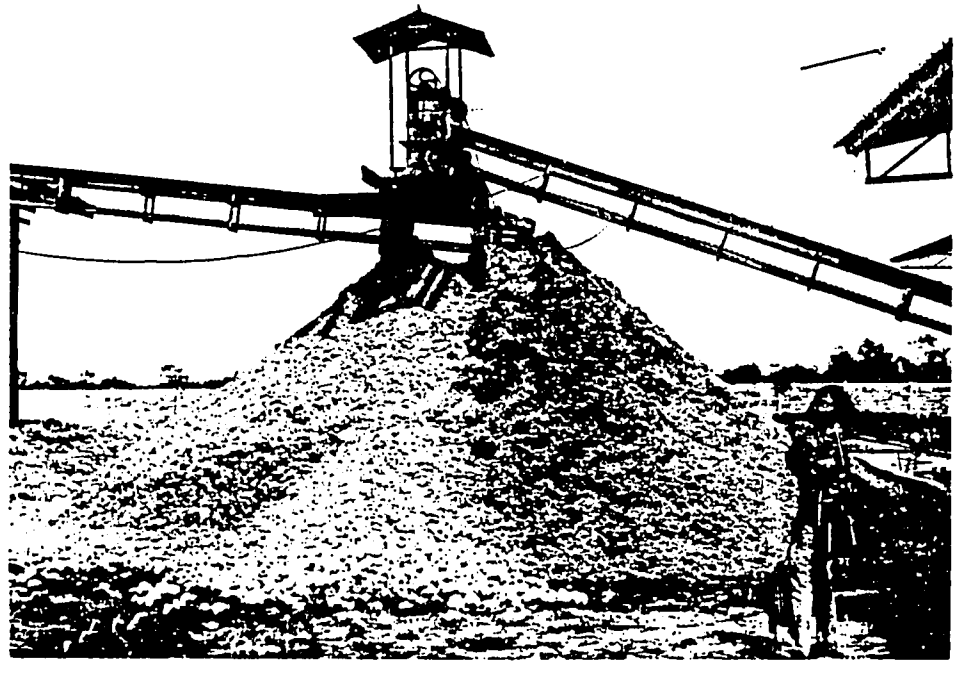


Cassava pellet mill - Kampangphet



Boiler for drying cassava flour - Kamphangphet

Centrifuge



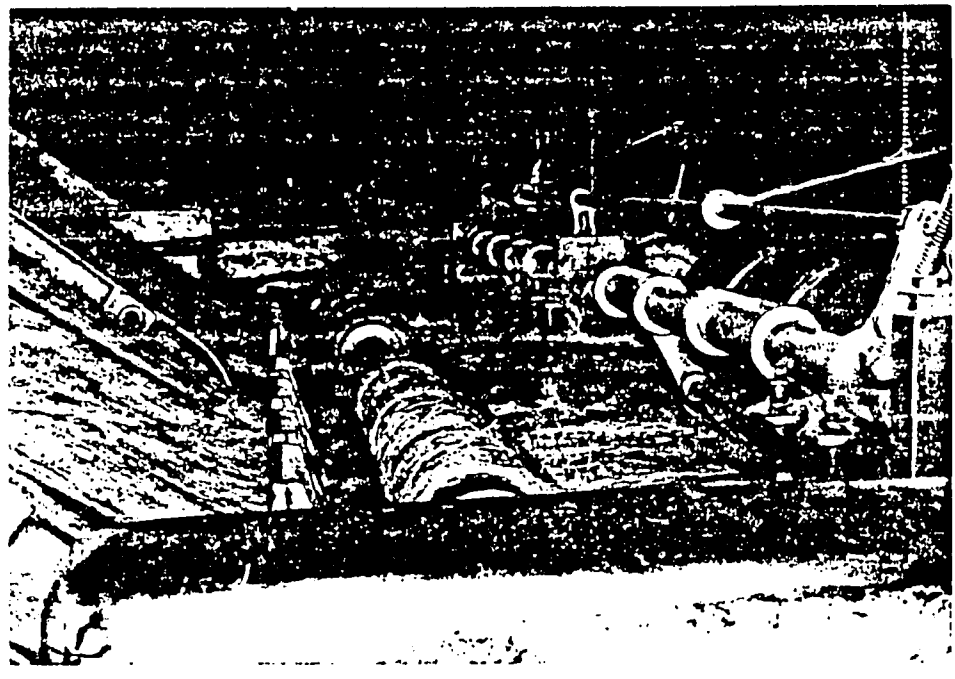
Flour mill residue used for binding pellets

SEQUENCE VII

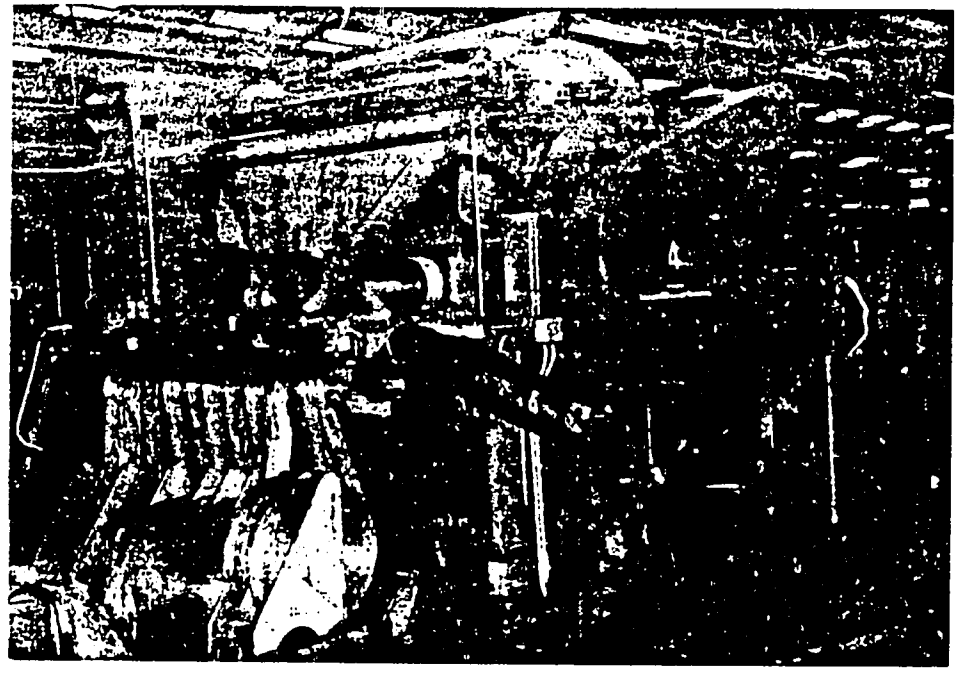
JUTE

Baled jute for processing - Udorn Thani

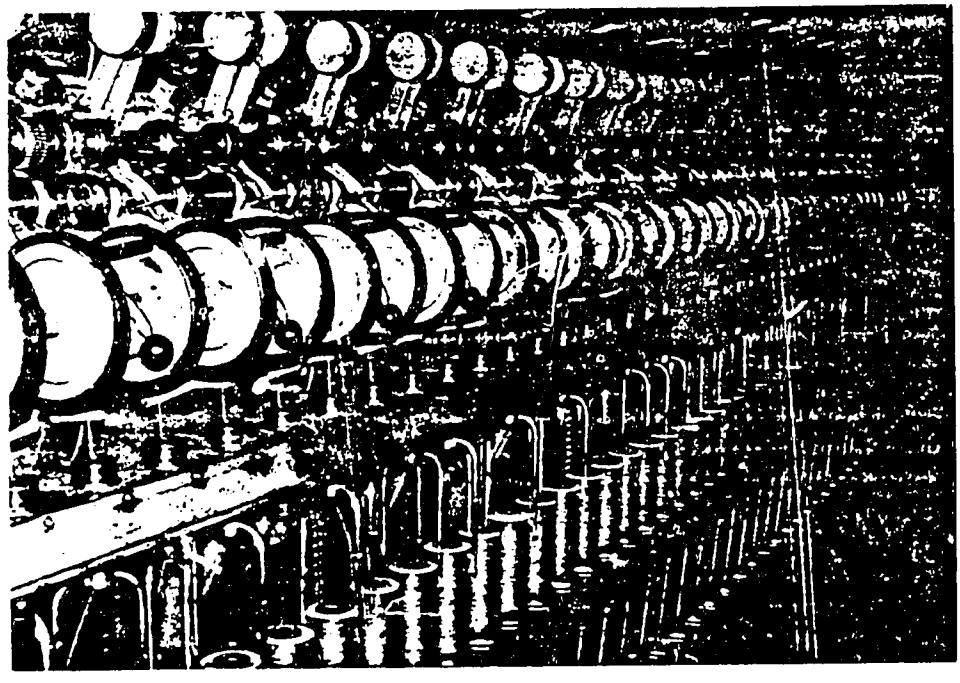
Rollers for cleaning jute



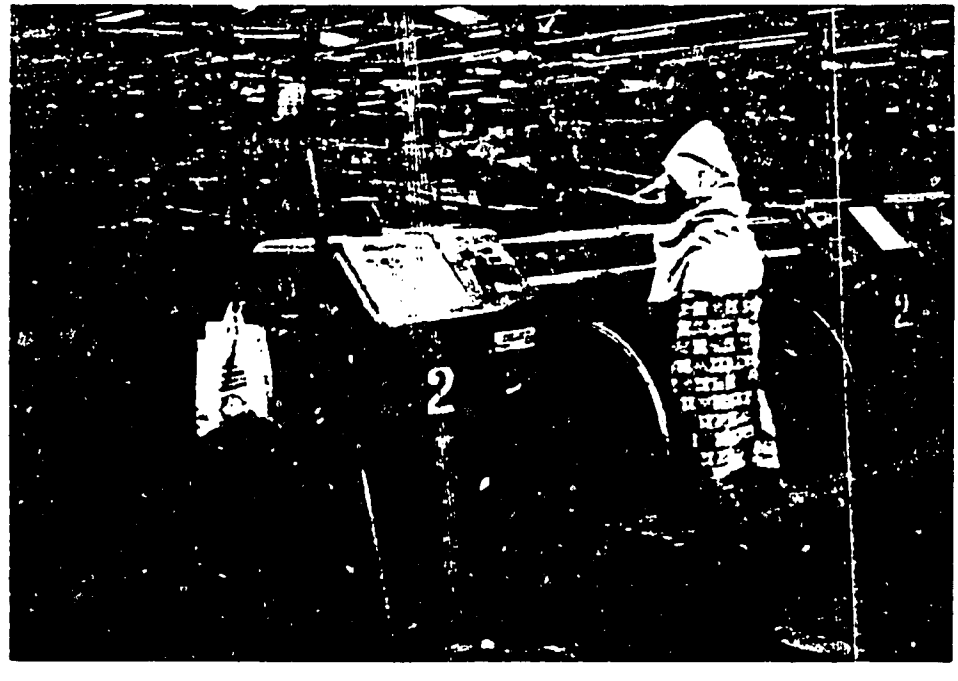
Combing machine



Carding machine



Spinning machine

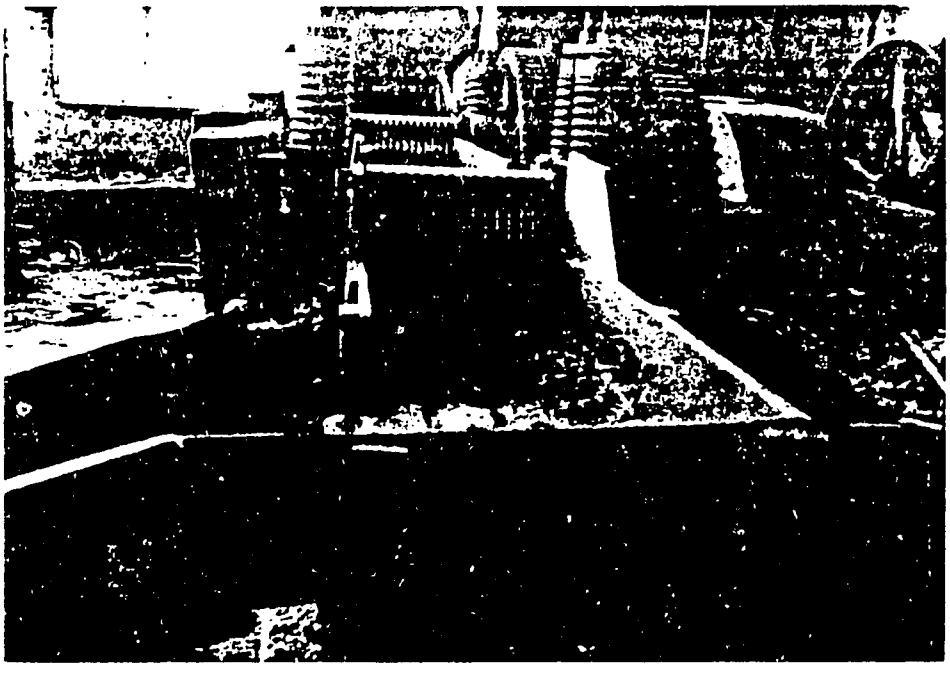


Warping machine

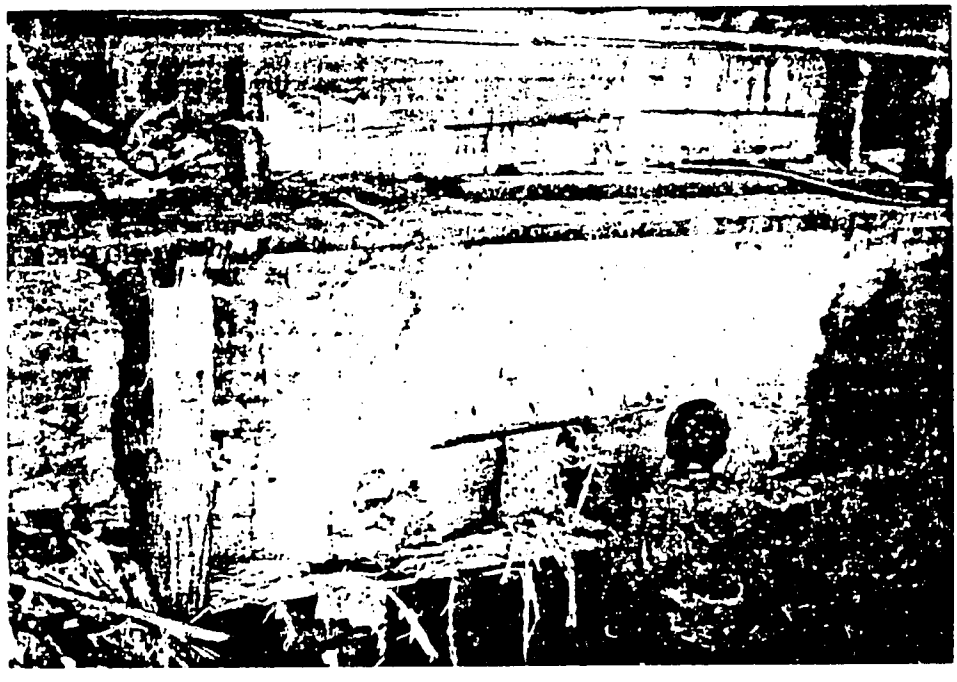
SEQUENCE VIII

RAW SUGAR

Bagasse - Korat



Cane grinding machine



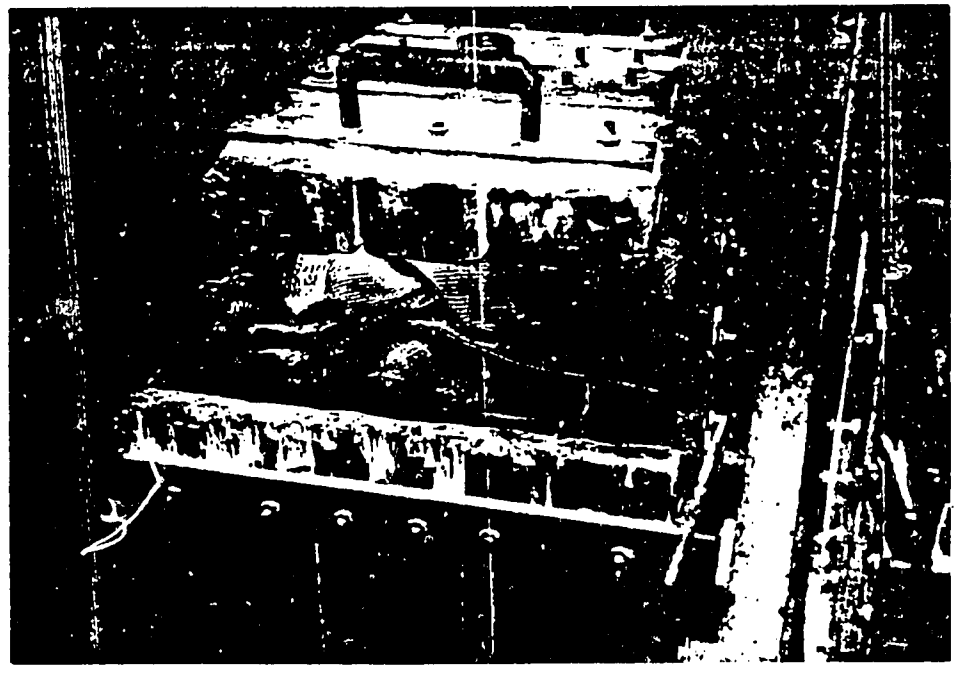
Bagasse fired stove

Adding water to the stove

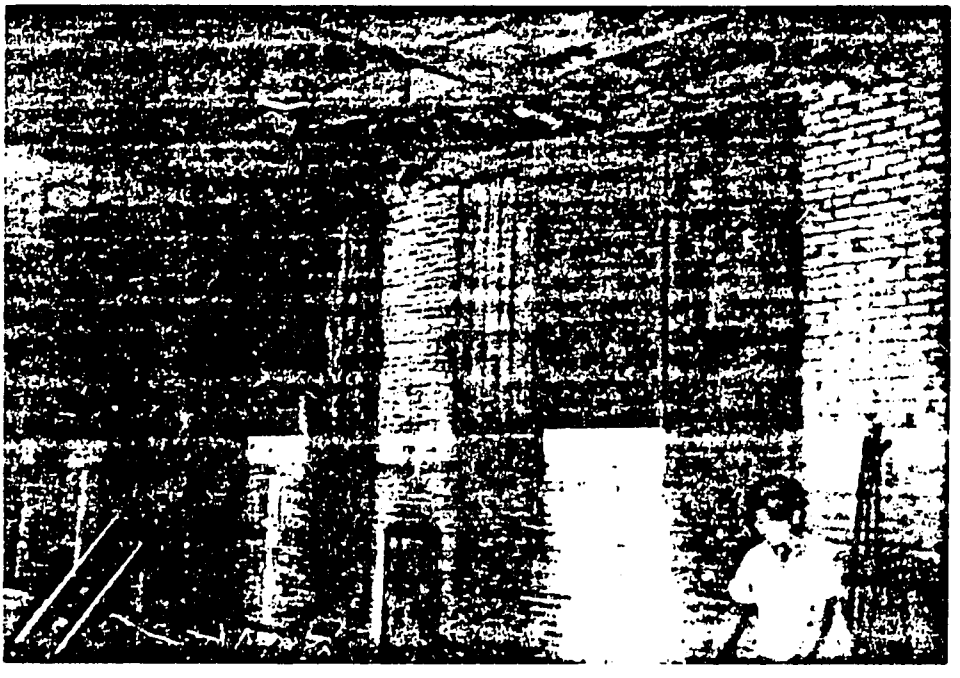
SEQUENCE IX

RUBBER

Cleaning rubber mats - Songkla



Placing rubber mats in drying press



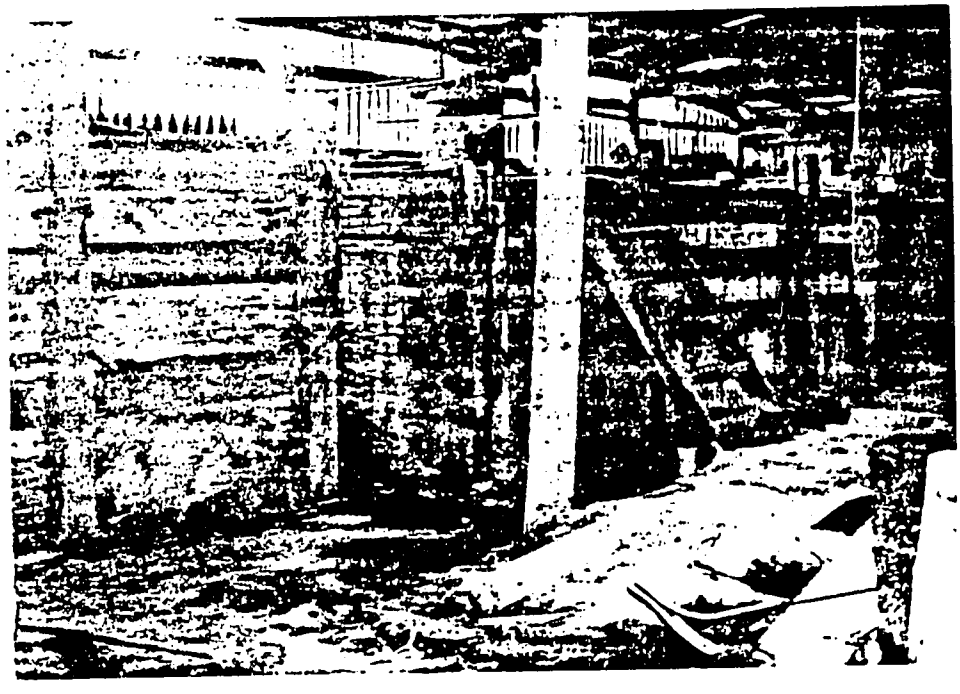
Drying ovens

Cutting rubber strips

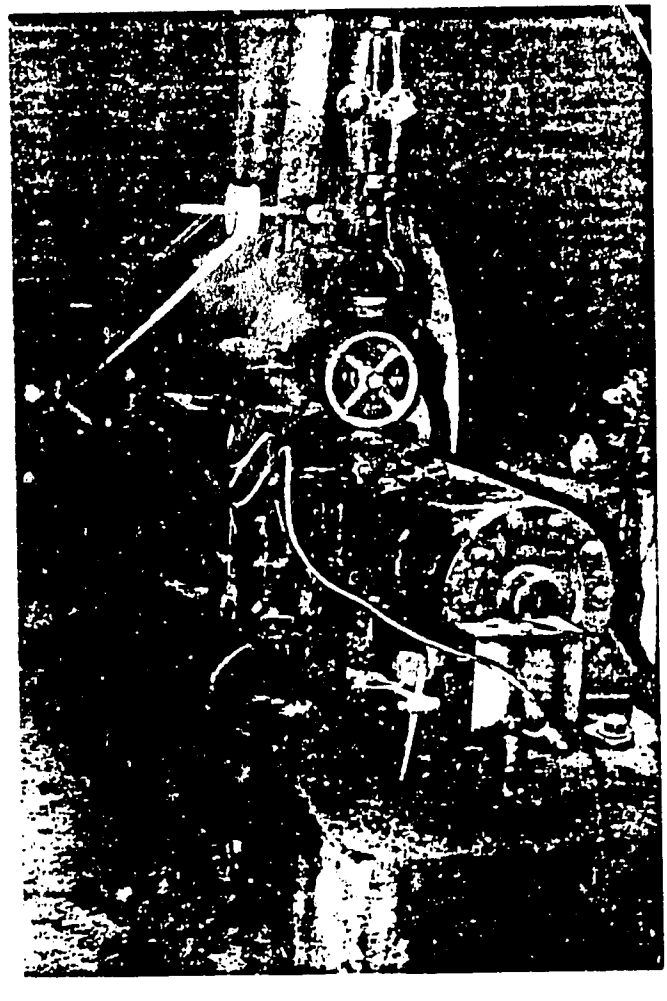
Bale of rubber prepared for shipping

SEQUENCE X

RICE



Boiler structure for rice mill - Udorn Thani



Steam engine

Rice husk loading chute for boiler

Traditional mill with imported grinding unit

SEQUENCE IX

SALT

Salt factory using sawdust fuel in evaporating stoves - Udorn Thani

Evaporating stoves with suspended baskets of salt

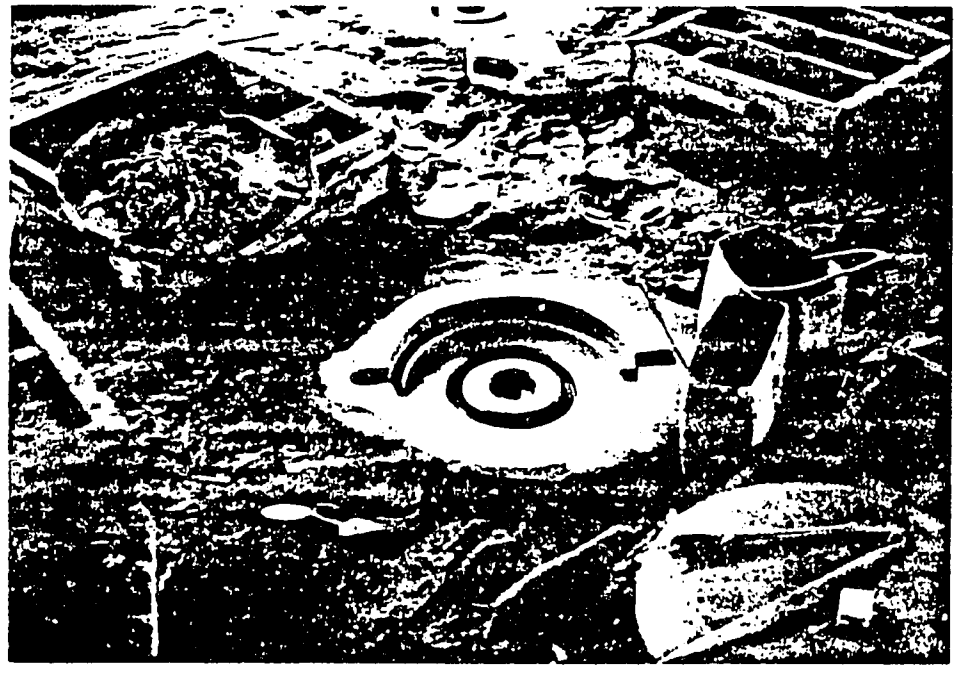
Salt packed into straw containers for sale

SEQUENCE XII

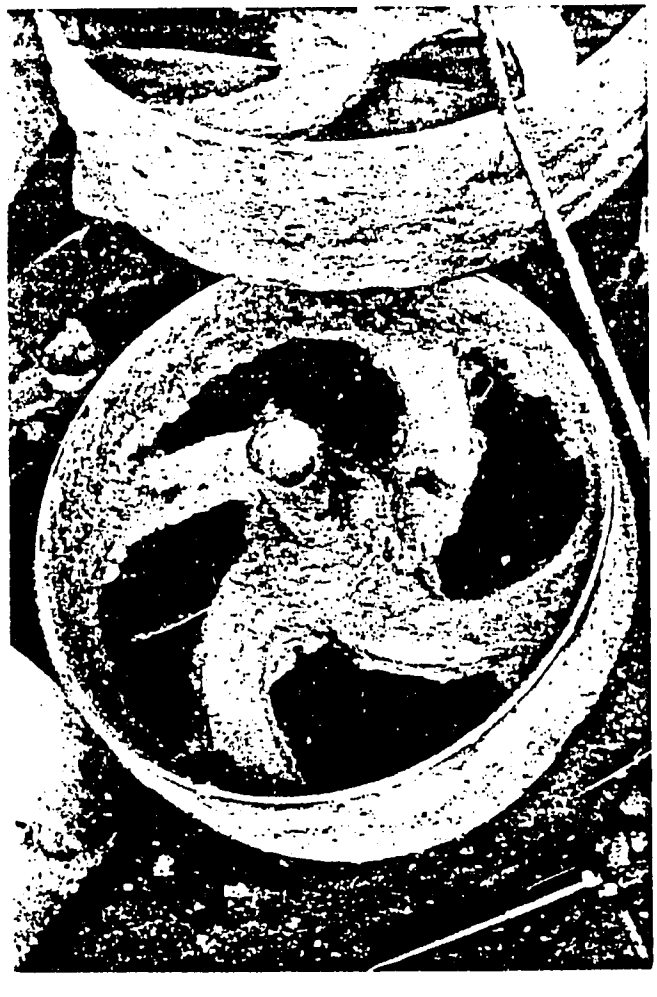
METAL CASTINGS

Furnaces for melting scrap iron

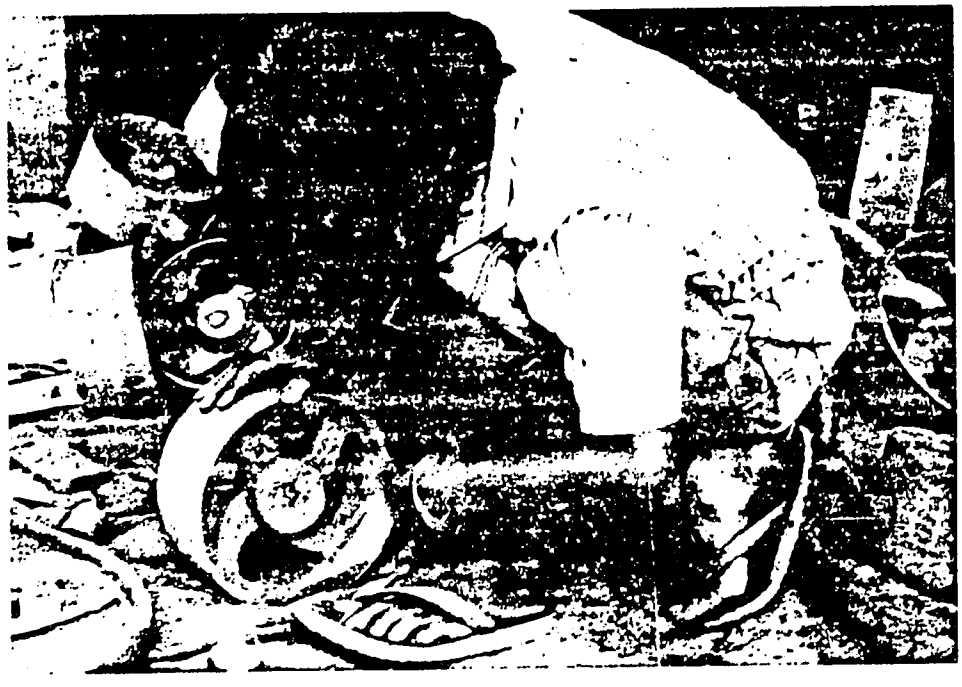
Cupolas



Sand mold for casting rice mill parts



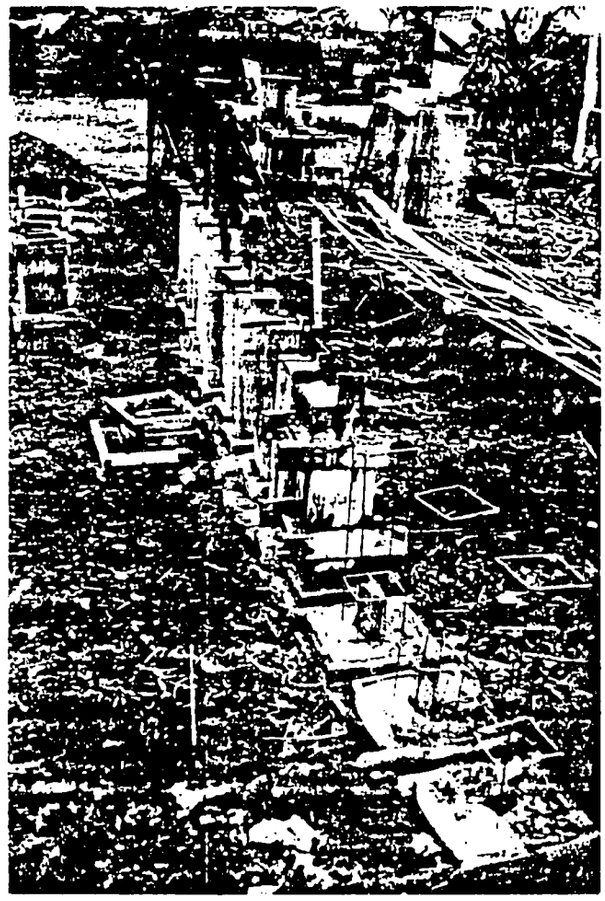
Sample castings



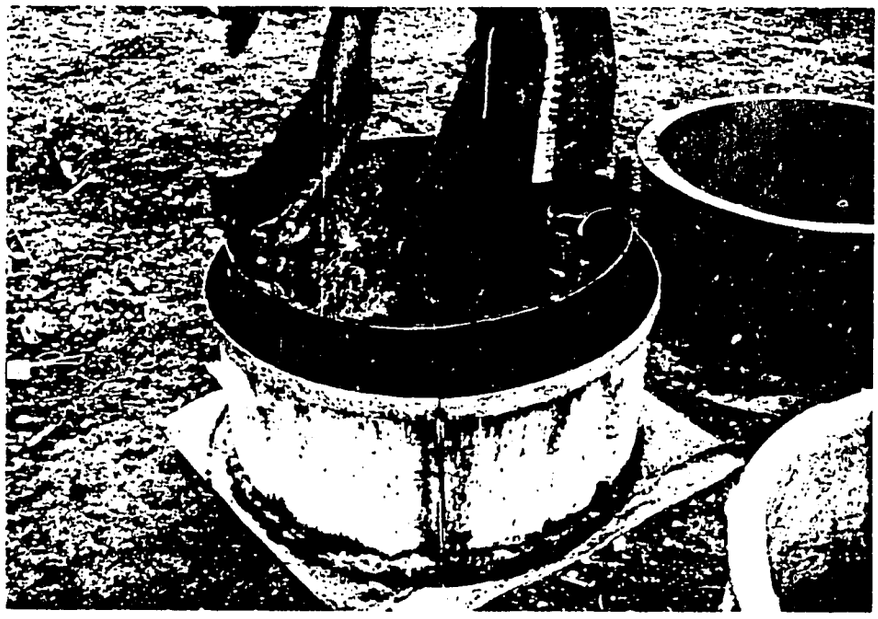
Finishing the metal casting

SEQUENCE XIII

CONCRETE FORMS



Forms for house post footings



Forming well rings

Drying well rings and house posts